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(54) **Improved electrode assembly for electric arc furnaces.**

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Description

This invention relates to improvements in electrode assemblies for electric arc furnaces, particularly but not exclusively arc furnaces used for steel making.

In a widely used form of electric arc furnace, several, usually three, consumable graphite electrodes extend substantially vertically downwardly from electrode clamps, through apertures in the roof of the furnace (if a roof is provided) and into the furnace charge. In order to strike and maintain a proper arc during operation of the furnace, it is necessary to allow for significant vertical movement of the individual electrodes, whilst in the case of steel making furnaces, it must be possible to withdraw the electrodes sufficiently upward relative to the furnace roof to allow the latter to be swung clear of the remainder of the furnace structure. It must also be possible to feed the electrode downwardly relative to the clamp to compensate for erosion of the electrode tip during use.

Various problems are associated with the facts that a substantial distance separates the effective lower tip of each electrode and its supporting clamp, and that substantial vertical relative movement is necessary between the electrodes and the furnace roof. Gases may escape from the furnace between the electrode and the furnace roof, or if the furnace is operated at subatmospheric pressure, cold air may be drawn in through the same gap. The outer surface of the electrode is subject to erosion through oxidation caused by the hot gases within the furnace, and this problem is aggravated by heating of the electrode caused both by heat from the furnace interior and by electrical heating caused by the electrical resistance of the electrode to the current passing therethrough.

Two main approaches have been adopted in response to these problems. Firstly, various forms of telescoping seal have been proposed for use between individual electrodes and the furnace roof. For example, in FR—A—1,418,153 (IRSID), a sleeve extending downwardly from the electrode clamp moves vertically in a water filled annular chamber extending upwardly from the furnace roof. In US—A—4,306,726 (Lefebvre) a series of concentric sleeves with sliding seals provides a telescoping gas seal between the electrodes and the furnace roof. Both of these arrangements have the disadvantage that it is not practicable to accommodate the large range of vertical electrode movement required in a steel making furnace, whilst a major part of the weight of the seal structure must be supported by the furnace roof in an area where it is normally sought to avoid unnecessary loadings.

The second approach has been to seek reduction of heating of the electrode. Numerous proposals have been made for fluid (usually water) cooled electrode structures, which reduce the length of graphite electrodes required. Examples may be found in US—A—4,121,042 and 4,168,392 (Prenn), 4,287,381 (Montgomery), FR—A—1,418,153 referred to above and FR—A—Nos. 2,176,546 and 2,222,821 (IRSID), DE—A—2430817 (Sigri), GB—A—1,223,162 (Ostberg) and BE—A—867,876 (Korf-Stahl AG). All of these proposals have in common that the cooling arrangement is more or less complex and expensive, and that it is not possible continuously to add additional electrode sections to the top of the electrode to replace erosion from the bottom of the electrode. Rather, the entire electrode assembly must sooner or later be removed in order to replace the tip portion if this is consumable.

In GB—A—664,298, an arrangement is proposed in which the electrode is supported within a water cooled sleeve, the lower end of which is in electrical contact with the electrode, and the upper end of which is held by the electrode clamp instead of the electrode itself. In this arrangement, the portion of the electrode within the sleeve does not have to transmit electric current, and the outer surface of this same portion is shielded from the electrode gases. In practice, it is extremely difficult to maintain adequate electrical contact between the bottom of the sleeve and the electrode. The arrangement described relies upon external screw threading of the electrode, both for transmitting current and for advancing the electrode through the sleeve, which means that electrodes of conventional design cannot be employed. Moreover, in order to achieve the object of the invention, the sleeve must extend close to the tip of the electrode. This is not practicable in many applications because of the risk that the sleeve will be damaged or destroyed by arcing from the furnace charge. An alternative approach is found described in GB—A—2,000,947A (Korf-Stahl AG) in which a water cooled jacket is provided around the electrode so as to shroud and support the entire electrode apart from the tip. In order to protect the jacket from arcing, it is insulated from the electrode, and provided with a refractory cladding. Additionally, an arc control magnet must be provided so as further to reduce the risk of arcing. The sleeve is supported from an electrode support arm which supports the electrode through a drive mechanism which also must maintain insulation between the electrode and the arm, a separate electrical connection being made to the electrode. It is suggested that the sleeve might be supported from a conductive electrode clamp but in this case some arrangement would be necessary to isolate the sleeve electrically from the clamp. In order to maintain insulation between the sleeve and the electrode it is necessary to provide guides for the electrode within the lower part of the sleeve in a vulnerable position near the tip of the electrode.

We have found a means of significantly reducing undesirable erosion of consumable electrodes in electric arc furnaces, and where applicable reducing or substantially preventing gas leakage between the electrodes and a furnace roof, whilst permitting a large range of vertical reciprocal movement of the electrode relative thereto, without either unduly stressing the furnace roof or obstructing replacement of consumable electrodes by the coupling of additional electrode elements to the top end of the electrode.

What constitutes the invention is defined in the following claim 1.

By using a sleeve depending from an electrode clamp, a useful degree of shielding and cooling of a vulnerable portion of the electrode is achieved, without in any way obstructing normal advance of the electrode through the clamp, and without obstructing vertical movement of the electrode. It is unnecessary to insulate the sleeve electrically from the electrode clamp, and unnecessary and undesirable to provide guides for the electrode within the sleeve.

Preferably, a furnace according to the invention further includes means for defining a passageway for the electrode through a roof of the furnace, the vertical extent of the sleeve being such that it will extend into the passageway throughout its normal range of movement. This provides some degree of restriction of the gap through which gases may pass around the electrode, and provides some shielding of the roof structure. Apart from the passageway-defining means, no additional load is applied to the furnace roof, and the arrangement is well adapted to the provision of a more effective electrode seal.

Preferably also an annular seal is provided sliding on the sleeve and providing a seal between the sleeve and the passageway-defining means when the sleeve extends into the latter. In one arrangement means can be provided retaining the seal on the external surface of the sleeve. In an alternative arrangement, the seal is captive at the top of the passageway-defining means and defines a tapered top entry thereto for the bottom end of the sleeve.

