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(54) 'IMPROVED COMBINED MOULD
ELEMENT AND SEAL'

(71) We, RIEBER & SON A/S, a Norwegian Company, of Nostegt. 58, 5000 Bergen, NORWAY, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a combined mould element and annular seal.

The combination is designed for sealing-off a joint between a socket end and an insert end of two co-operating pipes which are formed from thermoplastic material.

The mould element is being used as a portion of a body of a mould for both fabricating a groove in said end of the one pipe and simultaneously inserting the seal in an internal groove in the socket end produced during the making of the socket.

The combined mould element and seal has accordingly two distinct and different purposes, i.e. one as a mould element and one as a seal. In this respect, the expression "mould element" and the expression "seal" will be used in this specification to clarify the purpose being described at that point. It will, however, be understood that both expressions refer to the same unit.

Processes of using the same unit as a combined mould element and seal are known: U.S. Patent Specification No. 3,776,682, issued to Parmann, and U.S. Patent Specification No. 3,520,047 issued to Mühler, are relevant.

U.S. Patent Specification No. 3,776,682 describes a combined mould element and sealing ring made of rubber. The mould element is supported on a mandrel by means of a support member which is movable in

axial direction on the mandrel drift.

U.S. Patent Specification No. 3,520,047 describes a sealing ring laterally connected to coherent support rings. One of said support rings is supported on the mandrel in one case by means of a shoulder on the mandrel or drift and in another case by means of stopping means which is movable in radial direction on the drift.

In general, many different problems are involved in using a combined mould element and sealing ring, and such problems relate to:

- the design and production of such combined mould element and sealing ring,
- the process involving using the mould element as a portion of the body of a mould and including using the mould element as a sealing ring in the internal groove in the socket end produced thereby,
- the process of assembling and joining a spigot end and a socket end provided with the sealing ring, and
- the functioning of the sealing ring in a pipe line comprising joints of spigot and socket ends.

These problems which will be evident from the following specification have hitherto not been looked upon as a whole to a sufficient degree, and many of the problems have mostly been looked upon and solved individually.

One aim of the present invention is to solve as many as possible or most of such problems in a single solution of the present invention.

Design and production of a combined mould element and sealing ring.

It is evident that a sealing ring made entirely of elastically yielding material, such

as rubber, can be produced with a simple design and produced relatively easily with uncomplicated production equipment. However, such production may involve problems regarding production tolerances. Further, such sealing ring made entirely of elastically yielding material is lacking necessary support properties and may involve problems when being used as mould element as well as when being used as a sealing ring. In order to solve these problems, different solutions have been suggested to compensate said lack of support properties in sealing rings made of elastically yielding material. One such solution is suggested in U.S. Patent Specification 3,776,682 using a separate support member to support the mould element when producing the socket end. However, the construction is more or less unsupported as a sealing ring. Another solution is suggested in U.S. Patent Specification 3,520,047 using two mould element forming support rings connected to the sealing ring. In this latter embodiment the sealing ring is being left solely as a sealing ring in a space between the mould element forming support rings. It is evident that such a combined mould element and sealing ring made of three separate parts complicate the production of the construction unit. Such a complicated construction unit involves, however, more or less the same additional support means as the first mentioned construction unit made solely of elastically yielding material. In addition, said complicated construction unit involves further problems regarding production tolerance and varying effects under different conditions in use.

A further aim is to control the elastic yielding effect by incorporating a local support in the sealing ring.

Use of the mould element.

When using the sealing ring as a mould element, the same has to be moved on to a mandrel, located in desired position thereon, supported accurately thereon and maintained in the desired shape of the mould element during the process of fabricating the socket end on the cooperating mandrel and mould element.

Yet another aim of the present invention is to incorporate a local support in the sealing ring and thus make it possible to allow the mould element to yield in a controlled manner when being moved on to and supported on the mandrel and also to support the mould element accurately on the mandrel.

A further aim of the present invention is to allow the combined mould element and sealing ring to be used in different producing apparatuses, such as those described in U.S. Patent Specifications 3,776,682 and 3,520,047 and that described in U.S. Patent

Specification 3,793,427 issued to Heisler. *Assembling and joining spigot and socket ends.*

During assembling and joining the spigot and socket ends, the sealing ring will be compressed in a manner, corresponding substantially to the compression of the mould element during withdrawal of the socket and the mould element from the mandrel.

Due to the close diameter tolerances achieved by shrinking the pipe end directly upon a supported mould element (sealing ring), assembly forces can be kept low and at a constant rate. A further aim of the present invention is to enable a simple production of sockets which are ready for use without even making lubrication or chamfering of insertion ends necessary.

Function of the sealing ring in a pipe line.

The maintenance of the elastically yielding properties of the sealing ring is above all important when the sealing ring is being used in a pipe line, but it is also of vital importance that such yielding effect be controlled.

Due to the expansion of the grooved portion of the socket and wherein the sealing ring is supported, the pipe wall is stretched, and thereby causes formation of a relatively thin and weakened pipe wall which may have insufficient strength for support purposes.

On storage and transportation, the pipes rest as a rule abutting just on the most stretched out parts of the pipe end. Hence, an effective support of these parts will be able to prevent unintended deformations, and even breakages, as a consequence of blows such as readily occur during transportation and handling of the pipes.

Unintentional loading will also be primarily transferred to the most outwardly projecting parts of the socket end, something which can easily lead to deformations and associated leakage in the joints.

An effective support of the annular groove of the socket end will thus contribute to reduce the risk of unintended deformations and the danger of leakages and breakages as well.

In connection with heat strains in the pipes, such as can occur on storage (stacking of the pipes) in hot summer weather, and by use close to sources of heat (steam pipes in the same ditch) etc., a bracing of the annular groove by the use of a stiffened sealing ring will contribute to increase the safety against deformations, shrinkages of the material and resulting leakages etc.

