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A Note on the Development of Sensitive Pressure Operated Water Contacts for Use on Seaplanes

By

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MARINE AIRCRAFT EXPERIMENTAL ESTABLISHMENT

A NOTE ON THE DEVELOPMENT OF SENSITIVE PRESSURE OPERATED WATER CONTACTS FOR USE ON SEAPLANES

by

R. PARKER, B.Sc.

SUMMAQY

A pressure operated water contact has been developed, suitable for indicating the instants of take-off and touch-down for a seaplane hull.

Flight tests have shown that the instrument is accurate in operation and sufficiently robust for normal flight test use.

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1. INTRODUCTION

A means of indicating the instant of making and breaking contact between the hull of a flying boat and the water was required to assist pilots and flight observers, and to produce an indication on automatic observer records, etc.

Attempts had been made to use the electrical conducting properties of the water, but the principle was found to be unreliable.

This report deals with the development of indicators which make and. break an electrical circuit dependent on the external pressure on a diaphragm. An indication is given while the flying boat is planing on the water at speeds which give pressures greater than the operating pressure of the instrument. On a boat with large draft flotation pressures will be sufficient to give an 'on' indication also.

2. PRINCIPLE OF OPERATION (See Figure 1)

The instrument is mounted in a suitable ring secured to the skin of the planing bottom so that the spigot fits into a hole in the skin and comes flush with the cuter surface.

A flexible diaphragm is located in the end face of this, and is therefore deflected inwards by the external water pressure.

A push rod connects the centre of the diaphragm to a leaf spring mounted as a cantilever and carrying an electrical contact at the free end. A second leaf spring is mounted similarly near the first one and carries a second contact immediately over the first. The end of this spring rests against a screw which presses it towards the first spring and provides a means of adjusting the gap between the two contacts.

When the diaphragm is deflected by the water pressure, the first spring moves with it and the contacts approach each other. The pressure at which they touch depends on thestiffness of the diaphragm end first spring assembly and the contact gap (which is adjustable).

The leaf springs and contacts are insulated from all other parts and may be used to operate an indicator light, relay circuit or any suitable system.

3. INITIAL DESIGNS

The two original pressure contact designs (Figure 1) were intended to operate between 2 and 3 P.S.I. On tests these were found to have the following faults:-

(a) The gap between the contacts was extremely small and could not be set accurately to the required operating pressure. (The gap was too small to measure but was estimated at about 0.0005 in. or less).

(b) After a few applications of pressure, the operating value was found to have changed - generally to a lower value.

/Two

Two further Instruments were made to a modified design, which made provision for an adjustable lever arm on the moving spring (Figure 1).

On bench tests these were still difficult to adjust but 'the operating pressure did not vary so erratically due to loading, though it ass not constant.

The instruments were subjected to repeated applications of pressure of about 20 P.S.I. for 15,000 cycles of operation with the contacts operating a 24 volt, 3 watt lamp and a veeder counter (total current approximately 200 mA). The contacts continued to function, but afterwards the operating pressures were found to have changed from between 2 and 3 P.S.I. to about 0.5 P.S.I., with a considerable backlash between closing and opening pressures (the amount was not constant for more than a few minutes at a time). The gap between the contacts was still extremely small - considerably less than 0.001 in. when set to operate between 2 and 3 P.S.I.

These two instruments were carefully re-set and Installed in a Sunderland aircraft for trials, one at the main step and one at the rear step. One instrument ceased to function after five take-offs and landings, and the other after seventeen.

When the contacts failed, they remained in the closed position.

titer removal from the aircraft, the following facts were noted:-

(a) One instrument had begun to function again, but its operating pressure was extremely low and unreliable.

(b) In both instruments a small drop of moisture had collected between the contact points, though the rest of the inside appeared to be perfectly dry. When the moisture was removed, no improvement in operation could be detected.

4. DEVELOPMENT AND TESTS OF LATEST FORM OF INSTRUMENT (See Figure 2)

A series of experimental modifications and tests were made as follow,, the aim being to increase the contact movement, and therefore gap, for the predetermined operating pressure.

It was decided that a diaphragm less than 0.003 in. thick would be too liable to damage, while a flat one of that thickness was too stiff, owing to the tension forces.

