

## HOW THINGS WORK

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## SWITCHES

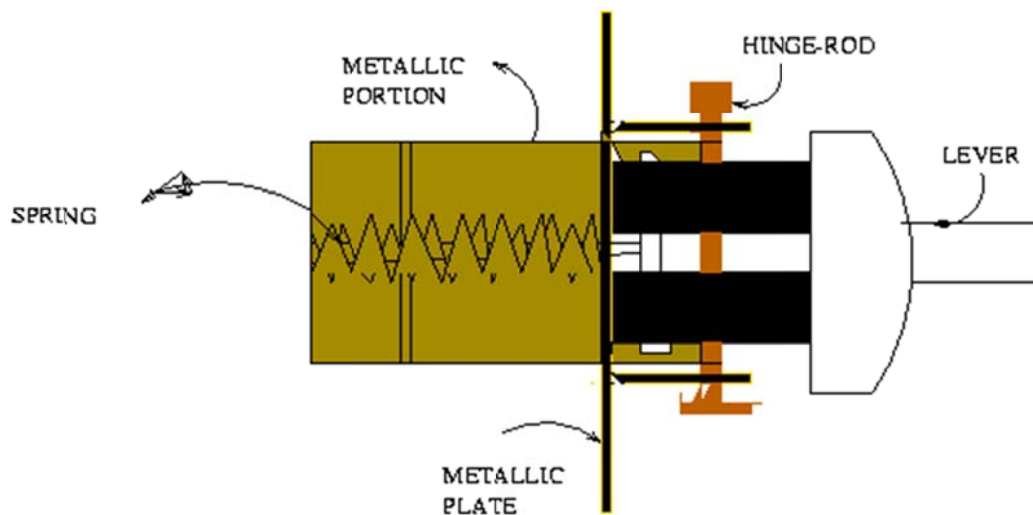
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**DEFINITION:-** A Switch is a general name for a device used for effecting the completion & interruption of an electric circuit.

An elementary switch consists of a pair of conductors which can either be brought into contact or separated and thus close and open an electrical circuit.

Switch consists of two parts viz. controlling part and base.  
The below diagram shows the controlling portion.

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top view of the controlling portion

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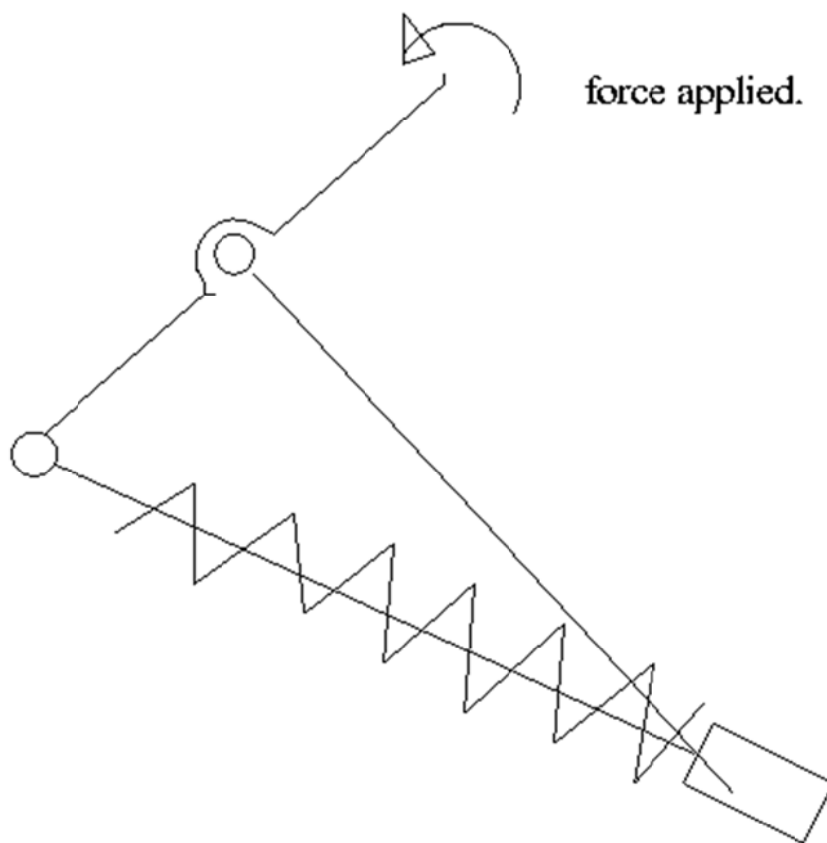
## COMPONENTS

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We have chosen the TUMBLER SWITCH for study which was commonly used in houses some time before. It consists of some links which generates the required motion. It can clearly be seen that the degrees of freedom of the mechanism is one (since only one input motion needs to be specified to determine the dynamics of other links).

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We here show a rough line diagram of the mechanism -



## Line Diagram

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## LINKS AND THEIR FUNCTIONS

### LINK 1:- FIXED LINK.

It fixes the mechanical components of the switch with the base through screws..Other components of the mechanism move relative to it.

### LINK 2 :- THE LEVER.

The only visible part of the mechanism from outside .Whatever external torque is applied it is to this link ,it rotates and thus it is our **Input link**.

