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ELECTRIC BELLS, INDICATORS AND RELAYS

THERMIONIC VALVES FOR RADIO RECEIVERS

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HOUSE TELEPHONE SYSTEMS

TUNING COILS AND INDUCTANCES

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PART 32

A PRACTICAL WORK WRITTEN BY EXPERTS

ELECTRIC BELLS, INDICATORS AND RELAYS

PRACTICAL NOTES AND USEFUL CIRCUITS

By Frank H. Collis

ELECTRICAL bells date back to about the year 1830 and were used commercially in about 1850.

Their simplicity, or so-thought simplicity, has been the cause of much trouble, because in many cases they have *not* been taken seriously. Like many other things, if properly treated, they will prove a trusty servant and, indeed, when so entrusted they are of vital importance.

Types of Bells Generally Used.

There are so many types of electric bells that it would be impossible to deal with all of them in this article. Those which are mostly used are for dwelling houses, offices, hotel, fire and burglar alarms, and even these range from 2 inches to 12 inches in diameter and are used on voltages from 2 to 200 D.C. or A.C.; from batteries, transformers and lighting mains.

A Three-inch House Bell Installation.

Let us first deal with the most used 3-inch house bell installation, but before we start I would like to stress the importance in the choice of one's materials; there are many pitfalls that the inexperienced will not detect. It pays to buy the best materials obtained from manufacturers of repute.

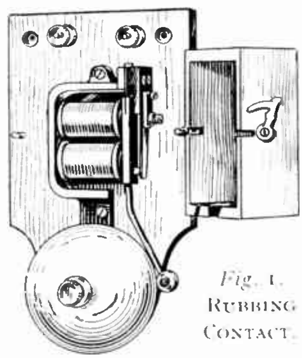


Fig. 1. Rubbing Contact.

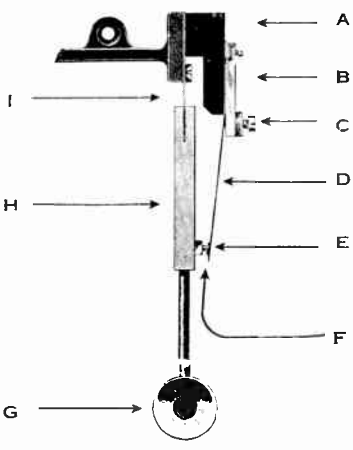


Fig. 2.—Main Points of a Rubbing Contact.

A, fibre insulator; B, polished and lacquered brass plate; C, adjusting screw and lock nut; D, coppered steel contact spring; E, rubbing contact; F, gold-silver contacts; G, brass knob; H, soft iron armature; I, coppered steel armature spring.

The *case* of the bell should be made from hard wood such as teak or mahogany.

The *frame* of best soft grey iron.

The *cores and armature* of non-magnetic iron to prevent residual magnetism; there should be a brass or copper pip to prevent them touching. The *bobbins* of box wood wound to the correct resistance with either silk or enamel covered wire; for the bell in question $3\frac{1}{2}$ to 5 ohms is usual. The *hammer*—stem of nickel silver and brass knob. The *springs* of coppered steel. The *contact* of gold-silver or silver. There are two types of contact makers: the rubbing type, which cleans itself in use, also gives a very even stroke and is economical in current consumption, and the pillar type. The *gong* should be of bell metal mounted on a separate pillar for the purpose.

The Pushes.

Having decided on the bell, let us next choose the *pushes*. The essential part is the contact, and to ensure that it remains clean, it should be made from non-ferrous metals such as phosphor-bronze, copper or nickel-silver, etc., with either a rubbing contact or point contact. In the former case gold-silver or silver should be used. These can be mounted in any good insulating material to suit the necessary purpose or decorations for inside or outside use. In the latter case the mounting should be watertight.

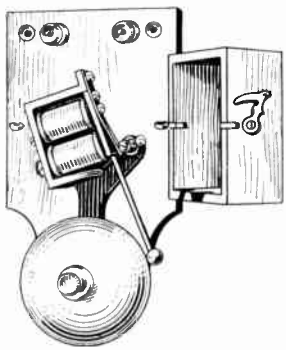


Fig. 3. — Pillar Type Contact.

Wire.

Next comes the wire, and the thickness will depend on the length of the run. I do not recommend anything less than 1/20 S.W.G. for normal short runs and 1/18 S.W.G. for moderate long runs. The wire should be of high conductivity tinned copper wire with a minimum covering of pure india rubber, double cotton covered and paraffin-waxed.

There are much better insulations which could be used with advantage.

The installing of the wire is as important as that of electric light, and should have adequate protection in tubing or casing, and properly made joints are *most* essential.

The Batteries.

These can be either Leclanché cells, sack cells, or dry batteries, but here again be very guarded what you choose. Don't try to judge by the outside appearance. It is the *inside* that matters, such as the quality of the carbon, the porous pots surrounded by the correct quantity of best quality peroxide of manganese, best hard drawn zinc and good crystal sal-ammoniac.

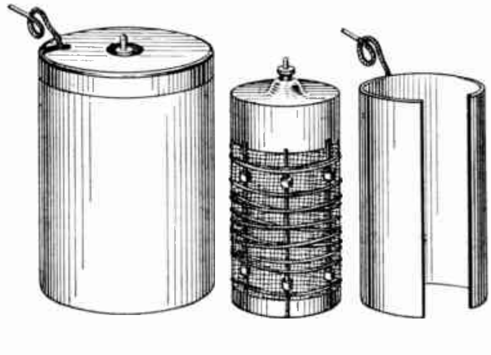


Fig. 5.—How a Sack Cell is Constructed.

Internal Resistance.

This should be as low as possible, and if found to be high it may be due to mal-assembly or presence of impurities or other non-electrical properties.

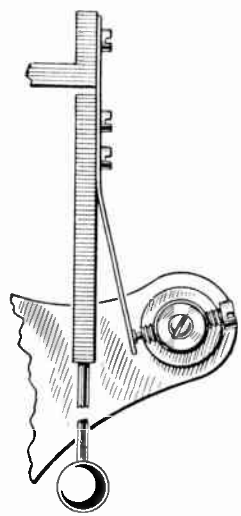


Fig. 4.
Details of Pillar Type Contact.

The purpose of a primary cell is to provide chemical energy that is directly converted into controlled energy and capable of portability, and is really only a step from Volta's pieces of zinc and copper joined by wire and dipped into diluted sulphuric acid.

The modern form of dry cell is made on the same lines, except that the chemicals employed need no attention, such as attention to the electrolyte, coupled with the advantage that they are an entirely self-contained unit.

Solution for Leclanché Cell.

Seven ounces of sal-ammoniac to one quart of water is a good solution for

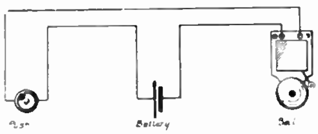


Fig. 6.—A Simple Bell Circuit.

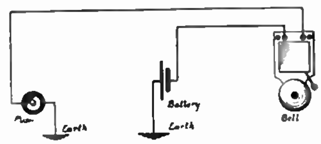


Fig. 7.—A Simple Bell Circuit with Earth Connection, i.e., a Water Main.

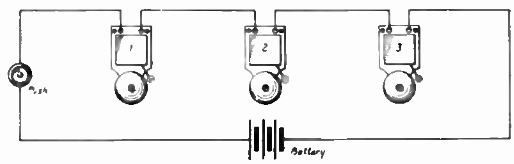


Fig. 8 (*Right*).—Bells in Series.
Nos. 2 and 3 are single stroke and the E.M.F. must be increased in proportion to the number of bells used.

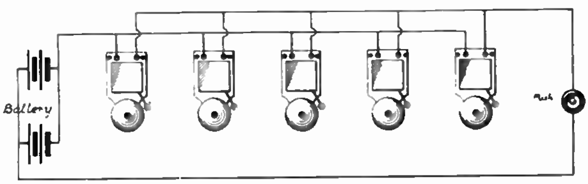


Fig. 9 (*Left*).—A Number of Bells in Parallel.
It is essential that the resistance is properly adjusted.

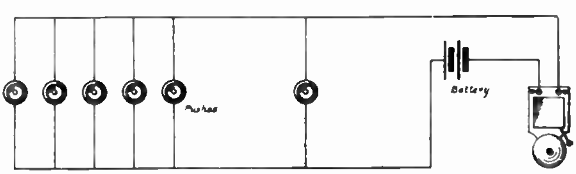


Fig. 10 (*Right*).—Circuit for One Bell Controlled from a Number of Points.
Any push when pressed completes the circuit.

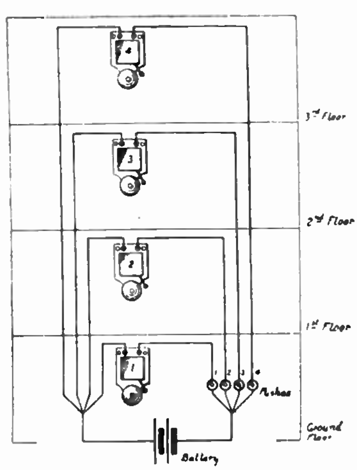


Fig. 11.—A System of Bells for Flats, etc.
Any bell may be rung from one point.

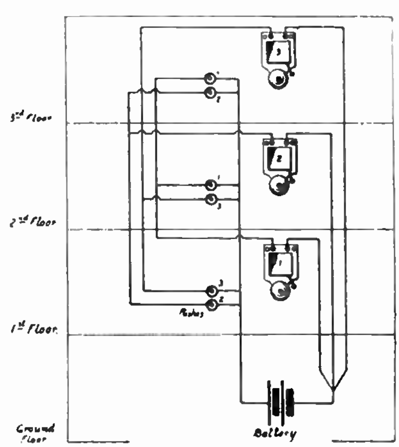


Fig. 12.—A Receiving or Sending System.
This is very useful for speaking tubes or lifts.

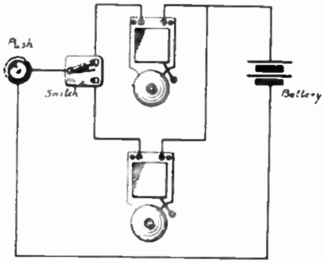


Fig. 13.—CIRCUIT FOR DAY AND NIGHT CALLS.
Two bells may be rung from one push by means of a two-way switch.

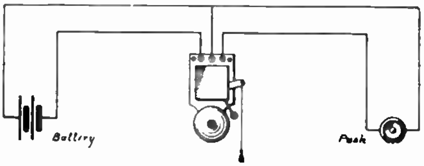


Fig. 14. TYPICAL SYSTEM FOR CASES WHERE A PROLONGED CALL IS NEEDED.
Once this bell is set ringing it will not stop until the cord is pulled.

Leclanché cells, and three cells of either type is the usual battery used on normal runs. These should be placed in a dry place, preferably enclosed in a wooden box.

A.C. Supply.

When the electric light supply is A.C. special bell transformers may be used in place of batteries, but it is essential that the correct size transformer (properly earthed and with the necessary fuses) is installed for the amount of current demanded. For the installation just mentioned a 5-watt would be sufficient, and it must be remembered that a higher voltage is usually required from A.C. than D.C. This size transformer would also be sufficiently large to work a normal size indicator, such as a six-hole, in conjunction with a bell. The resistance of the bell should be wound so that it is suitable to work with the indicator *in all cases*.

Transformers for Bell Circuits.

These are made in many sizes according to the required output, and one must first ascertain this to arrive at the correct size required. They are usually supplied to give this quantity of output in watts, which is the constant output. That is to say, in a 5-watt transformer a 5-watt lamp could burn constantly without over heating. Some cheap transformers on the market are only 5-watt intermittent and would not stand this test, but would over heat.

A good transformer should be encased in a soft grey iron casting, with air spacing fixing lugs, terminals totally enclosed in porcelain insulators, highest quality insulated laminated cores, the primary and secondary windings thoroughly insulated from one another, and an earth shield fitted to prevent the supply pressure from reaching the bell circuit.

TABLE SHOWING TYPICAL TRANSFORMER OUTPUTS.

Primary Voltage.	Approx. Output in Watts.	Secondary Voltage Tappings.	Suitable for Operating	Current.	
				Watts.	Volts.
100/130 or 200/250	5	4, 8, 12	2 watts 2 watts One 3-inch bell and indicator, average size	4	8
	10	4, 8, 12	4 watts 2 watts Two 3-inch bells in parallel and indicator	6	12
	20	6, 12, 18	9 watts One 6-inch bell, teak or iron case	9	18
	40	8, 16, 24	12 watts 8-inch or 10-inch bell, teak or iron case	12	24

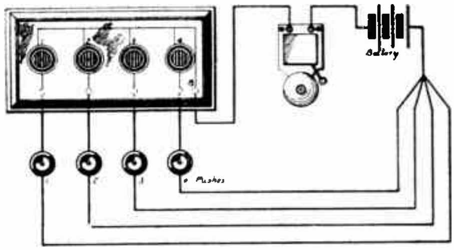


Fig. 15.—A Simple Indicator Circuit with Bell.

Any size indicator, either pendulum or mechanical, may be wired as shown.

The method of determining the output is amps. × volts = watts, and the table on the facing page gives a few examples. The voltage and periodicity should always be stated when ordering.

Having briefly described the most generally used bell installation and the different essential points, which may be taken as a general rule, one may turn to Figs. 6 to 14 showing some alternative circuits.

INDICATORS.

The three most popular types of indicators used are *pendulum*, *mechanical replacement* and *electrical replacement*.

The movements themselves should be of robust construction, preferably with brass frames, non-magnetic soft iron cores. Boxwood bobbins, wound to an approximate resistance of $3\frac{1}{2}$ ohms for general use, enclosed in hard wood, damp and dust proof cases, with glass or zinc screens, should be used. All joints of the internal wiring should be soldered and substantial brass terminals provided for the common and line wires.

It is most important that when a bell is used in conjunction with an indicator it should be wound to a resistance that will balance with the indicator movement, taking also into consideration the resistance of the length of the run.

If a large size bell or a number of bells are being used, it is then advisable to incorporate a relay that balances with the indicator to actuate these, still remembering that the number of bells should be of the same resistance as each other.

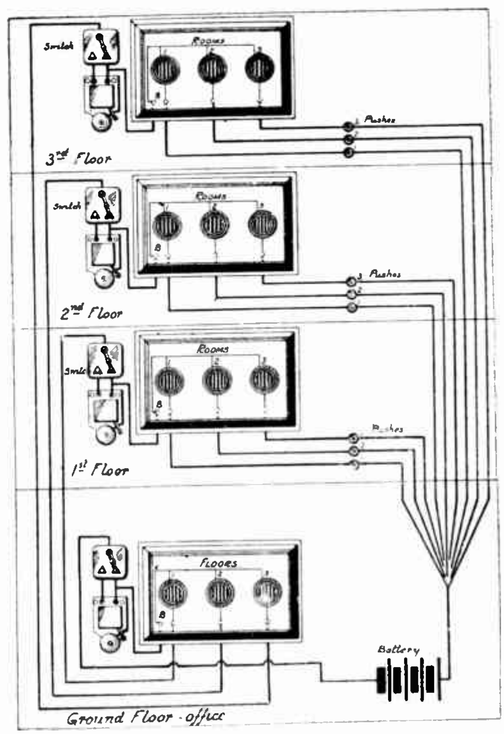


Fig. 16.—Indicator Circuit for Hotels.

This system is for use by attendants on each floor by day, and by one attendant on ground floor by night. When key indicator is not in use the switch should be closed; when separate floor bells are not required the switch controlling them must also be closed.

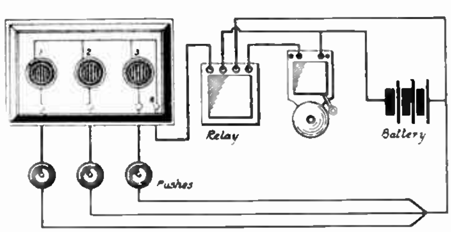


Fig. 17. Connections for Ordinary Indicators Relay and Bell.

Figs. 15–17 and 21–25 give an idea of some different circuits in which indicators are used.

Another type of *indicator system* which is rapidly coming into favour is the *luminous system*, mostly used in hotels, ships, hospitals, etc. There are several methods, but here is a general idea. The method consists of a door lamp fitting, and a relay

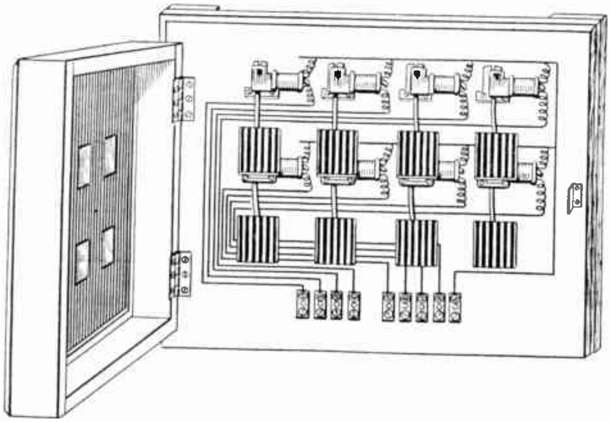


Fig. 18A.—The Pendulum Type of Indicator.

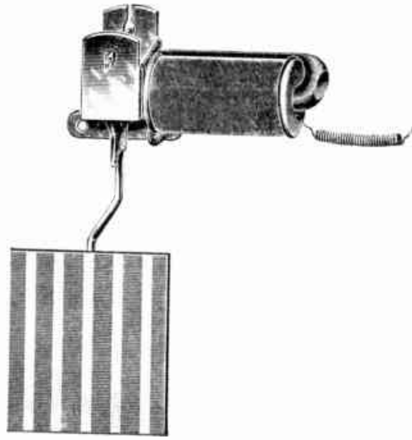


Fig. 18B.—Movement of Pendulum Type of Indicator.

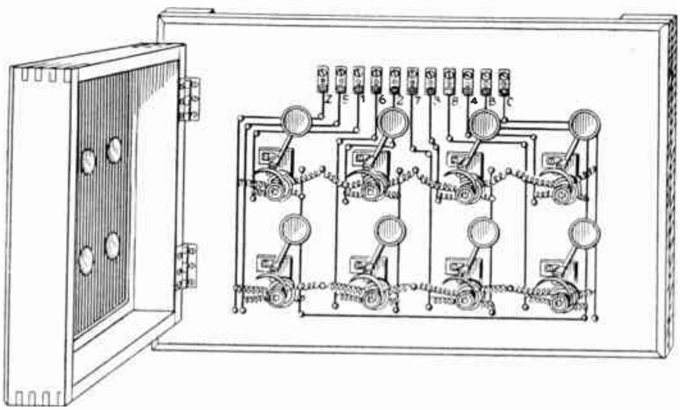


Fig. 19A.—The Electrical Replacement Type of Indicator.

Fig. 19B.—Movement of Electrical Indicator.

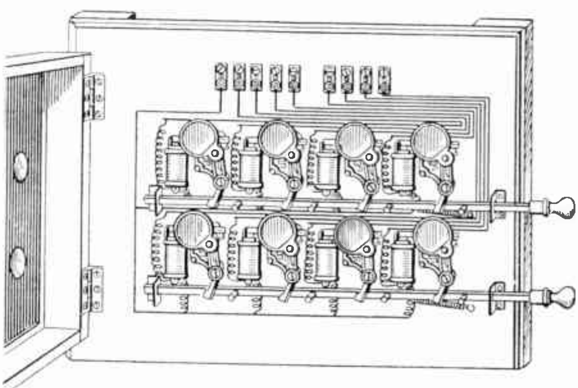


Fig. 20A.—The Mechanical Replacement Type of Indicator.

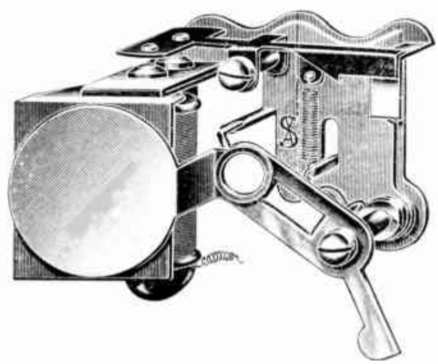


Fig. 20B.—Movement of Mechanical Indicator.

reset push to each room; a section lamp indicator, buzzer, relay and battery or transformer in each servery, and a double change-over switch for transferring the calls from that particular servery to the master indicator board. Buzzers may be fixed at convenient points to ensure that the servant is never out of hearing. Fig. 23 shows the method of operation.

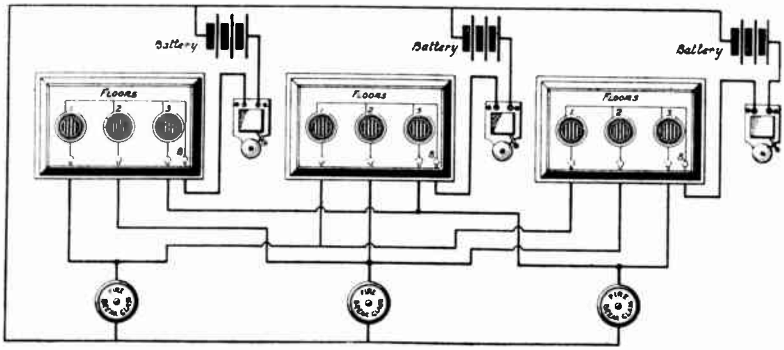


Fig. 21.—A Simple Fire Alarm System for a House or Building. On whatever floor the fire occurs the alarm is given. This action rings all bells and drops all flags relating to that particular floor. A separate battery is advised for each floor. Care must be taken to connect similar poles.