Especially for pipes which are to be utilised with internal excess pressures, the thinner material in the rubber ring groove represents a serious weakness of the pipe.

On using conventional rubber sealing rings, these are pressed together by the

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internal pressure medium and the pressure forces are transferred to the annular groove by a combination of direct pressure from a packing means and pressure from the pressure medium *per se*.

Hitherto, in order to reduce the pressure loading against the outwardly stretched and thinned zones of the pipe groove - and without limiting the permitted internal excess pressure - thermoplastic pressure pipes are provided with a local reinforcement by means of a heavier wall thickness in the stretched area.

The thickening of the pipe wall has been constructed in two main ways which both act to complicate and make expensive the manufacture of the pipes due to increased weight of the pipes and auxiliary production equipment etc. United Kingdom Patent Specification No. 997,551 proposes thickening of the pipe material in the socket end during the extrusion process which additional step involves the need for extra mechanical machinery and the danger that the thickening does not come at the correct location etc. It has also been suggested to apply a reinforcing sleeve outside the pipe end, as shown in the German Patent Specification 1,742,418. The necessity of having two wall thicknesses under control is also undesired from a production point of view. The application of a reinforcing sleeve involves much extra work with the cutting, putting on and securing of the sleeve during the socket operation. As the stretched groove areas often crack by the socketing process, it is very undesirable if these cracks appear between the sleeve and the pipe itself because such cracks cannot be detected.

The automation of the socket operation is complicated by the common modes of production, in addition to production capacity being reduced by the longer heating and cooling times of the thicker pipe ends.

According to one aspect of the present invention, there is provided a method of forming a socket end portion in a terminal part of a thermoplastic material pipe, which method comprises the steps of locating an annular mould element on a mandrel, the element comprising a rigid annular member attached to an annular mass of elastomeric material extending radially and/or axially from the annular member to define a unitary body, the annular mass being of greater volume than the annular member; heating the terminal part of the pipe; causing relative motion between the terminal part and the mandrel to cause or allow the terminal part to flow over the mould element and a part of the mandrel to insert the mould element into the terminal part, the mould element thereby forming a groove in the wall of the pipe; reducing the temperature of the ter-

terminal part; and effecting withdrawal of the mandrel from the cooled terminal part to form the socket end portion and to leave the mould element retained in the groove so as to define an annular seal in the socket end portion for sealing engagement with another pipe.

According to another aspect of the present invention, there is provided a mould element for forming a socket end portion in a terminal part of a thermoplastic material pipe and for defining an annular seal in the formed socket end portion for sealing engagement with another pipe, said element comprising a rigid annular member attached to an annular mass of elastomeric material extending radially and/or axially from said annular member to define a unitary body, said annular mass being of greater volume than said annular member, said annular member rendering a marginal zone of said body stable as regards its shape with respect to the remainder of said body.

The invention will now be described, by way of example, with reference to the accompanying drawings in which:

Fig. 1 and 2 are cut-off, vertical sections of a mould apparatus for producing the socket end of the pipe with associated annular seal, illustrated in two succeeding fabrication steps;

Fig. 3 is a vertical section, on an enlarged scale, of a detail of the connection between an insert end of a first pipe and a socket end of a second pipe with associated seal;

Fig. 4, 5 and 7 are vertical sections, on an enlarged scale, of three different embodiments of the seal;

Fig. 6 is a vertical section of the seal of Fig. 5 in an unloaded condition;

Fig. 8 is a cut-off vertical section of a pipe joint with a seal arranged in position between socket end and insert end;

Fig. 9 is a vertical section, on an enlarged scale, of the seal shown in Fig. 8 in an unloaded condition;

Fig. 10 is a cut-off vertical section, on an enlarged scale, along the line A-A of Fig. 9;

Fig. 11 is a side elevation, partly in vertical section, of another apparatus for the fabrication of a socket end with a combined mould element and seal according to the invention;

Fig. 12 is a vertical section of a portion of Fig. 11 on a larger scale and with the seal in position.

Fig. 13-16 illustrate various steps of the fabrication of the socket end;

Fig. 17 is a vertical section of a further embodiment of a seal designed for use in the apparatus shown in Fig. 11;

Fig. 18 is a vertical section, on an enlarged scale, of the apparatus of Fig. 11 using a modified seal;

Fig. 19 is a vertical section of the seal

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shown in Fig. 18 in an unloaded condition;

Fig. 20 is a vertical section, on an enlarged scale, of a modified apparatus of Fig. 11 using another modified seal; and,

5 Fig. 21 is a vertical section of the seal shown in Fig. 20 in an unloaded condition.

Referring to Fig. 1 and 2, a mould apparatus for the production of a socket end on a first pipe A of thermoplastic material comprises a substantially cylindrical mandrel 10; a combined annular mould element and annular seal 11, which can be readily threaded on and off the main surface 12 of the mandrel; and a tubular support 13 which can be displaced axially to and fro on a main right cylindrical surface 12 of the mandrel. Such a mould apparatus is disclosed further in U.S. Patent Specification 3,776,682 from which document the method of fabricating such a socket end can also be deduced.

The mandrel or drift 10 is provided with a leading closed end surface 14 which, via a first surface-forming conical surface 15, passes into a first cylindrical surface 16 having a diameter d corresponding to the inner diameter of the pipe which is to be threaded in on the mandrel 10. From the cylindrical surface 16, there extends obliquely outwards a second, shape-yielding, conical surface 17 to a second, cylindrical surface 18 having a diameter D corresponding substantially to the inner diameter of the socket end which is to be fabricated on the mandrel.

