NEW DESIGN OF MULTIPLE-CABLE WATERTIGHT GLAND

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Introduction

The standard multiple-cable gland in naval service for electric cables penetrating ships' bulkheads and decks is the rubber-filled gland commonly known as the 'Goo' gland (FIG. 1). This gland was first introduced into H.M. ships late in the 1950's in H.M.S. *Tiger*. Since this period, dockyards have had the problem during ships' refits of changing and altering electrical cable installations involving 'Goo' glands with all the attendant difficulties associated with the latter. The rubber-filled gland has never been a popular gland to install as the filling of the gland with rubber solution can be a messy business. However, even more important, should subsequent alterations to cable runs affect these glands it is often simpler to burn out the welded-in gland and remove the cables rather than attempt to extract specific cables and replace them with others.

Development of a new design of multiple-cable gland to replace the 'Goo' gland has therefore long been a worthwhile target. The development of heat-shrinkable plastic materials over the last few years and the acceptance into service of the now well-established in-line jointing techniques for repairing ships' cables using heat-shrinkable sleeving led Devonport Dockyard in 1970

FIG. 1—TYPICAL RUBBER-FILLED MULTIWAY BULKHEAD GLAND

to consider using heat-shrinkable moulded products in a new concept for a multiple-cable gland. During the past two years, the Cable Section of the Ship Department has completed the development of the new gland.

Any new design of multiple-cable gland to replace the existing 'Goo' gland should as far as possible meet the following requirements:

(*a*) Occupy no more bulkhead space than the equivalent 'Goo' gland.

(*b*) Save weight.

(*c*) Lower total cost (including installation).

(*d*) Be hydrostatically pressure tight to 1 bar.

(*e*) Provide an effective fire barrier to the spread of fire.

(*f*) Incorporate flexibility in its design to facilitate cheap and easy cable alterations to be made in service.

(*g*) Withstand the normal environmental and durability tests for service use.