A corrugated diaphragm was therefore spun from 0.0035 in. thick German silver sheet, with six circular corrugations approximately 1/32 in. deep in the radius of 1/2 in. This was mounted in a solid mounting ring similar to the flat diaphragm, but with the two halves of the ring secured togetnar with countersunk head screws and jointing compound Instead of soldering.

This diaphragm was found to be very flexible, compared with the original flat one, and was fitted in 3 complete unit.

When the push rod between the diaphragm and leaf spring was secured in place, the sensitivity was lower than expected but better than nith a flat diaphragm.

/It

It was noted that the push rod was being bent considerably during loading, in a manner which suggested that it was contributing to the apparent stiffness of the leaf spring by virtue of the rigid fixing between them.

The solid rod was then replaced by a tufnol rod with spherical ends which rest in conical seatings. One seating is in a bush soldered to the centre of the diaphragm, and one in a bush on the end of a screwed rod. fitting in a threaded bush on the leaf spring. By means of this thread and a lock nut the assembly is adjusted to give a small residual compressive load on the rod to prevent any slack or chatter occurring.

This greatly increased the sensitivity of the system and a movement of the order of 0.005 in. at the contact points was achieved for 2.5 P.S.I. applied pressure. Backlash between closing and opening was less than 0.1 P.S.I.

After the instrument had been subjected to test pressures of the order of 100 P.S.I., the operating pressure was found to have changed slightly, suggesting deformation of the corrugations. In the first assembly, the movement of the diaphragm was limited by a slightly conical face which allowed no movement at the outside edge and 0.010 in. at the centre. A new backing plate was then made which allowed the same range of movement, but had a corrugated face which fitted the corrugations of the diaphragm instead of making contact on only one line of each ridge.

When this was assembled and tested, repeated loading up to 100 P.S.I. had no significant effect on the operating pressure.

Too complete units were assembled as described above, and given rigorous bench tests with results as shown in Table I.

Small silica gel. containers were fitted inside the units to prevent moisture collecting and the covers secured down to give as water-tight an assembly as possible.

These two units were then fitted in a Sunderland aircraft and used for eighteen take-offs and landings, during which they functioned correctly. Eleven of these take-offs and landings were in rough hater conditions, when several impacts occurred on each run.

After removal from the aircraft, the operating pressures were checked and found to be unchanged and the units in good condition, except for the anti-corrosion plating on the diaphragm assembly.

Both units were then dismantled, cleaned and replated, and reassembled. The bench tests were repeated, with similar results to the previous one, and the instruments installed in a Solent aircraft. The instruments remained in position for 27 days, during which the aircraft was waterborne for 16 days. In this time, 21 take-offs and landings and 2 hours water handling tests were carried out, during which the water contacts functioned satisfactorily.

One instrument was damaged, due to the aircraft striking an underwater obstruction, the other was removed and found to be in good order with the operating pressure unchanged.

The final instrument is shoan in Figures 2, 3 and 4.

/5. DISCUSSION

5. DISCUSSION

The improved performance can be attributed to the increased movement of the whole mechanism which has made adjustment easier, the effects of minor amounts of slack or stickiness less and the operating point more definite.

This increased movement is due mainly to the double joint in the push rod, but the greeter flexibility of the diaphragm also contributes considerably.

The constancy of the operating pressure after application of very high overload pressures is due to the more flexible diaphragm and the correctly fitting backing plate which provides a stop while the diaphragm is well within the elastic limit of the material. It is probable that a thicker diaphragm could be used to give greater safety from accidental damage, without seriously impairing the performance, but this is not felt to be necessary.

Screwing the diaphragm assembly together instead of soldering has proved quite satisfactory, and reduced the difficulties always encountered when a thin diaphrsgm has to be considerably heated.

It will be noted (Table I) that, in both instruments, re-setting was required after an increase in operating pressure. This results from an increase in the contact gap, which is consistent with a bedding-in of the Joints in the push rod. This only occurs on the first prolonged loading of the instrument, and has not been found to occur a second time.

6. ACKNOWLEDGMENT

Acknowledgment is made to Mr Balls and Mr Pearce of the M.A.E.E. Light Engineering Section, who were responsible for developing the method of manufacturing the spun diaphragm and. the manufacture of the pivoted push rod to the briefest instructions.

TABLE I

Bench Tests of Two Instruments

Instrument No.1

contacts set at 2.65 P.S.I.

