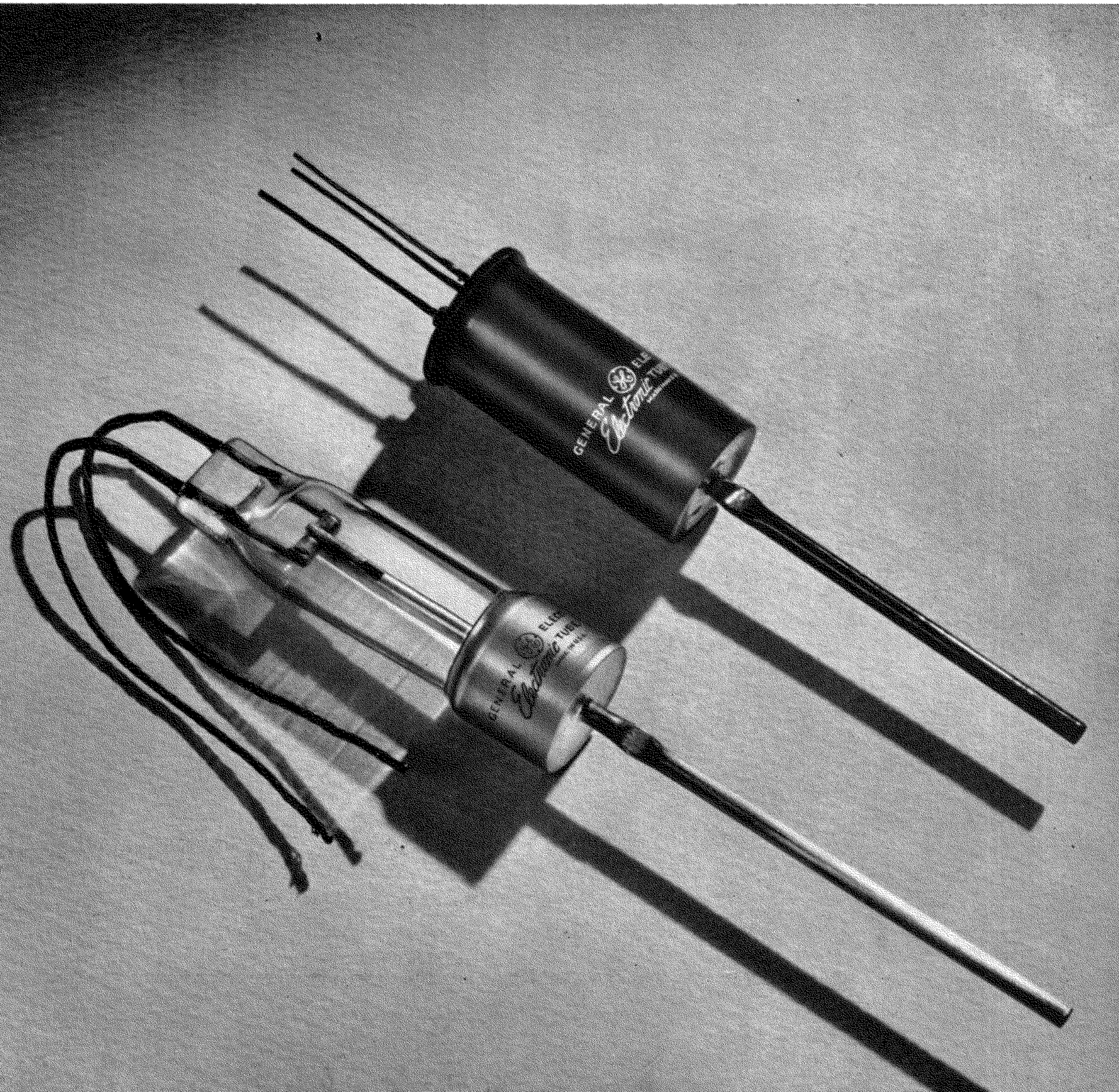
GENERAL ELECTRIC

VACUUM SWITCHES



DESCRIPTION

The vacuum switch is a vacuum device incorporating movable and fixed contacts, arranged so that a mechanical motion of the movable contact makes or breaks the switch circuit. The motion of the movable contact is obtained by means of a flexible diaphragm mounted on a metal cup to which the glass or metal body of the switch is attached. The fixed contact leads are mounted on the body of the switch.