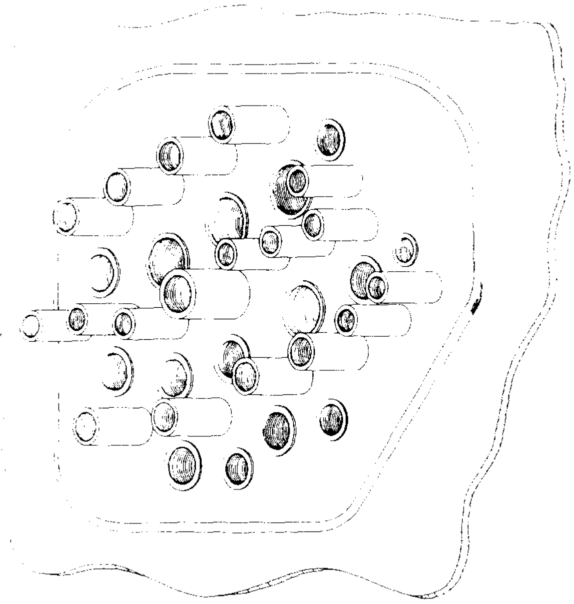


FIG. 2—VIEW OF ASSEMBLED GLAND PLATE

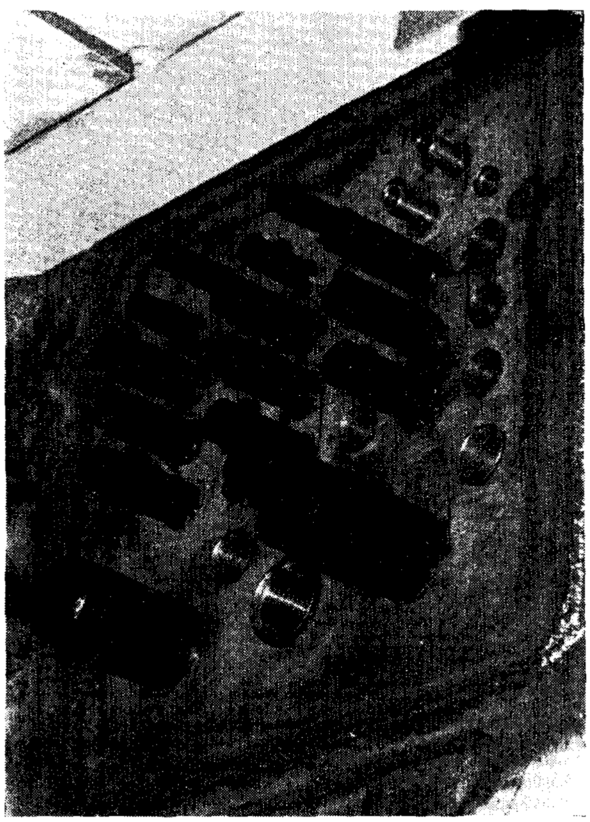


FIG. 3—GLAND PLATE INSTALLED WITH EXPANDED BOOTS FITTED

The Heat-Shrinkable Moulded-Boot Multiple-Cable Gland

Basic Concept

The assembly and installation of this gland comprises, in its simplest form, a steel gland-plate of any convenient shape into which the relevant number and sizes of gland tubes are fitted, adjacent tubes being fitted on opposite sides of the gland plate (FIG. 2). This fabricated assembly is then lap welded into the hole cut from the bulkhead or deck. Expanded, heat-shrinkable moulded boots of the correct size are slid over each of the tubes (FIG. 3) before the electric cables are reeved through the gland tubes and secured by the cable support system. The cable sheaths require only a superficial wipe in order to achieve a good bond with the adhesive coating on the inside of the boots.

The moulded parts are then successively shrunk down over the gland tubes and cables, using hot air from a suitable form of heat gun. Finally the fire barrier material is injected into the gland tubes around the cables using a hand-held injection gun.

The guidance information being provided to users of this new design of gland will incorporate sufficient flexibility to enable staffs to achieve the maximum density of cables for any particular location in a ship consistent with maintaining minimum strength requirements of the bulkhead.

Test Programme

A specimen of a fully-assembled gland has satisfactorily completed a series of tests which included the following:

(*a*) Hydrostatic pressure test to 1 bar.
(*b*) Shock test to Naval Shock Standard 2.
(*c*) Vibration test to SES 5 Test A.
(*d*) Low temperature test to −40°C.
(*e*) Fire barrier test.
(*f*) Temperature cycling test between 110° and 20°C.

As a matter of interest, the pressure required to destroy the moulded part/gland tube bond was found to be over 20 bars with the pressure applied from inside the tube!

FIG. 4—ARRANGEMENT OF FIRE BARRIER TEST

The fire barrier test was included in the test programme as a result of experience from a number of fires in ships. The standard accepted for the test was that the gland should present a barrier to penetration from a fire located on one side of the bulkhead and adjacent to it for a period of at least twenty minutes, based on the assumption that in most instances it would allow time for the discovery of the fire followed by implementation of measures to contain the fire. The fire test was carried out using a radiant heat source (surface temperature 900°C) placed at an angle of 45° to the gland plate such that the surface of the gland plate was between 4 inches and 14 inches away from the heat source (FIG. 4).

Gland Plate Assembly

Standard 6 mm plate is used for the gland plate to be welded to the bulkhead. Six sizes of standard solid-drawn steel conduit tube to BS 3602 cover the range of ships' cable sizes (FIG. 5). The tubes are cut to between 50 and 70 mm in length and a small shoulder is machined at one end to facilitate the swaging operation. Various methods of securing the tubes to the gland plate were investigated including welding, swaging, expanding and screwing; of these swaging proved to afford the best compromise between cheapness, ease of assembly, and density of penetrations (FIG. 6). No treatment of the surfaces of either the gland plate or tubes is necessary. In order to allow sufficient clearance to permit insertion of the fire barrier material, it was found necessary that there should be a minimum clearance of 6 mm between the outside diameter of the cable and the internal diameter of the gland tube.