The invention will be further described in the accompanying drawingsin which:—

Figure 1 is a vertical section through an electric arc furnace incorporating electrode assemblies in accordance with a first embodiment of the invention;

Figure 2 is a fragmentary view on a larger scale showing additional detail of those portions of the electrode assemblies which differ from conventional practice;

Figure 3 is a fragmentary view on a still larger scale showing portions of the electrode assembly when the electrode is raised above its normal operating range of movements so as to permit swinging of the upper portion of the furnace to one side;

Figure 4 is a view of part of an electrode assembly in accordance with a second embodiment of the invention;

Figure 5 is a view corresponding to Figure 3 and showing the second embodiment;

Figure 6 is a view corresponding to Figure 4 and showing an electrode assembly in accordance with a third embodiment;

Figure 7 is a view corresponding to Figure 4 and showing a fourth embodiment;

Figure 8 is a view corresponding to Figure 3 and showing the fourth embodiment; and

Figure 9 is a fragmentary vertical section showing parts of a fifth embodiment.

Referring first to Figure 1, an illustrative electric arc furnace 2 is shown. Since however the features of the furnace other than the electrode assemblies form no part of the invention, they will not be described in detail. The furnace 2 has a roof 4, and a refractory lining 6 for containing a charge which may have a maximum melt level 8. Means (not shown) are provided for swinging the roof 4 and electrode assemblies relative to the furnace, for example so that a fresh charge may be introduced. To permit this, it will be apparent that electrode assemblies 10 must be raised to a level such that the lower tips 12 of electrodes 14 will clear the remainder of the furnace structure. The electrodes shown are convention consumable electrodes, formed by connecting standard electrode elements 16 end to end in vertical alignment. The electrodes pass through conventional electrode clamps 18 which releasably support the electrodes so that the string of electrode elements can be moved through the clamp to compensate for the erosion which occurs at tip 12 as the electrode is consumed. Each clamp also served to conduct current to the respective electrode. Particularly during the early stages of a melt, a substantial degree of up and down movement of electrodes may be necessary as an arc is struck and a desired current level maintained, and a further range of movement is necessary to accommodate erosion of the electrode between successive adjustments of the clamps 18. The clamps are supported, by means not shown, so as to provide this normal operating range of movement, together with the additional range of upward movement required when the roof of the furnace is to be swung as described above. To accommodate this movement the electrodes pass through apertures 20 in a central electrically insulative portion 22 of the furnace roof. Although only two electrodes are actually shown in Figure 1, there will normally be a group of three symmetrically placed electrodes, one for each phase of a three phase current supply.

Thus far, the elements described have been entirely conventional, and indeed it is a feature of the invention that it can readily be incorporated into existing furnace installations without major modification of the original structure of the latter. As compared with a conventional furnace structure, each electrode clamp supports a depending water cooled sleeve 24 which surrounds the portion of the electrode 14 beneath the clamp 18. The sleeve is supported from the electrode clamps by bolts 26, and a seal 28 is provided to prevent a through flow of gas between the sleeve and the electrode. The sleeve has water inlet and outlet connections 30 (only one is shown), and internal ribs 32 to strengthen the sleeve and guide the flow of water or alternative cooling fluid within the sleeve to provide effective cooling of the latter. The sleeve is preferably fabricated from non-magnetic stainless steel in order to resist corrosion and magnetically induced eddy currents. The vertical extent of the sleeve is such that during normal operation of the furnace, i.e. except during charging and initial start-up, it will at all times extend into the opening 20, as extended in this instance by a water cooled annulus 34 which is supplied with cooling water through connections 36 (again only one is shown). The annulus may also be fabricated from non-magnetic stainless steel.

In order to render unlikely the striking of an arc to the sleeve 24 and thus damaging it, and to minimize the adherence to the sleeve of material spattered within the furnace, the lower end of the sleeve ends well short of the lower end of the electrode. In practice, the extent of the sleeve should be such that it will never extend down to arcing proximity of a level at which conductive material is found in the furnace. This level will be above the maximum melt level 8 in the furnace by an amount depending on how "quietly" the furnace operates and the nature of the furnace charge. For example, in a furnace used for melting steel scrap, unmolten metallic material could contact the electrode substantially above the melt level, and the same could occur in other operations in which there is violent activity within the furnace.

Even this limited degree of shrouding provides very important advantages. Although the sleeve is dimensioned so that it is loose on the electrode and preferably spaced from it so that it will not obstruct longitudinal movement of the electrode 14 through the clamp 18, it will shroud the electrode sufficiently to eliminate any substantial sidewall oxidation of the electrode within the sleeve, and will provide significant cooling of this portion of the electrode. Even without the sealing arrangement to be described below, the sleeve will also act to restrict the flow of gases through the opening 20, and will shield the electrode from this flow.

The provision of the sleeve moreover makes it particularly easy to provide sealing of the opening 20 in a manner which will not obstruct upward movement of the electrode beyond its normal range of movement when it is desired to swing the furnace roof 4. As best seen in Figure 2, a metallic sealing ring 40 rests on a seating formed by the annulus 34 and supports a high temperature seal element 42, for example of silica fibre, in sliding contact with the outer surface of the sleeve 24, so as to maintain a substantially gas-tight seal throughout the normal range of movement of the electrodes, this range being illustrated by the electrode assemblies shown in the right and left hand sides respectively of Figures 1 and 2. Since the seal elements slide on the water cooled surface of the sleeve 24, problems that would otherwise occur in maintaining a seal with the hot, rough and irregular surface of the electrode itself are eliminated. The annulus 34 not only provides a seating for the ring 40, but also defines the opening 20 and protects the fabric of the furnace roof.

In order to provide for additional upward movement of the electrode, the sleeve is provided with a lip 44 at its lower end, which engages the sealing ring 40 and lifts it clear of the annulus 34 as shown in Figure 3. The loss of sealing at this stage is not important, since it will usually occur only during short parts of the furnace operating cycle. The ability of the sealing ring 40 to lift from the annulus 34 will also prevent the seal 42 from being damaged should foreign matter adhere to the exterior of the sleeve 24.

