Sept. 1, 1964 D. O. McCALL 3,146,510

MOLD FOR CASTING ELONGATED HOLLOW OBJECTS

Filed Feb. 26, 1962 2 Sheets-Sheet 1

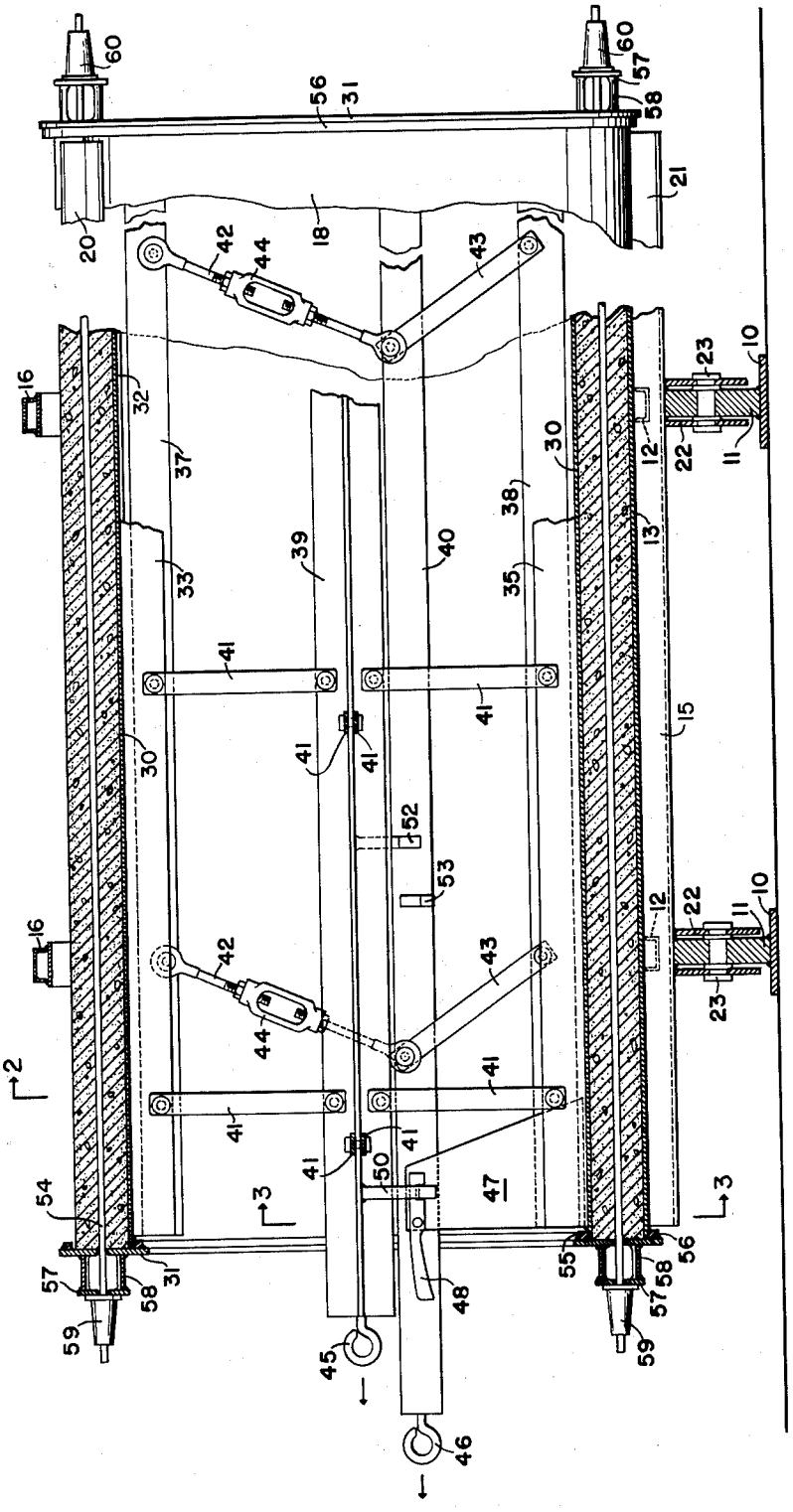


FIG. 1

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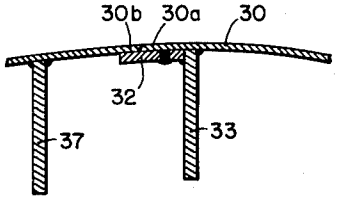