RELAYS.

There are many types of relays, but we will deal with those that are mostly used, and I may say that they could be used more frequently with advantage. Their simplicity and construction are somewhat similar to that of a bell movement, with the exception that the armature does not tremble but is positive in action to make or break a contact; in other words, an electrically operated switch. There are four terminals provided, two to operate the relay bobbins and two for the contact. Some relays are intermittent and others continuous action, either open or closed circuit. The ordinary intermittent open circuit relay is actuated only while the push is being pressed, and the ordinary continuous action relay releases a contact arm immediately the press is pushed, which remains *on* until replaced. The resistance of these is usually about 5 ohms.

The Closed Circuit Relay.

This is used on a closed circuit system where the current is continually on, and immediately it is broken the contact is made. The resistance of these relays must be high, for the purpose of using as little current as possible, and should be wound to about 200 ohms.

This system makes an ideal burglar alarm, as shown in Figs. 31 to 33.

Low to High Voltage Relay.

There is another type of *relay for low to high voltage* where it is necessary to actuate a syren or H.V. bell from a bell circuit. These are made for intermittent action, continuous action, electrical or mechanical replacement. The contact for these can be a mercury tube switch.

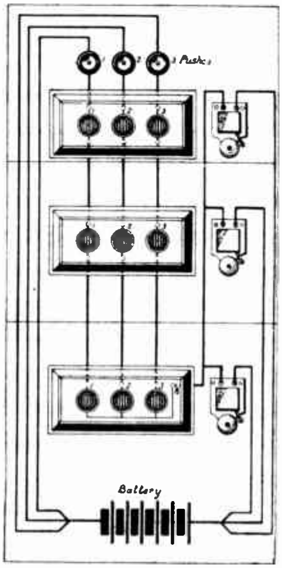


Fig. 22.—A Handy Method for Use Where Indicators and Bells are to Work Simultaneously, if More than One Indicator is Required.

One may be fitted in the hall, one in the kitchen, and one in the servants' rooms.

The Fire Alarm Push.

The one that is mostly used is constructed in an iron case about 5 inches in diameter, painted red, with the instructions plainly written: "In case of fire break glass." The breaking of the glass is all that is necessary as the

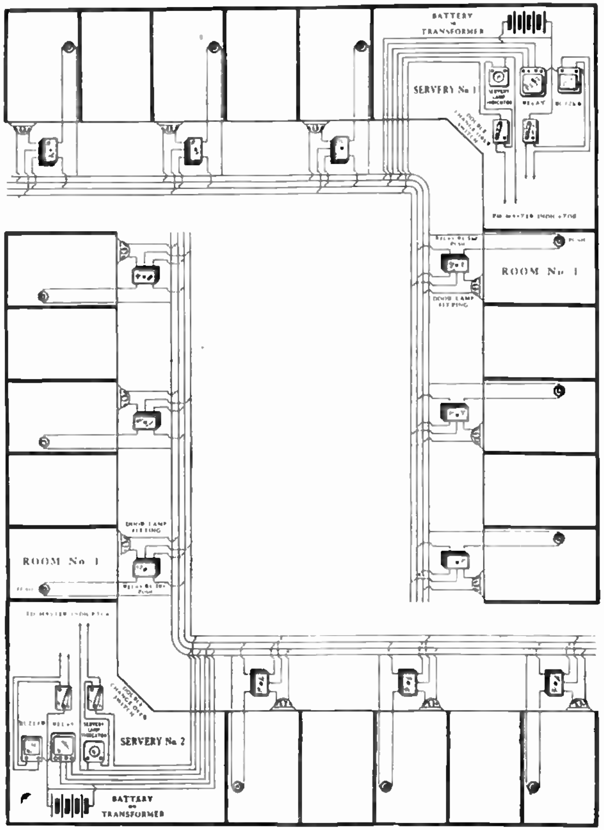


Fig. 23.—"Sax" Simple Luminous Call System.
Assuming that the push in room No. 1 is pressed, the lamp outside the room and the lamp in the servery glow. The audible signal sounds. Directly the pressure is released the audible signal stops, but the lamps remain alight. The maid arriving in room No. 1 presses the relay reset push which extinguishes the lamp.

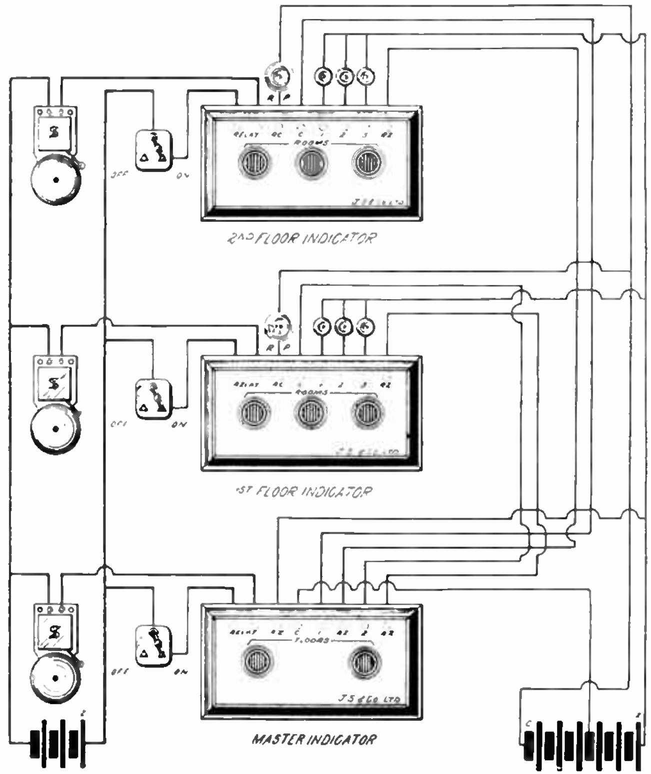


Fig. 24.—Hotel System with "Sax" Electrical Indicator.
When push 1 or 2 is pressed, the corresponding movement on the landing board, together with the correlated movement on keyboard, is indicated. The keyboard shows from which floor the call is made. When the replacement push is pressed it replaces both movements.

push is so constructed that the plunger is immediately released by this action and remains on until replaced, thus continually ringing the alarm. The necessary number of pushes are fitted round the building wired in parallel so that either one will give the alarm. These pushes are also provided with a means of testing the circuit at any period without breaking the glass.

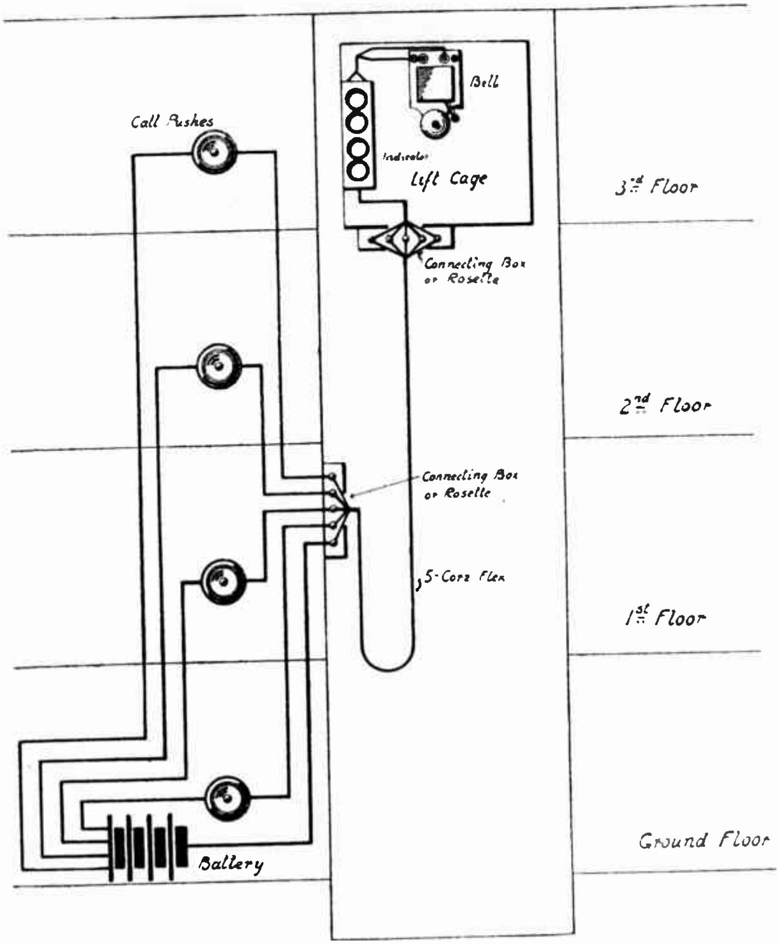


Fig. 25.—Diagram of a Lift Call Bell Circuit. Mechanical replacement is used in this system.

BELLS FOR DIFFERENT PURPOSES.

As only one type has been mentioned it would be as well to state some of the other types and their uses, as the variation is really surprising. The usual range is from 2 inches to 12 inches wound from 2 volts to 200 volts, with round, sheep, church and wire gongs for various tones.

There is the usual trembling bell in a wood case, continuous ringing bell, single stroke bell, combined bell and relay, indicating bell, dinner gong in sound box, iron clad weatherproof bell, gas and watertight mining bell, under-dome church gong bell, under-dome circular bell for domestic, traction and ambulance use, under-dome single stroke circular bell for trams, trains, buses, etc., and many others.

It should be remembered that *laminated* cores are necessary when used on alternating current.

HOW TO TEST A BELL INSTALLATION.

Now that we have an idea of what can be used in a bell installation, the question arises, how to find and rectify a fault should one occur. Let us imagine that you have been called to an average-sized house to find out why, when any of the pushes is pressed, the bell does not ring.

Test the Batteries First.

I suggest that you should first go to the batteries and test them. Make certain that there are no loose connections to the

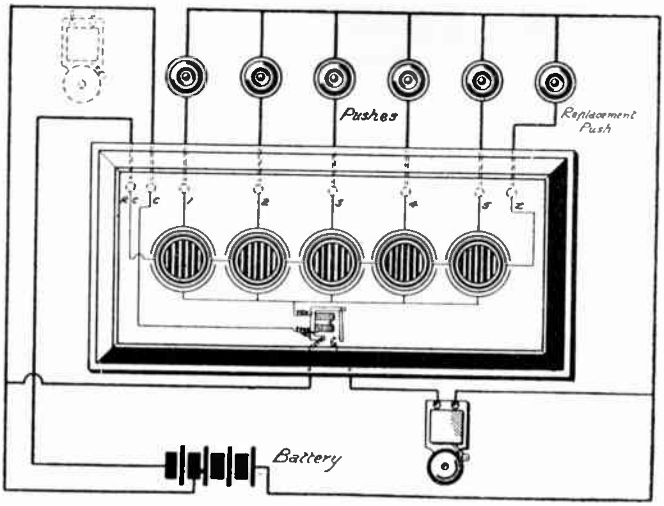


Fig. 26.—ELECTRICAL REPLACEMENT SYSTEM FOR SMALL CIRCUITS.

For larger circuits it is advisable to employ a separate ringing battery. The bell shown in dotted lines is used when no relay is employed.

batteries. If Leclanché cells, and the zinc has worn thin, it would be as well to replace it, clean the whole cell thoroughly and add fresh solution. If dry cells, find out how long they have been in use, and if old, replace. If comparatively new, test each one with a voltmeter and a 5-ohm resistance between the terminals (see Fig. 34), and if when held on for a few minutes the reading falls quickly, it would be as well to replace. Another method is to use a $1\frac{1}{2}$-volt lamp in place of the voltmeter. One faulty cell in a battery will affect the lot.

Examining the Bell and Indicator.

If the batteries are found correct look next to the bell and the indicator. A bell and indicator properly made and adjusted to work with each other by a reliable manufacturer should not, however, need any further attention. I have had very many instances of both giving over 25 years' service without the slightest attention except for the renewal of batteries.

The first thing to do is to disconnect the batteries and join the two ends of the line wires together, taking one or two cells to test the bell and then the indicator both separately and together.

One may now find that both work all right separately but not together. You may remember that I have already mentioned the fact that a bell used in conjunction with an indicator should be wound to a resistance that will balance with the indicator. For instance, if a 10-ohm bell is wired in series with a $3\frac{1}{2}$-ohm indicator, the bell will ring but will not pass sufficient current to operate the indicator, or *vice versa*.

Faults to Look for with Bells.

If the bell is at fault, there are several points that may require attention. The contacts may be dirty or may want adjusting. To do this and to prevent the armature knocking the cores, the hammer should be pressed to the gong, leaving a space of about $\frac{1}{32}$ in. between the armature and cores and $\frac{1}{32}$ in. between the contacts. Now adjust and tighten up the binding screw or lock nut to prevent it working loose in use.

The tension of the armature spring may want adjusting. The connections at the terminals may have become loose or it may be found that the wire from the bobbins has broken. A bobbin may be tested with a cell and voltmeter or lamp

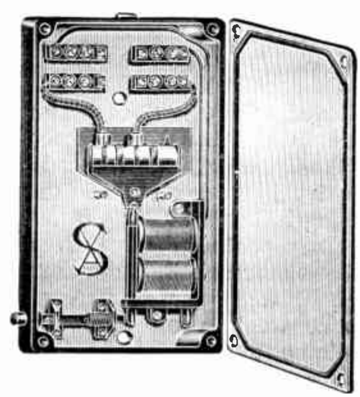


Fig. 27.—A LOW TO HIGH VOLTAGE RELAY.

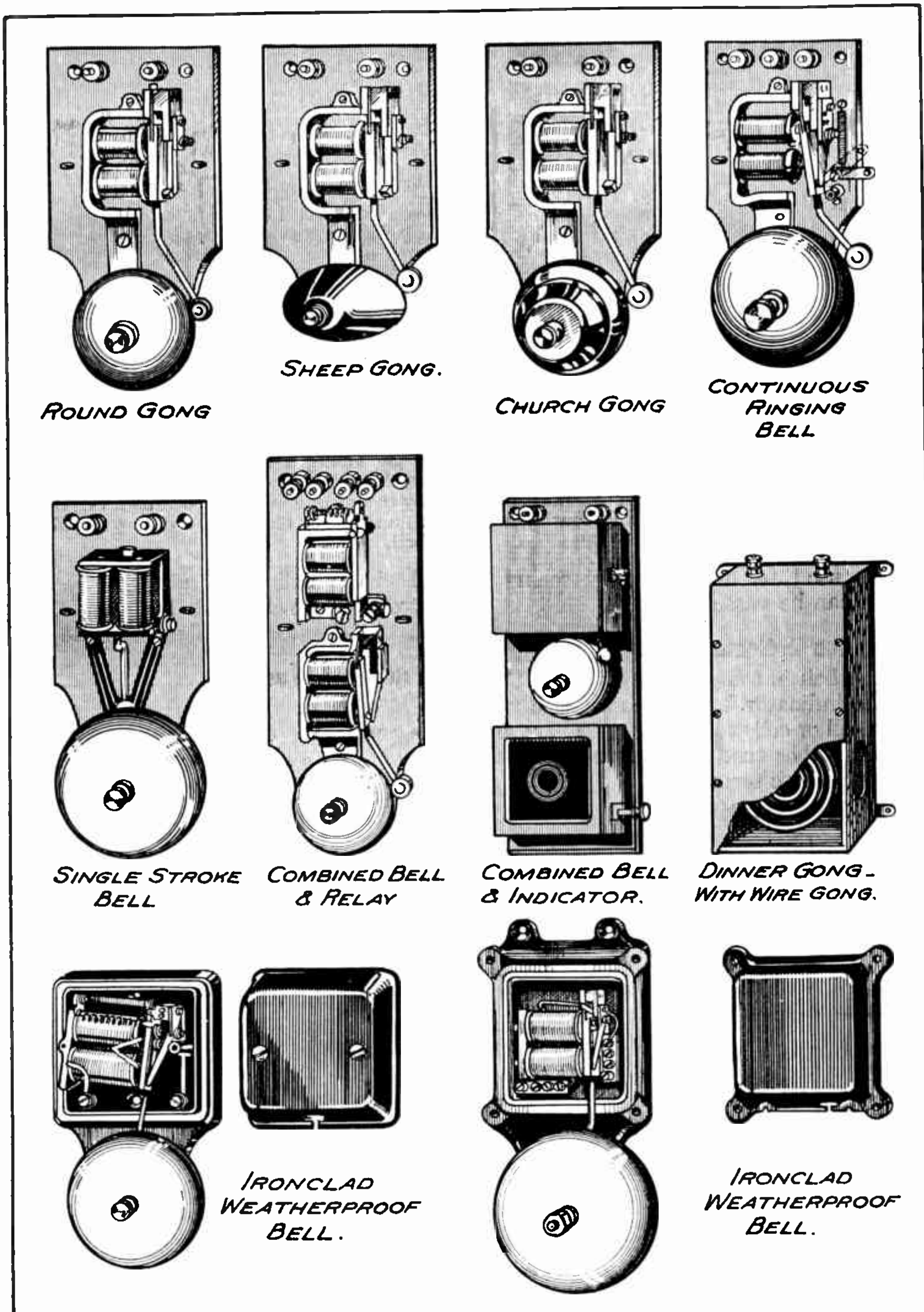


Fig. 28.—SOME TYPICAL BELLS FOR VARIOUS PURPOSES.

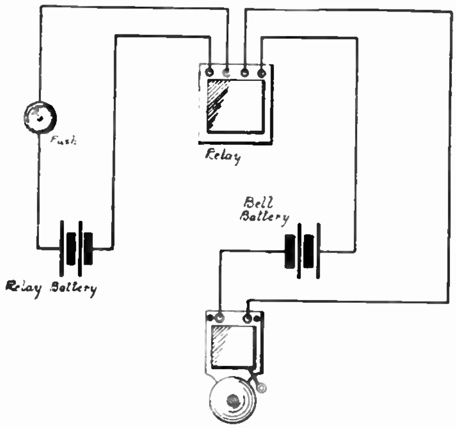


Fig. 29.—A SIMPLE RELAY CIRCUIT.
The relay is placed as near the bell as possible, thereby cutting out the resistance of the run from the bell circuit. A continuous action relay, if used instead of the above relay, would make the bell ring continuously until replaced.

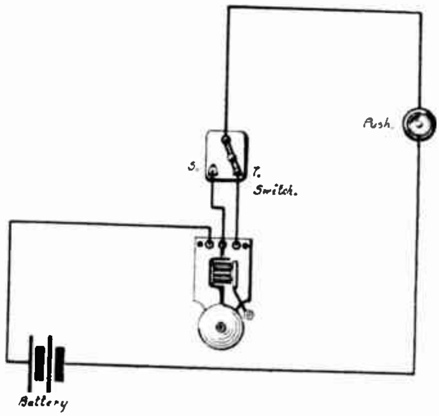


Fig. 30.—A USEFUL CIRCUIT ARRANGEMENT.
By fitting a third terminal, connected to the iron frame of an ordinary bell, and by means of a switch, it can be used either as a single-stroke or an ordinary trembler bell.

already used for the cells, by seeing if current can be passed through.

Testing the Indicator.

If the bell is found to be in order then test the indicator by connecting one wire from a cell or cells to the common wire and with the other test each movement from their respective terminals.

If both bell and indicator are found correct and will work together, then one must look to the installation of the wiring.

Faults with Pushes.

I have not mentioned anything about the pushes as it would be unlikely that they would all go wrong together, and we should not have started to test had it

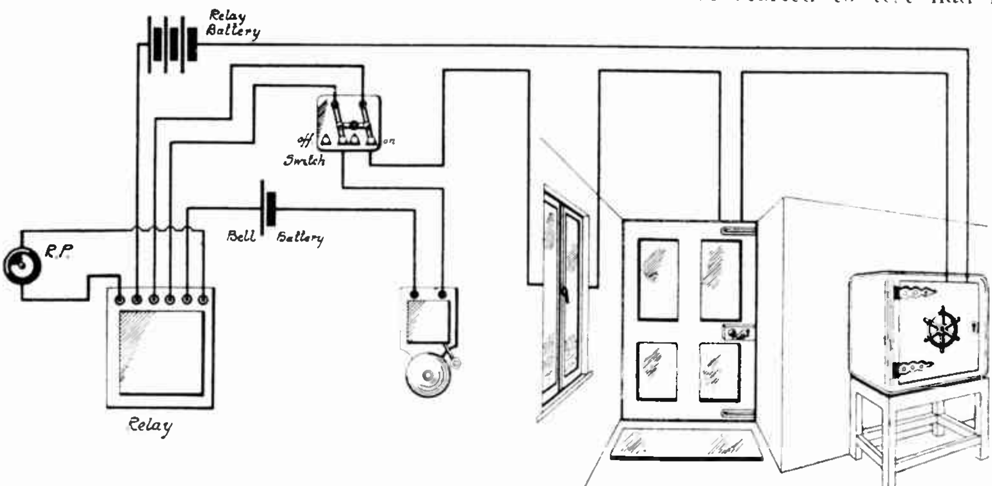


Fig. 31.—A BURGLAR ALARM SYSTEM INCORPORATING THE "SAX" CLOSED CIRCUIT CONTINUOUS ACTION RELAY WITH AN ELECTRICAL REPLACEMENT.
When all doors are shut and the switch closed, the alarm rings until replaced by replacement push, thus testing the system. Being a closed circuit the wires cannot be tampered with. The relay is wound to a high resistance ensuring a long life to the cells. When a door is opened the bell cannot be stopped except by the replacement push, even if the door is again closed.