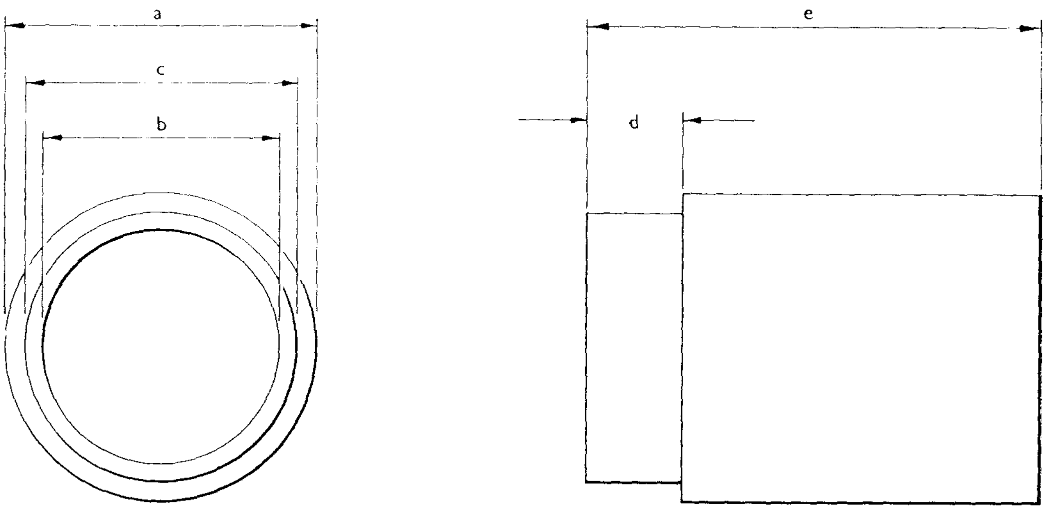


FIG. 5—GLAND TUBE SIZES—MILLIMETRES

		a	b	c	d	e	Material
Gland Letter Reference	Gland tube N.S.N.	Nom O/D	Nom I/D	Spigot Diameter	Spigot Length	Total Length	Steel pipe N.S.N. 4710-99-
A		21.3	14.9	18.2 $\pm$ 0.1	10	50	571-1648
B		26.9	19.7	23.2 $\pm$ 0.1	10	50	571-1652
C		33.7	25.7	29.7 $\pm$ 0.1	10	50	571-1656
D		42.4	36.0	39.2 $\pm$ 0.1	10	50	521-3267
E		48.3	41.9	45.2 $\pm$ 0.1	10	50	521-3268
F		60.3	53.1	56.7 $\pm$ 0.1	10	50	521-3269