The second, cylindrical surface 18 is coaxial with, and has the same radius as, a third, cylindrical surface 19.

Intermediate the surfaces 18 and 19, two peripheral grooves 20 and 21 are provided, the grooves being spaced by a fourth cylindrical surface 22 similar to the second and third surfaces. The surfaces 18, 19 and 22 define the main surface 12.

The two peripheral grooves 20 and 21 are, as shown in U.S. Patent Specification 3,776,682, connected, via radial bores 23, 24 to a common central and axially extending bore 25 in the drift and communicate with a source of reduced pressure (not shown further) via the central bore 25.

The peripheral grooves serve to ensure, in a known manner, good air exhaustion around the whole of the periphery of the drift on both sides of the mould element so that the hot pipe end does not get the opportunity to seal the radial bores for air exhaustion. Furthermore, the peripheral grooves serve as a clear limitation of the three surface sections 18, 19 and 22 of the drift so that the individual working of these is simplified as is customary in machine construction.

The surfaces 18, 22 and 19 are designed substantially right cylindrical but may be designed according to the dimensions and tolerances which are desired internally in

the finished socket end. Thus the drift surface 18 may be slightly conical to produce socket ends which are to provide a force fit between socket and insert ends so that the socket joint can, alternatively, be glued as required for tensile strong joints. The surface 19 is arranged to have approximately the same diameter as the insert end which is later to be mounted in the socket end since this reduces the risk of pressing out the sealing element into the annular gap between socket end and insert end by internal excess pressure in the pipes combined with ordinary not reinforced sealing rings.

The fourth surface 22 serves, in accordance with U.S. Patent Specification 3,776,682, as an abutment for a combined mould element and sealing ring and is adapted, in similarity with the remaining drift or mandrel surfaces, to the desired internal dimensions in the finally formed and shape-stable socket end.

In compression gaskets where the sealing ring is to be pressed together against the surface of an insert end, there is utilised, in a known manner, a combined mould element and sealing ring having a minimum diameter somewhat less than the insert end.

Since the mould element is normally disposed on the drift with a weak prestressing of the elastic zones, the diameter of the fourth surface 22 mostly is designed to be somewhat larger than the corresponding minimum diameter of the annular mould element.

Peripheral grooves 20 and 21 are specially shallow and have a maximum depth of about 3% of the diameter of the drift.

With the need for extra axial centering of the mould element, one or both of the grooves can be utilised for positioning of the mould element as is illustrated in the embodiment of Fig. 4.

In pressure pipes, as well as pressureless pipes, the groove depth in the aforementioned case will, when the pipe diameter varies between 90 mm and 315 mm, vary from 1% to 2% of the diameter of the pipe if the groove is to be utilised for the reception of the compression portion of the annular seal or that portion of the seal which has the smallest diameter.

The combined annular mould element and annular seal 11 is fabricated from a mass of elastomeric material which, in the illustrated embodiments, consists of rubber. This mass is locally supported by a rigid or relatively non-elastomeric material, for example, metal, such as steel, or a rigid plastics material. In the illustrated embodiments, the non-elastomeric material is in the form of an annular member 26 of steel which, together with the rubber, constitutes a unitary member, defining between outer and inner surfaces thereof a body with

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mainly drop-shaped cross-section.

In Fig. 1 and 2, the application of the unitary annular seal 11 as an active part (mould element) of the mould apparatus is illustrated. In Fig. 1, the mould element is shown as a conical portion of the mould apparatus for the radial expansion of a socket end 27 of the pipe A. The pushing-on force of the pipe towards the mould element is shown by an arrow 28. On retracting the tubular support 13 from the position shown in Fig. 1 to the position shown in Fig. 2, the free or outer end of the pipe A will conform inwardly against the third surface 19 as is shown in Fig. 2, by means of the vacuum effect which is obtained via the radial bores 24 and the peripheral groove 21. After cooling down of the formed, yet hot socket end, the finished formed, shape-stable socket end is drawn off the drift in the direction of an arrow 29. By means of a bore 30 (Fig. 4 and 7), which emerges in the fourth surface 22, there can be supplied a lubricant to the radially inner surface of the mould element 11 so as to reduce the friction between the drift and the socket end, during withdrawal of the socket end together with the annular seal 11 from the drift.

In general, the mould element 11 will be compressed in a manner corresponding substantially to the compression which the sealing ring is exposed to by the later mounting of a pipe joint on introducing an insert end 31 (Fig. 3) in the socket end 27. At the same time, the combined mould element and seal 11 will have applied thereon the lubricant which is necessary for the later mounting. In this way, the pipes can be delivered ready for mounting to users which represents a substantial step forward in plumbing. In Fig. 3, the pipes A and B are shown after jointing together.

The mould element as shown in Fig. 4 is provided with a first conical under or inner surface portion 11a which terminates relatively tightly against the fourth cylindrical surface 22 of the drift. The surface portion 11a connects with a second, inner surface portion 11c which is convex. The convex surface portion 11c projects radially inwards to a level radially within the fourth surface 22 and is received by abutment against the bottom of the one side part of the groove 21 and laterally of the bore 24. From the surface portion 11c, the sealing ring extends upwards in a convex back surface portion 11d which, with its radially inner part, forms an abutment against a correspondingly shaped surface of the tubular support 13. The back surface portion 11d passes further over into a convexly curved outer surface portion 11e which, in turn, connects with an obliquely extending, leading surface portion 11f. The surface portion 11f extends substantially in a straight line towards a

pointed, leading side edge 11g.