In some instances it may be desirable to extend the annulus 34 vertically to provide arrangements such as those shown in Figures 4, 5 and 6. In Figure 4, the annulus 34 is replaced by a water cooled sleeve in portions 46 and 48. The portion 46 extends through the opening 20, and defines a passageway sufficiently long to shroud the sleeve 24 even when the latter is in its lowermost position. The external surface of the portion 46 of the sleeve extending into the furnace has a refractory coating 50. Such an arrangement may be necessary in some cases to shield the sleeve 24 from exceptionally severe spattering within the furnace. The portion 48 provides an upward extension of the opening 20 which reduces the extent to which the sleeve 24 needs to project within the furnace. The arrangement of Figures 4 and 5 has the disadvantage that it applies additional loading to the furnace roof, and the simplified arrangement using an annulus 34, or a shorter sleeve 52 as shown in Figure 6, will often be adequate.

It should also be understood that not all electric arc furnaces even have a roof, and in the absence of such a roof, the annulus or sleeve is of course not required.

Referring now to Figures 7 and 8, an alternative form of seal 54 is illustrated, which remains captive on the upper portion 56 of two water cooled sleeve portions 56, 58 defining the passage 20 through the furnace roof. The seal comprises an annular seal member 60 defining a frusto-conical passage, the narrow end of which will just pass the sleeve 24. The seal member rest on an annular bearing pad 62 within a holder 64 within which the seal member is urged towards a centred position by locating pins 66 and spring 68. The sleeve 24, which in this case lacks a lip 44, can withdraw from the member 60 when it is desired to lift the electrode beyond their normal range of movement. The tapered opening at the top of the element 60, and the centering action of the springs 68, assist the sleeve to re-enter the seal 60 when the electrode is lowered. Since the interengaging parts are water cooled and shielded from the heat of the furnace, a fairly small clearance is permissible between the seal 60 and the sleeve 24.

Particularly where accumulation of foreign matter on the sleeve 24 is a problem, the arrangement shown in Figure 9 may be preferred. Here a seal assembly is mounted on the annulus 34 (see Figures 1 and 2), and comprises a plurality of hinged segments 70 (only one is shown), connected by hinges 72 to a mounting ring 74 supported on the annulus 34. Each segment carries at its inner end a graphite sealing element 76 which is urged inwardly and upwardly towards the sleeve 24 by a counterweight 80 at the outer end of the segment. The sealing element can, because of its hinged mounting, ride over obstructions on the surface of the sleeve 24 as the electrode moves up and down. The geometry of the arrangement precludes a perfect seal as the segments hinge independently, but a large measure of control can nevertheless be exercised over gas flow into or out of the furnace.

Claims

1. An electric furnace (2) including a vertically movable electrode assembly (10) comprising a consumable electrode (14) consisting of a plurality of consumable electrode elements (16) coupled end to end in vertical alignment, an electrode clamp (18) gripping, surrounding and passing current to said electrode (14) at a level on the electrode (14) which will be above said furnace (2) throughout the range of movement of said electrode (14), and a fluid-cooled sleeve (24) extending downwardly from the electrode clamp (18) around the electrode (14), the electrode (14) being loosely shrouded by the sleeve (24) and the sleeve (24) having a gas tight connection to the electrode clamp (18) to prevent flow of gas between the sleeve (24) and the electrode (14), characterised in that the sleeve (24) is fixed to the electrode clamp (18) so as to prevent the flow of gas between the sleeve (24) and the electrode (14), and depends from the clamp (18) into the furnace (2), the vertical extent of the sleeve (24) below the clamp (18) being such that its lower end is located within the furnace (2) throughout the range of vertical movement of the assembly (10) occurring during normal operation of the furnace (2), so that the sleeve (24) ends short of arcing proximity of the highest anticipated level at which conductive material will occur within the furnace (2).

2. A furnace (2) according to claim 1, with an electric arc furnace having a roof (4) characterised by fluid-cooled means (34: 46, 48: 56, 58: 52) for defining a passageway (20) for the electrode (14) through the furnace roof (4), the vertical extent of the sleeve (24) being such that it will extend into said passageway (20), throughout its normal range of movement during operation of the furnace (2) and beneath said passageway (20) during at least part of said range of movement.

3. A furnace (2) as claimed in claim 2, characterised by an annular seal (40, 42) being provided sliding on the sleeve (24) and providing a seal between the sleeve (24) and the passageway-defining means.

4. A furnace (2) as claimed in claim 3, characterised in that means (68, 80) is provided retaining the seal (40, 42: 60: 76) on the external surface of the sleeve (24).

5. A furnace (2) as claimed in claim 4 characterised in that the seal comprises an annular sealing ring (40) which normally rests on a seating on top of the passageway-defining means (34), and an annular sealing element (42) supported by the ring (40), and wherein a lip (44) is provided on the external surface of the sleeve (24) to limit its upward withdrawal through the ring (40).

6. A furnace (2) as claimed in claim 3, characterised in that the seal (54: 70, 76) is captive at the top of the passageway-defining means (34) and defines a tapered top entry thereto for the bottom end of the sleeve (24).

7. A furnace (2) as claimed in claim 6, characterised in that the seal (54) comprises an annular holder (64) supported by and concentric with the passageway-defining means (56, 58), an annular seal ring (60) within the holder (64) and defining a central opening from top to bottom, and means (66, 68) within the holder (64) urging the seal ring (60) towards a centred position.

8. A furnace (2) as claimed in claim 6, characterised in that the seal comprises a plurality of segments (70) individually hinged around the periphery of the passageway-defining means (34, 74), each segment (70) having a counterweight (80) outwardly of its hinge (72), and a seal element (76) inwardly of its hinge (72) such that the seal elements (76) are tapered inwardly and upwardly against the sleeve (24).

9. A furnace (2) according to claim 2, characterised in that the passageway-defining means comprises a fluid cooled sleeve (48, 56) which extends substantially upwardly above the furnace roof (4).

10. A furnace (2) according to claim 2, characterised in that the passageway-defining means comprises a fluid cooled sleeve (46) which extends substantially downwardly below the furnace roof (4).