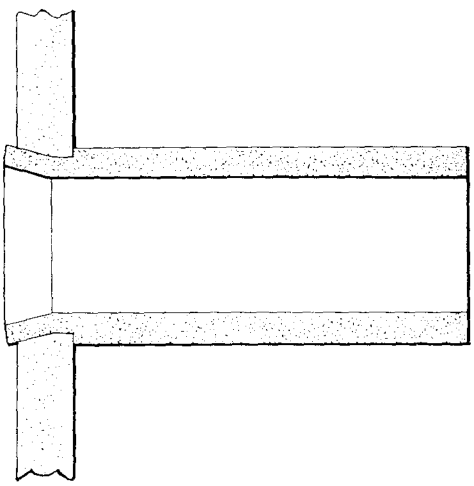


FIG. 6—GLAND TUBE SWAGED TO PLATE

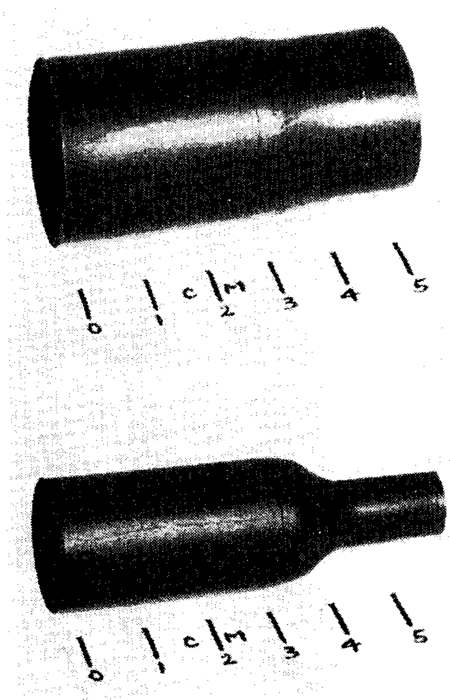
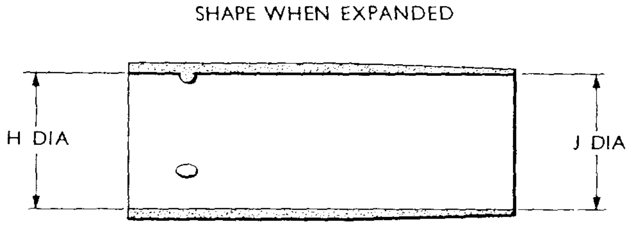
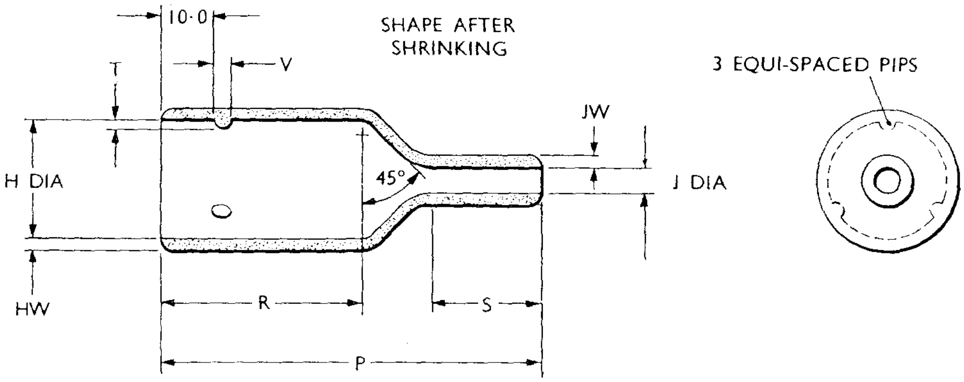


FIG. 7—THE COMMERCIAL HEAT-SHRINKABLE BOOT



H MIN	J MIN	
29	29	mm
1·14	1·14	in.



PROPOSED SPECIFICATION CONTROL DRAWING DIMENSIONS

PART NUMBER	H MAX	J MAX	P ± 10%	R ± 10%	S ± 10%	HW ± 20%	JW ± 20%	T	V	
	25	7·0	80	42	22	2·0	2·0	2·0	5·0	mm
	0·98	0·28	3·15	1·65	0·87	0·08	0·08	0·08	0·20	in

FIG. 8—MOULDED PART—NEW DESIGN

Heat-Shrinkable Moulded Boot

The moulded parts commercially available (the 'boots') were found to be unsatisfactory for a number of reasons but primarily did not provide an adequate length of boot to bond with the cable sheath (see FIG. 7). Although the shrink ratio of the polyolefin material is normally 3:1, the commercial sizes available were not compatible with ships' cables. A modified design of boot was therefore developed (FIG. 8) which overcomes this shortcoming and incorporates additional features such as three 'pimples' on the internal face to ensure adequate retention of the expanded boot on the gland tubes during the cable reeving operation.

Under normal conditions of storage, the boots have an indefinite shelf life. As an alternative to polyolefin, moulded parts made of a silicone-based material can be used in locations where the ambient temperature is likely to exceed 70°C, e.g. close to the deckheads of machinery spaces in steam-driven ships.

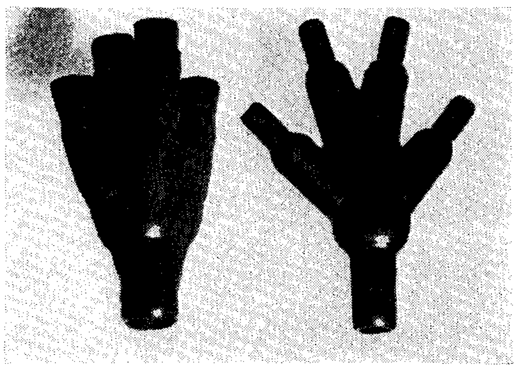


FIG. 9—HEAT-SHRINKABLE BOOT WITH MULTIPLE OUTLETS

Moulded Parts with Multiple Outlets

A number of parts with multiple outlets (FIG. 9) have been included within the range of boot sizes recommended for naval service. Normally either two or four outlets would be used but it is possible to obtain boots with up to nine outlets. Use of the multiple-outlet boot permits an increase in the cable penetration of any one gland without a corresponding increase in gland area. In addition to the normal moulded boots, blanking caps of the same material and in a variety of sizes can be used to seal spare ways designed into glands to allow for subsequent cable additions.