In the embodiment as shown in Fig. 4, there is introduced a hoop-shaped steel ring member 26a in the radially outer part of the mould element, with the radially outer surface of the ring member being coincident with the leading surface portion 11f. The ring member 26a is spaced from the curved outer surface portion 11e so that this part of the mould element can conform elastomerically to the peripheral groove which is formed on the inner side of the socket end, more or less independently of the ring member 26a. Furthermore, the ring member 26a is spaced from the leading side edge 11g to define a wedge-shaped elastomeric part by the leading side edge and between the surfaces 11a and 11f. In Fig. 4, part of the mould element is shown received radially inside the surface 18 or 22, the wedge-shaped portion projecting free-endedly outwards over the groove 20, that is to say without forming an abutment against the bottom of the groove. The wedge-shaped part will, if desired, be able to spring somewhat inwards into the groove 20 during fabrication of the socket end and will, if desired, be able to form a lip seal against the insert end of the pipe B during uniting of the pipes A and B or by excess pressure occurring in the joint between the pipes A and B during use in a pipe line. The ring member 26a will, in the illustrated embodiment, be able to brace the mould element in an effective manner so that the mould element is ensured a position in a shape stable, but nevertheless partially elastic, condition on the drift as well as bracing the seal in the finished fabricated socket end. The ring member 26a will be able to exert a certain stiffening of the combined mould element and seal, not only in the zone which directly supports the ring member 26a, but also in somewhat more remote zones of the mould element and seal and especially within that zone which is defined between the surfaces 11a and 11f. The zones which are defined between the surfaces 11c, 11d, 11e are, on the other hand, unsupported and can be compressed and/or displaced relative to the more stiffened zone between the surfaces 11a and 11f. The zone between the surfaces 11c-11e exerts the particular sealing effect, with compression sealing, by means of the nose part which is formed by the convex surface 11c.

In Fig. 5, there is illustrated another construction to that which is illustrated in Fig. 4. An essential difference is that the ring member 26b is extended wholly downwards to the leading side edge 11g. In this case, the surface 11a is right cylindrical and is arranged to lie flush on with the drift surfaces 18 and 22.

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compression seal as shown in Fig. 4 is replaced by a lip seal 11c defined by a recessed surface portion 11b within the drop-shaped body of the combined annular mould element and annular seal as illustrated in Fig. 5. Fig. 6, illustrates the seal and its sealing lip 11c in unloaded condition. In Fig. 5, the mould element with its sealing lip is strongly compressed against the cylindrical surface 22 which is coaxial with, and has the same radius as, the cylindrical surfaces 18 and 19.

In Fig. 7, there is illustrated a rather different construction in which a ring member 26d is disposed at the back surface portion 11d of the mould element so that the ring member forms a direct abutment against the tubular support 13. The cross-section of the unitary body of the combined mould element and seal is mainly drop-shaped. Between a conical first inner surface portion 11a and a convex second inner surface portion 11c there is a recessed, concave surface portion 11b. The back side portion 11d in this embodiment is, however, concave. In such a case, a significant axial and radial compression of the seal can be permitted, together with a relatively large movement of the leading edge 11d of the seal, while nevertheless maintaining the shape stability and self-centering ability of the seal. A positioning of the ring member 26d is chosen at a level radially outwards of the leading edge 11g of the mould element in order, thereby, to ensure an intentional pressing down of the leading edge 11g during the pushing-on of the hot pipe end of the sealing ring.

The rigid ring member can be positioned and employed for the reception of the axially acting pushing-on forces which occur on pushing on the hot pipe end onto the mould element. Thus, the ring member can be employed for the support of the mould element against an axially displaceable support sleeve, as shown in Fig. 7; for support against point-formed abutment members in the form of pins projecting radially outwards such as utilised in U.S. Patent Specification No. 3,520,047; or for support against support edges permanently connected to the drift as are used in the same aforementioned patent specification.

It is apparent that the ring member can be designed in various other ways and can be positioned in various ways other than those which are shown in the accompanying embodiment in order to be adapted according to existing support means of the mould apparatus, or, in order to satisfy other demands of the sealing ring. If desired, two or more of the ring members 26a (or 26b), 26d can be combined in a single construction and, moreover, such ring members can be connected to each other into a coherent rigid member, for example with separate

connecting webs between the parts (not shown).

Referring to Fig. 8, there is shown a first pipe A with a formed socket end 27 and a second pipe B with a corresponding insert end 31. The socket end 27 is fabricated as shown and described above and the insert end portion is chamfered from the free edge to define a conical drawing-on edge 31a. As a result of the seal being permanently locked, the conical edge can, if desired, be dispensed with without the danger of pushing in the sealing ring on mounting.

Fig. 8 shows a part of the socket end 27a having a reduced material thickness which has arisen as a consequence of the expansion of the material of the socket end on forming an internal groove 27b for an annular seal 11. In order to compensate for the weakness in the socket end which said expansion has caused, the seal 11 has been additionally reinforced relative to the seal of the previously described embodiments. In this connection, there is utilised a ring member 36 which stretches over the largest part of the extent of the width of the seal, that is to say in the illustrated embodiment over the greatest part of the outer surface portions 11d, 11e, 11f of the seal but with exposure of outer surface portion 11h just by the edge 11g of the seal (see also Fig. 9). The ring member 36 is disposed so that it constitutes the radially outer surface of the seal over the greater part of the width of the seal. This is done in order to ensure an effective controlled reinforcement of the outer surface of the seal.

There must be particularly emphasized, the advantage which is obtained by designing the ring member 36 as a double curved bracing body, one thereby being able to utilise a relatively thin-walled metal hoop ring member of especially rigid form, which is particularly favourable for the reception of radial loadings with minimal deformation of the ring member. The ring member can, however, have different shapes. A conical portion 36a of the ring member 36, as illustrated, is especially suitable for forming an internal support for the socket end 27 in the weakened part 27a, which surrounds the groove 27b, and for absorbing the internal pressure loadings which are exerted in a radial direction outwardly against the seal without loading the weakened part 27a. The conical portion 36a will, in addition, form an effective support for the seal and prevent it from being pressed into the annular gap between spigot end and socket end by internal excess pressure in the pipe line.