### LINK 3 :-

Is is hinged to the input link .It passes through a compression spring.The link moves in a circle as the Input link is moved,the direction of rotation being opposite to that of the input link.

#### LINK 4 :- OUTPUT LINK.

The whole mechanism is designed in such a way that this link trips from off to on position and vice-versa when desired.

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## LINK LENGTHS

Link lengths of a mechanism are chosen on the basis of desired relative motion required between the links.The switch we have chosen has got a crude design.The link lengths have been standardised nowadays for uniformity.

The lever is long enough so that it could easily be rotated with our hand.

Link-3 is sufficiently long to provide the necessary torque for rotation of the output link.

Output link length is so chosen is based on the calculation that when the input link rotates by 30 degrees (approx.)then it responds to it by giving a rotation of 40 degrees (approx) ,so that proper connection is acheived.

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## SPRING

There is a compression helical spring.Is is placed in such a way that when Link 3 rotates about the hinge in the lever the spring compresses till the metastable position and then elongates.Spring has got two main purposes --

- \*It stores energy and releases it at one go when needed.

- \*It provides mechanical pressure to ensure proper electrical connection between the output link and the connectors.

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Switch mechanism has two stable positions corresponding to lowest potential energy configurations. It has also got one metastable position.

- On Position: [LINE DIAGRAM/ ACTUAL DIAGRAM.](#)
- Off Position: [LINE DIAGRAM/ ACTUAL DIAGRAM.](#)
- Figure of [METASTABLE POSITION](#)

The input link is rotated by an external agent. Link3 also starts rotating and in the process it loses contact with the walls of the hole in the output link. The entire energy supplied by the external torque gets stored in the spring (leaving out the frictional losses). When the spring is maximum compressed (that is the potential energy of the system is maximum), all the forces acting are collinear and hence there is no torque on the output link. This is the metastable position of the mechanism because a little disturbance from this position changes the configuration of the system.

When the lever is slightly displaced from this position, the spring expands instantaneously and also link3 contacts the walls of one side of the hole. This causes an impulsive force to develop due to the contact between link3 & the output link. The component normal to the contact generates a torque on the output link and it trips from one side to another. The spring is responsible for the sudden jerk on the output link so that the transition is sudden.

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## MATERIAL SELECTION

Material selection is an important aspect of any design. They are chosen on the basis of properties desired.

**Base :-** It is made up of highly insulating and durable material usually some kind of inorganic or organic alloys, which is baked and made into required shape.

**Lever :-** It is made up of high strength PLASTIC which cannot be easily deformed. The plastic should have a sufficiently high melting point so that melting does not occur due to some internal arc production.

**Contacts :-** The material for the output link and the connectors should be able to make satisfactory contact at relatively low mechanical pressures, must be resistant to oxidation and other damages due to arcs. In our switch the contacts are made out of COPPER.

**Link 3 :-** It is made of cast iron.

**Spring :-** spring is made of spring steel.

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## METHOD OF PRODUCTION

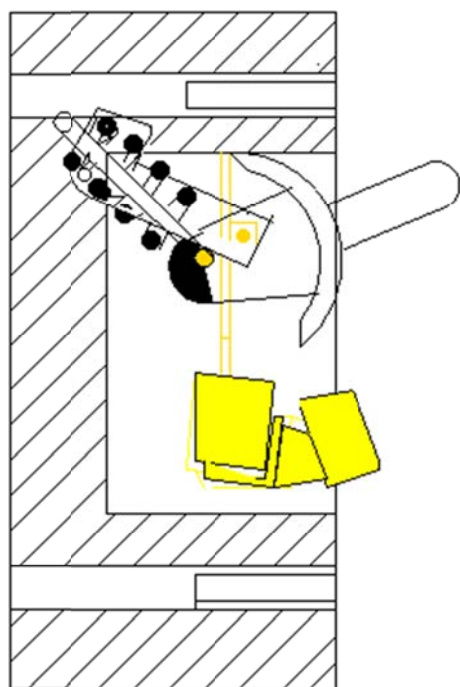
**Base and lever :-** Casting.

[Output link](#) :- Sheet metal forming.

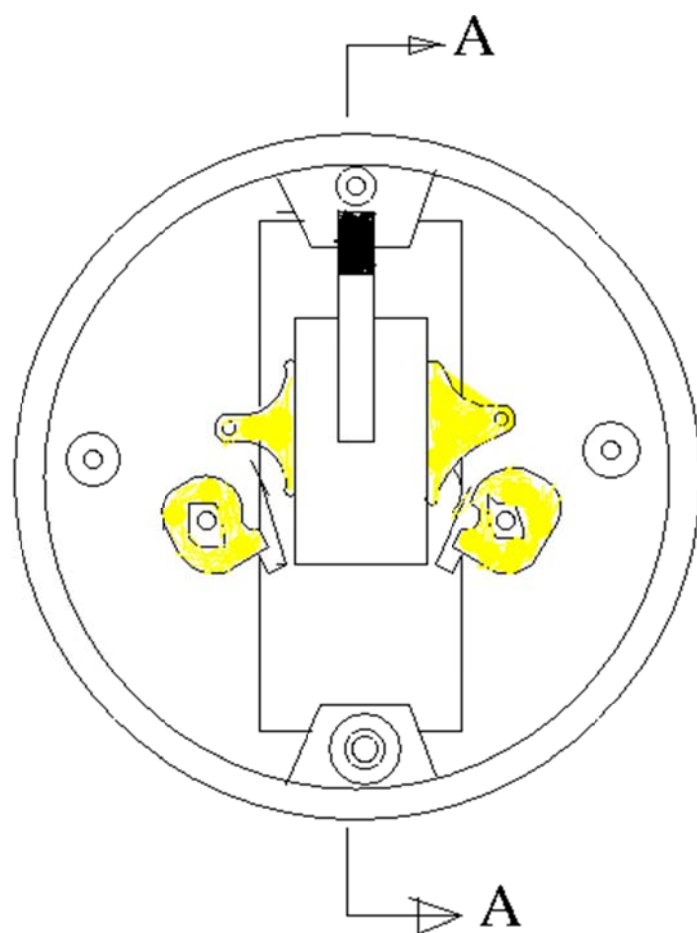
[Link 3](#) :- sheet metal forming.