Vacuum switches are useful in any application requiring the control of high voltages or high currents where space requirements are stringent. Since the contacts are mounted in a vacuum, they are relatively free from the effects of corrosion and arcing, are unaffected by dust or oxidation, and will give longer wear than exposed contacts.

MECHANICAL ADVANTAGES

Because General Electric vacuum switches operate mechanically, a variety of actuating means may be used. The flexible diaphragm used eliminates the necessity for an external fulcrum. This transmits movement to the contacts and acts as a natural fulcrum for the operating arm. Movement is obtained from the mechanism to be controlled, or from other apparatus to suit the application.

This movement is often provided by a slow-moving cam or by the movement of a thermostat. Air or liquid bellows, a rod-linkage system, an electrically operated relay, or almost any other means can be used to operate the vacuum switch. This is possible because a very small force is required to achieve the switching motion. There are several advantages which result from this feature.

The vacuum switch is capable of being operated over a wide range of speed. Operation from several cycles an hour to several thousand cycles per minute are permissible.

The contacts of the switches close without vibration, enabling them to be mounted on or near delicate instruments.

ELECTRICAL ADVANTAGES

The vacuum construction of the switch allows the use of close spacings between fixed and movable contacts, with the result that it is possible to interrupt high voltages although the movable contact travels only a few thousandths of an inch. This small movement brings about an economy of space that is possible only with vacuum switches.

In air-break switches, the breaking of the switch contact is accompanied by an ionization of the air present around the contacts. This ionization causes an arc to occur, with subsequent heat loss, and the switch is unable to break the circuit rapidly.

In vacuum switches, there being no gas present as a source of ions, a very rapid break is made. (See under "Installation and Operation.")

Under some conditions an arc or spark will occur, but this condition will exist only when the switch is handling high currents. If such currents were broken by an equivalent air switch, welded contacts might easily result.

The fact that arcs rarely occur, or, if they occur, are not in air, brings up two important advantages of vacuum switches over air switches. Because of the enclosed construction, G-E switches are especially valuable for use in flour mills, magnesium finishing rooms, and similar dust-laden atmospheres.

In addition to operating under the adverse conditions described above, G-E vacuum switches are capable of operating under any liquid which provides sufficient insulation for the leads so that an external short is obviated. Some liquids, such as transformer oil, will actually increase the external voltage breakdown allowable, and thus reduce maintenance to a minimum.

RATINGS

Vacuum switches are rated in terms of the following characteristics:

Internal Hold-Off Voltage

This is the maximum voltage that the vacuum switch can hold off internally; that is, when the movable contact is held against one stationary contact and the voltage is applied across the two stationary contacts. This voltage is usually expressed as an rms value.

The criterion of proper operation is absence of gas discharge. With the test voltage applied, there should be no evidence of a gas discharge. Fluorescence is a phenomenon which will not affect the operation of the switch.

External Hold-Off Voltage

This is the maximum voltage that the vacuum switch should be called upon to hold off externally; that is, from stationary contact to stationary contact, or from stationary contact to movable contact. This rating must specify an ambient humidity and assumes that the external surface of the switch is moderately clean. It is also necessary to provide corona shields of some sort in order to achieve the hold-off voltage stated for this rating.

This test is normally made at some external pressure lower than that encountered at sea level. This pressure is stated in terms of altitude in feet above sea level.

Interrupting Rating

This is a measure of the life expectancy of the vacuum switch. The life of the switch will depend upon the application in which it is used. Low-current, high-voltage applications cause no perceptible contact wear, and the life depends upon the mechanical strength of the switch diaphragm. High-current, low-voltage applications cause vaporization of the contact material, with subsequent shortening of life. Interrupting ratings are usually given on the basis of a certain number of allowable operations for several conditions of voltage and current.

Initial Tension

Initial tension is the force required on the movable contact to open the circuit, if the movable contact is touching one of the stationary contacts. This force is usually measured on the operating arm 5/8″ from the switch diaphragm.