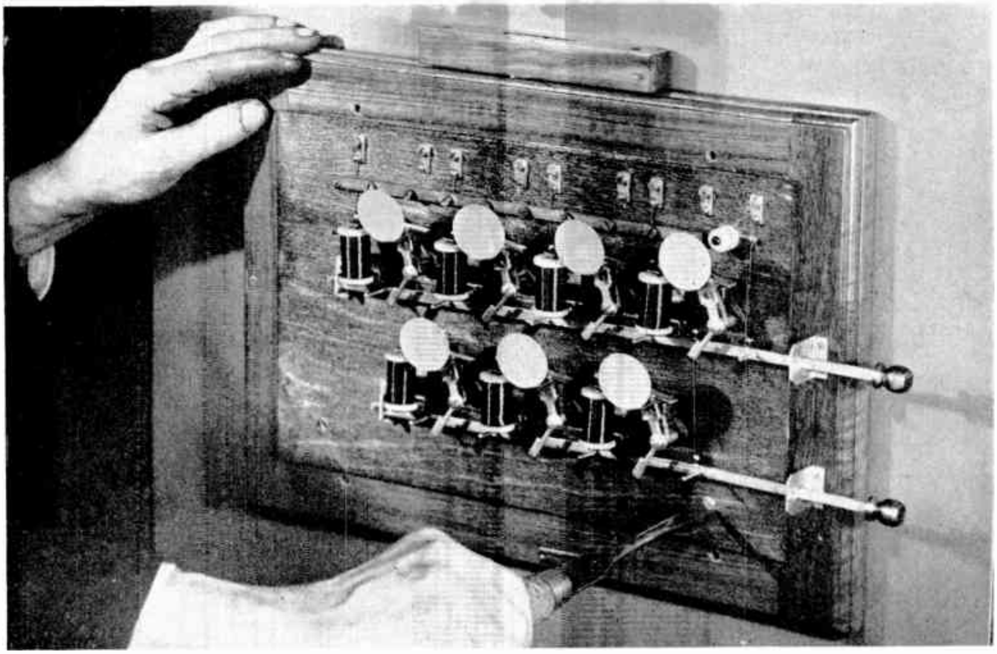


Fig. 31A.—Levelling Up with a Spirit Level and Screwing Indicator on to Wall.

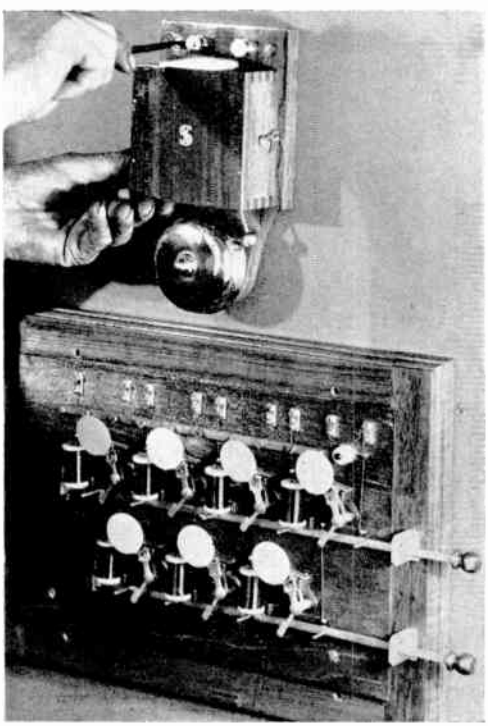
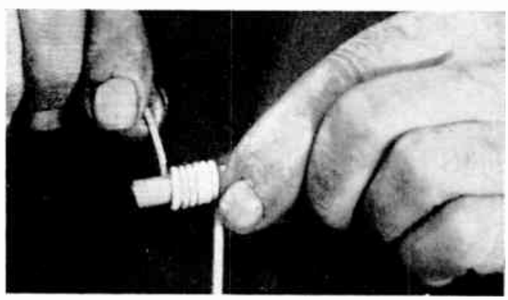


Fig. 31B.—Screwing the Bell into Position.
This is usually fixed above the indicator, as shown.



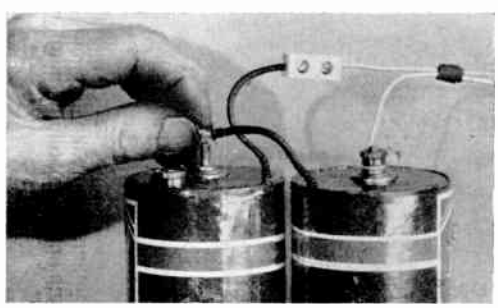


Fig. 31C (*Top*).—Making a Coil in the Wire Before Fixing to the Bell.
This is done round a pencil and is to allow for any breakage in the wire.

Fig. 31D (*Bottom*).—Wiring Up the Batteries in Series.

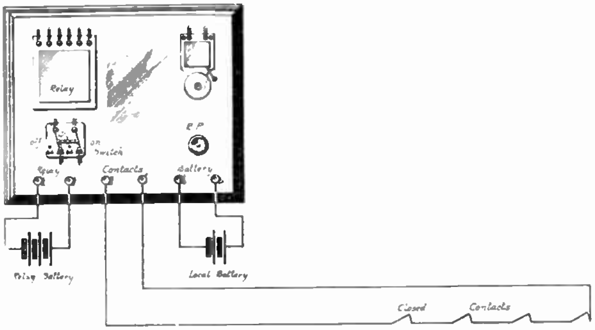


Fig. 32.—CIRCUIT OF A COMPLETE RELAY SET.
This is suitable for fixing in a room where alarm is to be given.

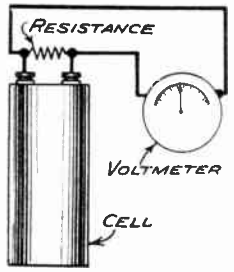


Fig. 34.—ARRANGEMENT FOR TESTING DRY CELLS.
A 5-ohm resistance should be used.

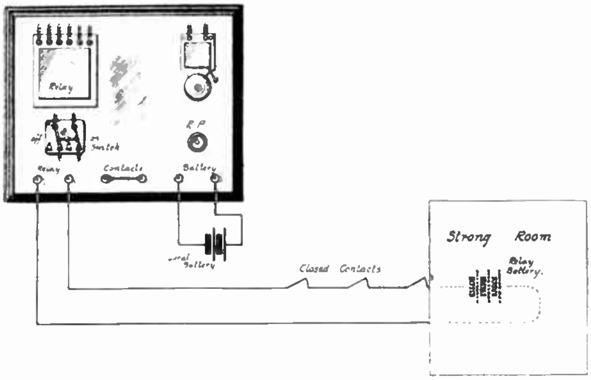


Fig. 33.—ALTERNATIVE ARRANGEMENT FOR RELAY SET.
To make the system shown in Fig. 32 absolutely foolproof it is necessary to short circuit the contact terminals and install relay battery in the strong room.

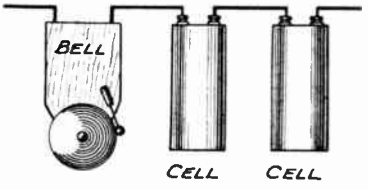


Fig. 35.—APPARATUS REQUIRED FOR TESTING CONTINUITY OF WIRING.

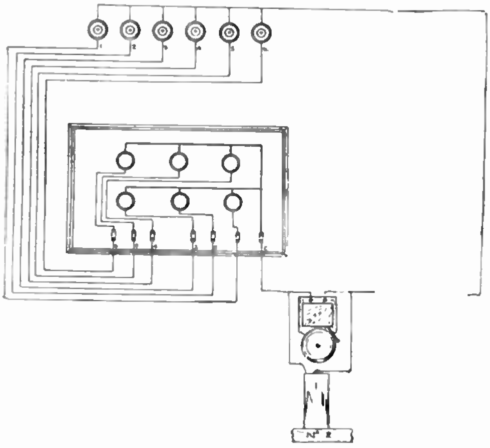


Fig. 36.—ARRANGEMENT FOR TESTING BELL.
The battery is connected directly across the two terminals of the bell.

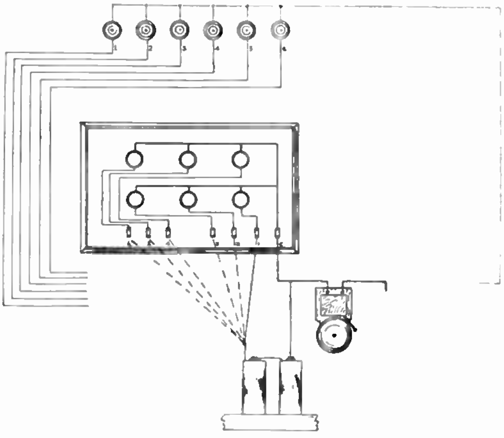


Fig. 37.—TESTING THE INDICATOR.
Each movement is tested in turn from its respective terminal.

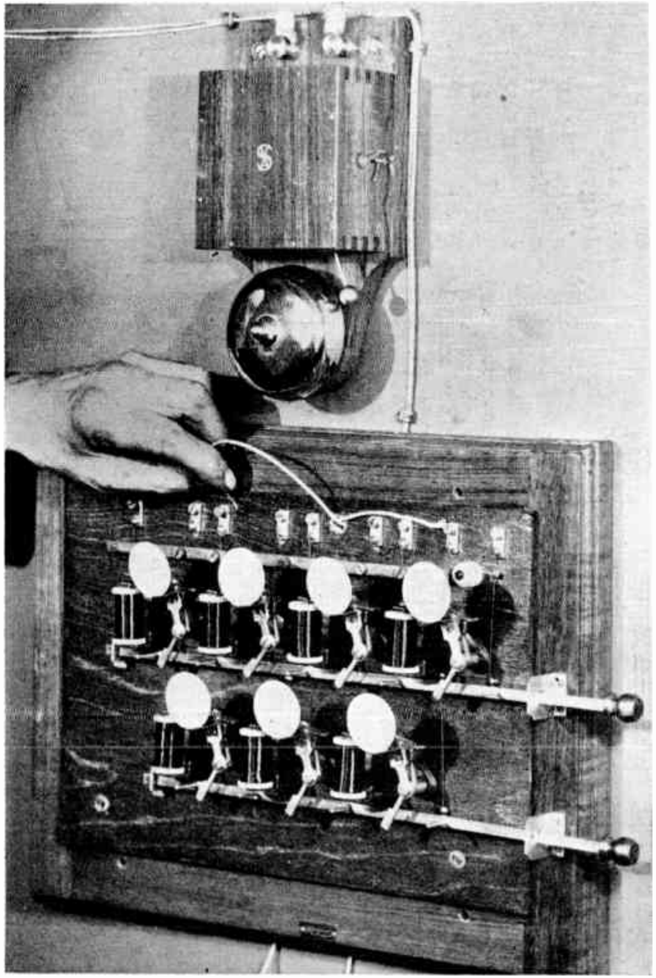


Fig. 37A.—WIRING THE BELL TO THE INDICATOR.
Note how the coil in the wire enables any adjustment to be made should the wire be broken.

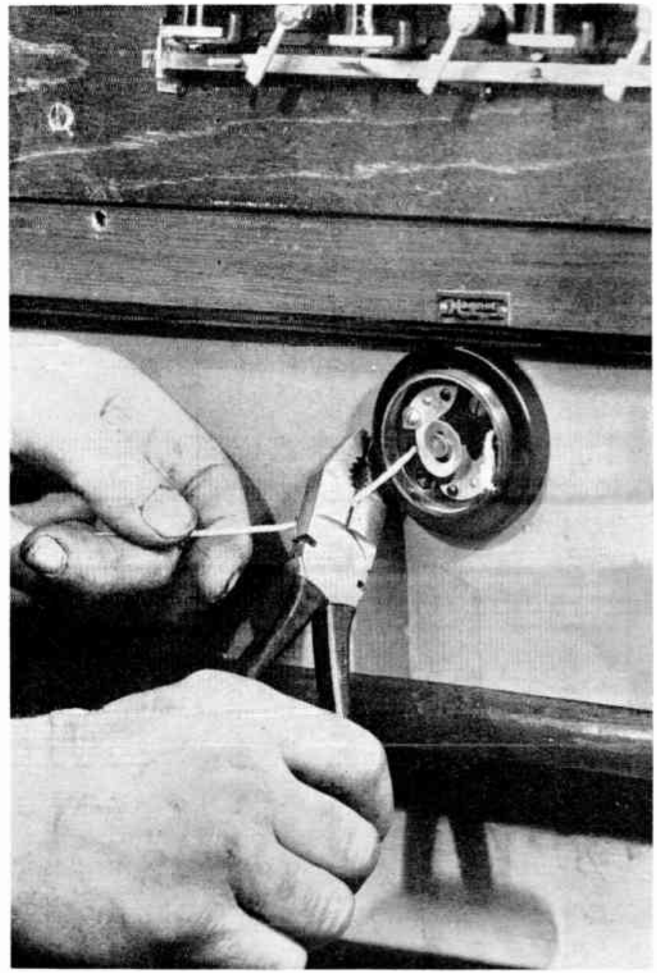


Fig. 37B.—CONNECTING UP THE PUSH.
This shows the wires which come from under the indicator and through the back of the push being cut to the required length.

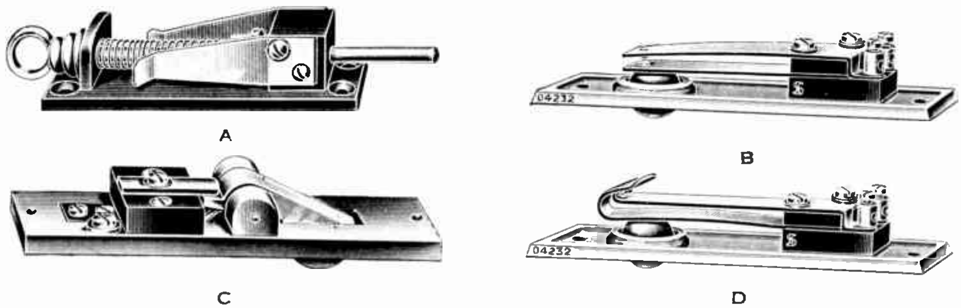


Fig. 38.—Some Typical Contact Systems.
A, pull contacts; B, closed contact; C, open-circuit contact; D, open contact.

been that only one or two would not function. Nevertheless, pushes are a common source of trouble, again depending on their quality.

Testing the Wiring.

Before testing the wiring it will be necessary to make up a small testing set consisting of two cells and a bell connected in series (see Fig. 35). We now connect the battery wire to the common wire of the circuit, remembering that we had already temporarily connected the two ends where the batteries were originally (see Fig. 39). This should make continuity with section No. 1 by closing the push and connecting the bell wire of the testing set to that section. We next repeat the operation on sections 2, 3, 4 and so on until the fault is found.

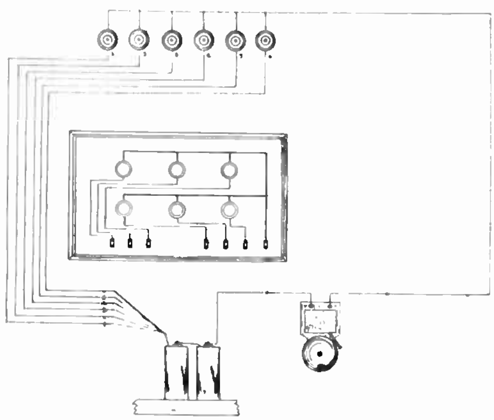


Fig. 39.—Testing the Pushes and Lines.
The indicator has been disconnected and each wire is tested in turn. When the push corresponding to the wire that is being tested is pressed, the bell should, of course, ring.

(The publishers wish to thank Messrs. Julius Sax & Co., Ltd., for the loan of the circuit diagrams, and Messrs. Troughton and Young Ltd., for facilities to stage the action photographs which accompany this article.)

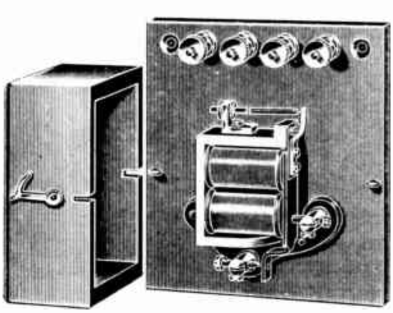


Fig. 40.—Open Circuit Relay.

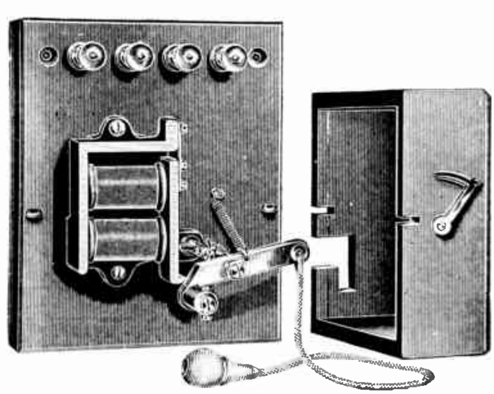


Fig. 41.—Continuous Action Relay.

THERMIONIC VALVES FOR RADIO RECEIVERS

By A. E. Watkins

RADIO could never have reached its present state of perfection had it not been for the advent of the thermionic valve. Many and varied have been the designs involved, but all operate on a common principle—the utilisation and control of the flow of electrons from a chemically prepared electron-emitting surface. This is called the filament or the cathode. In addition to this emitting surface a wireless valve must contain a plate or anode to which can be given a positive charge of electricity. In addition, to the plate and the cathode are one or more control electrodes which are called grids, excepting in the case of a rectifying valve where the grid is omitted.

THE CHOICE OF THE RIGHT TYPE OF VALVE.

A radio receiving set must incorporate a detector valve which may, or may not, be preceded by an H.F. amplifying valve, and must be succeeded by a stage or two of low frequency amplification to amplify the signals after they are passed on by the detector, if a loudspeaker is to be operated.

If considerable volume is required a super-power valve is necessary for the last stage, and in an A.C. mains operated set, often a rectifying valve is used for the H.T. current.

The choice of the right valve has much bearing on the performance of the receiver, and it is essential that the right type of valve should be used in the correct position in the receiver. In the case of mains-operated receivers in which the grid bias is obtained automatically, it is essential that the right type of valve for which the receiver has been designed should always be fitted, and if, for any reason, a change in the type of valve is desired, it is necessary either to find out from the receiver manufacturer if the valve is suitable, or to trace out the circuit and find the value of the grid bias resistance. By knowing the value of this resistance and the anode current, it is easy to find from

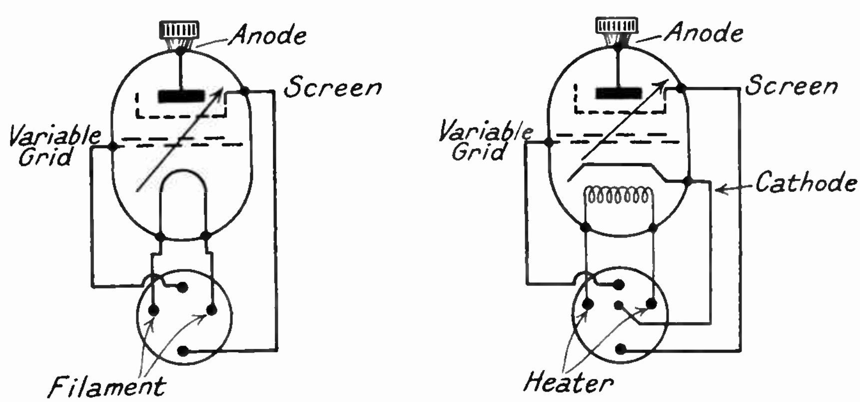


Fig. 1.—Internal Connections for Battery and Mains Variable-Mu Valves.
Variable-Mu valves are essentially screened-grid valves in which the control grid wires are not uniformly placed.

Type and Make.	Filament.		Impedance Ohms.	Amplification Factor.	Maximum Anode Volts.	Grid Bias.	Anode Current.	Screen Volts.	Mutual Conductance (mA./V.).
	Volts.	Amps.							
PM12 Mullard	2	0.15	*230,000	*200	150	—	*2.75	75	0.87 at { * Anode volts 100, Screen volts 75, Grid volts zero
220SG Cossor	2	0.2	200,000	320	150	1.5 at 150 v./a.	0.7 ma.	60-80	1.6
BY6 Eta	2	0.15	300,000	300	150	1	*2.5	80	1 at { 150 Anode, 80 Screen, * Grid Bias 1 volt

Fig. 2.—THREE SCREEN-GRID, 2-VOLT BATTERY VALVES FOR H.F. AMPLIFICATION, TOGETHER WITH TABLE SHOWING CHARACTERISTICS.
From left to right: Mullard PM12 (2 views); Cossor 220SG; Eta BY6.

the valve maker's table if this particular valve is suitable, or, should there be any doubt, the valve manufacturer will always give the necessary advice.

TYPES OF VALVES.

Valves may be classified under the following main headings :—

(1) Valves for Mains Receivers.

(A) Mains screened grid and variable mu, used for H.F. amplification.

(B) Mains triodes, high impedance for detector.

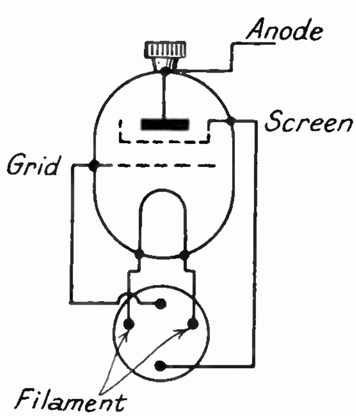


Fig. 3.—INTERNAL CONNECTIONS FOR A BATTERY SCREENED-GRID VALVE.

(C) Mains triodes for output.

(D) Mains triodes for super power output.