[Spring](#) :- cold working.

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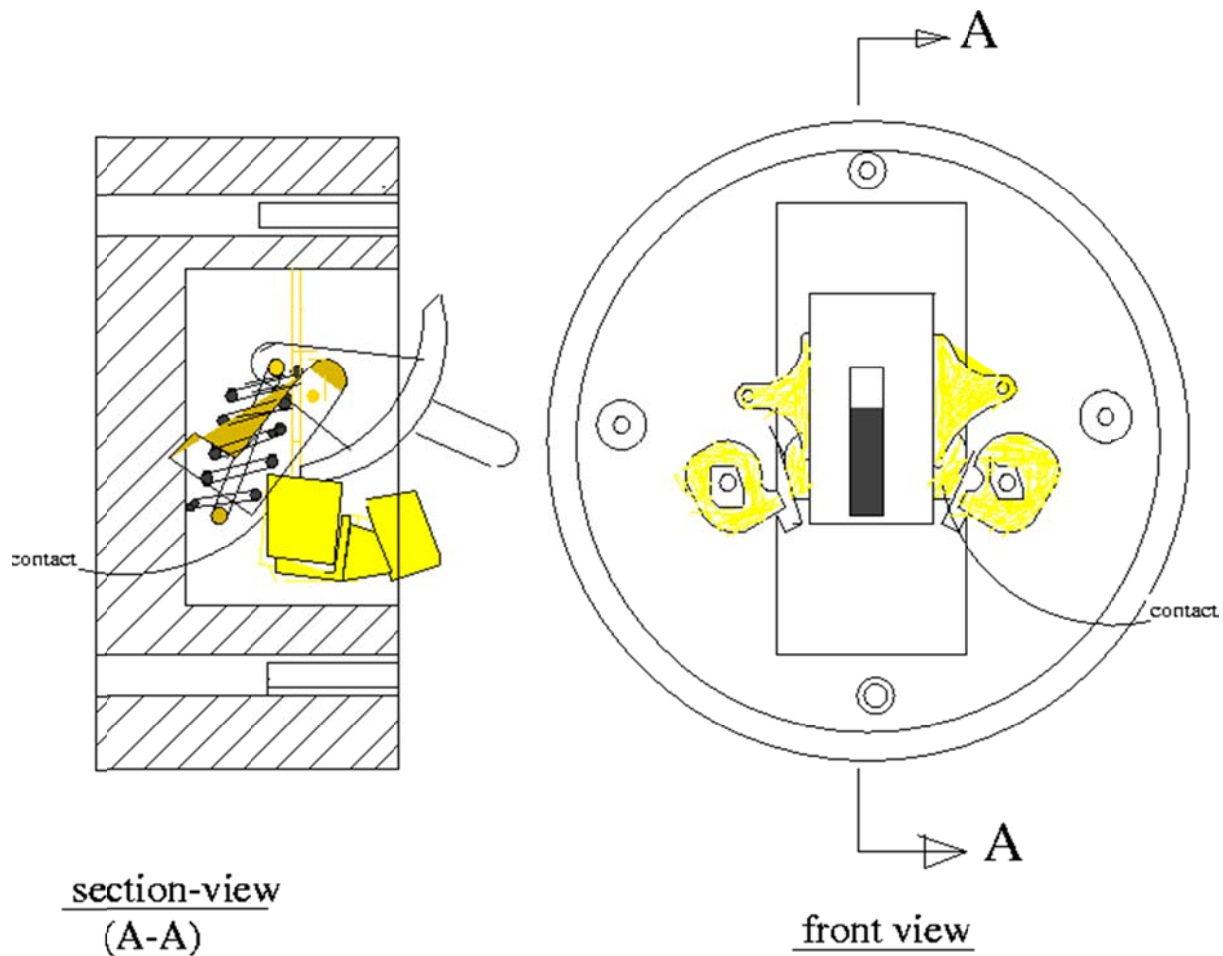


section-view  
(A-A)



front view

OFF-Position



ON-Position

## CLASSIFICATION

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SWITCHES are classified in many ways ,but for the purpose of study they can broadly be classified on the basis of method of ACTUATION used.The principal classes are -

### Manually Operated :--

These include push buttons,key switches,knife switches,toggle switches and are available in a profuse variety of sizes,styles and structures.

