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TRANSMITTING MOTION THROUGH THE WALLS OF SEALED VESSELS

ARTHUR L. RICHE
Micro Switch, Freeport

Introduction

Transmitting of motion through the walls of sealed vessels is a frequent requirement in laboratories and on industrial equipment. Use of magnetic influence through vessel walls to produce motion inside avoids the problems of maintaining hermetic seal and has the advantage of producing zero effect on internal volume. This method, however, is of limited usefulness.

Practically the same result is accomplished with a glass enclosure in which an inwardly extending, bellows-like portion resiliently supports a glass rod (Fig. 1). The support is sufficiently flexible to permit lever-like motion of the rod, which motion closes and opens electrical contacts with repeatable precision; that is, make and break of contact always occurs at the same position of the glass rod. High vacuum affords desirable contact functioning.

Sealed Switches Required on Aircraft

Because of its fragility, this unit is unsuited to many uses, such as on aircraft. The requirement there is for ruggedness as well as dependability. Switches must be sealed to prevent formation of frost on contacts as planes rapidly descend into damp, sea-level atmosphere after long exposure to the low pressure and extreme cold of high altitude. Operation of unsealed contacts in a test chamber, where pressure changes simulate ascent to 100,000 feet of altitude, shows that under such conditions arcing time increases and the switch may fail to open circuit.

This problem was first met by use of pressurized gas in a truly hermetic enclosure, shown diagrammatically in Figure 2. Motion is transmitted by a C-shaped yoke supported at its closed end by a "Wobblefram". Force and motion transmitted by this yoke are substantially unaffected by rise or fall of the "Wobblefram" due to changes in ambient pressure. Also, internal volume is substantially unaffected by the limited oscillating motion of operation. Flexible connections between the glass-bead-supported electrical terminals and the external wiring connectors protect the glass beads from damage by stresses. This unit was originally designed to be interchangeable with previously unsealed units (Fig. 3, A).

Requirements of the aircraft industry for reduction in size and weight led to design of the unit shown in Figure 3, B. Here, mo-

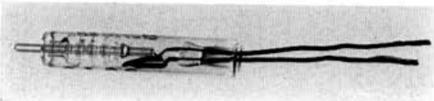

FIG. 1.—Glass-enclosed, evacuated, electric switch. Contacts moved by glass rod which pivots on bellows-like portion of envelope.

tion is transmitted to a subminiature snap-acting switch by a simple silicone diaphragm bonded between the reciprocating metal plunger and the aluminum housing. The small diameter of this diaphragm avoids serious effect on operating characteristics by altitude pressure changes. The thin aluminum shell is filled with epoxy resin which provides a satisfactory seal, combined with excellent electrical insulation. Electrical connections are brought out through flexible leads.

A New Sealing Method

These methods for sealing switch enclosures and transmitting limited, reciprocating motion solved only part of the altitude-switching problems, for spring - return operating mechanisms are also vulnerable to freezing but require greater motion than is afforded by diaphragms of any type. The need for transmitting unlimited rotary, as well as greater reciprocating, motion is met by a new method (Fig. 4). A silicone O-ring seals the stainless steel shaft through a stainless steel stem with a teflon scraper at the outer end of the stem to exclude dirt and to scrape ice from the shaft. This scraper is both self-lubricating and inert to oils, solvents, and other materials which might damage O-rings.

In Figure 4, the sealed stem is shown as solder-sealed to the housing of a plunger-actuated, double-pole, double-throw electric switch with terminals brought out through glass beads, fused between housing and electrodes. Silicone-insulated, lead wires are soldered to terminals. Insulation between the closely spaced joints and firm anchoring of the leads are provided by filling the terminal cap with epoxy resin. A return spring is built into the stem, and excursion of the plunger is limited to less than the distance between O-ring and teflon scraper. Thus, the perfection of seal between plunger and O-ring is protected against dust, damaging liquids, and mechanical roughening of the plunger surface.

Figure 5 shows the use of this type of seal on a relatively large piece of equipment. This unit is used in testing circuits prior to the release of guided missiles by the simultaneous operation of 72 electric switches. The seal must be such as to insure reliable functioning when exposed to the heat and sand of deserts, the cold and ice of the arctics, ocean spray, oils, or aromatic fuels.

Departure from the use of truly hermetic construction (fused joints

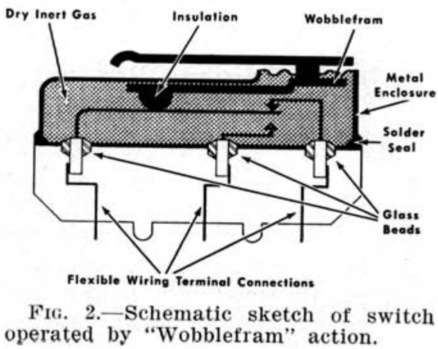

FIG. 2.—Schematic sketch of switch operated by "Wobblefram" action.

only) could be considered as acceptable only after the mass-spectrometer leak detector became available as a practical production tool. The method is first to pump the switch enclosure to a few hundredths of a micron of mercury pressure. When the pressure is down, a valve is moved which connects the mass spectrometer to the vacuum manifold. Helium is sprayed over the switch, and, if there is a leak large enough to fill a teaspoon with gas in 100 years, a howling sound gives warning and the instrument gives indication.