(E) Mains pentodes.

(F) Mains pentodes, directly heated.

(G) Mains triodes, directly heated.

All the foregoing valves are indirectly heated except where otherwise mentioned.

(2) Battery-operated Screened Grids and Variable Mu for H.F. Amplification.

Type and Make.	Filament.		Maximum Anode Volts.	Amplification Factor.	Impedance (Ohms).	Mutual Conductance (mA./V.).	Anode Current.
	Volts.	Amps.					
PM1HL Mullard	2	0.1	150	28	20,000	1.4	1.75 mA. at 150 V./A. 1.5—3 volts Grid Bias
HL210 Osram	2	0.1	150	20	*23,000	.87 at 100 V./A. Grid volts 0	4.5 mA. at 150 V. A. Grid volts zero
210 Det. Metallised Cossor	2	0.1	150	15	13,000 at 100 V./A.	1.15 at 100 V./A.	4 mA. at 100 V./A. Grid volts zero
BY1210 Eta	2	0.11	150	12 at 100 V./A.	10,000 at 100 V./A.	1.2 at 100 V./A.	4 mA. at 150 V./A. 5 volts Grid Bias

Fig. 4.—Some Typical 2-Volt Battery Detector Valves, with Table Showing Characteristics.
Left to right: Mullard PM1HL (2 views); Osram HL210; Cossor 210 Det. (Metallised), Eta BY1210

(A) Battery triodes with high impedance for detector.

(B) Battery triodes output.

(C) Battery triodes super-power.

(D) Battery pentodes.

All battery valves are directly heated.

(3) Rectifying Valves.

(A) Rectifying valves half-wave.

(B) Rectifying valves full-wave.

VALVE CONNECTIONS.

Battery-operated valves have four pin bases (except pentode, which has five pins or a side terminal); whereas in the case of mains indirectly heated valves there are usually five pins and, in some cases, an extra terminal at the side of the cap. This is particularly noticeable in the indirectly heated pentode; whereas in the case of the screened-grid valve for mains operated and also battery operated, the extra terminal is at the top of the valve and is always the anode.

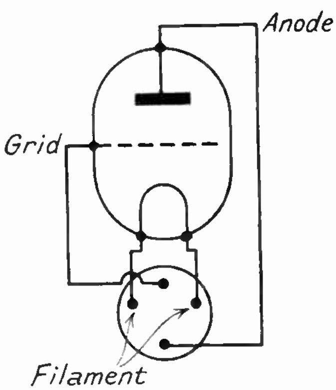


Fig. 5.—Connections for a Triode Battery Valve.

The connections of the anode, grid, filament and cathode are shown in the accompanying drawings, also the pin on the valve cap to which they are connected, and these connections should be carefully noted, for in many cases they are different for certain types of valves.

The list of valves may be sub-divided under the heading for which position in the receiver the valves are designed.

Type and Make.	Filament.		Impedance (Ohms).	Amplification Factor at 100 V. A., 0 G.V.	Maximum Anode Volts.	Grid Bias.		Anode Current (mA.).	Mutual Conductance (mA./V.) at 100 V. A.	Remarks.
	Volts.	Amps.				A./V.	V.			
PM2A Mullard	2	0.2	3,600	12.5	150	100 125 150	3 4.5 6	5 6 8	3.5	First stage L.F. amplifier or small power output
PM252 Mullard	2	0.4	1,900	7	150	100 125 150	6 7.5 9.5	11 14 19	3.7	Super power for last stage output
P215 Osram	2	0.15	5,000	7	150	100 125 150	7.5 10.5 12	5 6 8.5	1.4	Suitable for last stage, or before output valve
P240 Osram	2	0.4	2,500	4	150	110 130 150	16.5 21 24	12.5 14 17	1.6	Super power for last stage output
230XP Cossor	2	0.3	1,500	4.5	150	100 125 150	10.5 15.5 18	13 18 22	3	Super power output stage
BW303 Eta	2	0.32	2,700	3	150	80 100 150	8 16 25	7.5 8 11	1.1	Super power output stage

WARNING.—*The Grid Bias stated must be used with all the above valves. Never make any adjustments to Grid Bias without switching off H T. It is possible to ruin a valve by running even for a short time without Grid Bias.*

Fig. 6.—SOME TYPICAL 2-VOLT BATTERY VALVES FOR LOW FREQUENCY AMPLIFICATION, WITH TABLE SHOWING CHARACTERISTICS.

From left to right: Mullard PM2A (2 views); Mullard PM252; Osram P215; Osram P240; Cossor 230XP; Eta BW303.

First—for H.F. amplification.

Secondly—for detector.

Thirdly—for first L.F. stage.

Fourthly—for output stage.

The output stages depend upon the power required.

THE HIGH FREQUENCY VALVE.

The object of the high-frequency valve preceding the detector is (1) to increase the range of the receiver; (2) improve detector efficiency due to the magnified input to this stage; (3) increase selectivity; (4) provide better quality of reproduction as reaction may be avoided.

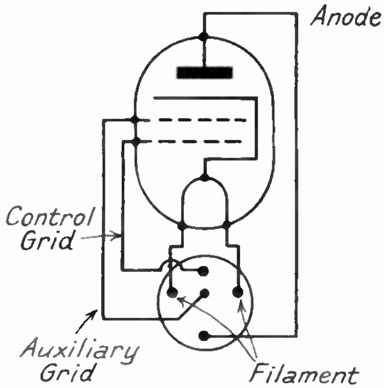
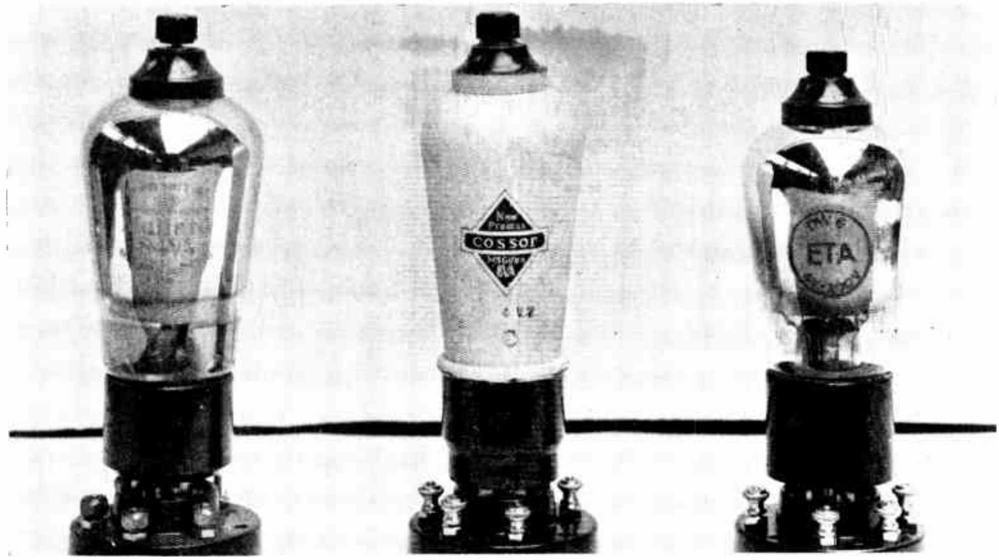


Fig. 7.—INTERNAL CONNECTIONS FOR BATTERY OR DIRECTLY HEATED PENTODE.

Screened Grids.

Modern receivers in which H.F. amplification is employed generally make use of the screened-grid type of valve. The screened-grid valve has advantages over



Type and Make.	Heater.		Maximum Anode Volts.	Screen Volts.	Impedance (Ohms).	Amplification Factor.	Grid Bias.	Anode Current.	Mutual Conductance (mA./V.).
	Volts.	Amps.							
S4VA Mullard	4	1.0	200	75	909,000 at 100 V./A. *75 V./S. Zero Grid V.	*1,000	1.0	*2.25	*1.1
M.S.G. HA Cossor Metallised	4	1.0	200	80	500,000	1,000	1.5	1.95 150 V./A. 80 V./S. 1.5 G.B.	2
DW6 Eta	4	1.0	200	75/100	800,000	1,000	1.5	0.5/1	—

Fig. 8.—Some Typical Indirectly Heated Mains Screen-Grid H.F. Valves, with Table Showing Characteristics;
From left to right: Mullard S4VA; Cossor M.S.G. HA; Eta DW6.

the ordinary three-electrode valve as it provides a much greater and more stable amplification over a wide band of wavelengths, but it is restricted to the set designed for screened grid amplification

Metallised Valves.

The H.F. valve should be screened, excepting in the case of metallised valves. The metallised valve has a coating of metal sprayed on to the glass and is connected to the earth. This earth connection is arranged by a connection in the valve itself to one of the valve filaments or cathode legs. The reason for screening or metallising the valves is that one of the greatest difficulties which confront the designer of modern wireless receivers is that of obtaining maximum amplification and the avoidance of accidental coupling between successive stages. If the valve is not screened, coupling

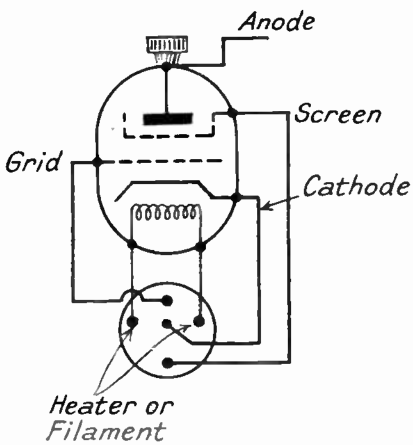
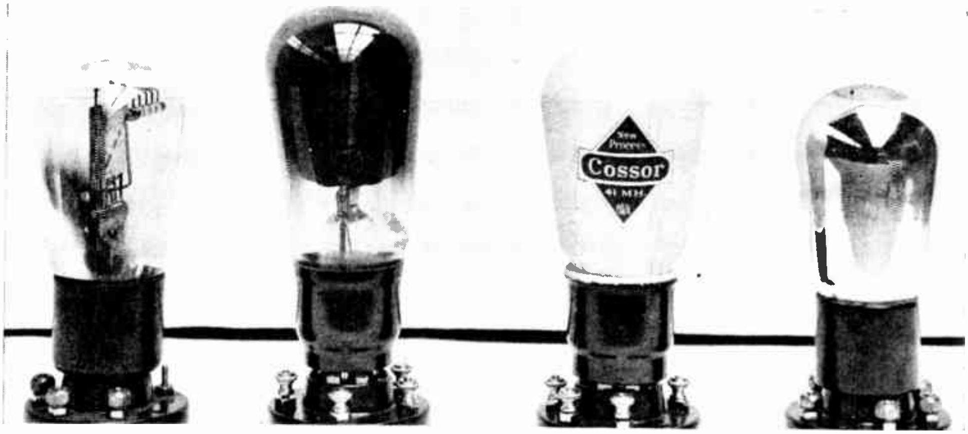


Fig. 9.—Internal Connections for a Mains Screen-Grid Valve.



Type and Make.	Heater. Volts.	Heater. Amps.	Maximum Anode Volts.	Amplification Factor.	Anode Impedance. Ohms.	Grid Bias.* V./A. V.	Anode Current (m.A.).	Mutual Conductance (m.A./V.).	Remarks.
904V Mullard	4	1.0	200	75	34,000	150 1.3 200 1.6	1.5 2.5	2.2	As Detector use grid leak 150-200 V./A. High-ratio transformers or resistance capacity
354 Mullard	4	1.0	200	35	10,000	100 2 150 3 200 4	2 3 4	3.5	As Detector grid leak or anode bend, first stage L.F. amplifier
MHL4 Osram	4	1.0	200	20	8,000	Detector 1.5+ 150 4 200 6	6-8 Permissible Anode Dissipation 4 watts	2.5	Detector grid leak or anode bend Suitable for power grid detector, first and second stage L.F.
41MH Cossor	4	1.0	200	72	18,000	100 1.5 150 2.5 200 3.0 84 Anode bend	Average 3.2	4	Detector, grid leak or anode bend
DW1508 Eta	4	1.0	150	15	7,500	100 4 150 6	3.5 5	2	Detector grid leak or first stage L.F. amplifier

* For L.F. amplification.

Fig. 10.—Indirectly Heated Mains Detector Valves with Table Showing Characteristics. From left to right: Mullard 354; Osram MHL4; Cossor 41MH; Eta DW1508.

between the anode and any nearby component is likely to occur, and this may give rise to instability. A metallised screened grid valve has the following advantages:

Coupling between the anode and nearby components is eliminated, giving stable working and allowing for maximum amplification.

The metallised coating reduces the anode capacity by about one-half, and therefore possesses greater safety.

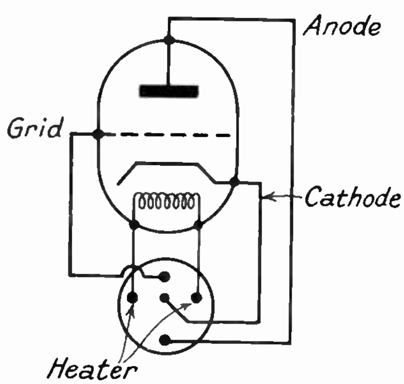


Fig. 11.—Internal Connections for a Triode Mains Valve.

Selectivity is increased by preventing unwanted signals from short-circuiting the tuned circuit through capacity coupling, and in the case of mains valves, mains hum is reduced.

THE DETECTOR VALVE.

Every receiver must use a detector valve, unless, of course, a crystal

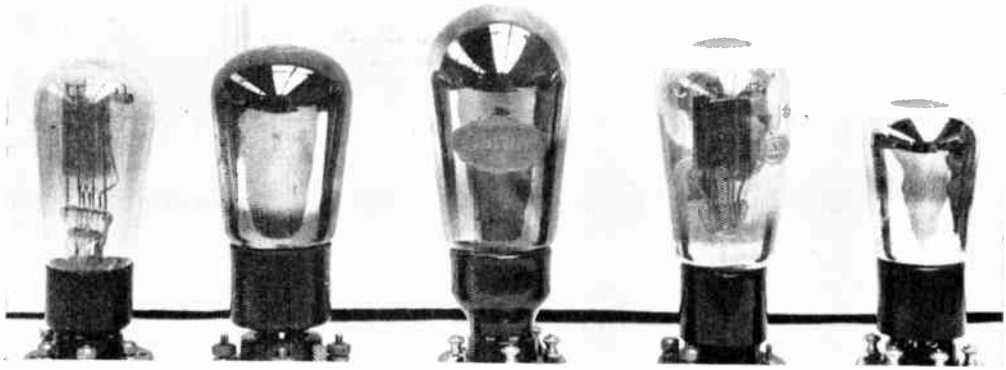
Type and Make.	Heater.		Max. Anode Volts.	Amplification Factor.	Anode Impedance.	Grid Bias. A., V. V.	Anode Current (mA.).	Anode Dissipation.	Mutual Conductance (mA./V.).	Remarks.
	Volts.	Amps.								
104V Mullard	4	1.0	200	10	2,850	100 5 150 8.5 200 12	9 13 17	3.5 watts approx.	3.5	Suitable for use as L.F. amplifier stage immediately preceding a large power valve
ML4 Osram	4	1.0	200	9	3,000	100 6 150 10 200 13	8 13.5 20	4 watts	3.0	Ditto
41MP Cossor	4	1.0	200	18.7 100 V./A.	2,500 100 V./A.	120 4 150 5 200 7.5	15 19 24	5 watts approx.	7.5 V.G. 0	Output stage and is ample for normal use and suitable for push-pull output
DW704 Eta	4	1.0	150	7	4,500	100 9 150 14	7.5 10	2.5 watts approx. output 180 mW.	1.5	Suitable for first stage or last stage when only a moderate output is required

Fig. 12.—SOME TYPICAL INDIRECTLY HEATED MAINS VALVES FOR LOW FREQUENCY AMPLIFICATION WITH TABLE SHOWING CHARACTERISTICS.

From left to right : Mullard 104V ; Osram ML4 ; Cossor 41MP ; Eta DW704. The internal connections are the same as those shown in Fig. 11.

is used, but this type of rectification is obsolete.

The valve in this stage of the receiver is the key to the receiving set. Probably, in most sets the choice of the characteristics for the detector valve is very elastic, but there are certain valves better suited to function in this position than others. In the case of a mains set if the valve is of the indirectly heated type, one valve or another of this class, with an impedance of about 10,000 ohms, such as Osram MH4, Mullard 354, or Cossor 41MHF, would not affect the operation or do any damage as, unless the valve operates on the anode bend principle, no bias is given to the grid. If the receiver has no H.F. amplification, and the input to the detector is reasonably small, a valve with a moderately high value of amplification factor should be chosen, but better quality may result from the use of a valve of low impedance, with a low value of grid leak. Usually a valve which has an amplification



Type and Make.	Heated.	Heater or Filament. Volts.	Heater or Filament. Amps.	Maximum Anode Volts.	Amplification Factor.	Anode Impedance.	Grid Bias A. V. V.	Anode Current.	Anode Dissipation.	Mutual Conductance (m.A./V.).	Remarks.
054V Mullard	In-directly.	4	1.0	200	5	1,250	100 14 150 18 200 28	20 30 30	6 watts	4	Suitable for use as an output valve for large speakers and push-pull
PM24C Pentone Mullard	Directly.	4	1.0	Anode 400 Screen 200	Approx. 75	Load impedance 6,000 to 10,000	28	30	12 watts	3	As output valve of high amplification, should not be used in intermediate stages. (This is one of the largest Pentone valves.)
PX4 Osram	Dir.	4	1.0	250	5	830	150 16 200 26 250 34	38 40 48	12 watts	6	Last stage power amplifying for large output.
DW302 Eta	Directly	4	1.05	250	3.5	2,800	180 34 250 50	33	1,600 mW.	1.95	Last stage output for large moving - coil speakers
DW 1003 Eta	In-directly.	4	1.0	200	10	3,300	100 6.5 150 10 200 12.5	12.5	380 mW.	3.3	Suitable for last stage operating small moving-coil speakers

Fig. 13.—SOME TYPICAL MAINS OUTPUT VALVES, WITH TABLE SHOWING CHARACTERISTICS. From left to right : Mullard 054V ; Mullard PM24C Pentone ; Osram PX4 ; Eta DW302 ; Eta DW1003.

value from 20/30 or even higher, will give good results, but the choice of this valve depends a lot upon the impedance of the transformer coupling the detector to the first L.F. valve.

If the primary has a high impedance, we are able to use a valve with a higher amplification factor, for, to obtain really satisfactory reproduction, the impedance of the

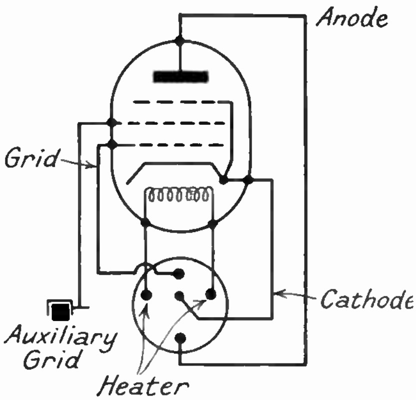


Fig. 14.—INTERNAL CONNECTIONS FOR INDIRECTLY HEATED PENTODE VALVES.

primary of the transformer should be approximately twice the impedance of the valve. That is why it is possible with a valve of lower impedance more satisfactory results may be obtained. For instance: a battery valve with an amplification factor of 35 may have an anode impedance of 60,000 ohms, whereas one with a magnification of 20 would only have an anode impe-

Type and Make.	Filament.		Anode Volts.	Rectified Current (m.A.).	Impedance (Ohms).	Class.
	Volts.	Amps.				
U10 Osram	4.0	1.0	250 — 250 R.M.S.	60	Not stated	Full wave
U12 Osram	4.0	2.5	350 — 350 R.M.S.	120	Not stated	Full wave
U8 (Photo) Osram	7.5	2.4	500 — 500 R.M.S.	120	160	Full wave
DU2 Mullard	4.0	1.0	Maximum 400 — 400 R.M.S.	75	400 — 400	Full wave

The above are only a few of the many types of Rectifier Valves.

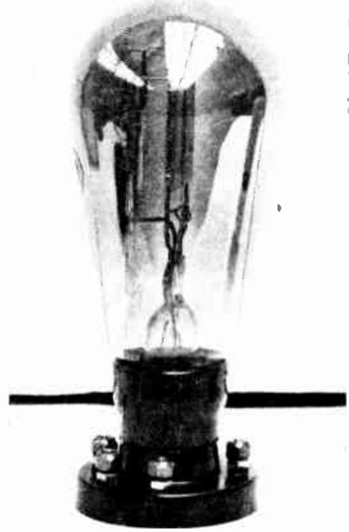


Fig. 15.—A Typical Rectifier Valve, Osram U 8, with Table Showing Characteristics.

dance of approximately 23,000 ohms. Of course, these figures vary with the make of valve and the type, but nevertheless, it is always the case that the higher the magnification, the greater the impedance.

With mains it is often advisable to use a metallised detector valve as the following advantages are thus obtained :—

The coupling from the anode to nearby components which often gives rise to instability is eliminated. The possibility of mains hum is reduced.

L.F. VALVES.

With most modern receivers it is desired to drive a loud speaker. It is thus necessary to add one or more stages of low frequency amplification.

The L.F. valve serves to magnify the weak signals after the detector, and the choice depends upon the volume of undistorted sound that is required, and secondly, on the nature of the H.T. supply available. Generally, it is wise to choose a valve with as low an impedance as possible, depending, of course, on whether the valve is coupled by means of a transformer or resistance capacity coupling, and secondly, as to whether there are one or more stages of L.F. amplification. The lower the impedance, the more H.T.