11. A furnace (2) according to claim 2, characterised in that the passageway-defining means comprises a fluid cooled sleeve (46, 48) of sufficient extent substantially to shroud the sleeve (24) extending from the electrode clamp (18) from the interior of the furnace throughout the normal range of electrode movement.

Patentansprüche

1. Elektrischer Ofen (2), umfassend eine vertikal bewegliche Elektrodenvorrichtung (10), die eine abschmelzbare Elektrode (14) bestehend aus einer Vielzahl abschmelzbarer Elektrodenelemente (16) aufweist, die in vertikaler Ausrichtung Ende an Ende miteinander verbunden sind, eine Elektrodenfassung (18), die die genannte Elektrode (14) hält, umgibt und Strom an diese in einer Höhe an der Elektrode (14) weiterleitet, die über den gesamten Bewegungsbereich der genannten Elektrode (14) oberhalb des genannten Ofens (2) liegt, und eine hydraulisch gekühlte

Hülse (24), die von der Elektrodenfassung (18) nach unten um die Elektrode (14) herum verläuft, wobei die Elektrode (14) von der Hülse (24) lose umschlossen ist und die Hülse (24) eine gasdichte Verbindung mit der Elektrodenfassung (18) aufweist, um einen Gasstrom zwischen der Hülse (24) und der Elektrode (14) zu verhindern, dadurch gekennzeichnet, daß die Hülse (24) an der Elektrodenfassung (18) befestigt ist, um den Gasstrom zwischen der Hülse (24) und der Elektrode (14) zu verhindern, und von der Fassung (18) in den Ofen (2) hinunterhängt, wobei der vertikale Verlauf der Hülse (24) unter die Fassung (18) so ist, daß sich deren unteres Ende über den vertikalen Bewegungsbereich der Vorrichtung (10) während des normalen Betriebs des Ofens (2) innerhalb des Ofens (2) befindet, so daß die Hülse (24) nahe der Überschlagsannäherung des höchsten voraussehbaren Niveaus endet, an dem sich leitendes Material innerhalb des Ofens (2) befindet.

2. Ofen (2) nach Anspruch 1 mit einem einen Deckel (4) aufweisenden elektrischen Lichtbogenofen, gekennzeichnet durch eine hydraulisch gekühlte Vorrichtung (34: 46, 48: 56, 58: 52) zur Bildung eines Kanals (20) für die Elektrode (14) durch den Ofendeckel (4), wobei die Hülse (24) in vertikaler Richtung so verläuft, daß sie während des Betriebs des Ofens (2) über ihren normalen Bewegungsbereich in den genannten Kanal (20) hinein und über wenigstens einen Teil des genannten Bewegungsbereiches bis unter den genannten Kanal (20) ragt.

3. Ofen (2) nach Anspruch 2, gekennzeichnet durch eine kreisrunde Dichtung (40, 42), die verschiebbar auf der Hülse (24) angeordnet ist und eine Dichtung zwischen der Hülse (24) und der den Kanal bildenden Vorrichtung bildet.

4. Ofen (2) nach Anspruch 3, dadurch gekennzeichnet, daß eine Vorrichtung (68, 80) vorgesehen ist, die die Dichtung (40, 42: 60: 76) an der Außenfläche der Hülse (24) hält.

5. Ofen (2) nach Anspruch 4, dadurch gekennzeichnet, daß die Dichtung einen kreisrunden Dichtungsring (40) aufweist, der normalerweise auf einem Sitz auf der Oberseite der den Kanal bildenden Vorrichtung (34) ruht, sowie ein durch den Ring (40) gestütztes kreisrundes Dichtungselement (42), und daß ein Finger (44) auf der Außenfläche der Hülse (24) vorgesehen ist, um deren Rückzug nach oben durch den Ring (40) zu begrenzen.

6. Ofen (2) nach Anspruch 3, dadurch gekennzeichnet, daß die Dichtung (54: 70, 76) auf der Oberseite der den Kanal bildenden Vorrichtung (34) gesichert ist und dazu einen konischen oberen Eingang für das untere Ende der Hülse (24) bildet.

7. Ofen (2) nach Anspruch 6, dadurch gekennzeichnet, daß die Dichtung (54) eine kreisrunde, von der den Kanal bildenden Vorrichtung (56, 58) getragene und mit dieser konzentrische Halterung (64), einen kreisrunden Dichtungsring (60) innerhalb der Halterung (64), der eine zentrale Öffnung von oben nach unten bildet, sowie eine Vorrichtung (66, 68) innerhalb der Halterung (64) aufweist, die den Dichtungsring (60) in eine mittlere Position drängt.

8. Ofen (2) nach Anspruch 6, dadurch gekennzeichnet, daß die Dichtung eine Vielzahl von Segmenten (70) umfaßt, die einzeln um den Umfang der den Kanal bildenden Vorrichtung (34, 74) herum angelenkt sind, wobei jedes Segment (70) außerhalb seiner Angel (72) ein Gegengewicht (80) und ein Dichtungselement (76) innerhalb seiner Angel (72) aufweist, so daß die Dichtungselemente (76) nach innen und nach oben konisch auf die Hülse (24) zulaufen.

9. Ofen (2) nach Anspruch 2, dadurch gekennzeichnet, daß die den Kanal bildende Vorrichtung eine hydraulisch gekühlte Hülse (48, 56) umfaßt, die im wesentlichen nach oben über den Ofendekkel (4) verläuft.

10. Ofen (2) nach Anspruch 2, dadurch gekennzeichnet, daß die den Kanal bildende Vorrichtung eine hydraulisch gekühlte Hülse (46) umfaßt, die im wesentlichen nach unten den Ofendeckel (4) verläuft.

11. Ofen (2) nach Anspruch 2, dadurch gekennzeichnet, daß die den Kanal bildende Vorrichtung eine hydraulische gekühlte Hülse (46, 48) umfaßt, die ausreichend lang ist, um die Hülse (24), die von der Elektrodenfassung (18) vom Ofeninneren durch den normalen Bereich der Elektrodenbewegung verlaüft, weitgehend zu umschließen.