By bracing the radially outer surface of the seal at 11d-11f with the ring member, one can, by utilising normal steel plate or similar material with an unworked surface, readily adjust the top surface with sufficient

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non-uniformity form small passages so as to ensure draining between the seal and the groove of the socket end in the fabricated socket end. However, in order to ensure controlled draining, the outer surface of the ring member (see Fig. 10) or the outer surface (i.e. the bulk material) of the seal is provided with relatively narrow and shallow, V-shaped grooves 36c which extend transversely of the ring member, i.e. longitudinally of the socket end. Even if the ring member is included in the mould surface of the combined mould and seal, the filling of the whole of the gap opening can be avoided by making the grooves sufficiently narrow. (The grooves are shown somewhat overly large in the drawing).

By ensuring the draining of the gap which is formed on the upper side of the ring member, there is obtained an effective sealing on that portion of the seal which is without reinforcement, that is to say at that part which borders on the surface 11h and which forms an abutment against the transition to the groove 27b. The pressure medium which acts against the inner side of the sealing ring, that is to say against the surface 11a, will normally press the surface 11h outwards into sealing abutment with the groove 27b but if, nevertheless, pressure medium should creep further outwards along the gap between the surface 11h and the groove 27b, such pressure medium will be able to be discharged in the gap which is formed between the groove 27b and the surfaces 11f, 11e, 11d. It has been found that a particularly effective seal can be obtained at the surface 11h just as a result of the draining off which occurs behind the surface 11h, since one obtains a lip seal, controlled by the pressure medium, at the edge 11g of the seal.

If the pressure medium is pressed outwards into the hollow space which is formed by the cavity 11b on the radially inner side of the seal, transmittal of the pressure to the socket end via the seal can be prevented since the seal has the ring member arranged radially outwards of the cavity 11b. The pressure increase in said hollow space will only increase the effect of the lip seal at the edge 11g and at the surface 11h without acting on the weakened part 27a of the socket end. The sealing portion which is located at the opposite, outwardly directed edge of the sealing ring and which is formed within the surface 11c, is essentially stiffened by the radially and inwardly directed edge part 36b of the ring member 36 without this part reducing the elastomeric sealing properties of the seal at the abutment surface of the sealing portion against the insert end of the internal pipe. If desired, the sealing surface 11c can possibly be designed with an extra sealing lip which is pressed down against the insert end 31 by internal excess pressure in

the pipe.

In Fig. 11, a second embodiment of an apparatus for fabrication of the socket end of a thermoplastic pipe is shown. The apparatus comprises a support member 50 which supports a compressed air cylinder 51 having an axially moveable piston 52 fixed to a tubular piston rod 53. The piston rod 53 extends right through the cylinder 51 through guides 54 and 55 at opposite ends of the cylinder. The cylinder includes packing rings 56 for sealing off the piston rod against the guides 54, 55 and against the piston 52. The piston rod 53 includes an axial bore 57 one end of which is connected to a flexible pipe 58 which, in a manner not shown, places the bore, via a control valve, in communication with a source of pressure medium (indicated by the arrow E₂) and with a reduced pressure source (indicated by the arrow E₁). The opposite end of the rod 53 supports a drift 59 having a head portion 60 which closes the other end of the bore 57 spaced from the other end of the rod, radial bores 61 extend outwardly towards an internal annular groove 62 in an axial bore 63 formed in the drift or mandrel. From the annular groove 62, radial bores 64 extend outwardly to an outer annular groove 65 in the drift. The rod 53 is received in the axial bore 63 and is sealed against the drift by means of packing rings 66 spaced axially outwards from the bores 61 and axially outwards of the annular groove 62. The support member 50 is fixed to an outer cylindrical support member 67 having an internal bore 68 which surrounds the inner end of the mandrel with a free fit as shown in Fig. 11. When the mandrel is disposed inwardly towards the cylinder 51, the bore 68 accommodates the whole of the drift (See Fig. 16). Just above the drift 59, there is arranged a water flushing device 69 which is fed with water F.

Fig. 12, shows an annular locking device 70 of elastomeric material, such as rubber, received in the annular groove 65. In the inactive position, as shown in Fig. 12, the locking device is drawn radially within the bottom of a relatively shallow, broad outer part 65a of the annular groove 65.

The locking device 70 is designed to be able to lock shut the mould element 11 at a definite position on the drift 59. This position is made secure by means of the annular groove part 65a which forms a depression in the main surface 72 of the drift. Fig. 12 shows that the ring 11 can be displaced relatively easily along the surface 72 of the drift with a supporting abutment between the surface of the drift and the inner surface portions 11a, 11b and 11c of the mould element 11. In the position which is shown in Fig. 12, where the mould element 11 is without engagement with the locking device,

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the inner surface portions 11a, 11c project only inwards into the groove part 65a without touching the bottom of the groove part.

In the illustrated embodiment, there is utilised a locking device 70 in the form of an elastomeric ring formed of rubber and of rectangular cross-section. In the rubber ring there are formed a series, for example 4-6, of radial bores 75 of relatively small diameter.

After the mould element is placed in position in the groove part 65a on the drift, as is shown in Fig. 12, pressure medium is fed to the radially inner side of the locking device 70 from the source E_2 via the bore 57, radial bores 61, inner annular groove 62, and radial bores 64 to the bottom of the annular groove 65. The elastomeric locking device will hereby be extended radially outwards through the groove 65a to engage with a recessed concave inner surface portion 11b of the mould element. Only small quantities of pressure medium leak outwards through the bores 75 of the locking device, and immediately the rubber ring forms an abutment against the surface portion 11b, the bores 75 are covered and shut off by means of the sealing ring. By means of the pressure medium, there is ensured an effective abutment between locking device and sealing ring.