Operating Force

Operating force is the energy required to move the movable contact from one stationary contact to the other, including initial tension. The measurement is usually made on the operating arm at a point 5/8″ from the diaphragm.

Arm Travel

The travel of the operating arm is the motion required to move the movable contact from one stationary contact to the other. The measurement is usually made on the operating arm 5/8″ from the diaphragm.

Maximum Continuous Current

This is the maximum current that may be carried safely by the switch for an indefinite period of time.

Maximum Allowable Force on Operating Arm

This is maximum force which may be applied to any point on the operating arm. This rating is important in that it dictates the design of the actuating mechanism. This rating must be observed carefully, as a value higher than that recommended will result in decreased life.

TYPES OF SWITCHES

Vacuum switches are made in two general types. The first type, exemplified by the FA-6 and FA-15, is an all-purpose switch for general switching applications. The second type, of which the GL-1S21* is an example, was designed with particular emphasis on external voltage breakdown. This results in a switch which is extremely useful at greatly reduced air pressures, such as are encountered in aircraft applications.

APPLICATIONS#

There are six properties peculiar to the vacuum switch which enable it to be used with extreme advantage in many applications.

1. Vacuum Construction

The fact that the switch contacts are enclosed in a vacuum contributes in general to all the various advantages found in the use of these switches.

Operation of other switches at extremely high altitudes is complicated by the fact that the distance between contacts having a given voltage impressed across them must be greatly increased due to the lowered air pressure. For example, if a given distance is able to hold off 30 kilovolts at sea level, it will arc over at approximately 7 kilovolts at an altitude of 50,000 feet.

Vacuum switches are unaffected internally by high-altitude operation. Externally, it is comparatively easy to provide a sufficiently long path so that the external voltage breakdown is adequate.

Applications made possible by the vacuum construction also take advantage of the fact that an arc cannot be sustained easily in a vacuum. When a circuit is broken by a vacuum switch, the arc produced by ionization of gas is minimized, inasmuch as there is practically no gas present. This means that by proper actuator design a very rapid break may be achieved, and a very high induced voltage may be obtained as a consequence of this rapid break.

2. Enclosed Construction

It is very often necessary to operate switches in the presence of gases, oil spray, heavy dust concentrations, or under conditions that adversely affect the operation of electrical equipment. The sealed construction of vacuum switches causes them to work most efficiently under such conditions.

The enclosed construction also minimizes the hazard of switching in an explosive atmosphere, as for example, in a flour mill.

3. Small Size and Weight

Inch-for-inch and ounce-for-ounce the vacuum switch will handle higher voltages at higher currents than any other type of switch. For example, a 20-ampere circuit-breaker for 600 volts alternating current may be approximately 2 cubic feet in volume.

The FA-15 vacuum switch will break 10 amperes at 600 volts alternating current and is only one

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five-hundreth the volume.

The vacuum switch will not operate at the above current for too many operations, but in any application where size or weight is the prime consideration, the vacuum switch can be used to advantage.

4. Low Operating Force

There are many applications where the force available for actuating a switch is very small. Among these are thermostats used in air-conditioning control. With the use of a vacuum switch, it is possible to handle the full load current without the use of auxiliary devices between the actuating force and the circuit to be controlled.

The circuit shown in Fig. 1 illustrates the vacuum switch used in a Wheatstone Bridge method of sampling gases dissolved in liquid. The vacuum switch is used as one arm of the bridge. In such an application the amount of power that can be used is very small. This circuit acts as a sensitive switching relay. It is useful in applications where there is a minimum of power available and where the indicating force is small in magnitude.

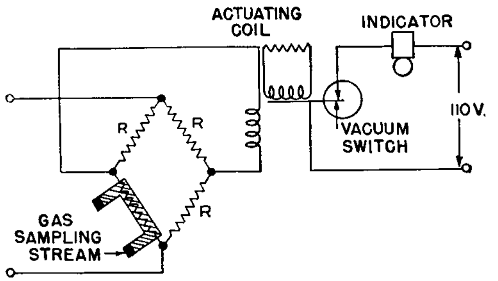

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Fig. 1—Wheatstone Bridge Circuit for Sampling Gases Dissolved in Liquid

Electronics Engineering Manual, Vol. III, P-73, McGraw-Hill Book Co., Inc.