88 P.S.I. applied 20 times.	Contacts	operated	at	2.7	P.S.I.
94 down to 80 P.S.I. applied for 1 hour.	"	"	"	3	"
* contacts re-set to 2.6 P.S.I.					
94 down to 84 P.S.I. applied for ½ hour.	"	"	"	2.7	"
90 P.S.I. applied 20 times.					
94 down to 80 P.S.I. applied for 1 hour.	"	"	"	2.7	"
90 P.S.I. applied 20 times,	"	"	"	2.7	"
90 down to 80 P.S.I. applied for &hour.	"	"	"	2.75	"

Note: Instrument left on rig for ½ hour with no load applied, and contacts operated at 2.65 P.S.I.

Instrument left on rig overnight with no load applied, and following morning contacts operated at 2.6 P.S.I.

Instrument No.2

Contacts set at 2.6 P.S.I.

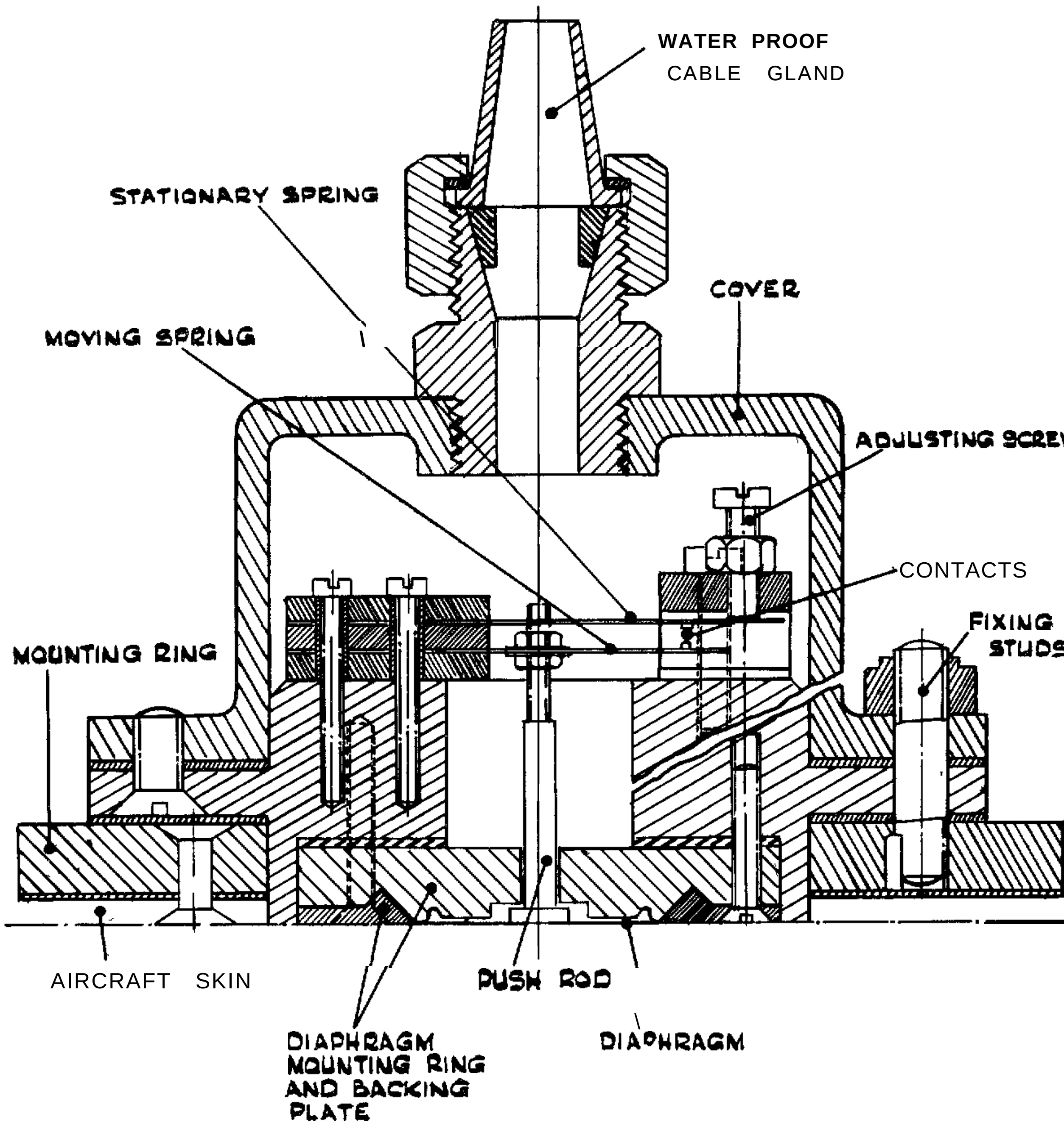
90 P.S.I. applied 20 times.	Contacts	operated	at	2.7	P.S.I.
92 down to 80 P.S.I. applied for 1¼ hours.	"	"	"	2.9	"
* Contacts re-set to 2.6 P.S.I.					
90 P.S.I. applied 20 times.	"	"	"	2.6	"
92 down to 85 P.S.I. applied for ½ hour.	"	"	"	2.65	"
90 P.S.I. applied 20 times.	"	"	"	2.75	"