Fig. 13, shows a pipe A of thermoplastic material the illustrated end of which pipe is heated to a suitable plastic condition so that it can be shaped over the drift 59 as is shown to the left of Fig. 13 and thereafter can be shaped over the mould element 11, such is illustrated in Fig. 14. During the pushing-on, the heated pipe end is moved axially on the drift or mandrel until it thrusts against a stop 77 on the outer support member 67.

After the pipe end is shaped with socket end 27, the pressure against the locking device 70 is released so that the device falls back into the position shown in Fig. 15. Afterwards, the locking device is placed under negative pressure vacuum from the source E_1 via the mentioned passages 57, 61, 62, 65, the negative pressure transmitting itself via the bores 75 of the locking device to the groove part 65a and providing for the drawing of the outer end of the socket end, tightly around the seal and downwards against the drift. It is evident from Fig. 15, that the outer end of the socket end, when sucked onto the drift, is drawn away from the abutment against the stop 77. After the negative pressure is shut off, and the socket end is cooled down, the socket end is pushed off the drift 59 by drawing the drift into the outer support member 67, as is shown in Fig. 16.

The mould element to be used in the apparatus illustrated in Figs. 11 to 16 is of the type illustrated in Fig. 9. The mould ele-

ment can, however, be modified as illustrated in Fig. 17, the main modification being the shape of the ring member which is similar to the ring member 26e illustrated in Fig. 3 and 4.

In the embodiments illustrated in Fig. 9 and 17, the recessed concave surface portion 11b is localised just below a part of the ring member 26b so that the radial force which is exerted against the mould element from the locking device 70 is intercepted and relieved in the bracing means, without essentially affecting the mass of the mould element. The ring member is arranged, in the axial direction, between the inner surface portion 11b and the inner surface portion 11a, and is further arranged radially just outside the concave inner surface portion 11b so that the pushing-on force from the hot pipe end against the mould element can be transferred from the ring member axially to the locking device 70 with radial support of the ring member against the locking device.

In Fig. 18, there is shown a modified construction of the drift illustrated in Figs. 11 to 16. Two parallel annular grooves 85 and 86 of mutually different diameter are arranged on the drift surface to support respectively the cylindrical inner surface portion 11a and the convex inner surface portion 11c of the mould element 11. Radially inwards of the annular grooves 85, 86 extend a series of parallel axial grooves 87. The grooves 87 extend axially beyond the grooves 85, 86 but have breadth and height dimensions preventing the mould element from closing the passages formed by said grooves 87. The grooves 87 communicate with a reduced pressure source (indicated by the arrow E_1 in Fig. 11) via bores 88, 89 and open radially into the grooves 85, 86 and in addition open radially towards the inner surface of the pipe end laterally of the mould element.

As illustrated in Fig. 18, the convex inner surface portion 11c of the mould element is modified in that an additional concave inner surface portion 11i and an additional convex back surface portion 11j extend from said inner convex surface portion 11c to said convex back surface portion 11d. By means of chained lines is illustrated a compression of the rear part of the mould element as provided by contraction of forces developed by the heated pipe end upon cooling thereof. It is evident from Fig. 18 that the rear part of the mould element is rather unsupported and accordingly can be compressed regardless of the ring member 26 which is supporting the remainder of the mould element.

Advantages in the socket fabrication as a result of the stiffened or braced mould element and sealing ring.

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ring member, be effected especially simply due to the fact that radially moveable locking devices can be pressed out against the mould element and can secure the latter with the reinforcement as a stop.

b) The forces which press the locking devices (a continuous circular rubber ring, steel spikes or the like) radially outwards can be permitted to vary within wide limits without affecting the socket forming operation. The forces which act on the mould element radially outwards are received by the reinforcement without the latter being deformed in such a way that the hot plastic pipe is prevented from being pushed over the latter.

c) In particular, the entry of the hot pipe end over the seal will not be hindered since the entering edge of the mould element for the hot pipe end is, by virtue of the rigid reinforcement, not allowed to be lifted up over the drift surface and does not cause "fishing" with the pipe end.

d) The locking devices do not participate in the moulding of the pipe end and can, therefore, be constructed without strong demands on dimensions and tolerances. The locking devices do not need either to support the mould element around the whole periphery as a consequence of the reinforcement, but can be divided up into three or more independent elements.

e) Since the reinforced mould element enables a radial clamping effect to be provided in the seal, it is possible to achieve a self-locking effect of the locking devices for securing the mould element in an axially non-displaceable manner on the drift against the pushing-on force of the hot pipe end.

f) The radial fixed locking of the mould element such as is made possible by the reinforcement of the latter, leads to an especially simple and correspondingly cheap and dependable socket-producing apparatus.

The apparatus to be used with the combined mould element and seal has simple movements and no complicated parts.

As a consequence of the reinforcement of the mould element, the mould element is maintained in its desired form and the hot pipe end is contracted about the mould element so that there is obtained optimum shaping of and tolerances in the pipe socket end.

In Fig. 19 is illustrated the mould element 11 in unloaded position and the drift surface 72 and the grooves 85, 86, 87 are indicated in chained lines. It is evident therefrom that the inner diameter of the cylindrical inner surface portion 11a of the mould element is smaller than the diameter of the groove 85 and to a greater extent greater than the diameter of the grooves 87, whereas the

inner diameter of the convex inner surface portion 11c is smaller than the diameter of said inner surface portion 11a and the inner diameter of the groove 86 but greater than the diameter of the grooves 87.