### Mechanically operated :--

These contain the spring and contact assemblies similar to those found in manually operated version but here the actuation is by means of mechanisms such as cams , linkages , hydraulic or pneumatic cylinders.

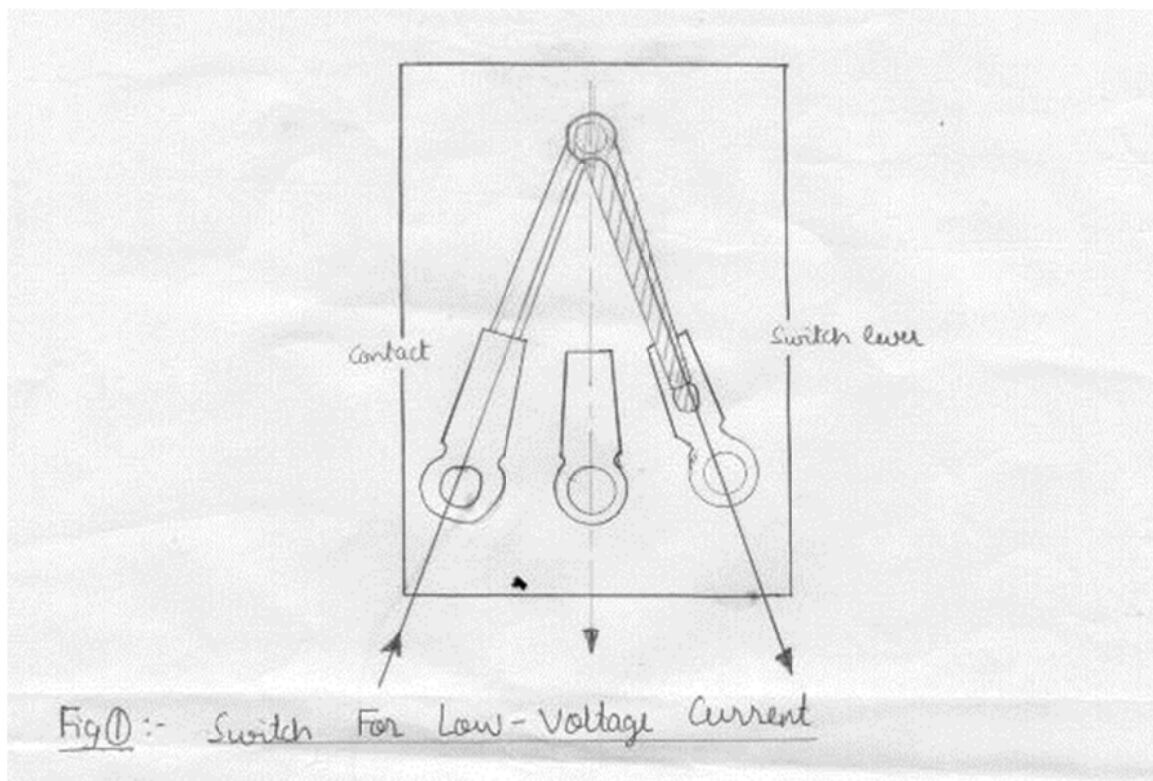


### Electro magnetically operated :--

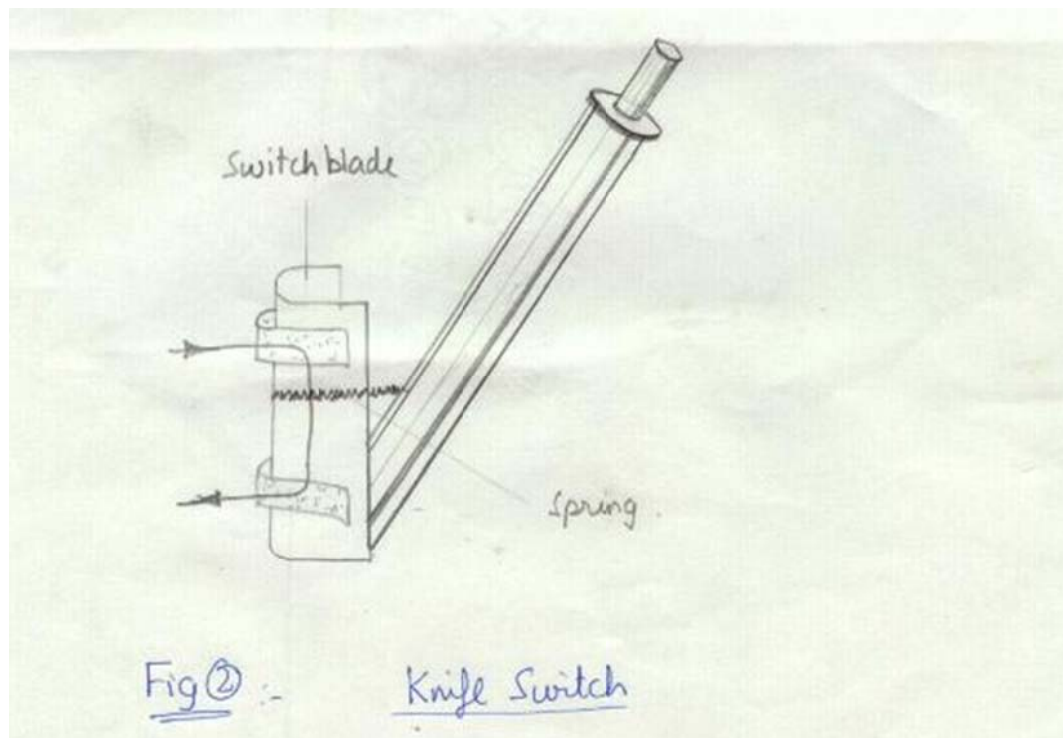
It is with in the class of the mechanically operated but is placed in a separate class because the electromagnetic mode of operation makes it possible for one switch to control the operation of another. This type of switch are known as relays.