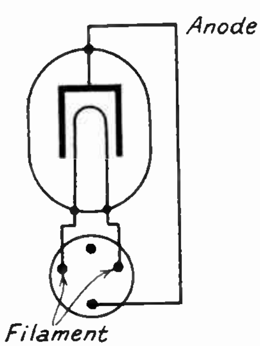


Fig. 16.—Internal Connections for Half-Wave Rectifier.

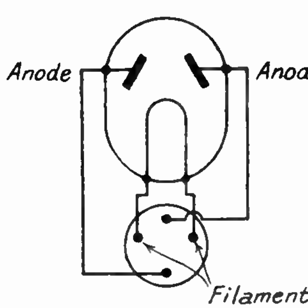


Fig. 17.—Internal Connections for Full-Wave Rectifier.

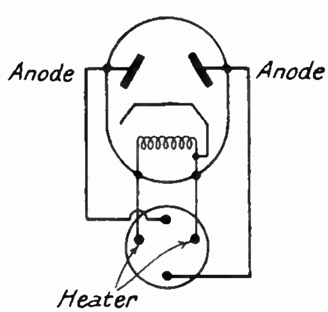


Fig. 18.—Internal Connections for Indirectly Heated Rectifier.

current, but more power output. Therefore, if it is a battery-operated receiver and the H.T. supply is obtained from batteries, the output valve should be of small power type designed to give the greatest undistorted volume consistent with a minimum economy in high-tension current. If the receiver or amplifier is required to deliver a considerable volume free from distorted output, it is advisable to employ a super-power valve in the last stage.

Such a valve is designed to handle a larger amount of power and, therefore, the H.T. supply should be adequate. This can be conveniently obtained from a mains H.T. unit, H.T. accumulators or if these cannot be charged conveniently, then use triple-size dry batteries.

How to Obtain Best Results.

To obtain the best results in the output stage, the impedance of the output valve and the loud-speaker should be matched and, if necessary, a suitable transformer or choke filter output used. In receivers employing only one stage of L.F. amplification, it is often convenient to use a pentode output valve. This type of valve has the advantage of providing the greatest magnification of weak signals, and can be fitted into any receiver which has hitherto employed an ordinary battery operated output valve with one stage of magnification; but it must be remembered with a pentode valve, that, as the output is greater, the strain on the H.T. supply will also be increased, and, therefore, should be supplied by means of an H.T. unit or triple-sized batteries and, of course, the grid bias must be adjusted accordingly.

L.F. Valves for Mains Sets.

In all mains operated receivers, particularly those in which grid bias is obtained by the method of dropping volts across a resistance in the cathode circuit, it is essential that only the valves for which the set is designed should be used. For instance, without certain alterations, a pentode directly heated or a pentode indirectly heated valve cannot be substituted in the output stage of a receiver which has been designed for the use of an indirectly heated triode super-power valve. Also, in some mains-operated receivers, and particularly those designed for large output, often push-pall output amplification is used, and in this case both valves should be matched, for should there be a wide difference in the values of the valves, distortion will occur.

Never replace a directly heated pentode by an indirectly heated pentode, unless certain alterations are made to the connections. The indirectly heated pentode always contains a centre bias pin for the cathode connection and a side terminal on the cap for the auxiliary grid. Therefore, should a directly heated pentode be replaced by an indirectly heated type the cathode will receive some 200 volts in excess of its requirements. The following alterations are therefore necessary:—

The centre socket of the valve holder must be connected to the bias resister and the disconnected lead joined to the side terminal. An examination of the drawing of the connections of these two valves will explain whether any of these alterations of connections are necessary.

GENERAL RECOMMENDATIONS WHEN FITTING VALVES TO RECEIVERS.

Obtain the valve-maker's recommended data and curves so that by knowing the approximate H.T. voltage, the correct adjustment of anode current and grid bias may be obtained. To assist in obtaining the correct adjustment it is essential that a milliammeter should be available, which can be connected in the anode lead. With certain types of instruments it is an advantage to have a fixed condenser connected across the two terminals of the instrument. It is now a simple matter to adjust the grid bias so that the needle of the milliammeter remains stationary at a given value, which should be approximately the anode current on the valve maker's curve, according to the value of the H.T. current.

If the grid bias of the various stages is correctly adjusted, the output should be free from distortion and when the milliammeter is placed in the last stage, it should remain fairly steady and not flick violently to and fro on loud passages of music or speech.

The milliammeter may also be used for testing the valve for loss of emission, as often a fault in a receiver may be due to a valve losing its emission. Therefore, if on connecting the milliammeter in series with the anode you are unable to obtain the correct deflection, it follows that the valve has lost its emission and is, therefore, useless.

Variable Mu Valves.

Variable mu valves are essentially screened-grid valves in which the control grid wires are not uniformly placed. The effect of this is to produce an H.F. valve which has a mutual conductance which varies over a wide range with the change of control grid bias.

Rectifying Valves.

Many mains receivers use a rectifying valve for the H.T. supply. Usually this is of the full-wave type. The half-wave type is often used in amplifiers for large power output. Two of these valves are used in parallel in such a manner as to rectify the full wave. Mostly, the filaments are directly heated but there are now appearing rectifying valves with indirectly heated filaments. The indirectly heated filaments for a rectifying valve not only have the advantage of a higher capacity for overload, but, by reason of the slow heating of the filament, no dangerous surge voltages are developed when switching on the receiver, and the condensers are, therefore, safeguarded from breakdown.

The cathode of these valves is internally connected to the heater. The important point to remember with rectifying valves is that the filament voltage should be correct with that of the transformer, and that the size should be such as to be capable of delivering the full output required by the receiver with a margin for overload, and lastly, that the voltage on the anode should not exceed the maker's instructions.

With so many types of valves, and such a number of manufacturers, it is impossible to give specific details of every type of valve manufactured, but fortunately, the valve manufacturers have standardised certain types of valves, and the connections of the various components of the valves to the pin of the cap, groups of valves, together with the internal connections, are shown in the accompanying photographs and drawings.

The technical information in regard to amplification factor, impedance, conductance, etc., has not been mentioned for every make of valve, and they are likely to vary from time to time according to improvements in designs; but all these particulars can be obtained from the valve manufacturers' catalogues, and it is, therefore, unnecessary to repeat these particulars.

QUESTIONS AND ANSWERS

What is the common principle on which all thermionic valves work?

The utilisation and control of the flow of electrons from a chemically prepared electron-emitting surface called the filament or cathode.

For what purposes is a high frequency valve used?

(1) To increase the range of the receiver.

(2) To improve detector efficiency due to the magnified input to this stage.

(3) To increase selectivity.

(4) To provide better quality of reproduction as reaction may be avoided.

Why should a high frequency valve be screened?

To avoid accidental coupling between successive stages. If the valve is not screened, coupling between the anode and any nearby component is likely to occur and may give rise to instability.

What main point would you bear in mind when choosing a detector valve for a receiver?

The impedance of the valve should be approximately half the impedance of the primary of the transformer coupling the detector to the first L.F. valve.

WIRING A BLOCK OF MODERN FLATS

By T. Linstead

How the Specification Differs from that of Smaller Property.

In a block of flats comprising, let us say, six residences, separate supplies must feed each flat, or in other words, each flat must be a complete installation. This will necessitate each installation having its own controlling fuses and meter, as apart from the company's cut-outs. The staircase will probably be required to be illuminated under separate conditions. First, each landing may be included on the installation of its corresponding flat. Another method is for the whole staircase to be supplied from its own circuit complete with its own meter.

The specification would almost certainly call for the work to be executed in screwed conduit, complete with inspection fittings, and the necessity for this arises when it is understood that modern flat construction usually incorporates such items as concrete or patent floors with the corresponding ceiling points below, inaccessible from above.

The Subdivision of Circuits.

Another likely difference in the specification is the method of protecting the wiring and appliances in such a building, as the number of points and the amount of current carried is usually much heavier, and also the fire insurance company's regulations are likely to be more stringent where two or more families are housed under one roof. Fig. 1 illustrates a typical system of distribution that could be used in such a building, and it would be good practice for the reader to study this in relation with the plan shown on page 1527.

The Construction of the Building to be Wired.

Fig. 2 is a ground floor plan of a typical block of flats, and we will assume that there are three floors in addition to those shown. There are then sixteen flats to be served in this block. The floors are suspended concrete and the roof is of similar material. All partitions are either breeze concrete or brickwork. The interior construction is modern in every description thereby implying that all work is to be concealed and that a number of labour-saving appliances operated by electricity will be used.

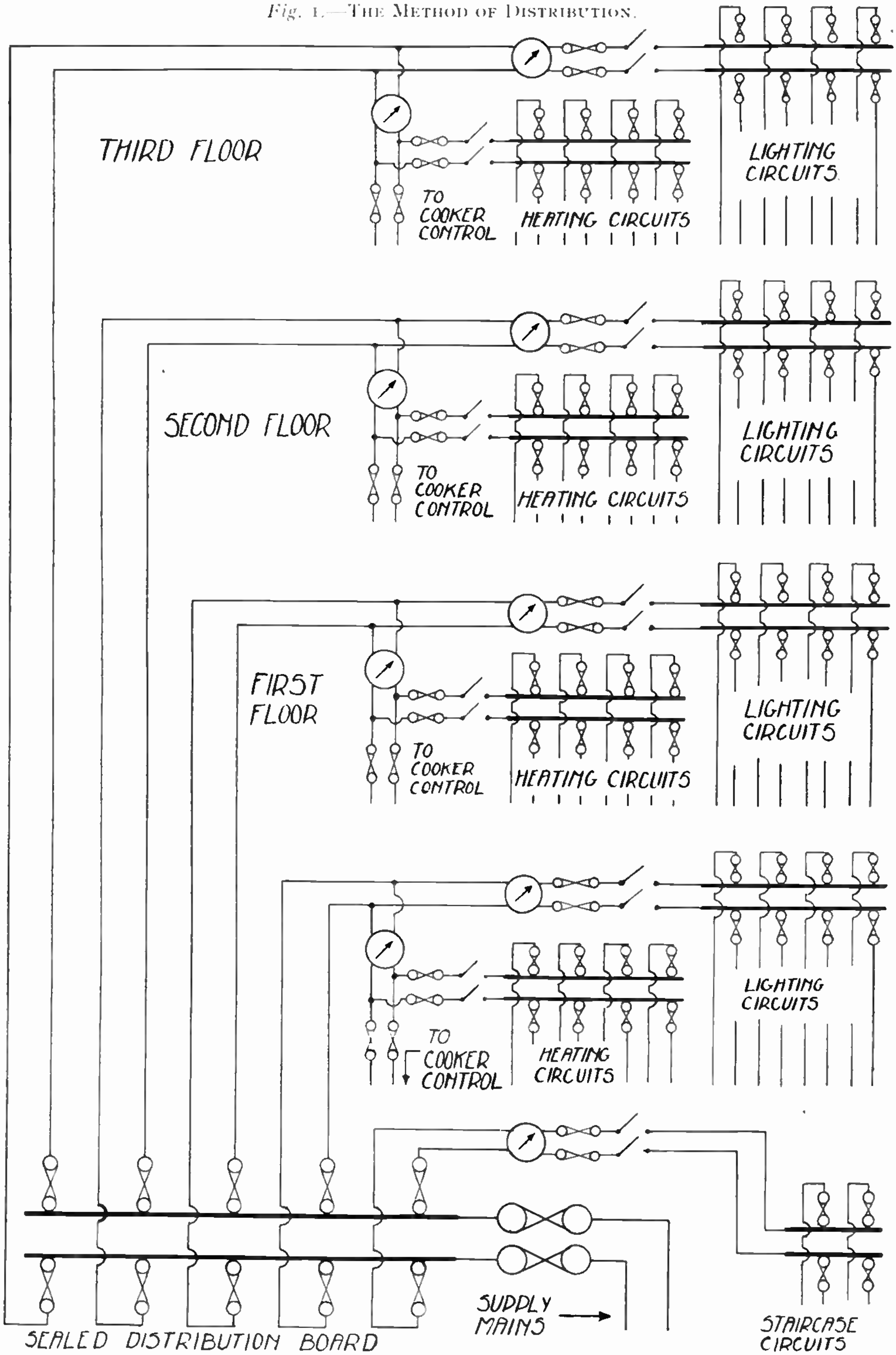
The Salient Features in the Specification.

As there is every likelihood of a large current consumption in a block of flats, no planning or work should be commenced until a consultation with the supply company has been held and their views and requirements ascertained; but we will assume that the company will bring a supply cable to a point underneath each staircase on the ground floor and from this the contractor is to split out in screwed conduit to serve each flat.

Distribution Board and Meter.

The distribution board and meter appertaining to each is to be installed in a suitable position in each flat as near to the entrance of the mains as possible. For example, on the ground floor extreme left-hand flat they would be placed on the main kitchen wall, marked "A," and in a similar position in its neighbour. On the two right-hand flats discretion would be necessary, and modern practice dictates that such gear should be placed on the kitchen wall marked "B." The reason for this being that main switches should always be in a quickly accessible position, and this would not be so if the specification as to proximity of entry of mains were strictly adhered to.

Fig. 1.—The Method of Distribution.



Type of Conduit.

The conduit is to be of screwed pattern with large-type inspection fittings. Fuse boxes and main switches, etc., are to be Home Office iron-clad pattern. All cables are to be insulated with V.I.R. and to have an insulation resistance of not less than 2,000 megohms per mile and only stranded conductors shall be used. All switches and sockets are to be of recessed pattern and all sockets are to be of three-pin type. From these observations one must conclude that the installation is required to be of the highest quality throughout.

Calculating the Load.

The first and most important operation in an installation of this nature is the calculation of the current likely to be carried in order to ascertain the sizes of cables and fuses necessary, and if such calculations are not provided by the architect they must be computed by the electrical contractor. For this purpose it will be necessary to be provided with a full schedule of the points required and, as near as can be determined, the wattage of the lamps and appliances that are likely to be used.

A TYPICAL INSTALLATION.

Let us now proceed with a typical illustration. The following is a schedule of the points required in say the extreme right-hand flat, and from it can readily be ascertained the total amperage that will be carried.

SCHEDULE OF LIGHTING POINTS.

Room.	Ceiling Points.	Wall Brackets	Skirting Plugs.	Maximum wattage of lamps and appliances to be used
Dining Room	1			300
,, ,,		4		160
,, ,,			2	150
Drawing Room	1			150
,, ,,		4		160
,, ,,			2	150
Hall ..	3			180
Bedroom 1 ..	2			120
,, 1 ..			2	140
,, 2 ..	2			120
,, 2 ..			2	140
,, 3 ..	1			60
Bathroom ..	1			75
,, ..		1		60
W.C. ..	1			40
Kitchen ..	2			200
Scullery ..	1			60
Total ..	15	9	8	2,265

SCHEDULE OF HEATING POINTS.

Room.	15 Amp. Points.	Possible use for :—	Maximum watts to be carried.
Dining Room ..	1	3 kw. fire ..	3,000
Drawing Room ..	1	3 kw. fire ..	3,000
Hall	1	Tube Heaters ..	1,000
Bedroom 1 ..	1	2 kw. fire ..	2,000
,, 2 ..	1	2 kw. fire ..	2,000
,, 3 ..	1	1 kw. fire ..	1,000
Bathroom ..	2	Towel airer, etc.	1,500
Kitchen	2	Appliances and water heater. ..	1,500
Total ..	10		15,000

Cooking Installation.

	Watts.
The cooker to be installed will be a 7 kw.	7,000
With a plug point in control switch for a kettle or similar appliance, say	750
Total	7,750

Summary.

	Watts.
Lighting	2,265
Heating	15,000
Cooking	7,750
Total	25,015

which on a 230-volt pressure = approx. 109 amps.

Choosing the Size of Conductors.

First let us take the lighting circuits and we see that the total wattage that would be used, assuming that they were all in operation at one time, would be about 2,265 watts, and on a 230-volt installation would mean that the wiring would have to carry 10 amps., but as the I.E.E. ruling dictates that sub-circuits carrying certain amperages shall only feed a given number of points, it would be well to divide the lighting installation into four sub-circuits as the number of points exceed 30. By using four sub-circuits for more than 30 points we are enabled to carry a maximum of 6 amperes on each sub-circuit ; in this

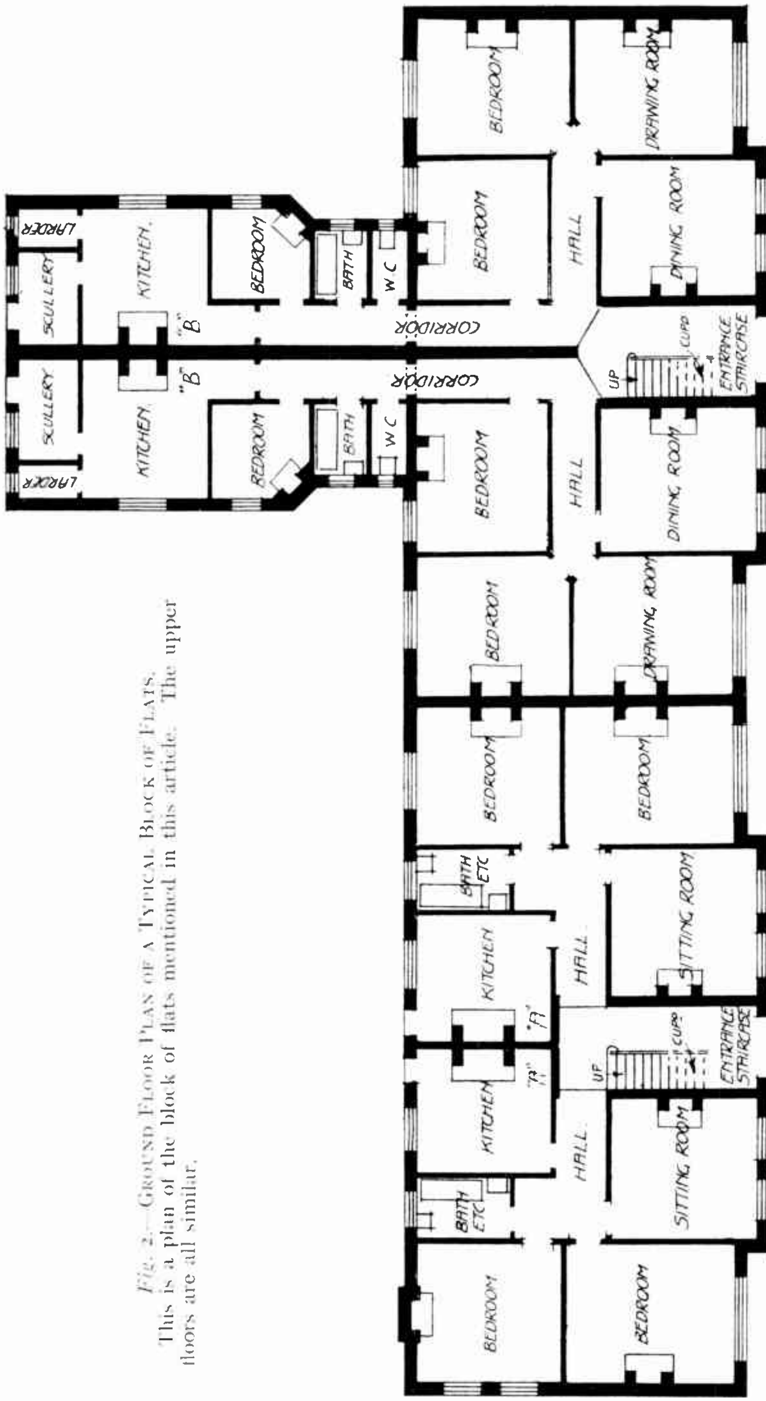


Fig. 2.—Ground Floor Plan of a Typical Block of Flats.
This is a plan of the block of flats mentioned in this article. The upper floors are all similar.

case a total of 24 amps. or 140 per cent. more than we require. For this purpose a 3/.029 conductor could be used as this has a safe carrying capacity of 7.8 amps. and we must so regulate our circuits that our total 10 amps. to be carried is divided into approximately $2\frac{1}{2}$ amps. on each circuit.

Size of Heating Cables.

In this case, and assuming as before that all are in operation at once, we have a total of 15,000 watts or a total of approximately 65 amps. Our maximum wattage at one point is 3,000 and under the rule that heating points must not be looped, but each pair of conductors returned separately to the distribution board, our total current carried at any one point would be 13 amps., and for this a 7/.029 conductor could be used as this has a safe carrying capacity of 18.2 amperes.

Size of Cables for the Cooking Installation.

Our last consideration is the cooking installation and this must be served by its own wiring and controlled by a separate gear. A 35-amp. installation needs a 7/.052 conductor to feed it, but it is safe to err on the large side where heavy currents are carried and a 7/.064 conductor is recommended.

Sizes of Distribution Boards and Switches.

Returning to the lighting circuits and our 10-amp. total capacity, a 15-amp. iron-clad double-pole switch and fuses

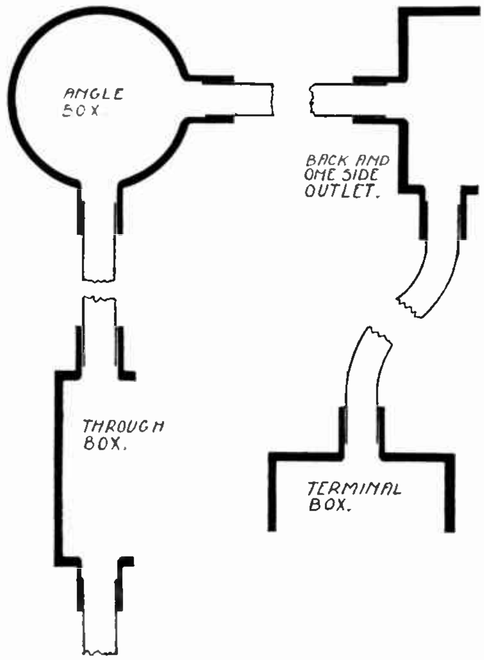


Fig. 3.—DIAGRAM SHOWING THE USE OF JUNCTION BOXES.