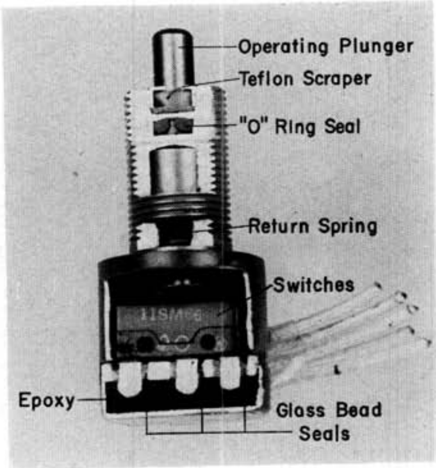

FIG. 4.—Cut-away section of sealed stem and double-pole, doublethrow, aircraft switch.

SEALS PASS SEVERE TESTS

Standardized seals of this type have been used on switches which have passed Military Standard tests. These tests include continuous operation during exposure to temperatures from +150° to —30° C. with shock change between those limits and with external pressures varying from 760 mm. to 100 microns. There are hours of exposure to a stream of sand and dust, and operation under a head of 36 inches of water, with rapid changes in temperature from +65° to +1° C. The non-wetting characteristic of teflon makes it possible for return springs to break instantly ⅛ inch of clear ice which has been held at —65° C. for 3 hours. No seal has ever developed a leak under any of these tests, as determined by the mass spectrometer.

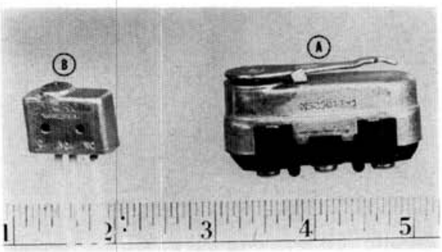

FIG. 3—*A*. Metal-jacketed, hermetically sealed, snap-acting switch. Operated by flexing "Wobblefram"; *B*. subminiature switch sealed within block of epoxy resin and operated through small-diameter diaphragm.

DESIGN IS SIMPLE — PRODUCTION REQUIREMENTS RIGID

Quantity production of seals which pass these tests is made possible by the simplicity of design. There is the further requirement, however, that materials and finishes be of the needed quality. The specially hardened, stainless steel shafts are polished to a permissible deviation from perfection no greater than six-millionths of an inch. O-rings are triply inspected for surface condition. Lubricant must not flow at 150° C. nor stiffen at —80° C.

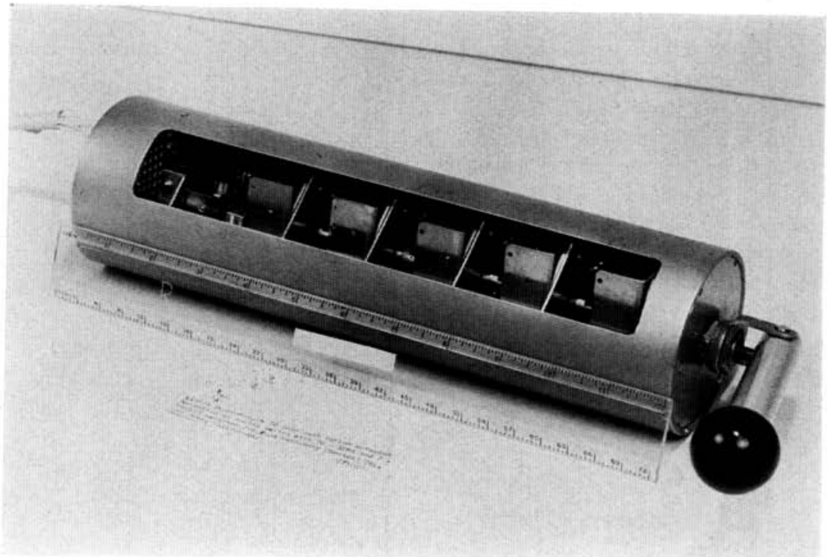

FIG. 5.—Sealed operating stem and cut-open housing for 70 subminiature and 2 heavy duty switches, simultaneously operated for testing of guided-missile, launching circuits.

By meeting these standards the seal between relatively moving surfaces is as perfect as if the surfaces were fused together.

SUMMARY

Simplicity of construction characterizes this new and widely useful method for transmitting unlimited rotary motion and substantial linear motion through the walls of vessels with the equivalent of hermetic sealing. Reliability of performance is accomplished by the use of suitably finished materials which are inert to ambient conditions. Lubricant must remain effective over the range of temperature exposure. Standardized sealed stems, which may include overtravel action and return springs, are readily attached to any desired enclosure and may also act as mounting means.