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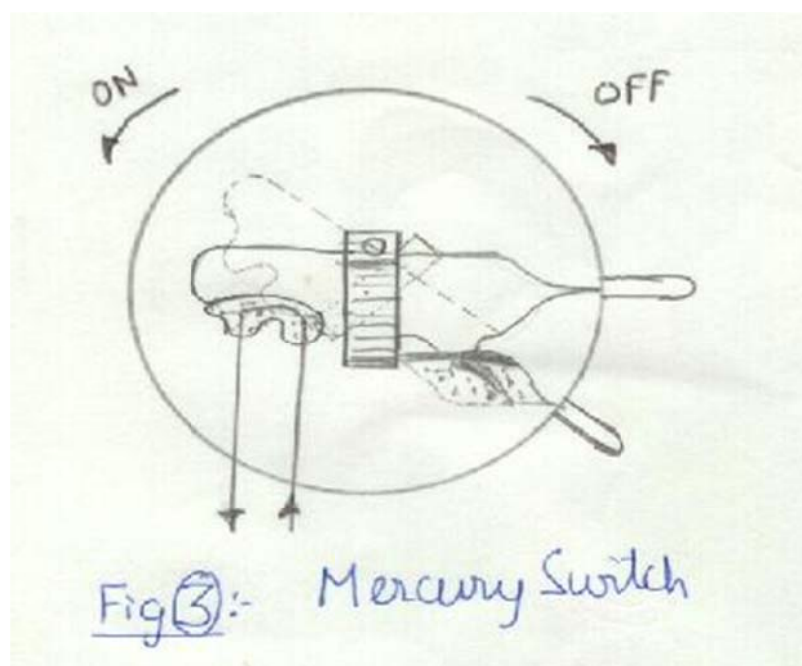
A brief description of the design on various actuation used and their applications is as follows.



This figure shows a very simple switch for low voltage current. This type is extensively used in the telecommunication engineering and for many other purposes eg in bell circuits. The switch lever is conductively connected to the contact K and can be connected to either of the two alternative circuits by setting it in the position I or II. A switch of this kind is unsuitable for heavy currents because considerable sparking would occur, more particularly on interruption of the current and this could give rise to dangerous arc formation. To prevent this, the interruption of the current must be accomplished as speedy as possible. For this reason knife switches are used. One such switch is shown in fig2.



In this type, the switch blade is connected to the lever by a spring. When the operating lever is pulled out, the spring is tensioned and then quickly pulls the blade out of the contact; the brief interruption spark then cannot develop into an arc. Another way to prevent arcing at the contacts is embodied in the mercury switch which is filled with a protective gas (inert gas, nitrogen). (fig 3)



The switches used for the domestic purposes are turn switches, tumbler switches, or push-button switches. These are shown in fig 4, 5 & 6 respectively.