FIG. 4

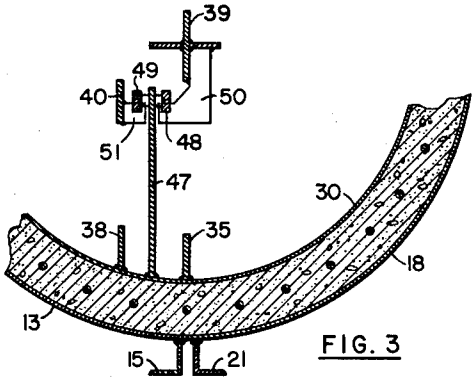


FIG. 3

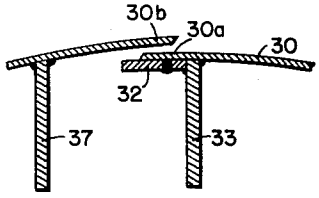


FIG. 5

FIG. 2

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3,146,510

MOLD FOR CASTING ELONGATED HOLLOW OBJECTS

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The invention relates to molds for casting elongated hollow concrete objects, such as tubular hollow piles or concrete pipe which may, if desired, be reinforced by longitudinal and/or circumferential or spiral metal bars embedded in the concrete. Such longitudinal bars, when provided, may be pre-stressed to place the hardened concrete into compressive stress.

It is known to cast such concrete objects in molds which comprise an outer mold having an interior molding surface and a core having an exterior molding surface and positioned to leave an intervening radial space between the molding surfaces for containing concrete and, when employed, longitudinal metal reinforcing bars. The said space may have any desired shape, for example, annular in cross section.

Difficulties have been encountered in the use of known designs of such molds for casting large objects, especially those of considerable length. Such castings may, for example, have diameters of two to eight feet, lengths of 50 to 150 feet, and wall thicknesses of three to ten inches. Among these difficulties are the removal of the hardened concrete objects from the outer mold due to the weight thereof; the difficulty of maintaining such a long core centered or otherwise positioned within the outer mold despite the long span between its ends, in opposition to its weight and tendency to float in the wet concrete; the difficulty of removing the core from the hardened concrete without recourse to a taper, which becomes impracticable when such great lengths are involved and, therefore, dictates the use of a contractible core; and the difficulty of insuring a liquid-tight seal along the length of the seam between the juxtaposed edges of a sheet of metal used to form a contractible core.

Further, prior designs have required strong and rigid constructions of the mold base structure for anchoring the ends of the metal reinforcing bars when the cast object is to be pre-stressed. This has been inconvenient when lengthy and/or large structures are cast. It may be noted that the total tension of the several metal bars is often several hundred thousand to a million or more pounds.

Moreover, prior core constructions employing resilient steel plates in sheet form, curved to cylindrical shape to form a shell and having a plurality of radial links pivotally connected to the shell interior and an axially movable rod for contracting and expanding the shell, have lacked the ability of achieving a liquid-tight seal between the juxtaposed marginal portions of the plates at the longitudinal seam, resulting in seepage of water carrying cement. Such seepage leads to rough deposits on the plates, which further aggravate seepage.

It is the general object of this invention to provide an improved mold for the casting of elongated, hollow concrete objects, such as piles and pipe.

A further object is to provide a contractible core suitable for use within outer molds having an improved seal between the marginal portions of the core shell along the longitudinal seam thereof. An ancillary object is to provide a stiff longitudinal sealing plate along the said seam in lieu of reliance upon a mere engagement between marginal strips of the metal plate which forms the shell, for achieving a more effective seal. Another ancillary

object is to provide mechanism for moving the relatively overlapping and underlapping marginal portions of the core shell into sealing engagement and for disengaging said portions from each other to facilitate contracting the shell, regardless of whether the said portions are integral parts of the metal sheet which constitutes the core shell or one of them is constituted by the aforementioned sealing plate.

Still another object is to provide an improved mold of the character indicated which does not require a base of sufficient strength to resist the pull of the reinforcing bars when they are tensioned to provide a pre-stressed concrete structure, but wherein the bar stress is carried by the mold itself, viz., by the outer mold and the core.

Still another object is to provide an improved mold suitable for casting heavy objects wherein the hardened object can be removed from the mold by a substantially horizontal or rolling movement, thereby obviating the need to employ hoisting equipment and permitting removal of said objects at an earlier time in the hardening period.