By the use of these it is possible to conduit a building without the use of elbows, etc., by making sets in the conduit where necessary.

should be used to control the entire lighting installation and a four-way 15-amp. Home Office pattern distribution board used for the sub-circuits. The reason for this latter being that the difference in cost is so slight between a 5 and 15-amp. Home Office board and the latter gives greater accessibility and a larger margin of safety.

Regarding the heating circuit, a 100-amp. iron-clad double-pole switch and fuses would be necessary for the control, and a 15-amp. nine-way distribution board.

Cooking Installation.

Lastly, we have to deal with the cooking installation, and in accordance with I.E.E. regulations this must be controlled by a separate switch in close proximity to the cooker, and there is on the market a switch box which comprises a double-pole main switch and fuses, a plug with its corresponding controlling switch for the kettle or other appliances, and a pilot lamp, and it is this type which the writer recommends. A 35-amp. switch of this description would be required. In addition a pair of 60-amp. heavy duty fuses should be fixed near the entrance of the mains into the flat, or, if required by the supply company, a 60-amp. double-pole main switch and fuses.

The Size of the Mains.

A pair of mains are now necessary to feed one flat, capable of carrying the total current capacity of the entire installation, in this case, 109 amps., and these would carry the current from the main distribution board, in the basement of the building or a similar position, to the flat.

These mains, especially those reaching to the top floor, will possibly be longer than any of the runs of wiring on any particular circuit throughout the flats, and will most certainly require the attention of the rule regarding voltage drop. They are to carry the entire current to the respective flats, and as the fall in pressure is regulated by the amount of current carried in conjunction with the length of cable, these cables are bound to be affected.

Voltage Drop.

The voltage drop that is likely to take place in a conductor can be found by multiplying the current in amperes by the resistance of the conductor in ohms, and this drop must not exceed 3 per cent. of the supply plus 1 volt. The following table shows the total length of cable sizes that can be used in circuit when carrying a given number of amps., and the size of the conductor should be ascertained from this table according to the length that is required to reach from the supply company's mains to each flat.

VULCANIZED RUBBER CABLES: CURRENT-CARRYING CAPACITY (SUBJECT TO VOLTAGE DROP) AND CORRESPONDING FALL IN PRESSURE.

Number and Diameter (in.) of Wires comprising Conductor.	Current Carrying Capacity of Single Cables run in Pairs.	Approximate Total length in Circuit (Lead plus Return) for 1-volt Drop with Maximum Permissible Current.
	amps.	feet.
1/.036	4.1	30
1/.044	6.1	30
3/.029	7.8	30
3/.036	12.0	29
1/.064	12.9	29
7/.029	18.2	28
7/.036	24.0	33
7/.044	31.0	39
7/.052	37.0	45
7/.064	46.0	55
19/.044	53.0	61
19/.052	64.0	71
19/.064	83.0	83
19/.072	97.0	90
19/.083	118.0	98
37/.064	130.0	103
37/.072	152.0	112
37/.083	184.0	123
37/.093	214.0	132
37/.103	240.0	145
61/.093	288.0	162
61/.103	332.0	172
91/.093	384.0	181
91/.103	461.0	185
127/.093	512.0	190
127/.103	595.0	200

A heavy-duty double-pole main switch and fuses of sufficient size to carry the total load must be used. In practice a 100-amp. switch and fuses would be used as the possibility of the entire load being carried at any one time would be very remote.

Voltage Drop on the Sub-Circuits.

It may happen that some of the lighting sub-circuits using 3/.029 conductors will be more than 30 ft. in length from the distribution board to the farthermost point on the installation. Likewise some of the heating circuits using 7/.029 will be more than 28 ft. in length, and where this occurs, larger conductors must be used, to ensure that the voltage drop over the total length of the circuit does not exceed the 3 per cent. of the supply voltage, plus 1 volt.

Allow a Safe Margin.

Particular attention is drawn to the fact that the figures used have been calculated on the assumption that the whole installation is in use at one time, but this is a remote possibility and is not often done in practice. However, the author has knowledge of cases where calculations

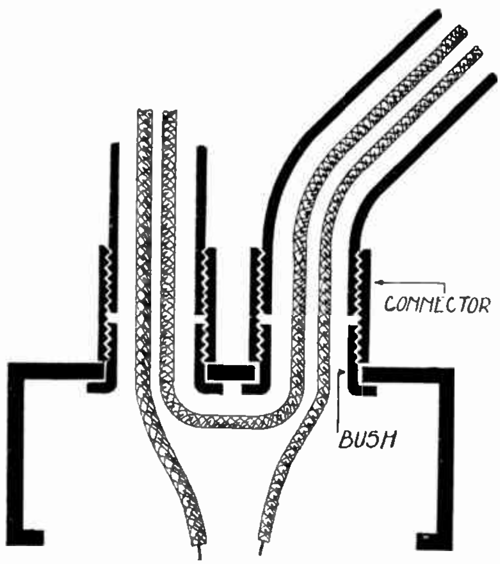


Fig. 4.—ANOTHER TYPE OF JUNCTION BOX.
The type shown above is known as a terminal and back outlet box, and allows the wire to pass the point if no connection is needed.

have been made on the assumption that 50 to 75 per cent. only of the total load would be required at any one time only to find that the occupier has experienced great trouble by so using every lamp and appliance, and it is, therefore, considered better to avoid trouble on this score by making the installation capable of carrying the full load.

The next thing to do is to determine the size of the conduits to carry the various cables and this should be done by con-

C

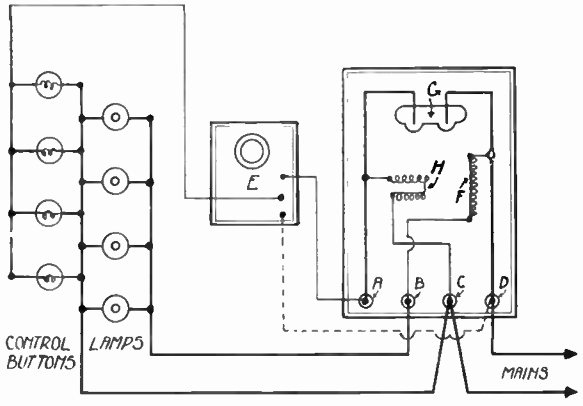


Fig. 5.—THE METHOD OF DELAY SWITCHING WITH A.C. Here is shown the method of connecting the lamps and control buttons to the delay switch. "E" is the change over time switch. A, B, C and D are the terminals of the delay switch. F is the coil excited when the push buttons are pressed. G is the mercury contact breaker and H the driving coil.

sulting the table of conduit capacities given on page 83.

LAYING THE CONDUIT.

The next step in the progress of the work is the commencement of the actual installation and a visit to the site by the wiring contractor would be advisable, in order that he may acquaint himself with the construction of the building by an actual inspection. Buildings rise so rapidly these days, due to their skeleton formation, that delay might mean that floors would be laid previous to his conduits being in position, whereas a little forethought would make the work much easier for the wiring contractor by his placing conduits in position before the concrete is poured, if he so prefers, and provided that this method is allowed by the architect.

Screwed Conduit.

The specification calls for screwed conduit, and as this is to be concealed, it should be galvanized, especially where in actual contact with plaster or brickwork. The best method to pursue in laying conduit in concrete is to run each section complete with its fittings and bends, etc., face downwards on the shuttering so that when the concrete is poured it firmly embeds itself around the conduit, thereby gaining a fixing along every part.

This should be done on each floor as the building rises and similarly on the roof, and provided instructions are given to the builder that the open ends are not to be obstructed, can remain while the plastering is proceeding.

When the conduit is laid in this way it necessitates great care in ensuring that all points are absolutely watertight and that the liquid of the concrete is not allowed to find its way into the inspection fittings.

Chasing the Concrete for the Conduits.

For those who are in doubt about the former method, chasing is the recognised rule, although the cost of labour is a considerable item. It is sometimes specified that this work is to be done by the builder, and if a word here is not out of place, the electrical contractor should make himself absolutely conversant with the terms of the specification when preparing his estimate.

Concealing the Conduit in the Walls.

The next consideration is the concealing of the conduit in the walls, and this naturally necessitates a great deal of chasing, unless arrangements are made with the builder to leave vertical chases in his brickwork. If this were done, say, at some position on the main wall the whole of the mains carrying conduits could be housed in this one chase as they rise to each flat, and then branching out in the concrete floor to their respective distribution boards.

Inspection Boxes.

When considering the runs of the conduit one must remember that inspection boxes are fitted with access covers and these must be so fitted that the cover lies flush with the finished face of the plaster, and it is essential to avoid too many of these occurring in the friezes and similar places where such unsightly finishings are liable to spoil the scheme of decorations. It is possible to conduit a building of this description without the use of these fittings by designing the installation in such a manner that each point is directly connected to its neighbour or neighbours, as shown in Fig. 3. For this purpose, practically the only fittings necessary are conduit boxes having varying numbers of side or back outlets, the conduit being connected directly between these boxes, and sets being made in the conduit where necessary to avoid the use of elbows.

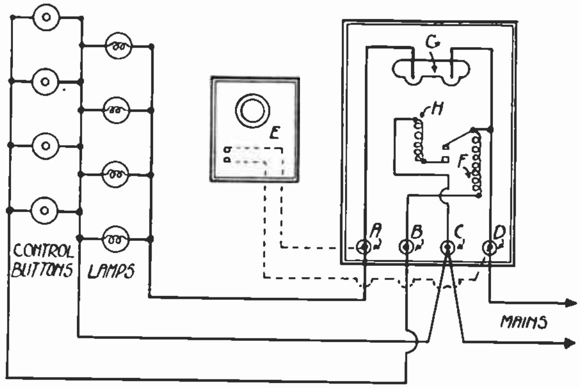


Fig. 6.—The Method of Delay Switching with D.C.
The method of connecting a D.C. delay switch differs from that of A.C., as shown above. E is the ordinary single-pole time switch and H is an electric-wound clock.

The Methods of Wiring.

In a building of this description the methods of threading the wires do not differ greatly from those used in smaller properties, except that the wires should never be threaded as the conduit is laid, but always left until the completion of the plaster, and the building is thoroughly dried out. Where the back and side outlet boxes are used as last explained for the purpose of wiring, these take the place of inspection fittings, and the conductors are threaded from point to point and passing the point if no connection is needed. The explanation of this is shown in Fig. 4, and this method has gained considerable popularity of late, being considered the most up-to-date method of wiring.

Using a Steel Tape.

When this system of conduit is employed, long runs often occur between boxes, and a series of bends around which it would be found exceedingly difficult to thread the wires. Use is therefore made of a steel tape. These are made in various ways. Some are assisted through the conduit by means of a ball fixed to one end, others have a small roller fitted. To the other end of this tape is fitted a loop to which a draw wire is made fast and pulled through the conduit.

The required number of conductors are then made fast to one end of this draw wire and pulled through in the same manner. A useful tip to assist the wires in slipping through the conduit is to smear them with french chalk as they are being paid into the conduits.

Methods of Switching.

It is not necessary to describe in detail all the various methods of switching that can be used throughout each flat as the majority of them are described elsewhere in this work and the contractor can adapt the particular method specified.

There is, however, a possibility that the staircase will require some special treatment in the matter of switching. In some cases (particularly when a caretaker is in residence) it may be sufficient to control the staircase lighting by one switch, hand operated. In the absence of a caretaker, this switch can be replaced by a time switch. This, however, has the disadvantage that the whole of the lights are cut off after a given time and cannot be used in the interim period between the operations of the clock.

The Delay System.

To overcome this difficulty the installation of the following system is recommended. The lights are first controlled by a time switch, which at the time of its disconnection brings into operation a delay system whereby light can be obtained for periods of fixed duration, usually about one to three minutes, upon pressing any one of a series of control buttons throughout the staircase. This period of three minutes is sufficient to allow a person to rise from bottom to top of the staircase or vice versa.

Connecting the Staircase Switching System.

Fig. 5 is a theoretical diagram of the wiring and connections of an apparatus made by the Venner Time Switches, Ltd., and it should be noted that the neutral or negative main is connected to terminal "C" of the delay switch and from this terminal is looped, as a common negative, to one side of the lamps and control buttons. The "positive" main is connected to terminal "D." The other sides of the lamps are then joined together and connected to the middle terminal of the special change-over time switch, while the opposite sides of the control buttons are similarly joined and connected to terminal "B" of the delay switch. The remaining terminal "A" is connected to one side of the change-over switch, the other side of which is connected by a loop to terminal "D."

The Operation of the System.

By studying Fig. 5 we are now enabled to trace out the path of the current and determine what takes place. When any of the push buttons are pressed a complete circuit is made across the mains which excites the push button coil, and, by the dropping of a mercury tube, causes contact to be made at the contact breaker "G." As soon as this happens, the current passes from the positive main via the contact "G" to the terminal "A," through the change-over switch and on to the lamps, through the lamps and back to the mains. While this current is flowing, a shunt current is also passing from "G," through the mechanism "H," to the terminal "C" and mains, enabling this mechanism to operate for its given period, at the end of which time it automatically breaks the contact "G" and thereby disconnects the whole circuit.

When the Delay System is Out of Use.

Now let us assume that the time has come for the lights to remain permanently on, from, say, seven o'clock till midnight. The change-over time switch has operated and broken the connection between the top terminal and middle, and thrown over to the middle and bottom terminal. The passage of the current is now as follows :—

From "positive" main to terminal "D" via the loop to the time switch, on to the lamps and back via the negative.

At midnight the change-over switch again operates, extinguishing the lights and repeating the operations with regard to the delay system.

Using the Apparatus on a D.C. Supply.

The internal connections and mechanism of the apparatus are slightly altered when required to be used with direct current, and Fig. 6 shows the amended arrangement.

Fixing the Fittings.

A word or two is now necessary regarding the fixing of switches and fittings, etc., in such a building. Being constructed of concrete, and possibly steel work, and most likely patent floors, the possibility of a leakage to earth is greater than is the case in buildings using wooden floors which are thoroughly dried.

We have noted from the specification that the plugs and sockets are to be of the three-pin type, and this is no idle request. The object of the third pin is to enable all the appliances to be efficiently earthed so that in the event of a leakage there is no danger to the user. These connections should be efficiently made, the third socket being well and truly connected to earth, and the metal work or outer casing of the appliances being connected to the third pin of the plug by means of a flexible cable incorporated with these making the electrical connections.

Earthing.

Another point that usually does not receive due consideration is that of earthing ordinary lighting switches. It is not a rule that can be enforced, but sheer common-sense will soon demand, that where steel work and concrete floors are in abundance, this question will have to receive attention.

Flexible Cables.

The flexible connections between pendants and appliances must also receive their due share of attention, and the current carrying capacities and maximum weights to be supported by these is fully dealt with on page 117 of this work.

HOUSE TELEPHONE SYSTEMS

By H. E. J. BUTLER

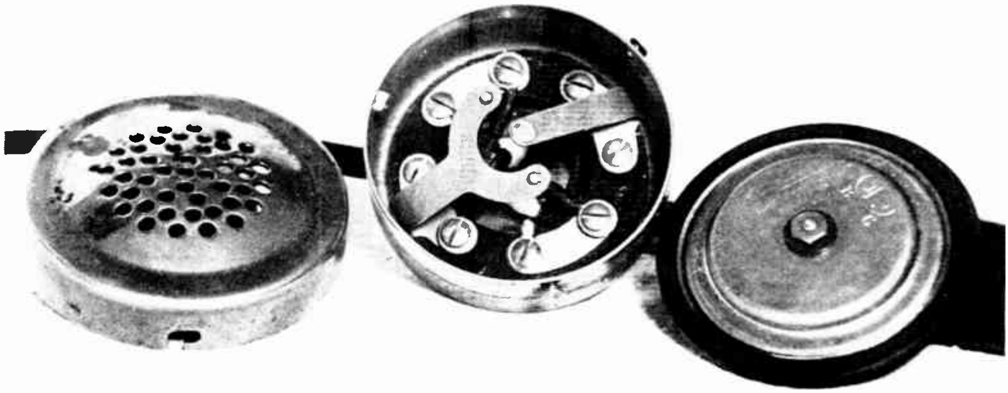


Fig. 1.—THE TRANSMITTER OF A TYPICAL TELEPHONE HAND SET.
The removable carbon microphone inset is shown on the right. The inset is insulated from the case of the transmitter by an ebonite ring, which is shouldered to register the inset centrally with its housing.

HOUSE telephones are essentially for communication over short distances and they are used in factories, business premises and private houses, when it is desirable to have a telephone independent of the Post Office telephone extensions.

The Components of a Telephone System.

The essential components of a telephone installation comprise the transmitter, receiver and battery. For signalling or ringing between stations, a buzzer or bell is necessary in addition. The battery used for speaking may also be used for ringing, but a separate battery is more usual. Ringing may be effected without a battery by means of a hand generator, or magneto as it is called. This method of ringing is more suitable for longer distances and where other adverse conditions, such as exist in mines, have to be overcome.

The Transmitter.

The transmitter consists of carbon granules held between two polished carbon electrodes. One electrode is fixed to the transmitter case and the other is secured to the diaphragm so that when spoken into it is free to vibrate. The carbon microphone is not sensitive until a current is passing between the electrodes via the carbon granules. When, however, a battery is connected across the transmitter, the vibrations imparted to the diaphragm by the action of speech cause the resistance of the carbon granules to vary in sympathy. Consequently, the current in the microphone circuit varies, and a receiver suitably connected in the circuit faithfully reproduces the original speech. Fig. 1 shows a transmitter of the removable inset type. The carbon microphone inset is shown on the right. The case of the transmitter has two springs, which make contact with the inset when it is secured in position. On the left is the protecting cover which has two bayonet fixings and a locking screw, to prevent the cover from working loose.

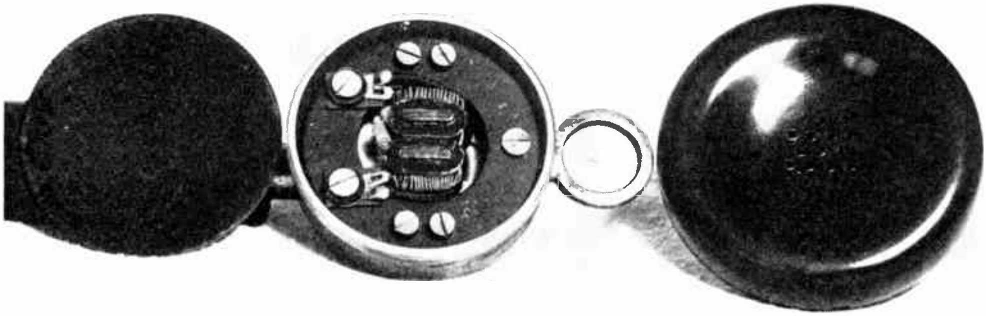


Fig. 2.—THE RECEIVER OF THE HAND SET SHOWN IN FIG. 1.
The annular permanent magnet in the base of the receiver magnetises the cores of the electromagnets so as to render the instrument as sensitive as possible.

The Receiver.

A typical telephone receiver is shown in Fig. 2. This consists of an electromagnet which causes the diaphragm to vibrate when the speech currents are passing through the windings. The receiver is rendered more sensitive by a permanent magnet which maintains a strong field between the poles and the diaphragm. In most circuits a steady flow of current is passed through the receiver in addition to the speech currents.

Polarity of Receiver Connections.

This is not essential for the operation of the receiver, but just for simplicity of operation. It is desirable to observe the polarity of the receiver connections so that the D.C. flowing through the receiver windings assists the permanent magnet. If the receiver is connected the wrong way round, it is rendered less sensitive owing to the partial neutralisation of the permanent magnet.

Combined Receiver and Transmitter.

More often than not the receiver and transmitter are combined into one instrument. This arrangement is variously known as a hand set, microtelephone, or hand combination. The hand set is made to hang on a switch hook of a wall-type

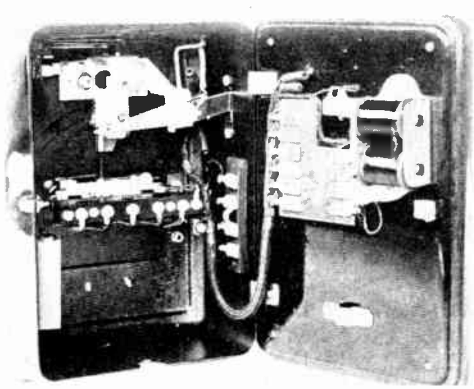


Fig. 3.—THE INTERIOR OF A SIEMENS WALL TYPE FIVE-LINE INTERCOMMUNICATION TELEPHONE.
In this type the contacts are controlled by the hook.

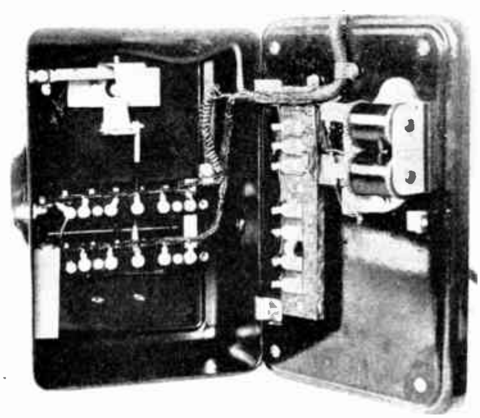


Fig. 4.—A DESK TYPE SIEMENS FIVE-LINE HOUSE TELEPHONE SET.
This is similar to the one shown in Fig. 3. In this type the contacts are controlled by the cradle.