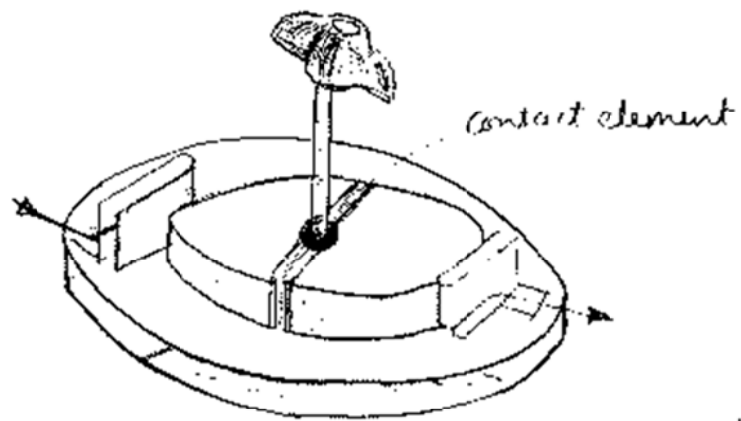


Fig ④ :- Turn Switch

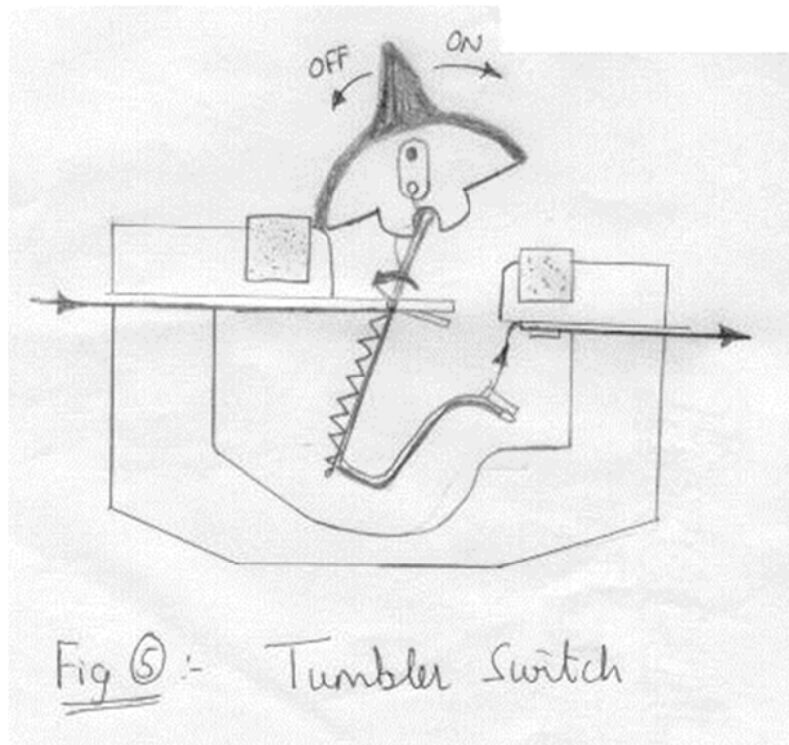
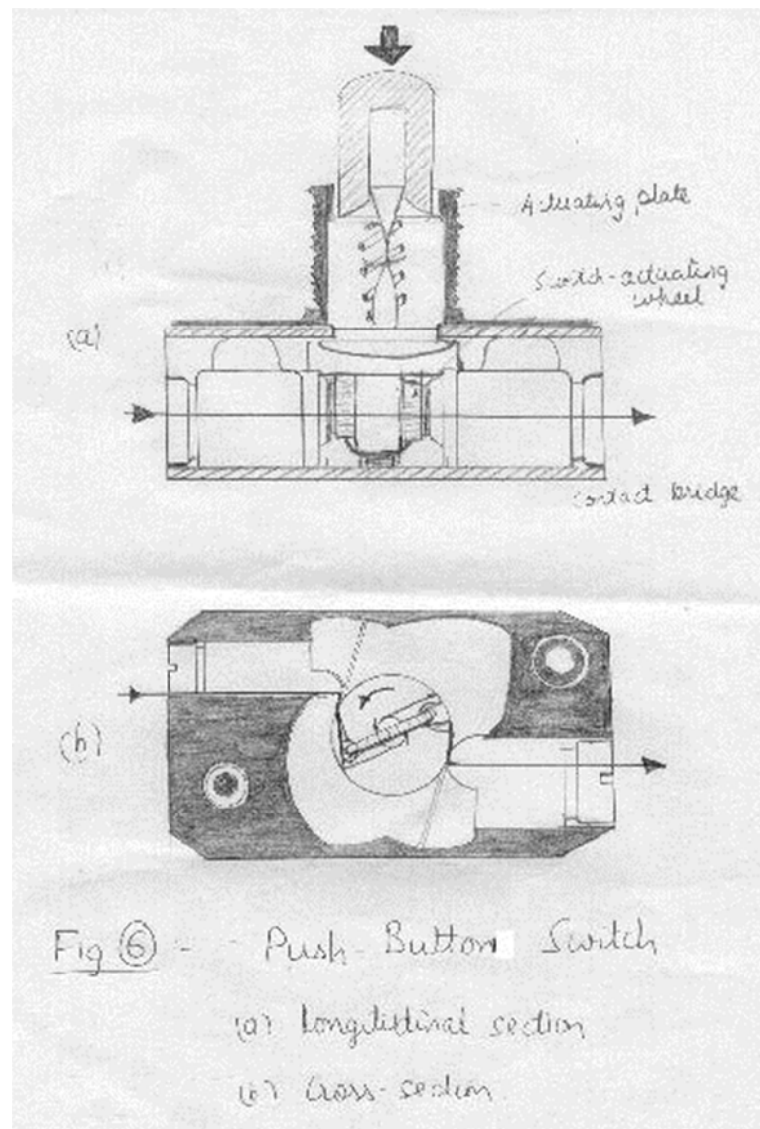
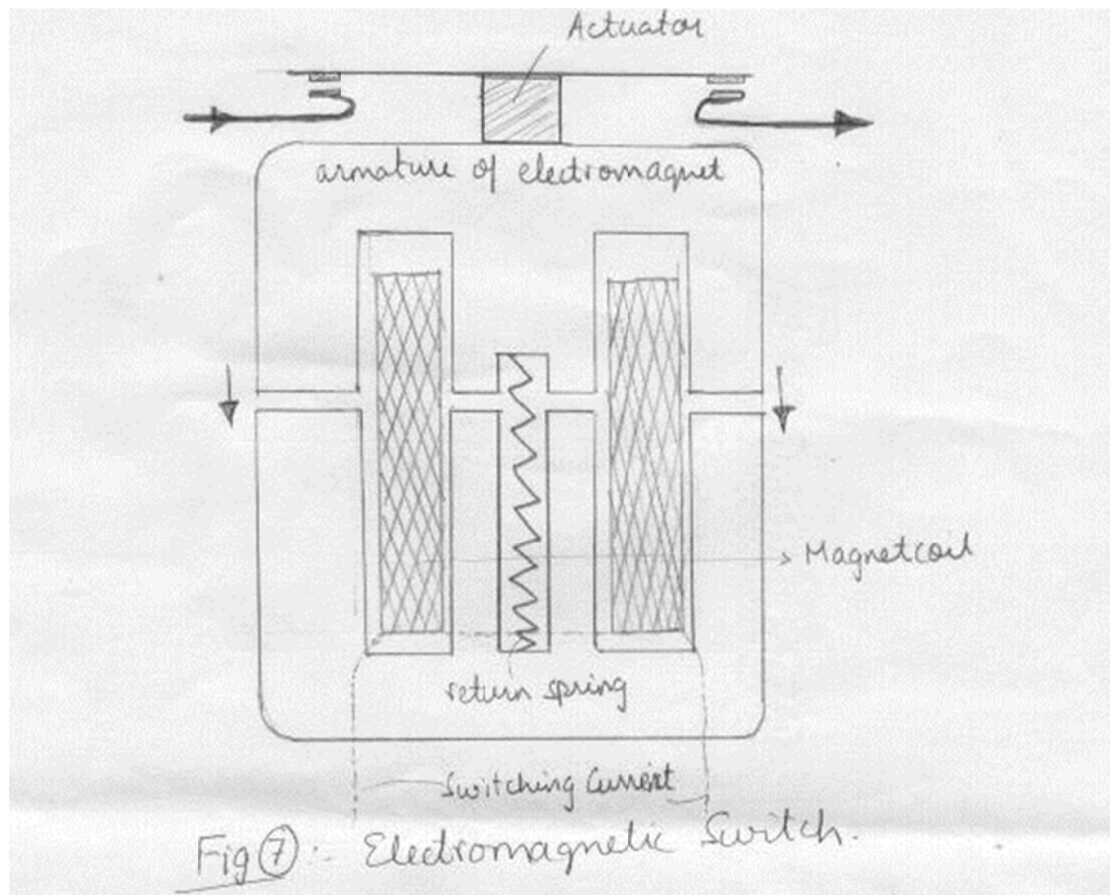