5. High-Speed Operation

Vacuum switches are constructed with the moving parts so light in weight that the speed at which they are capable of operating is limited more by the actuating equipment used than by the switch itself.

Vacuum switches are capable of being operated at several thousand cycles per minute and will accommodate a motion produced by an actuator when the rate of operation is changed rapidly over a period of a second or two.

6. Low-Speed Operation

The vacuum switch is so designed that there is no definite resting point or on-off position. For this reason the switch may be used in any application where the motion available for switching is extremely slow.

An application such as this is the operation of the switch by means of a cam, where the cam might be operated by some searching or hunting mechanism.

INSTALLATION AND OPERATION

Mechanical

Installation of G-E vacuum switches is simplified by their compact construction and by the fact that they can be mounted in any position.

Mounting may be accomplished by clamping to any portion of the body of the metal switch, FA-6, but glass-body switches must be mounted by clamping to the cylindrical metal cup. Suggested mounting arrangements will be found at the end of this article.

The clamping should be uniform, not unduly tight, and care should be used not to damage glass parts and seals. It is important that the clamp does not come closer than 1/16″ to the glass seal on the cup.

The actuator design must allow for overtravel of the operating mechanism so that sufficient contact pressure is applied to the switch. If this provision is not made, the maximum force allowable on the operating arm will be exceeded and serious damage to the diaphragm may result.

The pressure required to make good contact is much less than the rated safe pressure. Pressure in excess of the rated safe pressure imposes undue strains on the insulating glass as well as on the diaphragm.

Any connections made to the fixed contact leads should be flexible enough so that no part of the mounting strain is carried on the leads themselves.

When a vacuum switch is mounted in a holder it will be noticed that there is a great deal of freedom of movement of the operating arm. It is therefore necessary to design the actuator so that it holds the operating arm in position between the two stationary contacts.

Electrical

Electrical connection must be made either to the lead wire which is welded to the body in the case of the metal switch, or to the cap in the case of the glass switches.

As explained previously, the quick break given by a vacuum switch causes high induced voltages.

It is desirable to use a small capacitor (about 0.01 to 0.05 microfarad) across the contacts or across the load on non-inductive circuits when the current is more than 5 amperes. With inductive circuits the sum of the normal and transient voltages must be limited by a capacitor to a value not greater than the maximum voltage rating of the switch.

It is also advisable, in highly inductive circuits, to limit the value of capacitance required by use of a shunt resistance across the load. This resistance, while increasing the total current in the circuit will reduce greatly the amount of capacitance required. Too large a capacitance will cause unnecessary wear and welding at the contacts. When it is necessary to use a capacitance greater than 0.5 microfarad a small amount of series resistance may be used to slow up the discharge but care must be taken that the capacitor-resistance combination limits properly the voltage peak. Since failure of the switch will leave the load circuit closed, this switch is not recommended for applications where a closed circuit would result in failure of the apparatus unless an auxiliary means of opening the circuit is provided.

For high-voltage circuits, it is important that adequate precautions be taken to prevent corona.