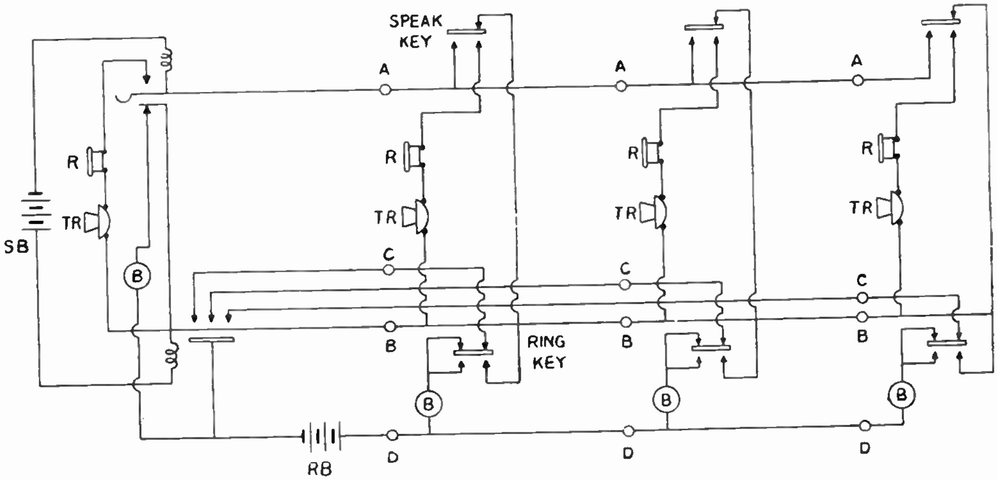


Fig. 5.—Master Station with Three Side Stations Arranged with Two Common Talking Lines A and B.

The master station can ring the side stations and the side stations can ring the master set. The side stations cannot ring one another. R is the receiver, TR transmitter, B buzzer, SB speaking battery, and RB ringing battery. This is a Standard Telephones and Cables system, using master set No. 44002 and 6043P side station sets.

telephone and to rest in the cradle of a desk instrument. Figs. 1 and 2 show the receiver and transmitter of a French hand set. One of the latest developments in hand sets is the Siemens microtelephone. The body of the instrument is moulded bakelite. The connections between the transmitter and receiver are set in the

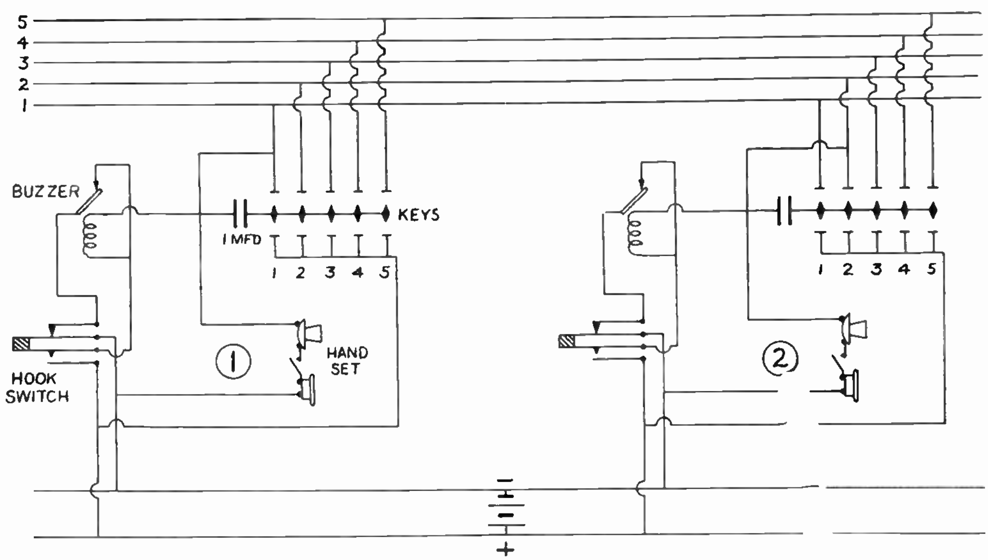


Fig. 6.—Two Stations of a 5-Line Intercommunication Telephone System.

All contacts are shown normal. When station 1 rings station 2 the plunger or key No. 2 makes on both top and bottom contact. When the key is released it is locked down so that it makes on the upper contact only. This type of system is arranged for common return, there being only one wire to each line. A Siemens system, types Q3484-Q3488, Q3494-Q3498.

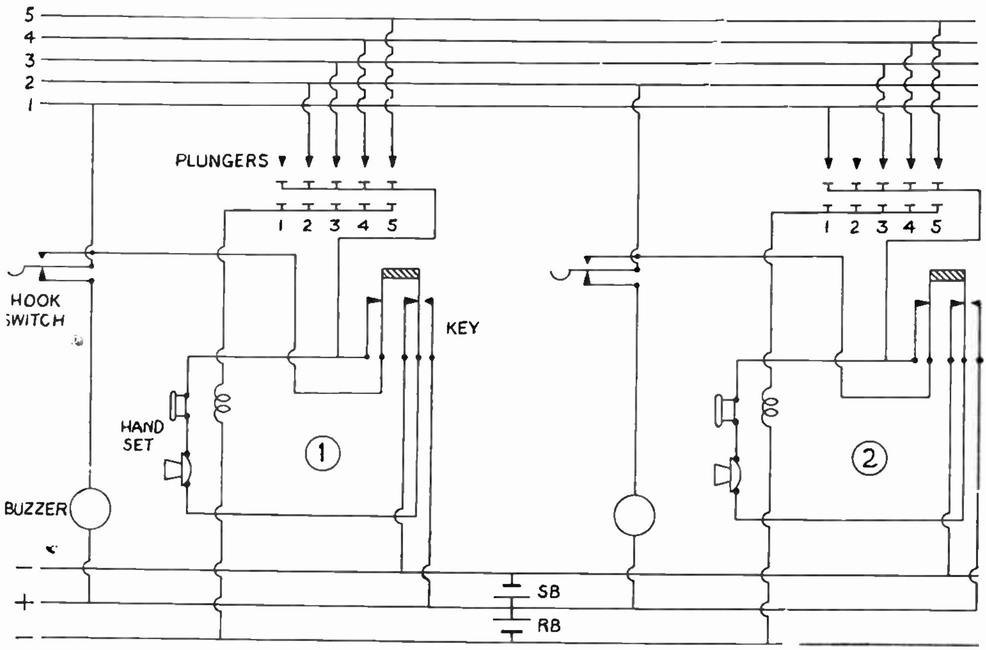


Fig. 7.—An Ericsson Intercommunication Telephone System.
This shows two stations of a 5-line equipment. All contacts are shown normal. When one of the selecting plungers is depressed fully the ringing circuit is established and when released it is locked on the upper contact so that speaking may take place. SB is the speaking battery and RB the ringing battery. The key is mechanically linked with the plungers.

bakelite during the moulding process, thus avoiding the threading of wires through the handle when fitting new cords. This microtelephone is used with the Siemens " Neophone " which is standardised by the Post Office for subscribers who wish for an instrument of superior design to the ordinary wall or desk telephone.

Batteries.

Dry batteries are the usual source of power for the house telephone. The current consumed is very small and one set of cells should last several months, unless traffic is heavy. The requirements of large installations are best satisfied by the use of accumulators. On a large system several speaking circuits may be in operation at the same time, and the current is more than can be maintained satisfactorily from dry cells.

There is usually one common battery which should be placed as centrally as possible in the system in a cool place. The local battery system uses a separate small battery at each station. No direct current passes over the lines when two stations are in communication, but only the speech currents. In another type of local battery system, the batteries of the two stations in communication are connected in series, in which instance the D.C. current must pass over the lines.

The number of cells, or the voltage of the battery, depends on the nature of the system and on the distance between stations. Generally, 6 volts may be regarded as the minimum for the speaking circuit and 24 a maximum. When a separate ringing battery is used, it may be of lower or higher voltage than the speaking battery, depending on the design of the buzzer and the distances.

Bells and Buzzers.

The type of bell used for battery ringing is essentially of the same construction as the ordinary domestic house bell. The buzzer is simply a bell without the hammer and gong. A buzzer is used when the loudness of a trembler bell is unnecessary. A different type of bell is used for magneto ringing. This is a polarised or A.C. bell. It has no contacts. The vibration of the polarised armature is caused by the alternating current passing through the magnet coils. The A.C. bell vibrates in sympathy with the frequency of the current generated by turning the magneto handle.

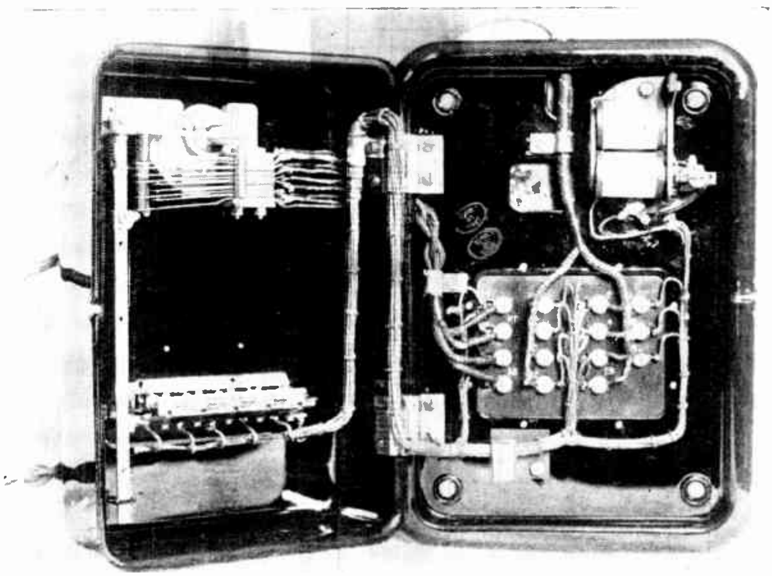


Fig. 8.—An Ericsson Five-line Intercommunication Telephone Set. This is a desk model. The wiring and contacts are readily accessible when the cover is opened.

Types of House Telephones.

The simplest type of house telephone is the one which provides for ringing only from a master station and speaking to and from one or more side stations. This type of system is suitable only for giving orders and messages, and is consequently not of much practical value.

The natural development of the system just described is to provide for ringing the master station from the side stations. This type of installation is useful when it is not desirable that the side stations should call one another. Fig. 5 shows the circuit of a Standard Telephones and Cables system of this type. A and B are the common talking lines which reduces the wiring to a minimum, although it does not prevent a second side station from overhearing when a conversation is taking place. The master station is on the left of the diagram. The energising current from the transmitters is obtained from the common battery SB. The two retard coils in series with the battery leads are necessary to prevent the speech currents passing round the battery circuit instead of through the microtelephone of the called station.

The next type of system provides for ringing and speaking both ways between two points. This is the simplest application of the intercommunication telephone.

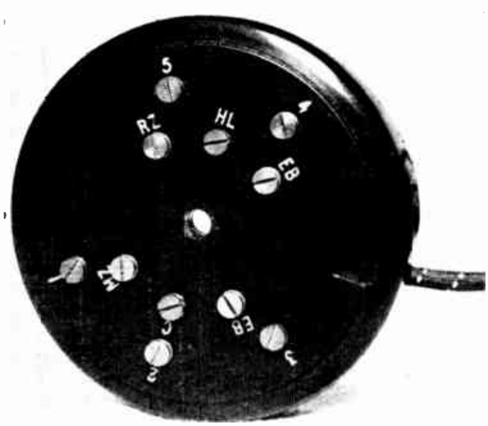


Fig. 9.—The Rosette of the Ericsson Set Shown in Fig. 8.
The rosette has a domed protecting cover.

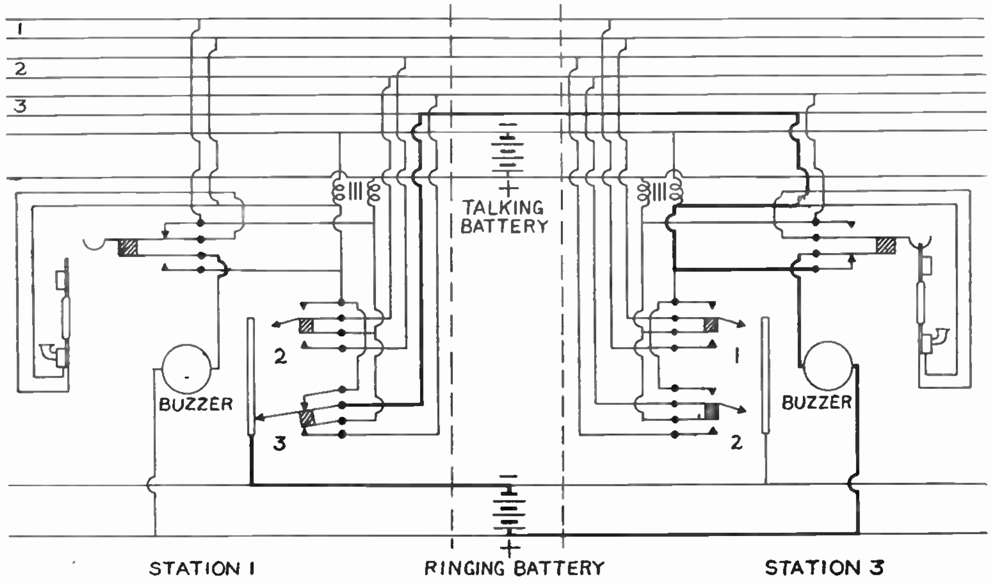


Fig. 10.—STANDARD TELEPHONES AND CABLES AUTOMATIC REPLACEMENT INTERPHONE SYSTEM. This shows two stations of a three-line circuit. This type of interphone has one less station-selecting button than the total number of lines. This diagram shows station 1 in the act of ringing station 3. Button 3 of station 1 is pushed right down. The path of the ringing current is shown by thick lines.

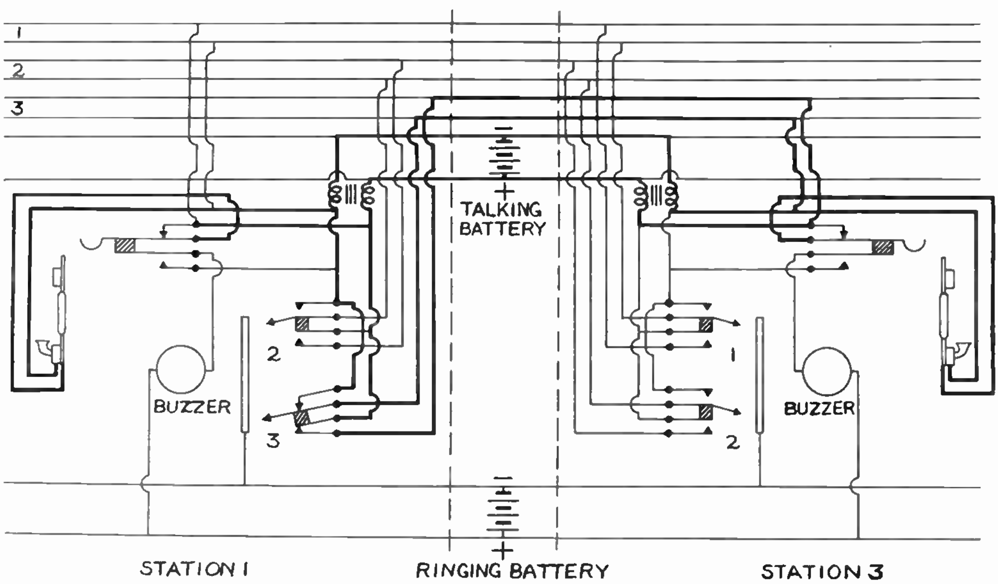


Fig. 11.—THE SAME SYSTEM AS FIG. 10, SHOWING THE CIRCUIT CONDITIONS WHEN STATION 1 HAS ESTABLISHED COMMUNICATION WITH STATION 3.
(Button 3 is now locked down.) The speaking circuits are shown by thick lines. This system has a full metallic circuit, that is to say, there are two wires to each line.

A Siemens System.

Fig. 6 shows a Siemens intercommunication telephone system for five statons. For the sake of simplicity only two stations are shown. The circuits of the other stations are the same. The only difference in the wiring of the stations is the one line connection known as the *home line*. Station No. 1 has its home line terminal connected to No. 1 line and similarly No. 2 station HL terminal is connected to No. 2 line. The wiring up of an installation of this type consists of a seven-core cable looped-in, by means of junction boxes, to each instrument. Fig. 3 shows the interior wiring of one of the sets of the Siemens system shown in Fig. 6. This is a wall type. The wiring is accomplished by connecting to the eight terminals on the back. The wires pass through the hole provided in the base of the cover. A similar Siemens instrument of the desk type is shown in Fig. 4. No wiring is necessary to the set itself with a desk instrument, because a separate junction box is provided at the end of the flexible cord, which is necessary with a desk set.

Fig. 12.—A SIEMENS 25-LINE RELAY TYPE PRIVATE AUTOMATIC EXCHANGE INCORPORATING THE "NEOPHONE" POST OFFICE PATTERN TELEPHONE.
This is a 24-volt system.

An Ericsson System.

The wiring diagram shown in Fig. 7 is an Ericsson 5-line intercommunication system. Only two stations are drawn, and all contacts are shown in their normal positions. In the Siemens system just described the microtelephones are in parallel when two stations are speaking, the current being fed through the buzzer windings which act as an induction coil and so prevents cross talk between two different conversations. The Ericsson system differs fundamentally in this respect. When both keys are in the speaking position it will be seen that the microtelephones of stations 1 and 2 are in series with one another and the speaking battery SB. In the Ericsson system the home line is not connected to the home plunger, but to the movable contact of the hook or cradle switch. The interior wiring and construction of one of these instruments is shown in Fig. 8. This is a desk model. A circular junction box for use

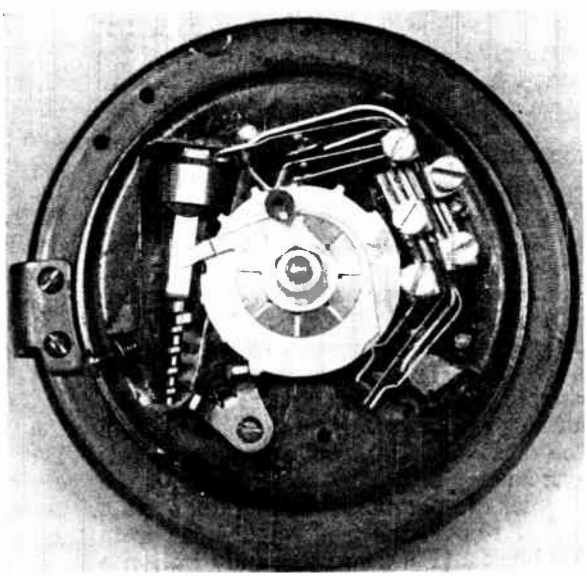


Fig 13.—THE UNDERSIDE OF A TYPICAL STANDARD DIAL.
Showing the contacts and the impulse wheel.

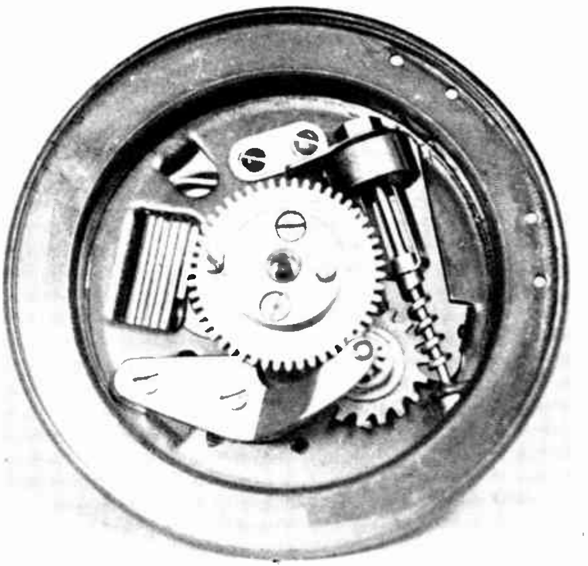


Fig. 14.—The Top of the Dial Shown in Fig. 13. With the number and finger plates removed to show the governing mechanism.

replies by lifting his microtelephone the ringing current is cut off and the hand set is energised. (Fig. 11.) When station No. 1 releases pressure from the key, it is locked down as in Fig. 11, so that the two lines of No. 3 station remain connected to the microtelephone of station 1. When the conversation is finished, and No. 1 replaces his microtelephone, the mechanical link between the cradle and the buttons restores the depressed key to its normal position.

Automatic Systems.

The key-operated type of house telephone just described is all that could be desired when there are only a few lines. When the number of stations exceeds 25, the instruments and wiring are necessarily very complicated and large. If space, neatness and efficiency justify the extra

with this system is shown in Fig. 9. The instruments are supplied with the flexible cord wired between the sets and the boxes. The terminals EB are for an extension bell. It will be seen that when wiring up set No. 1 the No. 1 line is taken to terminal HL (home line) instead of to terminal 1. Similarly line No. 5 is joined to HL of the junction box of station No. 5, instead of to terminal 5.

Standard Telephones and Cable System.