Note: Instrument left on rig for ½ hour with no load applied, and contacts operated at 2.7 P.S.I.

Instrument left on rig overnight with no load applied, and following morning contacts operated at 2.5 P.S.I.

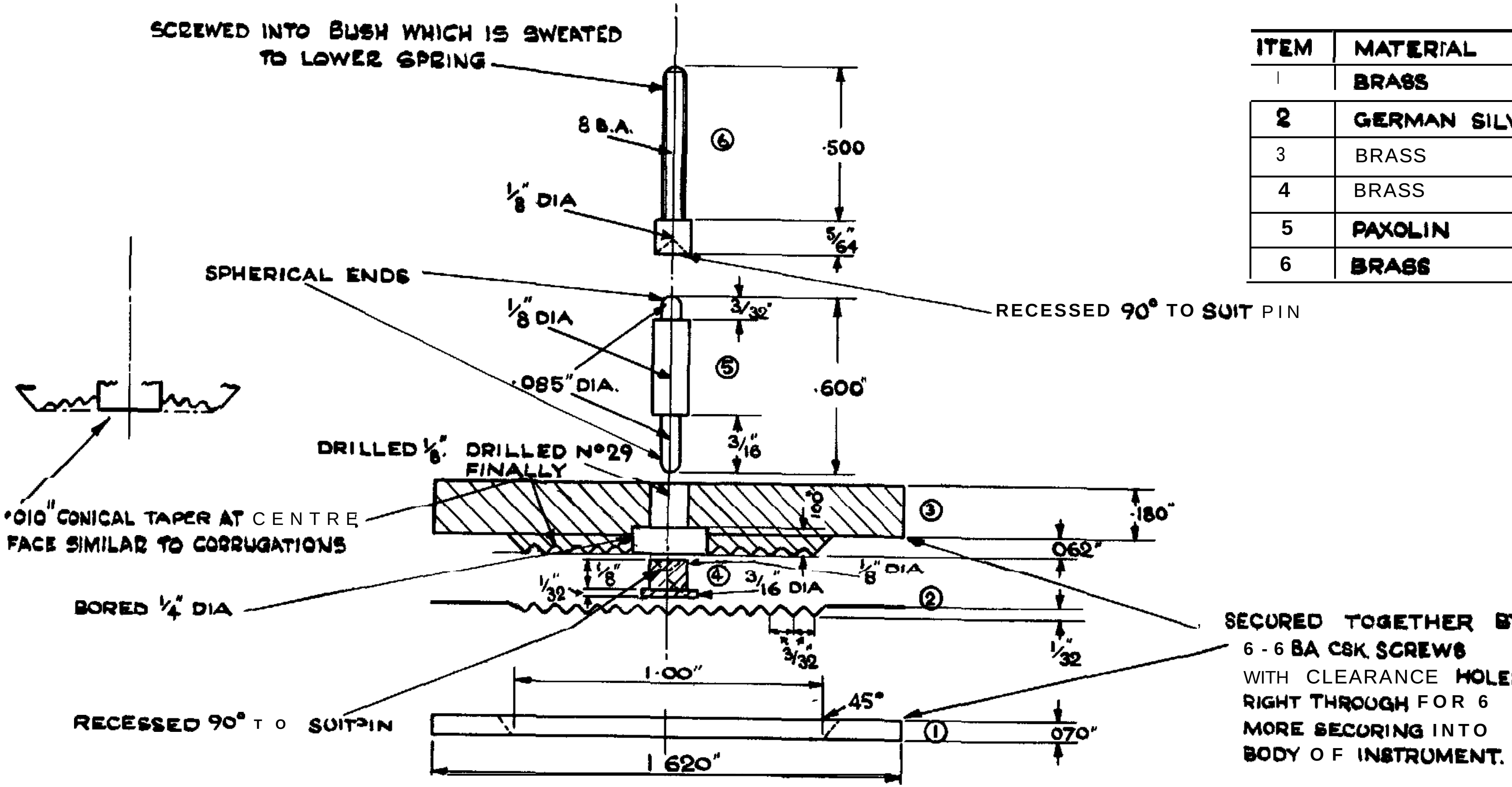
* Adjustments made.