VACUUM SWITCH MOUNTINGS

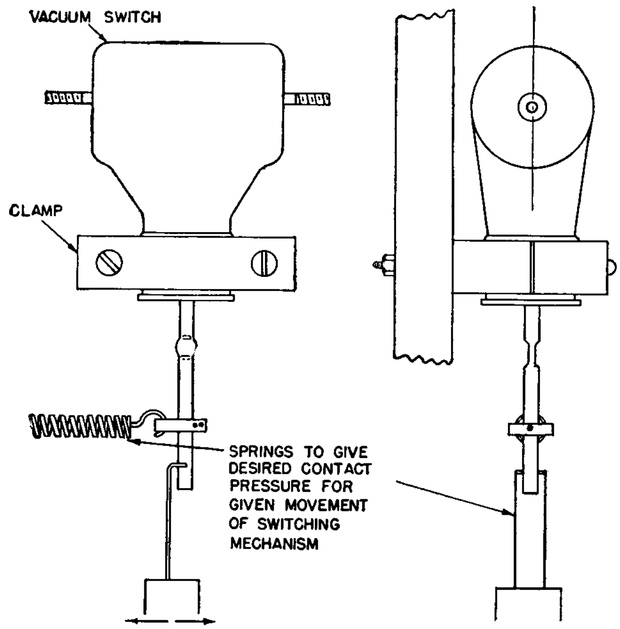

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Fig. 2

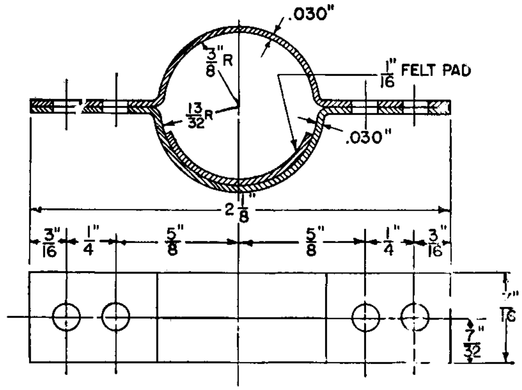

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Fig 3

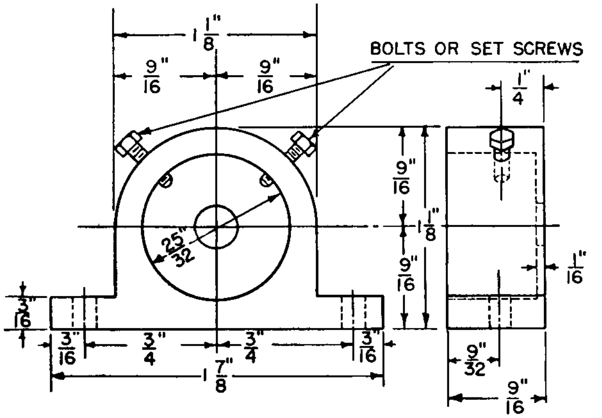

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Fig. 4

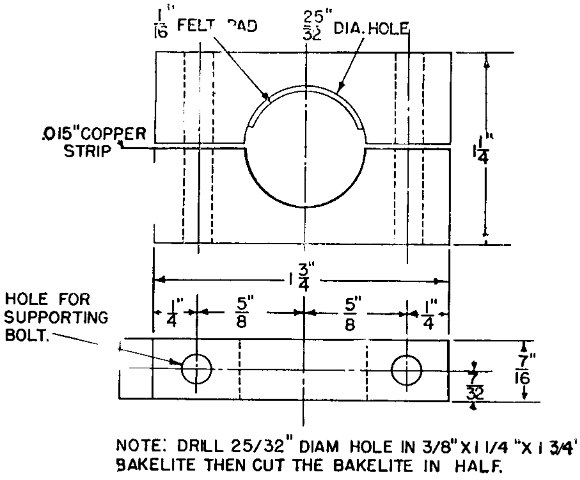

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Fig. 5

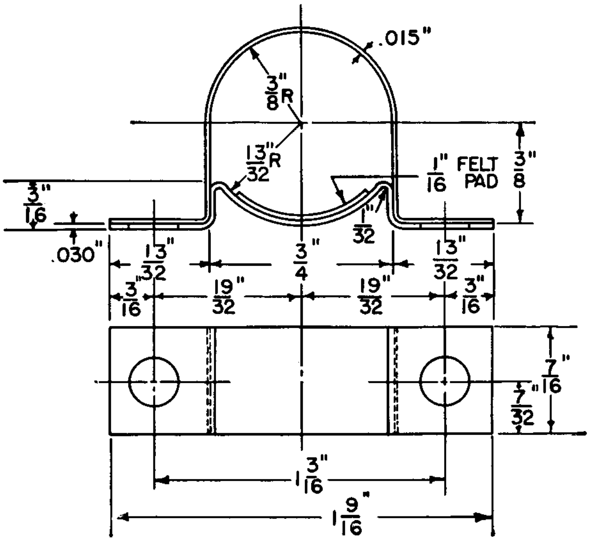

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Fig. 6

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