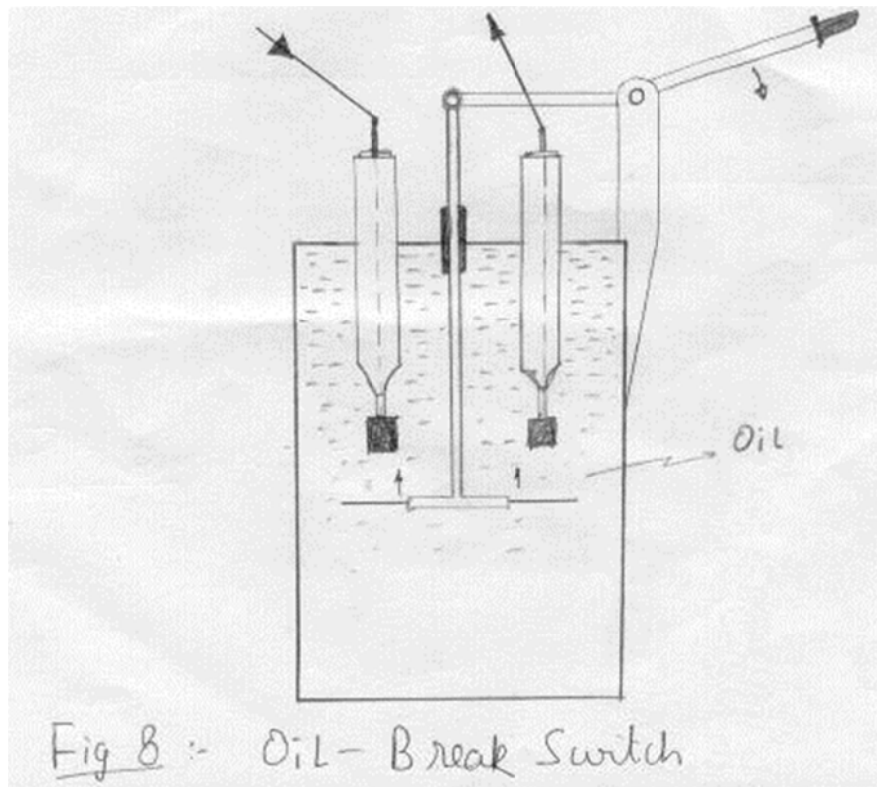
Fig ⑤ :- Tumbler Switch



Switches for very strong current are usually of the electromagnetically operated type, a eg. shown in Fig 7.



High tension switchgear is often of the oil break-type i.e. the contacts are separated under oil for the quick and effective extinction of the arc; the oil also serve as insulation.(fig 8)



Switches for very high voltages are often of the gas-blast type, in which a blast of high pressure hydrogen, air or other is directed on the arc at the moment of separation of contacts to accelerate its extinction.

The switch normally found in Indian household use is the manually operated one. The most common are the tumbler, key and push-button, etc.

The study done is on the Tumbler switch.