Revendications

1. Four électrique (2) comprenant un ensemble d'électrode (10) mobile verticalement, qui comprend une électrode consommable (14) constituée de plusieurs éléments d'électrode consommable (16) réunis bout à bout en ligne dans le sens vertical, un dispositif de serrage d'électrode (18) agrippant l'électrode (14), l'entourant et lui amenant du courant, à un niveau situé au-dessus du four (2) pendant la totalité de la course de l'électrode (14), et un fourreau refroidi par fluide (24) qui s'étend vers le bas du dispositif de serrage (18) autour de l'électrode (14), l'électrode (14) étant protégée lâchement par le fourreau (24) qui est relié d'une manière étanche aux gaz au dispositif de serrage d'électrode (18) pour empêcher le passage de gaz entre le fourreau (24) et l'électrode (14), caractérisé en ce que le fourreau (24) est fixé au dispositif de serrage d'électrode (18) de manière à empêcher le passage de gaz entre le fourreau (24) et l'électrode (14) s'étend vers le bas à partir du dispositif de serrage (18) et à l'intérieur du four (2), l'extension verticale du fourreau (24) en dessous du dispositif de serrage (18) étant telle que son extrémité inférieure soit située dans le four (2) pendant la totalité de la course verticale de l'ensemble d'électrode (10) qui est parcourue pendant un fonctionnement normal du four (2), de telle sorte que ce fourreau (24) se termine à une distance du plus haut niveau escompté de la matière conductrice dans le four (2) supérieure à la distance de jaillissement de l'arc.

2. Four (2) suivant la revendication 1, compre-

nant un four électrique à arc comportant un ciel (4), caractérisé par des moyens refroidis par fluide (34: 46, 48: 56, 58: 52) pour définir un passage (20) pour l'électrode (14) à travers le ciel (4) du four, l'extension verticale du fourreau (24) étant telle qu'il s'étende dans le passage (20), pendant la totalité de sa course normale au cours du fonctionnement du four (2) et en dessous de ce passage (20), pendant au moins une partie de cette course.

3. Four (2) suivant la revendication 2, caractérisé par un élément d'étanchéité annulaire (40, 42) prévu coulissant sur le fourreau (24) et établissant un joint d'étanchéité entre le fourreau (24) et les moyens définissant le passage.

4. Four (2) suivant la revendication 3, caractérisé en ce que des moyens (68, 80) sont prévus pour retenir l'élément d'étanchéité (40, 42: 60: 76) sur la surface externe du fourreau (24).

5. Four (2) suivant la revendication 4, caractérisé en ce que l'élément d'étanchéité comprend un anneau d'étanchéité (40) qui repose normalement sur un siège prévu sur le dessus du moyen (34) définissant le passage et un élément d'étanchéité annulaire (42) supporté par l'anneau (40), une lèvre (44) étant prévue sur la surface externe du fourreau (24) pour limiter son mouvement de retrait vers le haut à travers l'anneau (40).

6. Four (2) suivant la revendication 3, caractérisé en ce que l'élément d'étanchéité (54: 70, 76) est captif à l'extrémité du moyen (34) définissant le passage et définit une entrée supérieure tronconique du passage pour l'extrémité inférieure du fourreau (24).

7. Four (2) suivant la revendication 6, caractérisé en ce que l'élément d'étanchéité (54) comprend un support annulaire (64) supporté par le moyen (56, 58) définissant le passage et concentrique à celui-ci, un anneau d'étanchéité (60) prévu dans le support (64) et définissant une ouverture centrale du haut vers la bas, et des moyens (66, 68) dans le support (64) sollicitant l'anneau d'étanchéité (60) vers une position centrée.

8. Four (2) suivant la revendication 6, caractérisé en ce que l'élément d'étanchéité comprend plusieurs segments (70) montés à pivot individuellement autour de la périphérie des moyens (34, 74) définissant le passage, chaque segment (70) comportant un contrepoids (80) extérieurement à son pivot (72) et un élément d'étanchéité (76) intérieurement à son pivot (72) de sorte que les éléments d'étanchéité (76) sont sollicités vers l'intérieur et vers le haut contre le fourreau (24).

9. Four (2) suivant la revendication 2, caractérisé en ce que le moyen définissant le passage comprend une gaine refroidie par fluide (48, 56) qui s'étend en substance vers le haut au-dessus du ciel de four (4).

10. Four (2) suivant la revendication 2, caractérisé en ce que le moyen définissant le passage comprend une gaine refroidie par fluide (46) qui s'étend en substance vers le bas en dessous du ciel de four (4).

11. Four (2) suivant la revendication 2, caractérisé en ce que le moyen définissant le passage comprend une gaine refroidie par fluide (46, 48) d'une extension suffisante pour protéger en substance le forreau (24) partant du dispositif de serrage d'électrode (18) contre l'intérieur du four, pendant la totalité de la course normale de l'électrode.