FIG. 1



SECTION OF EARLY INSTRUMENT.

ITEM	MATERIAL
1	BRASS
2	GERMAN SILVER
3	BRASS
4	BRASS
5	PAXOLIN
6	BRASS



EXPLODED VIEW OF COMPONENTS MODIFIED IN DEVELOPMENT OF FINAL INSTRUMENT.

FIG. 2

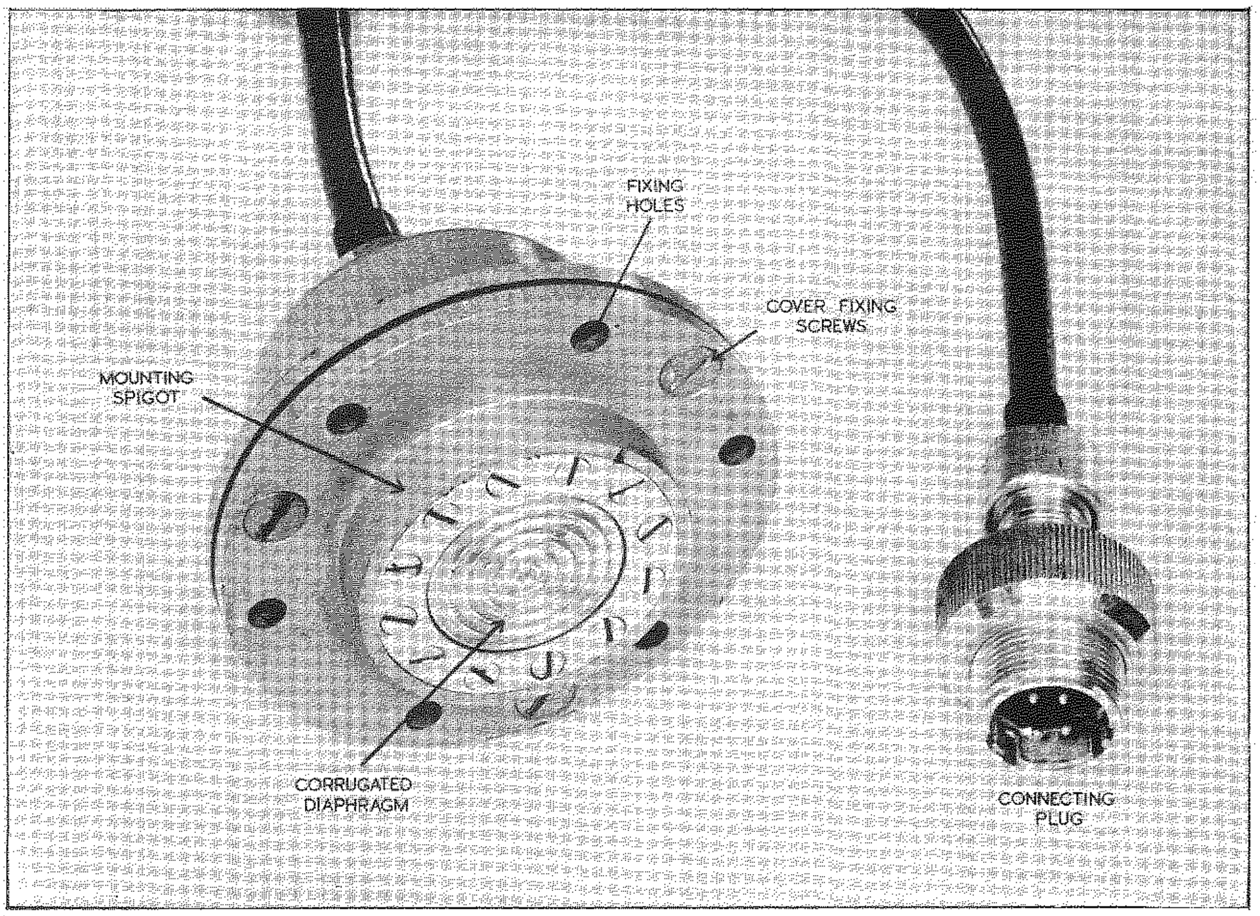


FIG. 3. COMPLETE WATER CONTACT, READY FOR INSTALLATION.