The wiring diagram of a typical Standard Telephones and Cables (Western Electric) system is shown in Figs. 10 and 11. This differs from the two systems just described, because a full metallic circuit is used instead of a common return. This is more effective in preventing cross-talk than when a common return is used. Separate ringing and speaking batteries are used, although both batteries are common to all the stations. The two diagrams of this system are drawn so as to indicate the manner of operation. In Fig. 10, station 1 has removed his microtelephone from the hook and is depressing fully button 3 of his set. The path of the ringing current is shown by thick lines. As soon as No. 3

expense an automatic system is to be preferred to the interphone sets. If the number of stations exceeds 25 an automatic system is the only satisfactory method of intercommunication. A 25-line Siemens relay automatic system is shown in Fig. 12. Where A.C. mains are available no batteries are required, all the current being supplied from a transrector specially designed for the purpose. In order to eliminate faults due to dirty contacts, of which there are several hundred in a 25-line equipment, all the relays are provided with double contacts. The Siemens system is unique in this respect.

The saving in wiring with an automatic system is considerable, because only two wires are necessary from each instrument to the exchange, so that the actual installation is of the simplest nature.

When more than 50 lines are required the selector automatic, as used by the Post Office, is to be recommended. The exchange equipment of this system is necessarily the most expensive of telephone apparatus, but permits any number of lines.

With all automatic systems absolute secrecy is ensured as it is impossible for a third party to connect to an engaged line.

TUNING COILS AND INDUCTANCES

NOTES ON DESIGNING FOR DIFFERENT TYPES OF RECEIVERS

By A. E. Watkins

Every radio receiver uses one or more tuning inductances, and although these have been used for many years, finality in design has not yet been reached, almost every design of receiver having some different form. This is not to be wondered at, for the details that can be varied are so numerous, and a number of different coils wound according to the taste of the designer may be equally efficient. It is the intention in this article to give a few hints which will guide the constructor in the design of coils suitable for various types of receivers.

Points to Watch in Designing Coils.

For instance, it is essential that the coil in a receiver, which has no H.F. amplification, should be of high efficiency. But if the receiver has one or more stages of H.F. amplification it is often advisable to reduce the efficiency of the coils so that they may be easily ganged together to stabilise the receiver. While it is easy to design a receiver with one stage of H.F. amplification with high-stage gain, it is extremely difficult to design one with two stages of H.F. amplification with a high-stage gain. It is better to design the tuning inductances in such a manner that the gain per stage is low. This particularly refers in the case of radio receivers designed commercially, for it is far better to add an extra valve and obtain consistent results.

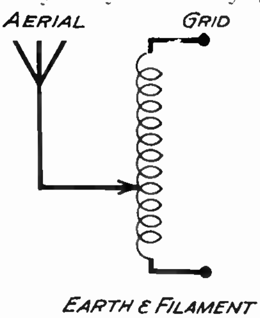


Fig. 1.—A Simple Aerial Tuning Inductance.
It is usual to tap the aerial near the bottom of the coil.

Self-Capacity.

The value for the medium-wave inductances should be, approximately, 200 micro-henrys. This value will satisfactorily tune from 200 to 600 metres with a standard .0005 condenser, while 2,000 micro-henrys would be perfectly suitable with the same condenser for the long-wave coil. Theoretically, the inductance of the coil may be made as large as we please, provided that we can reduce the capacity in parallel with it ; but when the coils are wired into the receiver, with the valves in circuit, there is an appreciableself-capacity in parallel with the inductance when the tuning dials are set at zero. This may be as large as 50 micro-micro-farads, even in a well-designed receiver, so that if we wish to tune down below 200 metres with a minimum capacity of 50 micro-micro-farads we cannot make the inductance exceed much more than 200 micro-henrys. This size will be found a safe value, and will even allow for screening of the coils.

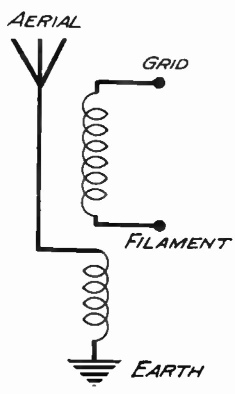


Fig. 2.—A Two-circuit Type of Tuning Inductance.
The aerial coupling coil is arranged at the earth end of the medium wave tuning inductance.

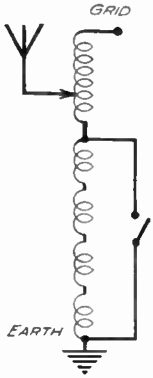


Fig. 3.—THE WRONG WAY OF INSERTING A WAVE CHANGE SWITCH.

When the switch is turned to the long-wave position the aerial is tapped at the top end of the inductance. A better arrangement is shown in Fig. 4.

Factors Which Govern the Value of a Coil.

When one comes to work out the best value of a coil on paper, one is confronted with very many variable factors and it is quite impossible with certainty to design the coils accurately. The variable factors which we come up against are :—

(1) The self-capacity of the wire and covering.

(2) The dielectric upon which the coil is wound.

(3) The spacing of the turns.

(4) The diameter of the coil.

And one or two other uncontrollable conditions.

Use Small Coils for Stability.

Also to obtain stability it is necessary to design the coil as small as possible, and this is often an advantage particularly in cases where there are a number of tuning inductances and band-pass tuning is employed, for, by winding the coil on a small diameter, it is much easier to adjust the coil by removing a number of turns of wire so that they are correctly matched, whereas if the coil is of large diameter, removing one turn would appreciably affect the inductance of the coil, and make it much more difficult to balance.

While a small diameter coil may not be so efficient as one a little larger, nevertheless, when a number of coils are used together and they are correctly matched, the overall efficiency may be greater. On the other hand, where there is only one tuning inductance to consider, we may design the coil to be as efficient as possible, and, owing to the fact that it is not necessary to screen one coil, a larger diameter may be used with advantage. There is, nowever, a limit to the diameter to which we should go, and also a limit to the length of the coil. The losses in a large coil can be considerably due to the self-capacity and also leakage effects.

Correct Size of Inductance.

In the early days of receiver designs it was considered that to use the largest inductance possible constituted the most efficient receiver, but this theory has been exploded long ago, and there is no question whatsoever that a coil larger than 4-in. in diameter is not advisable, and even this size only in rare cases, while in the case of multi-stage receivers, it is advisable to use coils as low as 1-in. diameter. A happy medium for a multi-stage receiver is $1\frac{1}{4}$-in. to $1\frac{1}{2}$-in. diameter.

Length of Inductance.

Apart from the diameter of the coil there is one other dimension which must not be overlooked, and that is the length. To obtain the most efficient inductance, the length of the winding should not exceed the diameter of the coil, or very little more than $1\frac{1}{2}$ times this. To arrive at the length of the coil and keep it within reasonable dimensions it is necessary to use a finer gauge of wire. Now if a coil is wound with fine wire and the length is kept reasonable, even if it is half the diameter, it is likely to be more efficient than that of a coil wound with thicker wire, which makes a large coil. The reason for this is that with the thicker wire the self-capacity of the coil would be much greater, and the losses greater due to the extra quantities of material upon which the coil is wound.

PRACTICAL HINTS ON WINDING COILS

Undoubtedly the best material for winding inductances, particularly those for the medium wave, is paxolin tube. Next

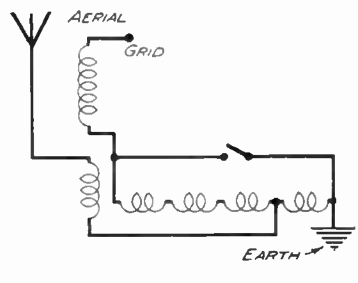


Fig. 4.—SUITABLE WAVE CHANGE SWITCH FOR SINGLE-CIRCUIT TUNERS.

This has the desired effect of transferring the aerial to the lower portions of the coil when the switch is turned to the long-wave position.

to this is ribbed ebonite or bakelite. All these three materials have good mechanical strength and electrical properties. Never attempt to use cardboard tubes, as even when these are impregnated with wax, they are most unsatisfactory and the loss is extremely high.

Wire Covering.

For the covering of the wire, silk is the best, and for all-round results, double silk-covered wire meets most requirements. Enamelled wire is perfectly satisfactory, provided it can be slightly spaced, for when the turns are wound close together, the self-capacity of these turns is greatly increased due to the small thickness of covering. Double cotton-covered wire is also satisfactory, but in this case, due to the thickness of insulation, the coil has to be made much longer than is necessary. Also, owing to the nature of cotton it is necessary that it should be impregnated. This further leads to dielectric losses, but in the case of silk covered wire, no treatment is necessary unless, of course, the coil has to be used in a situation in which dampness is prevalent.

Winding Long-wave Coils.

The long-wave coils may be wound in multi-layer coils, in the form of slot winding or the honeycomb pattern. The most important point is that they should be of such a design that the first and last turns are set as far apart as possible. This may be achieved by winding in the form of the honeycomb pattern, but this method, of course, requires a special machine. A simpler way is by winding sub-divided coils, which may conveniently be split into four sections in narrow slots. This will ensure that the top and bottom turns are far apart, and the sections reduce self-capacity.

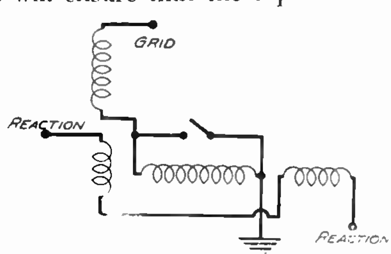


Fig. 6.—CIRCUIT FOR COILS IN WHICH TWO REACTION WINDINGS ARE USED, ONE FOR THE MEDIUM WAVES AND ONE FOR THE LONG WAVES.

TYPES OF TUNERS.

Aerial Tuning Inductances.

The first tuner in the receiver is the aerial tuning inductance. This may be a single coil, either with two windings or a band-pass tuning. If it is a single coil it is usual to tap the aerial near the bottom of the coil. The position of this tap depends upon the selectivity required. If it is of the two-circuit type, the aerial coupling coil is arranged at the earth end of the medium wave tuning inductance and consists of a small number of turns according to the selectivity required. As a rough guide usually 4 to 1 is perfectly satisfactory. This also applies to the position of the tap on the single coil.

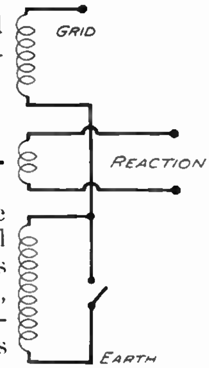


Fig. 5.—CIRCUIT FOR COILS DESIGNED WITH ONE REACTION WINDING TO ANSWER FOR BOTH MEDIUM AND LONG WAVES.

In the case of a single coil, we can have more than one tap so that the aerial may be adjusted to suit the conditions.

Band-pass Tuners.

Band-pass tuners are really two circuit tuners in which both circuits are tuned and coupled together by mutual inductance or capacity, and in the case of the mixed circuit, both inductance and capacity. For this type of tuner the diameter of the coils should be small so they may be accurately matched to ensure the ganged condensers correctly tuning over the whole range. This is fairly easy on the medium wave but when we come to the longer wave it is a little more difficult, for unless these windings are also accurately matched, slight variation will cause a tremendous difference in the condenser setting of one of the circuits.

Wave-changing Switches.

In all types of tuners some methods of wave-change switching is adopted. This is the most difficult part of the tuner for we have various problems to consider. The first is that of obtaining an equally efficient inductance both on the long and on the short waves with simple wave-change fittings. The more complicated the switches, the more difficulties we come up against. This particularly refers to the aerial tapping. On many tuners, when the switch is turned to the long wave position, the aerial, instead of being tapped at the bottom of the tuner, is now at the top end of the inductance, as Fig. 3. The aerial now imposes a heavy load upon the inductance and, therefore, throws the coils out of balance.

Arrangement for Single-circuit Tuners.

In the case of single-circuit tuners, the load of the aerial now being at the top end of the coil broadens the tuning considerably. To overcome this difficulty, the circuit in Fig. 4 is suggested, and is a system which the writer has found to be very satisfactory indeed, for not only is the switching still kept simple but it has the desired effect of transferring the aerial to the lower portions of the coil. The small coupling coil used for the medium wave does not have a very great effect upon the long wave and in the case of band-pass tuning, has been found to be quite reliable in regard to the matching of the coils, but the coils should be at right angles to one another.

Reaction Coils.

Many receivers make use of reaction. This may be added either to aerial coils where there is no H.F. stage or in the case where there are H.F. stages to the last coil, in front of the detector.

The number of turns for this reaction winding is very important, but it cannot be arrived at by calculations. It depends on the value of the reaction condenser and also upon the efficiency of the valve. If there are too many turns for a certain-sized condenser, over-reaction will occur and this may not have the effect of setting up violent oscillations, but of damping the whole signal. The number of turns for the reaction winding must be found experimentally, to obtain the most efficient reaction; from the writer's experience about one-third of the number of turns of the inductance, placed at the lower end of the coil and controlled by a suitable sized condenser, gives the best results.

Arrangements for Reaction Winding.

It is easier to vary the size of the condenser than to alter the winding. Some coils are designed with one reaction winding to answer for both the medium and long waves, as shown in Fig. 5. This is perfectly satisfactory provided that care is taken in placing both the medium and long wave coils at the correct distance from the reaction winding. It obviously follows that the reaction winding will be nearer to the long-wave coil and the space between the reaction winding and the medium wave.

The writer, however, uses another method in which two reaction windings are used, one for the long wave and one for the medium wave, as in Fig. 6. This method is covered by a patent of the writer, and is extremely useful in the case where the medium wave and the long wave coils are set at angles to one another, for then the reaction can be made constant over both the medium and the long waves without any difficulty, and no switch is necessary on the reaction winding.

Turns and Diameters for Different Types of Inductances.

As a guide in the design of coils, the number of turns and diameters of various types of inductances are given below. If any adjustment is found necessary, a turn or two more or less will rectify matters.

MEDIUM WAVE WINDINGS.

Diameter of former.	Length of Winding.	Gauge and covering of wire.
1¼"	1¾"	30 D.S.C.
1½"	2 1/16"	28 D.S.C.
2"	2"	26 D.S.C.
2½"	1 4/16"	26 D.S.C.
3"	1½"	24 D.S.C.
3½"	1 3/20"	24 D.S.C.
4"	1½"	22 D.S.C.

LONG WAVE SLOT WOUND.

Diameter (mean).	Turns approximately.	
1¾	190	Allowance is made for medium wave winding.
1½	180	
2	160	
3	140	
4	120	

PRACTICAL
ELECTRICAL ENGINEERING

Intended for Electric Lighting and Power Engineers.
Electricians and Wiremen. Wireless Dealers.
Students, Apprentices and Improvers in all Branches
of the Electrical and Wireless Industries

General Editor
EDWARD MOLLOY

VOL. IV

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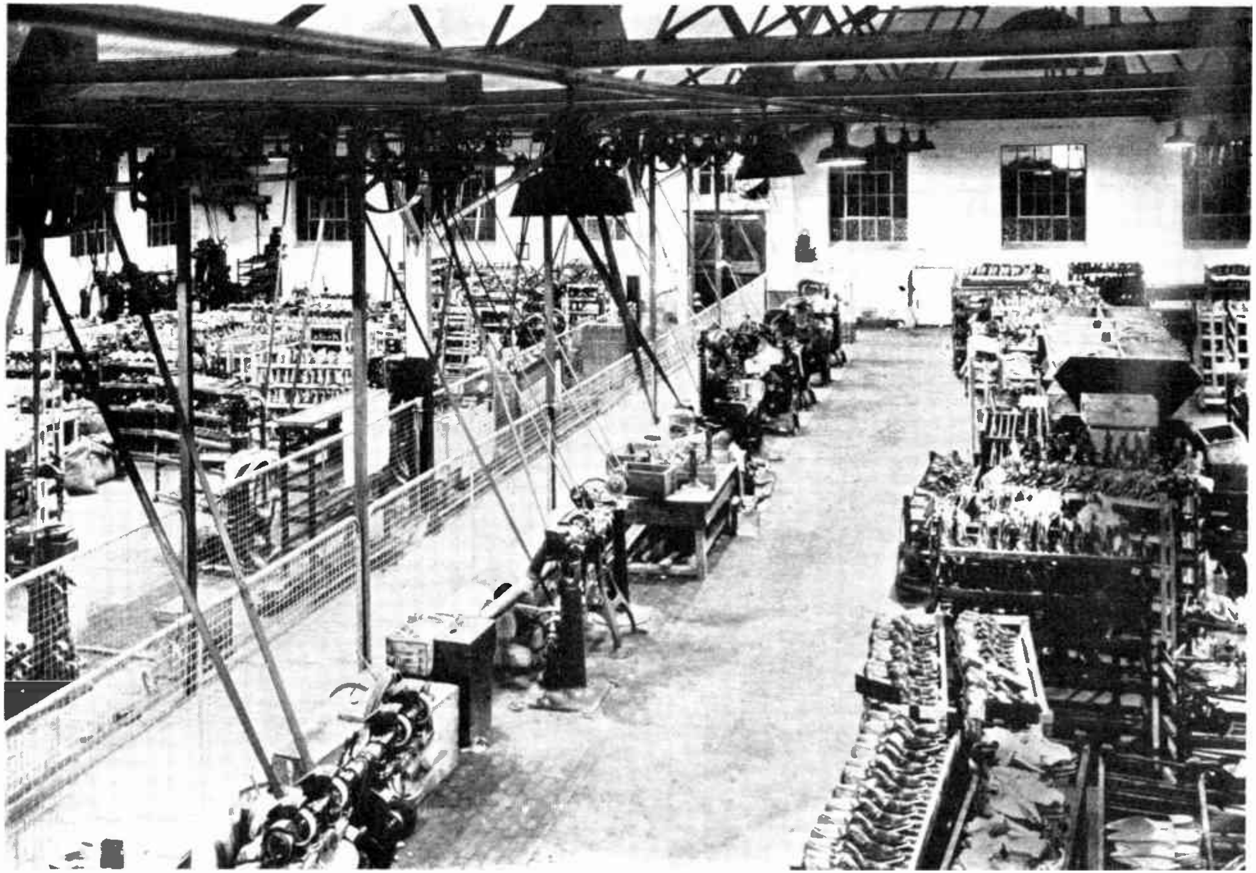

AN ENGINEERING WORKSHOP ILLUMINATED FROM OPEN TYPE REFLECTORS FIXED BELOW TIE BARS.

It will be seen that although there is almost complete darkness outside, the excellence of the lighting is such that the photograph appears to have been taken in the daylight.

PREFACE TO VOLUME IV

THE present volume opens with a most interesting survey of the Development of Electrical Machinery written by Professor Miles Walker, F.R.S. This article is well worth study by every electrical engineer. The "Flat Hand Rule" which is explained on the opening page will be found much more easy of application than the earlier rules for determining the relative directions of the magnetic field, induced E.M.F., and motion of a conductor. After a brief introduction, Professor Miles Walker reviews the development of dynamos, alternators, motors and converters from the time of Faraday up to the present day. Some idea of the progress made can be gathered from the fact that in the year 1900 a generator running at 3,000 revolutions per minute was considered "high powered" if it developed as much as 500 kilowatts, whilst to-day machines can be built to run at the same speed and develop 40,000 kilowatts.

Another article of particular interest in connection with electrical machinery is "*Starters and Control Gear for A.C. Industrial Motors*," by A. T. Dover, M.I.E.E. Many thousands of electric motors varying in size from a fraction of a horse-power to 5,000 horse-power are now in use in this country, and the number is being added to rapidly. A good knowledge of the methods by which these motors are controlled should form part of the mental equipment of every electrical engineer. Readers of PRACTICAL ELECTRICAL ENGINEERING will find Mr. Dover's article a valuable source of reference on this subject.

To digress for a moment from heavy electrical engineering to the lighter side—special attention is directed to the article which begins on page 1399 of this volume. It has been contributed to the work by Mr. T. E. Herbert, M.I.E.E., of the Post Office Engineering staff, a well-known authority on the subject of Telegraphy. In this article Mr. Herbert outlines all the systems at present in use in this country from the simplest railway telegraph equipment to the latest developments, such as the Teleprinter which enables a typewritten message to be transmitted direct over a telephone line.

Whilst the *principles* of electrical work do not vary whatever their application may be—there can be no doubt that a special type of electrical *practice* has been developed in connection with Automobile Engineering. In view of this, we have secured from the pen of Mr. Edward Hill, Technical Expert to Rotax, Ltd., a series of articles on this important subject. Readers who are interested in automobile work are recommended to study the following articles: "Dynamos, Starters and Cut-Outs," "Switches, Cables and Connectors," "Motor Car Ignition Systems," and "Electrical Accessories for Cars."

Items which are of special interest to those engaged on the wiring and contracting side of the industry form a substantial portion of the present volume. Practical Methods of Installing Small Generating Sets, The Illumination of Schools, Floodlighting, Repairs to Domestic Electrical Appliances, Surface Wiring Systems, Hospital Lighting, The Illumination of Flats and Hotels, and the Wiring of a Block of Flats, are some of the chief subjects dealt with under this heading.

Maintenance Engineers will find much useful information in the following articles: "The Testing of Small Motors," "Care and Maintenance of Electrical Machines," and the "Maintenance of Lifts." A special section has been devoted to the "Maintenance of Railway Electrical Equipment" in view of its intrinsic importance and the fact that very little information of a practical nature has ever been previously published on this subject.

Electrical engineers in the Radio Industry will find the articles on Installing Wireless Sets, Transformers, Valves, Condensers and other accessories well worth careful study. In conformity with the remainder of the work, they are packed with practical information and useful data presented in a convenient form.

E. M.

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