Repair of Moulded Parts

The success of the heat-shrinkable boot gland depends on the availability of a cheap and easy method of repair to make good any damage that may occur during installation or in service. Such a method exists by virtue of the split boot or split sleeve (FIG. 10). The latter comprises a specially designed moulded part incorporating a longitudinal split along its length. By wrapping the split part round the damaged part, securing the adjacent edges of the longitudinal split by means of a metal 'zipper' and then shrinking down in the normal way, an effective repair can be made which retains the watertight integrity of the gland. If a multiple-outlet boot has to be repaired, it is advisable to remove the damaged part first, wrap the individual cables with a few turns of rubber tape and then fit and shrink the split boot/sleeve over the whole.

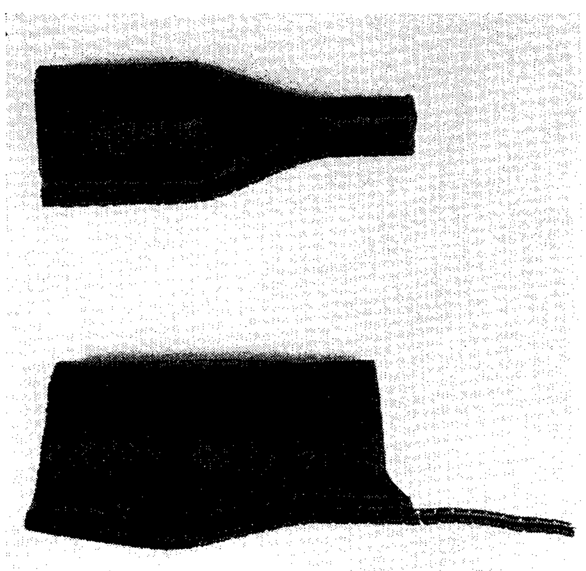


FIG. 10—THE SPLIT BOOT USED FOR REPAIR

All the moulded parts described are coated with hot-cure adhesive on the internal surfaces. This adhesive melts during the shrinking process and forms a watertight bond with the gland tube and cable sheath.

Screened Cables

A further possible development involves the use of heat-shrinkable moulded parts coated with metal on their internal surfaces. Applications where these items could be used cover situations where an effective bond is required between a collective screen of a cable and the bulkhead or deck being penetrated, e.g. in the latter case to achieve improved RF integrity of cable runs above the upper deck.

The installation technique would consist of placing two moulded boots over the gland tube before reeving the cable, one boot containing the metallic