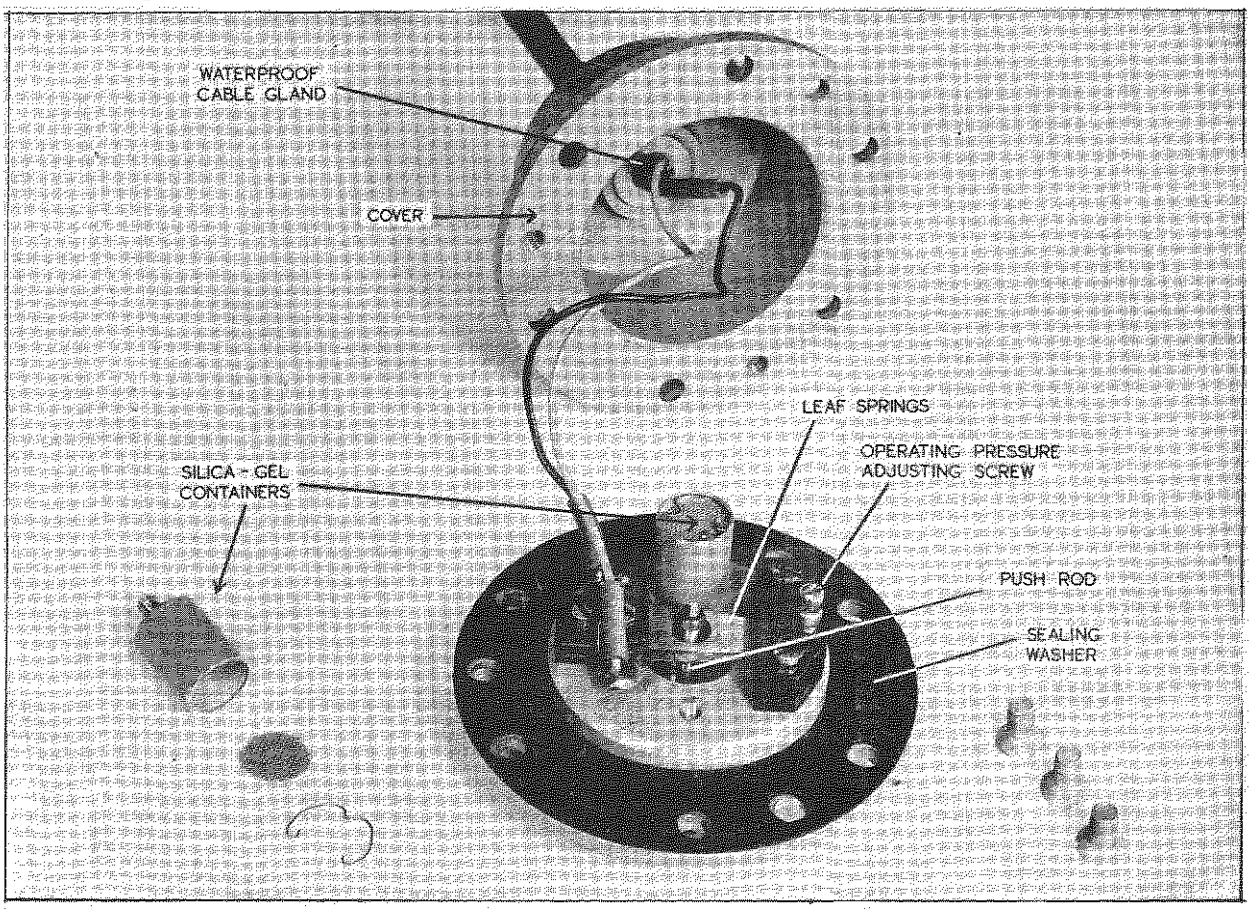


FIG. 4. INTERIOR OF WATER CONTACT. (ONE SILICA-GEL CONTAINER DISMANTLED.)

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