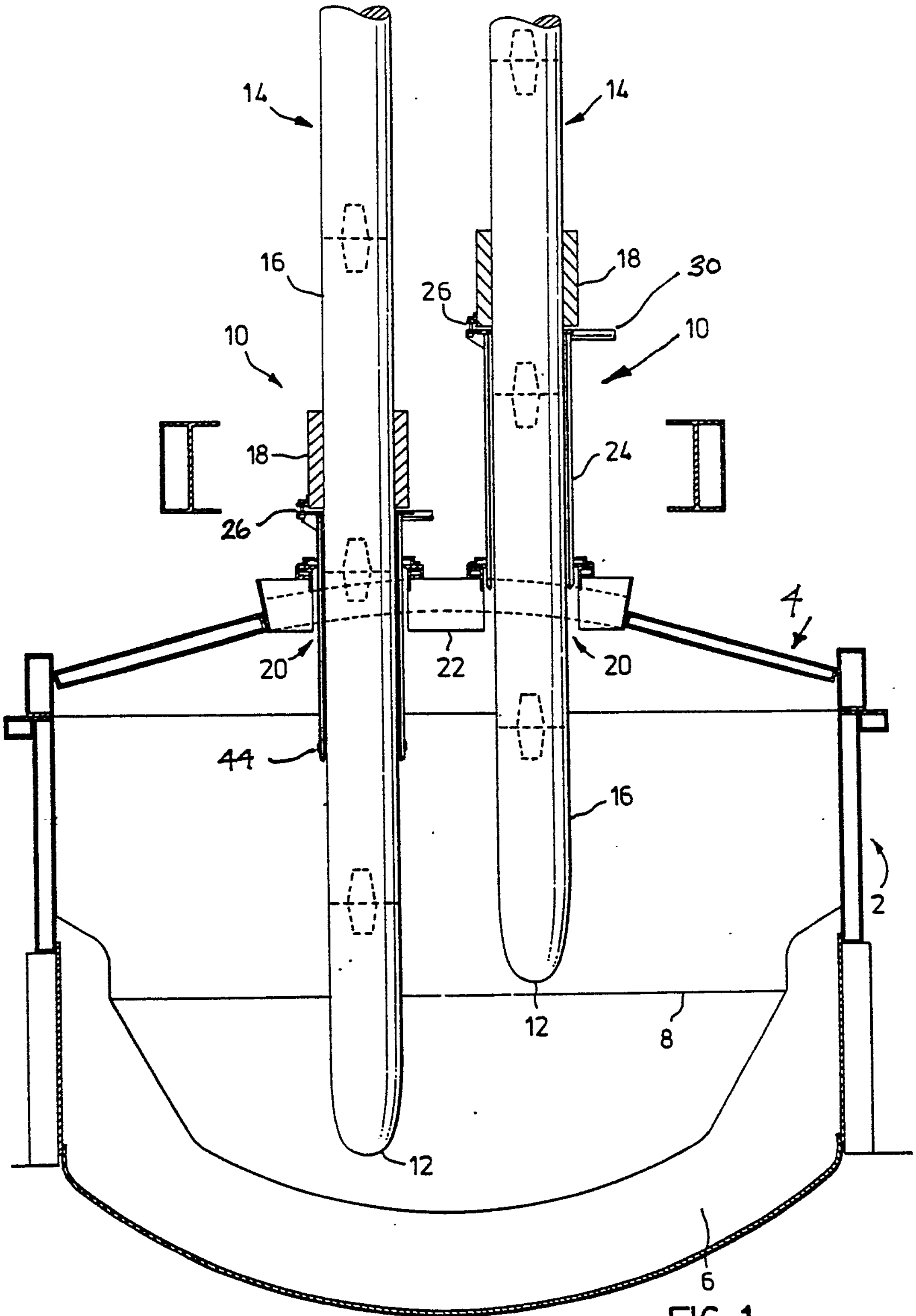

FIG. 1

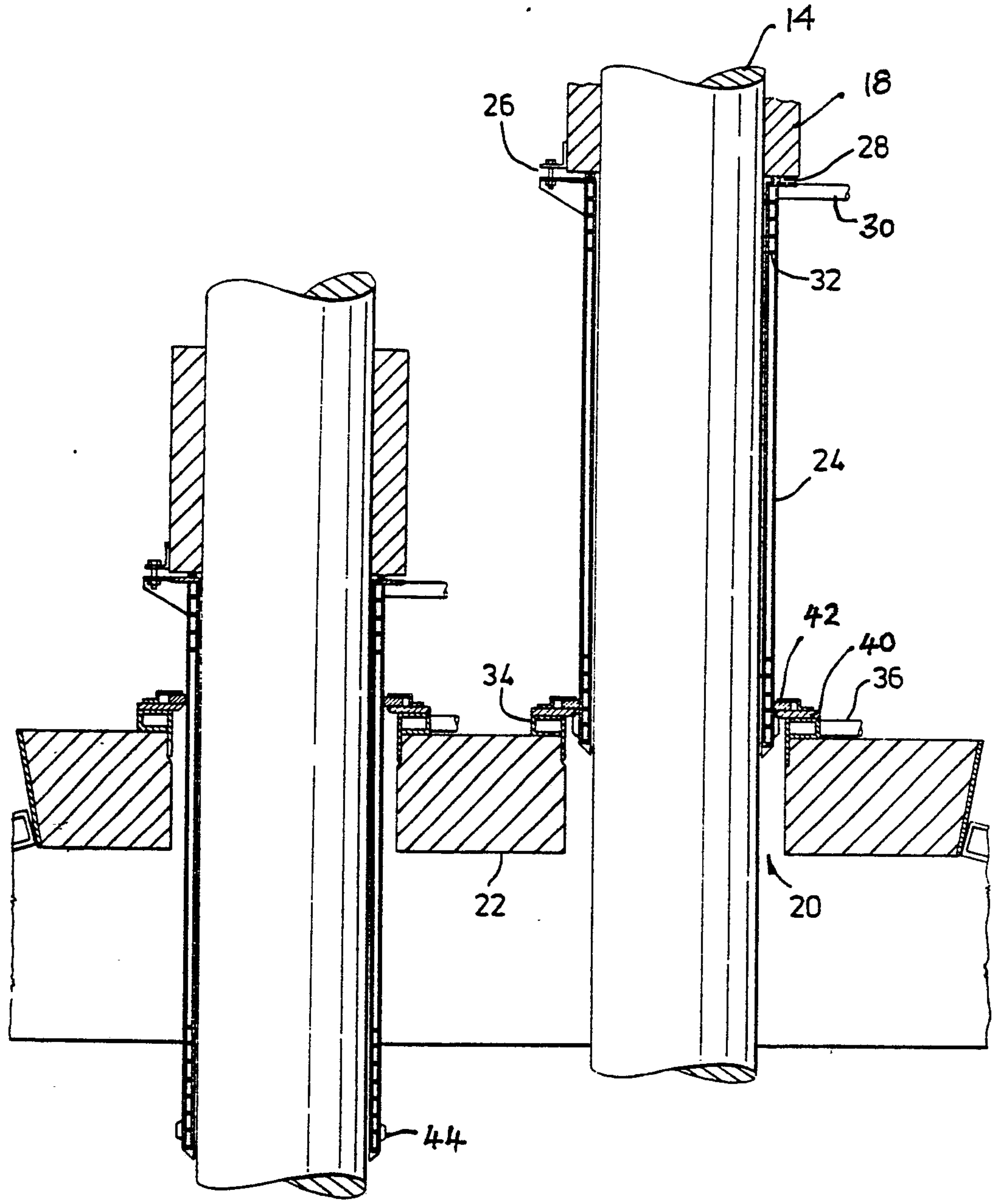

FIG. 2