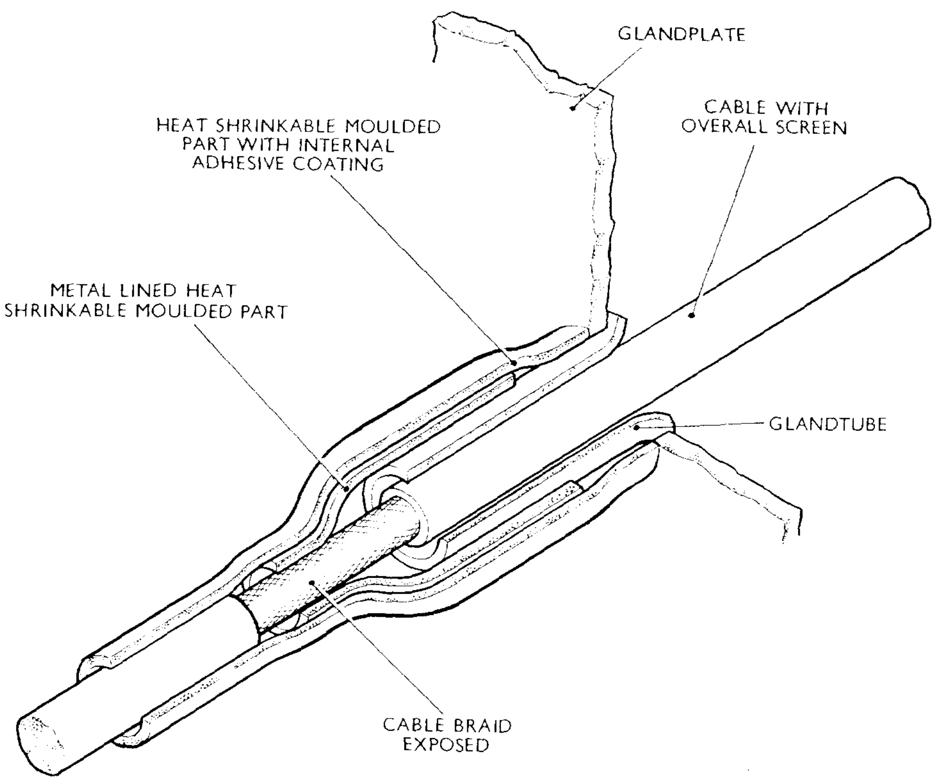


FIG. 11—INSTALLATION OF SCREENED CABLES

coating and a slightly longer boot containing the normal adhesive coating. After cleaning the gland tube surface and exposing the screen braid, the metal-coated boot would be shrunk over the tube and cable and subsequently the second and larger boot would be shrunk over the whole (FIG. 11).

Hot Air Guns

An improved design of hot-air gun has been developed to facilitate the shrinking of the moulded parts in confined spaces (FIG. 12). The design is based on the principle of splitting the conventional hot-air gun into two separate units comprising a blower unit and a heating unit. The two units are joined by a short length of flexible air hose. By this means the unit held in the hand becomes smaller and lighter and hence easier to use in confined spaces. The hand unit incorporates a spring-loaded safety switch. The blower unit is designed for attachment to the waist of the operator for convenience during use.

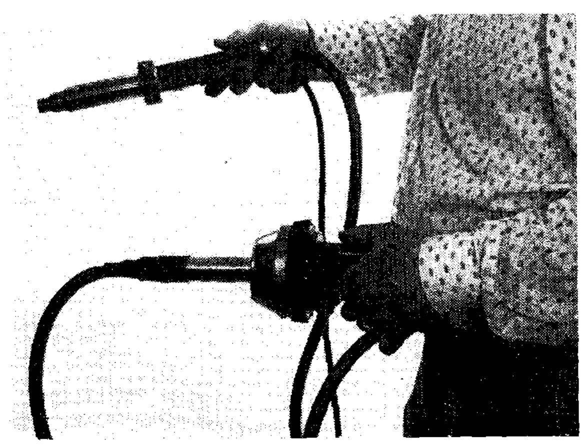


FIG. 12—THE MODIFIED HOT-AIR GUN

Advantages

The advantages of the new design of gland over the existing 'Goo' gland can be summarized as follows:

(*a*) Saving in weight (up to 50 per cent. over equivalent sized 'Goo' gland).
(*b*) Saving in overall cost (material, fabrication, and installation costs).
(*c*) Inherent flexibility of design facilitating alterations in service.
(*d*) Cheap and easy method of repair available.
(*e*) Cable sheath diameter variations are no problem.
(*f*) Can be any shape to make maximum use of the bulkhead space available.

Conclusions

As well as initial savings, the introduction into service of the heat-shrinkable moulded-boot gland should show savings in the longer term based on the assumption that alterations to cable runs can be carried out by removing only those cables no longer required and installing new cables without disturbing other cables in the same runs; considerable savings in cable costs and refitting costs should result.

A further area in which these principles can be applied is in connection with cable entries to equipments. This application could show even greater weight savings and cost benefits and this fact is at present being investigated within the Ship Department.

The techniques described in this article can also be adopted for pipe penetrations of bulkheads and decks.