Additional objects will become apparent from the following description.

In summary, the contractible core used in the mold according to the invention is formed of a cylindrical shell having respectively overlapping and underlapping marginal parts and has two separate mechanisms for expanding and contracting the shell, one acting on the parts of the shell which includes the underlapping part and the other acting on the overlapping part, said mechanisms being separately operable, e.g., sequentially and, in part, in unison, so that, while the shell is being contracted to permit its withdrawal from a cast object, the underlapping part is initially pulled radially inwards with respect to the overlapping part and thereafter all parts are contracted. The said mechanisms are arranged so that, when the core is being expanded prior to use in a casting operation, all parts are first expanded radially and, finally, the overlapping part is pulled radially inwards against the underlapping part to effect a seal.

The composite mold according to the invention comprises an outer mold and a contractible core, e.g., of the type described in the preceding paragraph, said outer mold and core being of substantially equal lengths, and end closure plates detachably secured to the ends of the outer mold and core, said plates having a plurality of holes for receiving the terminal portions of metal reinforcing bars which are secured in tension to the plates to force the latter into sealing engagement with the mold and core ends. The said plates bear against the outer mold and core, whereby the latter two are placed in axial compression and carry the force due to tensioning of the bars. Any suitable means, e.g., nuts, may be used to secure the bars. However, according to a preferred embodiment, the said closure plates carry auxiliary abutment plates spaced outwardly from the closure plates and having holes for the bars, the outer faces of the abutment plates being adapted for engagement by clamping elements attached to the reinforcing bars after the latter are tensioned, and the interval between the closure plates and the abutment plates providing access to the bars for severing them, e.g., by a flame torch, after the concrete has hardened sufficiently to be bonded to the bars, to permit removal of the closure plates.

The invention further provides an outer mold which comprises a fixed side wall mounted on a base and a hinged side wall which is pivoted on a longitudinal axis and is movable bodily to a level wholly below the lowest part of the molding surface of the fixed wall, whereby the hardened concrete object can be removed horizontally,

as by rolling it on supports emplaced over the lowered hinged wall.

Additional features will be described in the following detailed description, taken in connection with the drawings which form a part of this specification and show one preferred embodiment, wherein:

FIGURE 1 is a longitudinal sectional view of the composite mold containing a concrete object, taken on the line 1—1 of FIGURE 2;

FIGURE 2 is a transverse sectional view taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a fragmentary transverse sectional view of the lower part of the core, taken on the line 3—3 of FIGURE 1; and

FIGURES 4 and 5 are fragmentary transverse sectional views of the upper part of the core, drawn on an enlarged scale and showing, respectively, the core in operative, expanded and in partly contracted conditions.

Referring to the drawings in detail, the mold is mounted on footings **10** which carry vertical, parallel buttress plates **11** having flanges **11***a* and mounted at suitable intervals, such as five feet. Each plate is welded to a circumferential rib **12** which extends on the outer side of a fixed side wall **13** of the outer mold. The ribs may, for example, be curved channels. Longitudinal structural angles **14** and **15** are welded to the outside of the wall **13** and to the ribs to afford rigidity and transmit compressive stress between the ends of the mold. The angle **14** has notches outwardly from each rib to receive tie members **16**, to be described. Each rib carries at the top a pair of cheek plates **17** which project radially outward, are longitudinally spaced, and have aligned holes.

The outer mold further includes a hinged side wall **18** which is similarly reinforced by a series of ribs **19**, each situated in a transverse plane which contains a corresponding rib **12**. The hinged wall is also reinforced by a pair of longitudinal structural angles **20** and **21** of which the former is notched at intervals as described for the angle **14**. Vertical hinge plates **22**, arranged in pairs, are welded to the sides of the ribs **19** and have pivotal mountings on hinge pins **23** which are carried by the buttress plates **11** at a longitudinal hinge axis situated below the side walls. Each rib **19** carries at the top a pair of cheek plates **24** which project radially outward in alignment with the plates **17**, each plate **24** having a pair of holes for receiving locking pins, to be described. The outer mold walls **13** and **18** provide lower, lateral and upper interior molding surfaces but the last of these is, in this embodiment, discontinuous; thus, the side walls are spaced apart at the top to provide an intervening opening for the introduction of wet concrete. It is evident that the configuration of the mold walls can be as desired and that the invention is not restricted to the cylindrical shape with substantially circular cross section adopted in the illustrated embodiment.