With the mould element in position on the drift (Fig. 18) the locking device 70 is being pressed by pressure medium (from the pressure medium source E₂ as shown in Fig. 11) radially outwards against the concave inner surface portion 11b as explained above with reference to Figs. 11 to 16, whereas the inner surface portions 11a and 11c are being pressed against the bottom of their respective groove 85 and 86. The strongly compressed portions of the mould element, are illustrated by cross-hatching as shown at C in Fig. 18. It is possible to control such strongly compressed portions of the mould element and prevent that the socket end is loaded unduly by means of the rigid ring member 26 which is located radially outside said strongly compressed portions. It is thus possible to position the mould element accurately and securely on the drift by means of the clamping effect provided between the ring member 26 of the mould element and the groove 85 of the drift and the clamping effect provided between the ring member 26 and the locking device.

In the embodiment of Fig. 20, there is illustrated a single groove 95 to support the cylindrical inner surface portion 11a and the convex inner surface portion 11c of the mould element. Two annular grooves 96, 97 are located laterally of the groove 95 one at each side thereof and communicate separately with the bores 88, 89. The mould element is provided with a ring member 126 which consists of a first conical portion 126c corresponding to the ring member 26 of Fig. 18 and 19 and a second portion 126d extending at an angle from said conical portion 126c towards the rear portion of the mould element. Said second portion 126d is, in a preferred embodiment, illustrated in as being right cylindrical, but it is evident that various other shapes will also be possible.

By means of said second ring member portion 126d, a strongly compressed portion C of the mould element is supported radially inside said first ring member portion 126c, whereas an additional strongly compressed portion C₁ of the mould element is supported radially inside said second ring member portion 126d. This enables an additional support and additional friction of the mould element provided by the compressed mould element portion defined by the surface portion 11c. This further makes it possible to dispense with the locking device 70 as used in the embodiment of Fig. 18 and 19. The groove 65 which communicates with a reduced pressure source (indicated by the arrow E₁ in Fig. 11), communicates directly

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with the concave inner surface portion 11b of the mould element and provides a locking means for positioning and locking the mould element in the groove 95. It is, however, evident that the mould element 11 of Fig. 20 and 21 also can be used in the apparatus of Fig. 1 and 2. In such a case the outer surface diameter of the support ring 13 more or less corresponds to the outer surface diameter of the ring member portion 126d. In both cases the ring member portion 126d is acting as a partition wall between the strongly compressed portion C₁ of the mould element and the radially outer portion of the mould element defined between the convex outer surface portion 11e and said ring member portion 126d.

As the hot pipe end is pushed over the mould element, vacuum is applied through the bores 88 and 89. The hot pipe end is thus pressed against the outer contours of the mould element by the atmospheric pressure, thus compressing the radially outer portion of the mould element defined between the convex outer surface portion 11e and said ring member portion 126d.

As the hot pipe end is cooled off by means of water spraying, the pipe end contracts, and a tight seal between the groove portion of the pipe and the sealing ring (mould element) is achieved. By means of the ring member portion 126d the tight sealing against the groove is maintained even after the socket is released from the mandrel drift, and the diameter tolerances in the seal portion 11c, thus are held.

The very close tolerances achieved in the production of the reinforced mould element thereby reducing the stretching and thinning of the pipe material in the groove area which increases the strength of this pipe section.

The tight fit of the seal (mould element) also prevents impurities from entering the groove during transport and storage.

WHAT WE CLAIM IS:-

1. A method of forming a socket and portion in a terminal part of a thermoplastic material pipe, which method comprises the steps of locating an annular mould element on a mandrel, the element comprising a rigid annular member attached to an annular mass of elastomeric material extending radially and/or axially from the annular member to define a unitary body, the annular mass being of greater volume than the annular member; heating the terminal part of the pipe; causing relative motion between the terminal part and the mandrel to cause or allow the terminal part to flow over the mould element and a part of the mandrel to insert the mould element into the terminal part, the mould element thereby forming a groove in the wall of the pipe; reducing the temperature of the terminal part; and effecting withdrawal of the mandrel from the

cooled terminal part to form the socket end portion and to leave the mould element retained in the groove so as to define an annular seal in the socket end portion for sealing engagement.

2. A method as claimed in Claim 1 including the step of applying reduced pressure to the interior of the terminal part to cause the pipe to conform about the mandrel and the mould element.

3. A method of forming a socket end portion in a terminal part of a thermoplastic material pipe, the method being substantially as herein described with reference to the accompanying drawings.

4. A thermoplastic material pipe having a socket end portion formed by a method as claimed in any one of the preceding claims.

5. A mould element for forming a socket end portion in a terminal part of a thermoplastic material pipe and for defining an annular seal in the formed socket end portion for sealing engagement with another pipe, said element comprising a rigid annular member attached to an annular mass of elastomeric material extending radially and/or axially from said annular member to define a unitary body, said annular mass being of greater volume than said annular member, said annular member rendering a marginal zone of said body stable as regards its shape with respect to the remainder of said body.

6. A mould element as claimed in Claim 5 wherein said annular member has a conical surface coincident with a radially outer surface portion of said mass.

7. A mould element as claimed in Claim 5 wherein said annular member is provided with a conical outer surface.

8. A mould element as claimed in any one of the claims 5 to 7 wherein said body has a convexly curved radially outer surface portion.

9. A mould element as claimed in Claim 8 wherein said annular member has a convex surface coincident with said convexly curved surface portion.

10. A mould element as claimed in Claim 9 including draining passages in said convexly curved surface portion, said passages extending in the axial direction with respect to said mass.

11. A mould element as claimed in any one of Claims 5 to 9 wherein said annular member as a portion embedded in said body.