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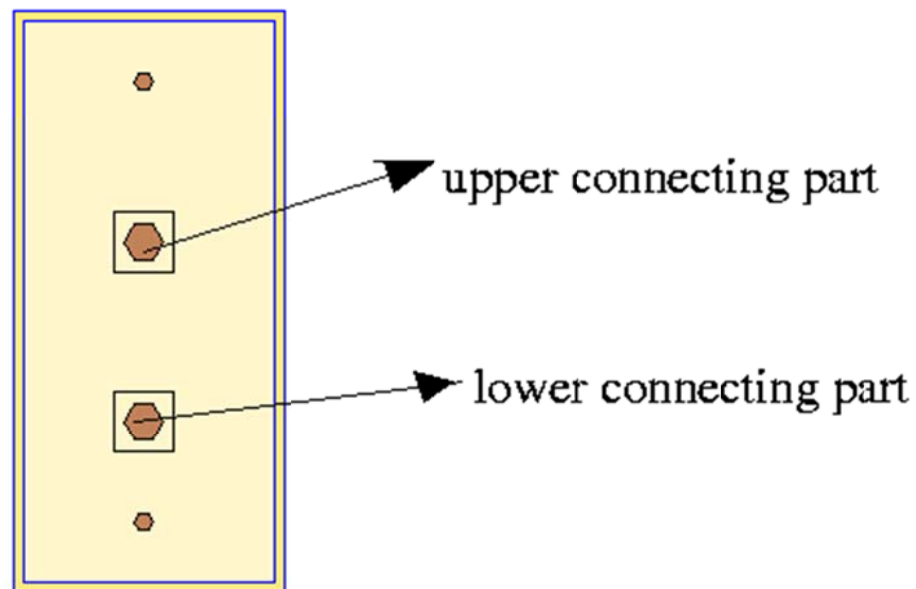
## IMPROVEMENTS

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The new version of tumbler switch nowadays very popular in India is the bed switch. It has replaced the conventional switches, the main reason being small size, easy to use & prone to less damage.

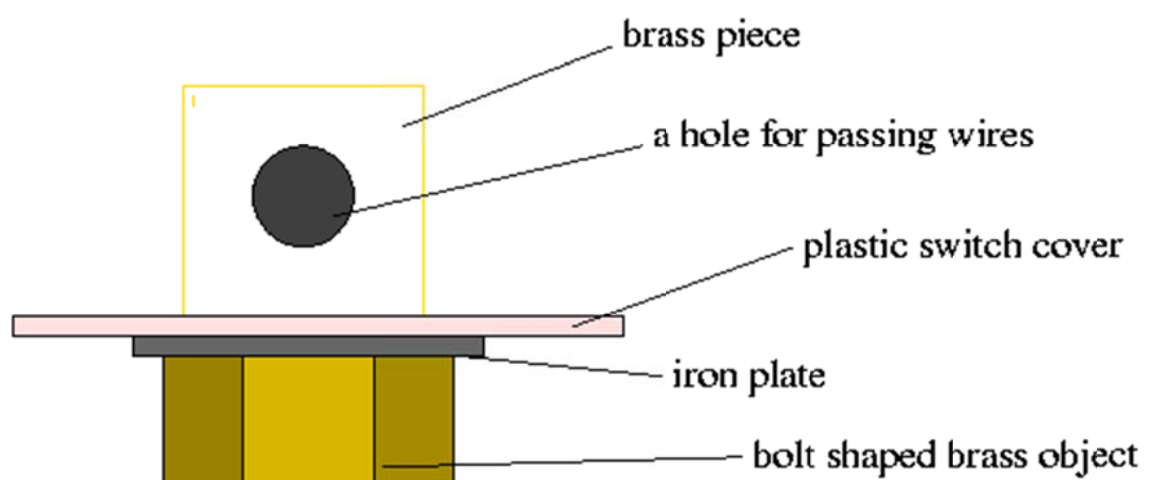
The basic mechanism remains the same => 2 stable position of spring & a metastable position are there, but the main difference being the size of spring is reduced & a less stiff spring being used, thus needing a small force to operate than the previous one.

There is almost no distinction between these two switches in the construction & working part. A small difference being in the way the circuit gets opened or shorted as shown in the figure.



### Back view of the unbroken bed-switch.

When we break the switch, we find that the lower connecting part in it's far end has some bolt shaped object projecting out, as shown in the figure below



### Side view of the lower-connecting portion.



The upper connecting part is the portion of the main controlling device of the switch.

When we apply force on the lever from the OFF-position, the spring gets expanded from the stable position (due to attachment with lever) & as soon as it crosses the metastable position, the lever itself moves down (rotates clockwise/anticlockwise depending on the side view) as shown in the figure.



The lever contains a conducting plate within its bolt which is attached to the upper connecting metal & on the lower part of the plate is a screw. After the lever moves down, the screw on the plate & the bolt on the lower connecting part get into contact, stopping the lever movement & completing the circuit. The figure below shows the on position.





The figure also shows the spring in one of its stable configuration.

When reverse force is applied ,(switching off),the contact between the screw & the bolt ,immediately breaks & thus opening the circuit. The lever comes to rest in the off position as the groove is provided in the plate of the lever which fits the link of the controlling portion.

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