The hinged side wall **18** can be swung outward and down to lie wholly below the lowermost level of the aforesaid molding surface. The bases **10** have the terminal portions shaped to permit downward movement of the hinge plates **22**, as is shown at **10***a*. When in its upper, closed position shown, the wall **18** is locked by a plurality of the aforementioned tie members **16**, each spanning the interval between the upper ends of a pair of ribs **12** and **19**. The tie members **16** are preferably arcuate, as shown, on a radius conforming to the exterior surfaces of the said ribs and of length to overlie the ends of the ribs; they may have box-shaped cross sections as appears in FIGURE 1. Each said tie member is mounted between pairs of cheek plates **17** at one end and **24** at the other, being pivotally connected to the former by a longitudinal hinge pin **25**. The end of the tie member at this hinge is rounded, so that the member can be swung counterclockwise (as viewed in FIGURE 2). Each tie member is secured to the cheek plates **24** by a pair of removable locking pins **26** and **27**, two such pins being preferably provided to promote rigidity in the closed structure. It is evident that the tie members are spaced above the cylindrical continuation of the upper interior molding surface and provide access for hand-trowelling.

The longitudinal ends of the side walls **13** and **18** are situated in transverse planes to form end abutment faces. These walls carry, at suitable longitudinal intervals, radial positioning pins **28**, preferably having a slight inward taper and blunt ends and provided with means for affording precise radial positioning, e.g. carrying a flange which engages an internally threaded bushing **29** welded to the side wall. These pins are threaded and are inserted from the outside when assembling the composite mold to center an inner contractible core **30**, and are located both in the lower half of the mold to support the weight of the core and in the upper half to prevent flotation of the core after pouring concrete. Although the ends of the core **30** are secured in fixed relation to the outer mold by rigid end plates **31**, to be described, such pins are desirable to minimize deflections of the core and consequent variations in the wall thickness of the cast object because of the long span of the core.

The contractible core **30** is a shell formed of a sheet of steel or other suitable metal preferably having some resiliency. It has a length equal to that of the outer mold walls **13** and **18** and ends are situated in transverse planes to provide end abutment faces. The core may have any desired cross section, e.g., circular as shown and may be substantially uniform in cross section throughout its length. The longitudinal edges are not permanently fixed but are in abutment to form a longitudinal seam. These edges may be beveled, as shown, or square. To effect a seal at the seam the marginal parts of the shell are formed to provide mutually overlapping and underlapping elements. To this end an underlapping, rigid sealing plate **32** is permanently fixed, as by welding, to the underside of the marginal strip **30***a* of the metal sheet. The outer face of this plate may be curved to conform to the shape of the inner surface of the shell when expanded. The plate **32** extends circumferentially beyond the abutting edges and is in sealing engagement with the underside of the marginal strip **30***b* due to pressure, as will appear.

The interior of the core carries, welded thereto, a plurality, e.g., six longitudinal anchoring ribs **33**, **34**, **35**, **36**, **37** and **38** which serve to stiffen the core and provide pivot anchors. It will be noted that these ribs are positioned in pairs, the first four being spaced circumferentially about 90° apart and the last two being slightly to one side of a vertical diametric plane. Further, it should be noted that the rib **33** is secured near the marginal strip **30***a* and rib **37** near the marginal strip **30***b*, which is the overlapping part of the shell at the seam.

The core contains a pair of axially disposed and axially movable actuating rods **39** and **40**. The former may be formed with a cross-shaped section to provide plates directed respectively toward the first four longitudinal ribs and is preferably situated at the central core axis. It is connected to the ribs **33–36** by radial links **41** which have pivotal connections at their ends on pivot axes which extend circumferentially with respect to the shell. The links are distributed longitudinally, e.g., one every three to ten feet along each said rib, and may be grouped. It is desirable to mount at least a pair of links extending in opposite directions at each transverse plane of attachment to transmit compressive stress diametrically. The lengths of the links are advantageously such that they extend radially, as is shown in FIGURE 1, when the core is fully expanded. Links **42** and **43** have pivotal connections between the rod **40** and the rib **37** or **38**, respectively, and are of lengths to be slightly inclined, as also appears in FIGURE 1, when the core is in operative condition. The latter links are substantially radial although slightly inclined and eccentric from the central axis, and are dis-

tributed along the length of the rod 40 and preferably arranged in pairs. If desired, the links of both rods may have turnbuckles, shown at 44 only for the links 42, to permit precise adjustment of their lengths.

