

UNITED STATES PATENT OFFICE

2,471,046

SUBMARINE CABLE REPEATER

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Application January 21, 1947, Serial No. 723,334
In Great Britain December 9, 1946

1 Claim. (Cl. 174—70)

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This invention relates to submarine cables and more particularly to an improved construction of housing for a loading coil or repeater or other form of apparatus incorporated at intervals in the cable.

These units are enclosed in housings or hollow containers which may be built as units distinct from the cable but connected to it by short armoured insulated connectors, or which may be so shaped that they can be incorporated beneath the armouring of the cable, when they form a bulge of 2 or 3 times its diameter, extending along its length for a distance of, for example, 5 or 10 feet.

This invention has for its object a design of housing combining great flexibility and resistance to crushing so as to be capable of withstanding the considerable hydraulic pressure to which the cable is likely to be exposed on the ocean bed, while permitting moderate bending of the housing e. g. when the cable is being laid.

According to this invention the repeater unit or other loading device is contained within a housing which includes a metallic sheath built up of a series of annular elements, which nest one within the other, and are so constructed as to be capable of limited angular displacement in relation to one another so as to afford maximum flexibility coupled with mechanical strength.

In carrying out the invention the sheath may be constructed from a series of short tubes formed at their ends with ball and socket joints.

The invention is illustrated in the accompanying drawing in which Figs. 1 and 2 are sectional views showing two alternative forms of flexible housing for submarine cable repeaters in accordance with the invention.

Referring to the accompanying drawings, the core of the cable is indicated generally at A, B being the repeater unit to which the central conductor C of the cable is connected by a jointing member J. The housing as a whole is encased in armouring wires W overlying a layer of water-resistant material F which preferably consists of polythene or a mixture thereof with other substances.

At each end the housing is fitted with an entry gland G of conventional design, the opening to which may be tapered as indicated in Figure 1, and packed with insulating material M. Alter-

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natively, the opening may be cylindrical as indicated in Fig. 2. The insulating layer F encircling the repeater housing may be carried over the glands G or be completed by a separate body of dielectric material H, which may be welded to the main cable insulation.

The repeater housing of this invention is constructed in such a manner as to possess maximum flexibility, coupled with resistance to crushing, and is built up of a series of elements 1 which are annular in form and formed of steel or other suitable material. The elements 1 are so joined to one another as to permit of relative angular displacement, and preferably as shown are in the form of nesting cups, each incorporating a ball and socket joint as the interconnecting means. For this purpose, each element 1 may be formed with male and female surfaces 2 and 3 of spherical contour so that in their normal position their interior diameters present a cylindrical interior surface, enclosing a space 5 within which the repeater B is housed. The male surfaces 2 merge into a plane outer surface 7 of constant diameter so that, as shown, the flexible housing is substantially tubular over its entire length with a smooth outer surface.

Each annular element in effect consist of a thick-walled steel tube of sufficiently short length to permit flexing of the composite structure. In one particular case this length is 2 inches, the inner diameter of the tubes being 2 $\frac{3}{8}$ " and the outer diameter 3 $\frac{1}{2}$ ". Each tube is machined externally at one end to spherical or substantially spherical form, while at the other end it is machined internally to a complementary shape, so that succeeding tubular elements may co-operate with one another by means of ball and socket joints. The edges of the tubes, especially those of the inner bore, are preferably slightly radiused to eliminate sharp corners.

Various alternative forms of annular elements are possible. For example, instead of being machined from lengths of steel tube, they may be castings of any suitable metal, and may be reduced in length as compared with the example given above. As yet another alternative, the elements may be pressings, produced for example from sheet steel or other suitable metal, and finished off by machining as required.

The annular elements 1 may constitute the sole

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mechanical protection for the repeater, but usually it is preferred to provide means for supporting these elements either externally or internally. In the construction shown in Fig. 1 a number of light gauge reinforcing wires 15 are applied directly over the annular elements, and are anchored at each end of the housing by clamps 16 as indicated or by welding.

The outermost elements 11 are also finished off with plane ends 12, and are located by means of a circumferential shoulder formed on bushes 13, which screw into the end elements 11. The bushes 13, which are suitably apertured to allow for the passage of the earthing wires S, are themselves formed with a spigoted end 18 to fit a recess in the inner face of the glands G, to which the earthing wires are separately soldered; the outermost elements indicated at 11, being modified by the provision of an annular groove to seat the clamps 16.

The reinforcing wires may be helically applied, or may be in the form of a braid. A metallic sheath 17, for example of lead or copper, is then extruded or otherwise formed over the housing and tapered down to the contour of the glands G, where it is preferably anchored, e. g. by soldering; and over this is formed the water-resistant layer F. The latter may be composed of polythene mixed with material in powder form to render it conductive so as to provide ground contact for the repeater earthing wires. Alternatively, ground contact may be obtained in the manner disclosed in co-pending United States Patent application, Serial No. 682,262, filed July 9, 1946, of John Norman Dean and Esmond Wassell Smith, now Patent No. 2,465,069, March 22, 1949.

In assembling this construction, the annular elements are threaded onto a suitable temporary support and the reinforcing or supporting wires 15 applied and anchored. The temporary support is then removed, the repeater units are inserted, the earthing wires S are led out and the glands and other end parts fitted. The lead or other metallic sheath 17, is then applied and its ends shaped to the contour of the glands and preferably soldered thereto, after which the water-resistant layer F is applied, the repeater units are connected to the cable conductors and the water-resistant layer is welded to the cable dielectric with the interposition of the dielectric H.

In the process of the normal cable armouring operation the serving and cable armour wires are then carried over the entire length of the

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housing, being increased in number if necessary in order to form a closed sheath around it.

Referring now to Fig. 2, there is illustrated a construction in which an internal support is provided for the annular elements 1. In the example shown, this support consists of a length of flexible metallic tubing 10 such as described in the aforesaid co-pending application 682,262, within which the repeater units are housed and over which the annular elements are slid to build up the pressure-resistant housing. In this case the bushes 13 screw into the ends of the flexible tubing. Metallic sheath, plastic sheath and external armouring are then applied as described above.

It will be appreciated that the annular elements are free to take up small angular displacements in respect to each other, so that they may fit the curvature of the whole structure when it is bent. They are, however, prevented from being separated one from another by the longitudinal strength of the closed cage formed by the armouring wires.

What we claim is:

In a submarine cable, the combination with a core including a central conductor; of a repeater housing comprising an entry gland at each end thereof for locating said central conductor; a series of annular elements which nest one within the other to form a metallic sheath and which form with each other, ball and socket joints so as to be capable of limited relative angular displacement while contiguous elements of said series are maintained continuously in annular surface contact to thereby provide a constantly uninterrupted housing irrespective of their angularly displaced condition, and means for centering the end elements of said series in relation to the glands.

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