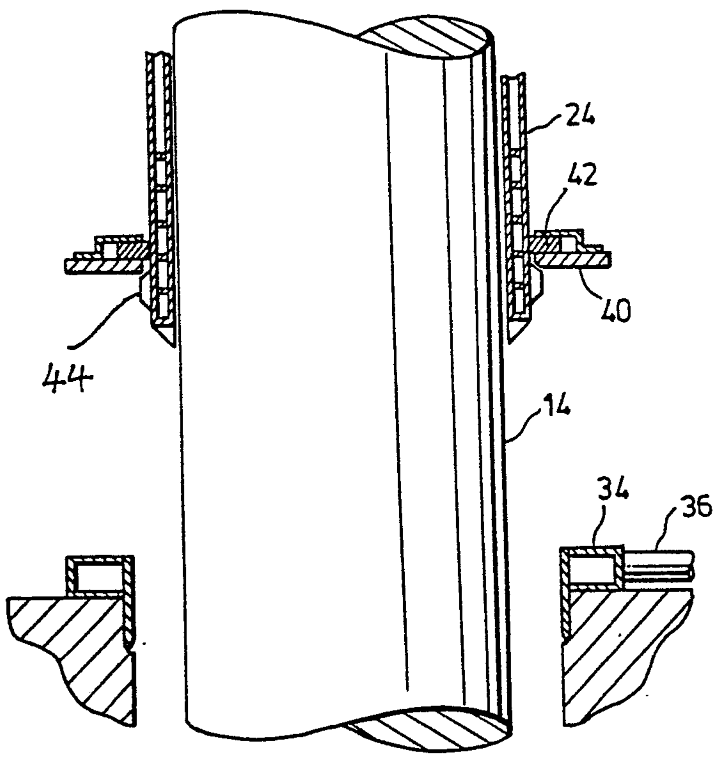

FIG. 3

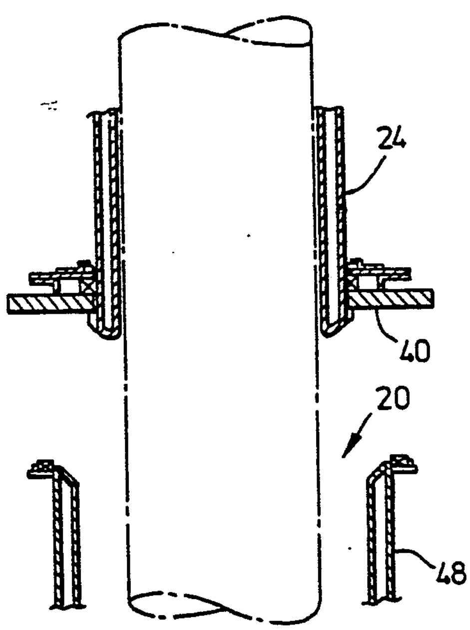

FIG. 5

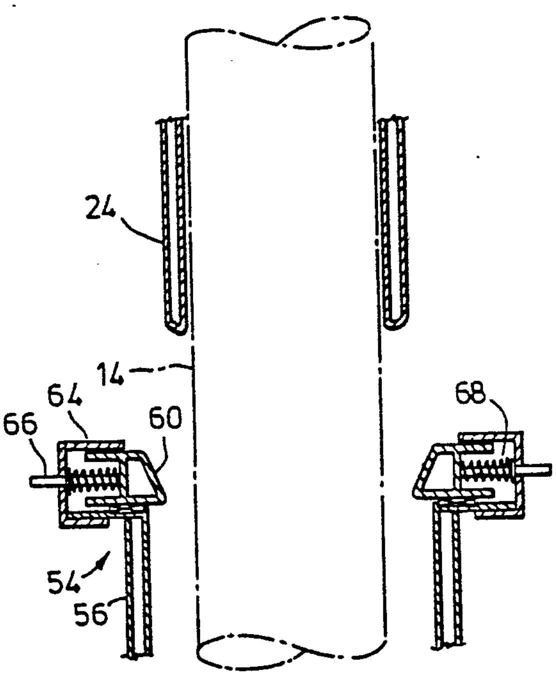