The ends of the actuating rods 39 and 40 are provided with means, such as eye-fittings 45 and 46, for attaching a pulling device, such as cables. Moreover, a mechanism of any suitable type is provided for maintaining these rods in correct positions along the core axis. Such mechanism is represented by a radial anchor plate 47 carried by the core shell at one end and having a longitudinal connection thereto so as not to hinder its flexing action, and carrying a pair of pivotally mounted latches 48 and 49. These latches engage bracket plates 50 and 51, respectively, which are fixed to the rods 39 and 40, respectively. These latches secure the actuating rods against axial movement with respect to the core. It is evident that this latching arrangement is in no way restrictive of the invention.

The actuating rods are optionally provided with a lost-motion connection which causes the rod 40 to be moved axially by the rod 39 after a limited motion of the latter rod alone. This connection may include a pair of brackets 52 and 53 which are fixed to the rods 39 and 40, respectively, and are positioned for engagement but displaced axially out of engagement when the rods are in the latched positions shown.

The core is contracted from the expanded condition shown as follows, it being assumed that it is surrounded by hardened concrete: The latch 48 is released and a cable is attached to the eye 45 and pulled by a winch to shift the rod 39 to the left as viewed in FIGURE 1. This tilts the links 41 and contracts parts of the shell, especially the underlapping marginal part constituted by the strip 30*a* and the sealing plate 32; however, the overlapping part, constituted by the strip 30*b*, remains radially extended by the links 42, 43, whereby there is a radial separation between the underlapping and overlapping parts, as is shown in FIGURE 5. The latch 49 is then released and the cable is pulled farther, bringing the bracket 52 into engagement with the bracket 53 and causing the rod 40 to move axially in unison with the rod 39. This further tilts the links 42 and 43 as well as the links 41 and contracts all parts of the shell. In this action the shell flexes and the overlapping strip 30*b* slides over the strip 30*a*, resulting in the radial separation of the shell from the concrete. Continued pull on the cable slides the contracted core out of the hardened concrete object.

The core is expanded to place it into operative condition while outside of the outer mold or while the hinged side wall thereof is open. This operation involves the following steps: First both rods 39 and 40 are moved axially toward the right (as viewed in FIGURE 1), e.g., by pulling on the end of the rod 40, which transmits motion to the rod 39 through the engaged brackets 52 and 53. The rod 39 is then secured by its latch 48 to maintain the links 41 in fully extended positions. At this stage the rod 40 is farther to the right than appears in FIGURE 1 and the links 42 and 43 are radial or more nearly radial than shown. The rod 40 is then pulled toward the left by applying tension to the eye 45 to contract the overlapping part 30*b* and press it into sealing engagement with the rigid sealing plate 32. The rod 40 is then secured by its latch 49. The core is then ready for use.

The ends of the composite mold are closed by the annular end closure plates 31, previously mentioned, which are in sealing engagement with the end abutment faces of the outer mold walls and the core. Each end plate has a plurality of holes situated in the annular part spanning the radial interval between the core and the outer mold walls and longitudinal metal reinforcing bars 54 are extended between the plates through these holes. The end plates have concentric aligning collars 55 and 56 for positioning them in relation to the outer mold and core. According to a preferred arrangement for securing the reinforcing bars, each end plate carries abutment plates 57 which are mounted on spacer boxes 58 having lateral openings. The abutment plates, thus spaced outwardly from the end plates 31, have holes aligned with those in the end plates for receiving the terminal parts of the reinforcing bars.

When attaching the bars, a suitable clamp 59 is attached to one end of each bar and a slidable clamp 60 is slid about the projecting other end. The latter clamps may include wedges for gripping the bars against motion in one direction but permitting sliding motion in the other. Such clamps are well known. A hydraulic jack is then connected to the protruding tip of each bar and the bar is tensioned to a desired pull, such as five to thirty thousand pounds. The clamp 60 is then forced into firm abutting relation to the abutment plate 57. In this manner the end plates 31 are pressed firmly against the end abutment faces of the outer mold walls and the core which carry the total stress due to the bars. The stiffening ribs and angles previously described aid in transmitting the stress and prevent buckling.