12. A mould element as claimed in any one of claims 5 to 11 wherein the radially innermost surface of said mass comprises a first and a second inner surface portion and a recessed inner surface portion therebetween, and at least a part of said rigid annular member is located radially outside said recessed surface portion.

with the concave inner surface portion 11b of the mould element and provides a locking means for positioning and locking the mould element in the groove 95. It is, however, evident that the mould element 11 of Fig. 20 and 21 also can be used in the apparatus of Fig. 1 and 2. In such a case the outer surface diameter of the support ring 13 more or less corresponds to the outer surface diameter of the ring member portion 126d. In both cases the ring member portion 126d is acting as a partition wall between the strongly compressed portion C₁ of the mould element and the radially outer portion of the mould element defined between the convex outer surface portion 11e and said ring member portion 126d.

As the hot pipe end is pushed over the mould element, vacuum is applied through the bores 88 and 89. The hot pipe end is thus pressed against the outer countours of the mould element by the atmospheric pressure, thus compressing the radially outer portion of the mould element defined between the convex outer surface portion 11e and said ring member portion 126d.

As the hot pipe end is cooled off by means of water spraying, the pipe end contracts, and a tight seal between the groove portion of the pipe and the sealing ring (mould element) is achieved. By means of the ring member portion 126d the tight sealing against the groove is maintained even after the socket is released from the mandrel drift, and the diameter tolerances in the seal portion 11c, thus are held.

The very close tolerances achieved in the production of the reinforced mould element thereby reducing the stretching and thinning of the pipe material in the groove area which increases the strength of this pipe section.

The tight fit of the seal (mould element) also prevents impurities from entering the groove during transport and storage.

WHAT WE CLAIM IS:-

1. A method of forming a socket and portion in a terminal part of a thermoplastic material pipe, which method comprises the steps of locating an annular mould element on a mandrel, the element comprising a rigid annular member attached to an annular mass of elastomeric material extending radially and/or axially from the annular member to define a unitary body, the annular mass being of greater volume than the annular member; heating the terminal part of the pipe; causing relative motion between the terminal part and the mandrel to cause or allow the terminal part to flow over the mould element and a part of the mandrel to insert the mould element into the terminal part, the mould element thereby forming a groove in the wall of the pipe; reducing the temperature of the terminal part; and effecting withdrawal of the mandrel from the

cooled terminal part to form the socket end portion and to leave the mould element retained in the groove so as to define an annular seal in the socket end portion for sealing engagement.

2. A method as claimed in Claim 1 including the step of applying reduced pressure to the interior of the terminal part to cause the pipe to conform about the mandrel and the mould element.

3. A method of forming a socket end portion in a terminal part of a thermoplastic material pipe, the method being substantially as herein described with reference to the accompanying drawings.

4. A thermoplastic material pipe having a socket end portion formed by a method as claimed in any one of the preceding claims.

5. A mould element for forming a socket end portion in a terminal part of a thermoplastic material pipe and for defining an annular seal in the formed socket end portion for sealing engagement with another pipe, said element comprising a rigid annular member attached to an annular mass of elastomeric material extending radially and/or axially from said annular member to define a unitary body, said annular mass being of greater volume than said annular member, said annular member rendering a marginal zone of said body stable as regards its shape with respect to the remainder of said body.

6. A mould element as claimed in Claim 5 wherein said annular member has a conical surface coincident with a radially outer surface portion of said mass.

7. A mould element as claimed in Claim 5 wherein said annular member is provided with a conical outer surface.

8. A mould element as claimed in any one of the claims 5 to 7 wherein said body has a convexly curved radially outer surface portion.

9. A mould element as claimed in Claim 8 wherein said annular member has a convex surface coincident with said convexly curved surface portion.

10. A mould element as claimed in Claim 9 including draining passages in said convexly curved surface portion, said passages extending in the axial direction with respect to said mass.

11. A mould element as claimed in any one of Claims 5 to 9 wherein said annular member as a portion embedded in said body.

12. A mould element as claimed in any one of claims 5 to 11 wherein the radially innermost surface of said mass comprises a first and a second inner surface portion and a recessed inner surface portion therebetween, and at least a part of said rigid annular member is located radially outside said recessed surface portion.



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13. A mould element as claimed in Claim 12 wherein said annular member extends in the axial direction with respect to said body in spaced relationship from at least a part of said recessed inner surface portion.

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14. A mould element as claimed in any one of claims 5 to 13 wherein said body comprises an elastomeric lip portion spaced axially from said annular member.

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15. A mould element as claimed in any one of claims 5 to 14 wherein said rigid material is metal or rigid plastics material.

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16. A mould element as claimed in Claim 15 wherein said metal is steel.

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17. A mould element as claimed in any one of claims 5 to 16 wherein said elastomeric material is a rubber.

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18. A mould element as claimed in any one of claims 5 to 8 wherein said body has a first inner surface portion, a second inner surface portion, and a recessed inner surface portion between said first and said second inner surface portions, and an obliquely extending surface portion co-operating with said first inner surface portion to define a

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wedge portion; and said rigid material is disposed in said wedge portion.

19. A mould element as claimed in Claim 18 wherein said second inner surface portion forms a radially inwardly directed lip, and said recessed portion is dimensioned to receive said lip upon deformation of said second inner surface portion.

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20. A mould element as claimed in Claim 18 or Claim 19 wherein said first inner surface portion is conical.

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21. A mould element as claimed in any one of claims 5 to 20 wherein a section of said annular member contained in a plane at right angles to the axis is circular.

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22. A mould element as claimed in any one of claims 5 to 21 wherein a section of said body contained in a plane at right angles to the axis is mainly drop-shaped.

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23. A mould element substantially as herein described with reference to, and as shown in, the accompanying drawings.

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