In use, after the composite mold has been assembled as was described above, wet concrete is poured into the annular space surrounding the core 30 through the top opening between the upper ends of the side walls 13 and 18 and the mold is vibrated by applying a vibrating tool, to eliminate voids. The top part of the poured concrete is then hand-trowelled to a finished surface; however, the invention is not restricted to this technique and it is possible to apply a top closure, as is known in other prior art molds.

When the concrete has hardened sufficiently to form a bond to the reinforcing bars 54, these are severed between the end plates 31 and the abutment plates 57, e.g., by applying a torch through the openings in the spacer boxes 58. The end closure plates 31 are then removed, and the core 30 is contracted and pulled out of the hardened concrete object in the manner previously described.

To remove the casting from the outer mold the positioning pins 28 are removed by unscrewing them, the locking pins 26 and 27 are withdrawn to release the tie members 16, and the latter are swung upwardly about their hinge pins 25. The hinged side wall 18 is then swung outwardly and down about its hinge pins 23 and a plurality of horizontal supports (not shown) are emplaced over the lowered side wall to permit the casting to be rolled out of the mold.

I claim as my invention:

1. A contractible tubular core which comprises:

(*a*) an outer cylindrical shell having a longitudinal seam formed by respectively overlapping and underlapping circumferentially extended marginal parts of the shell,

(*b*) first means including an actuating rod disposed axially within the shell and a first plurality of links distributed longitudinally and pivotally connected to said rod and shell for contracting and expanding said shell including only said underlapping part thereof but excluding said overlapping part thereof by movement of said rod, and

(*c*) second means operable independently of said first means for contracting said overlapping part both after contraction and after expansion of said underlapping part and for expanding said overlapping part, said second means comprising a second plurality of links pivotally connected to the shell near said overlapping marginal part and mounted in pushing and pulling relation to a part of the shell which is substantially opposite to said overlapping part.

2. A core as defined in claim 1 wherein said shell is formed of resilient sheet metal having longitudinal edges which are in abutment at said seam when the shell is

expanded, said marginal underlapping part of the shell being a stiff sealing plate permanently secured to the marginal strip of the sheet adjoining one of said edges on the inner side thereof and extending circumferentially beyond said edge and being in sealing engagement with the inner side of the strip adjoining the other edge of the sheet, the last-mentioned strip constituting the said overlapping part.

3. A contractible tubular core which comprises:

(*a*) an outer cylindrical shell having a longitudinal seam formed by respectively overlapping and underlapping circumferentially extended marginal parts of the shell,

(*b*) first means including a first actuating rod disposed axially within the shell and a first plurality of links distributed longitudinally and pivotally connected to said rod and shell including only said underlapping part thereof but excluding said overlapping part thereof by movement of said rod, and

(*c*) second means comprising a second actuating rod disposed axially within the shell and movable axially with respect to said shell and also with respect to said first rod and comprising, further, a second plurality of links distributed longitudinally and pivotally connected to said shell and second rod, for contracting said overlapping part both after contraction and after expansion of said underlapping part and for expanding said overlapping part,

(*d*) some of the second plurality of links being connected to the shell near said overlapping part and others being connected to a part of the shell which is substantially opposite to said overlapping part.

4. A contractible tubular core which comprises:

(*a*) an outer cylindrical shell having a longitudinal seam formed by respectively overlapping and underlapping circumferentially extended marginal parts of the shell,

(*b*) a first axial actuating rod situated within the shell and axially movable relatively thereto,

(*c*) a first group of links distributed longitudinally and interconnecting said first rod and the shell, some of said links being connected to the shell near said underlapping part, said links extending radially outwards from the rod in several directions such as to maintain the rod in the axial position thereof,

(*d*) a second actuating rod also disposed axially within the shell and movable axially relatively to the shell and to said first rod, and

(*e*) a second group of radial links distributed longitudinally and interconnected between said second rod and the shell, at least some of said links being connected to the shell near said overlapping part for controlling the radial position of the overlapping part independently of the underlapping part,

(*f*) said links having pivotal connections to said shell and to the respective rods.

5. In combination with the contractible core as defined in claim 4, a lost-motion unit interconnecting said first and second rods and including mutually engageable elements respectively on the first and second rods and positioned thereon so that the first rod can be moved axially independently of the other rod through only a limited distance, whereby a continuous displacement of the first rod causes a delayed axial displacement of the second rod for contracting the overlapping part after contraction of the underlapping part.

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