FIG. 8

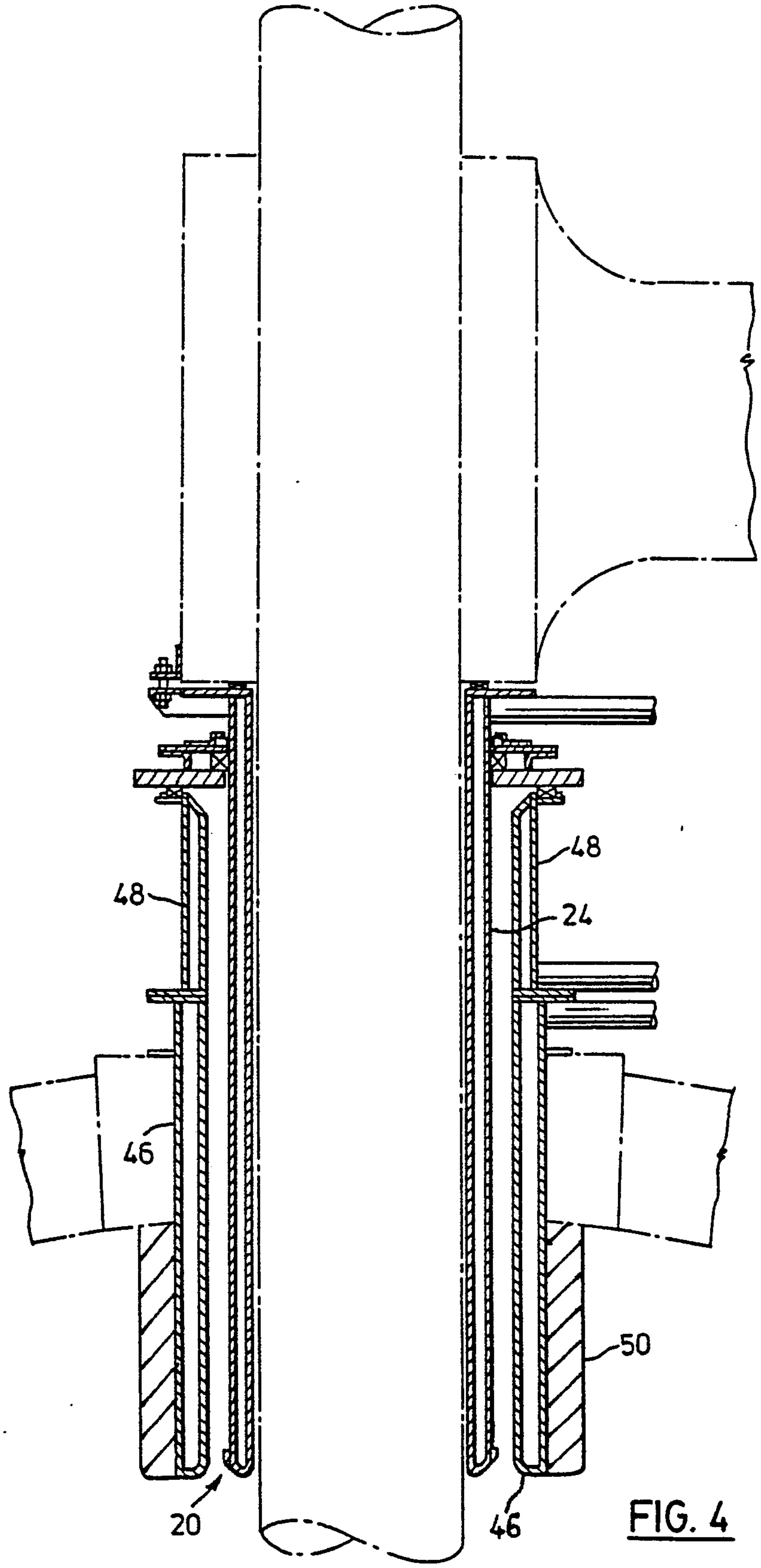

FIG. 4

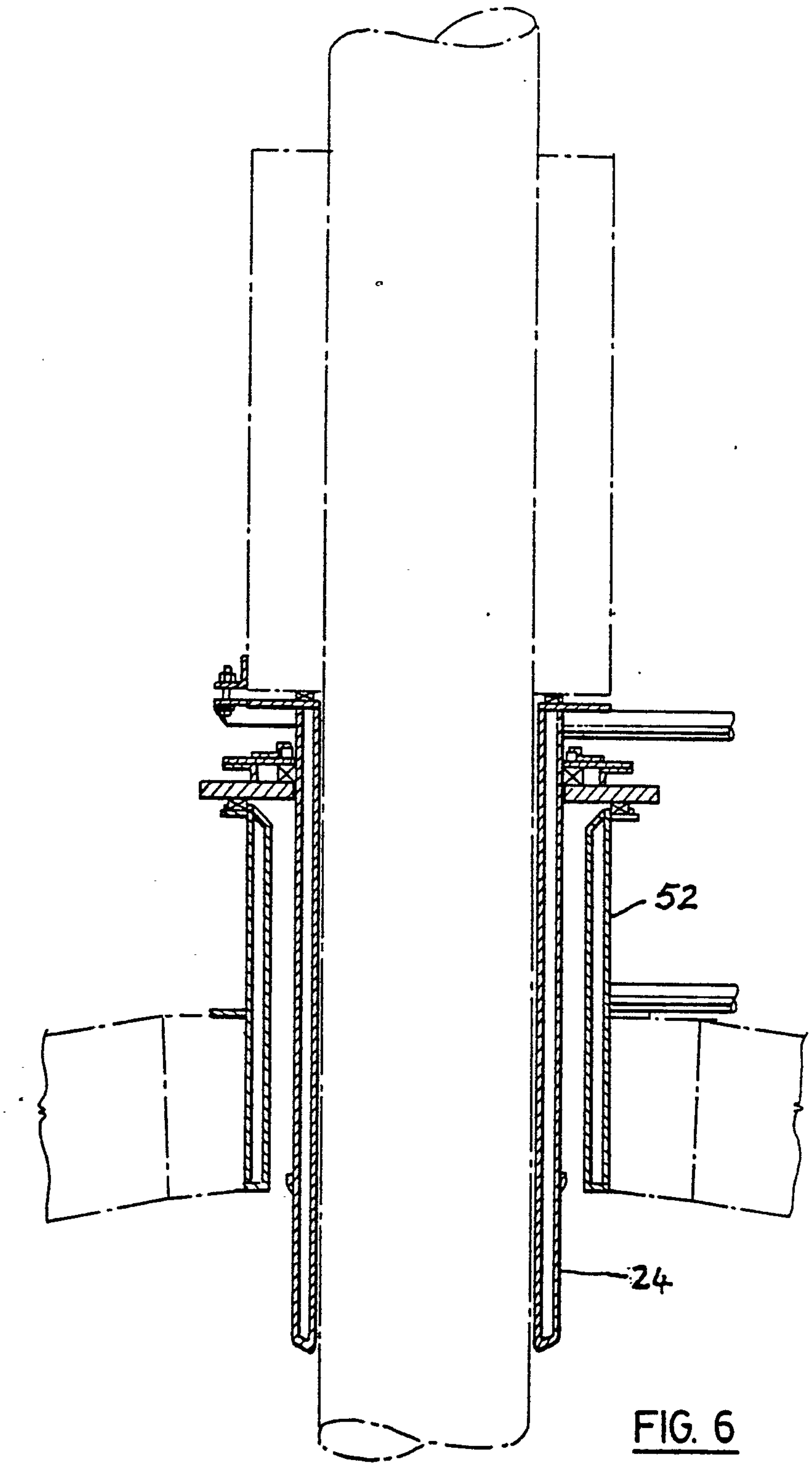

FIG. 6

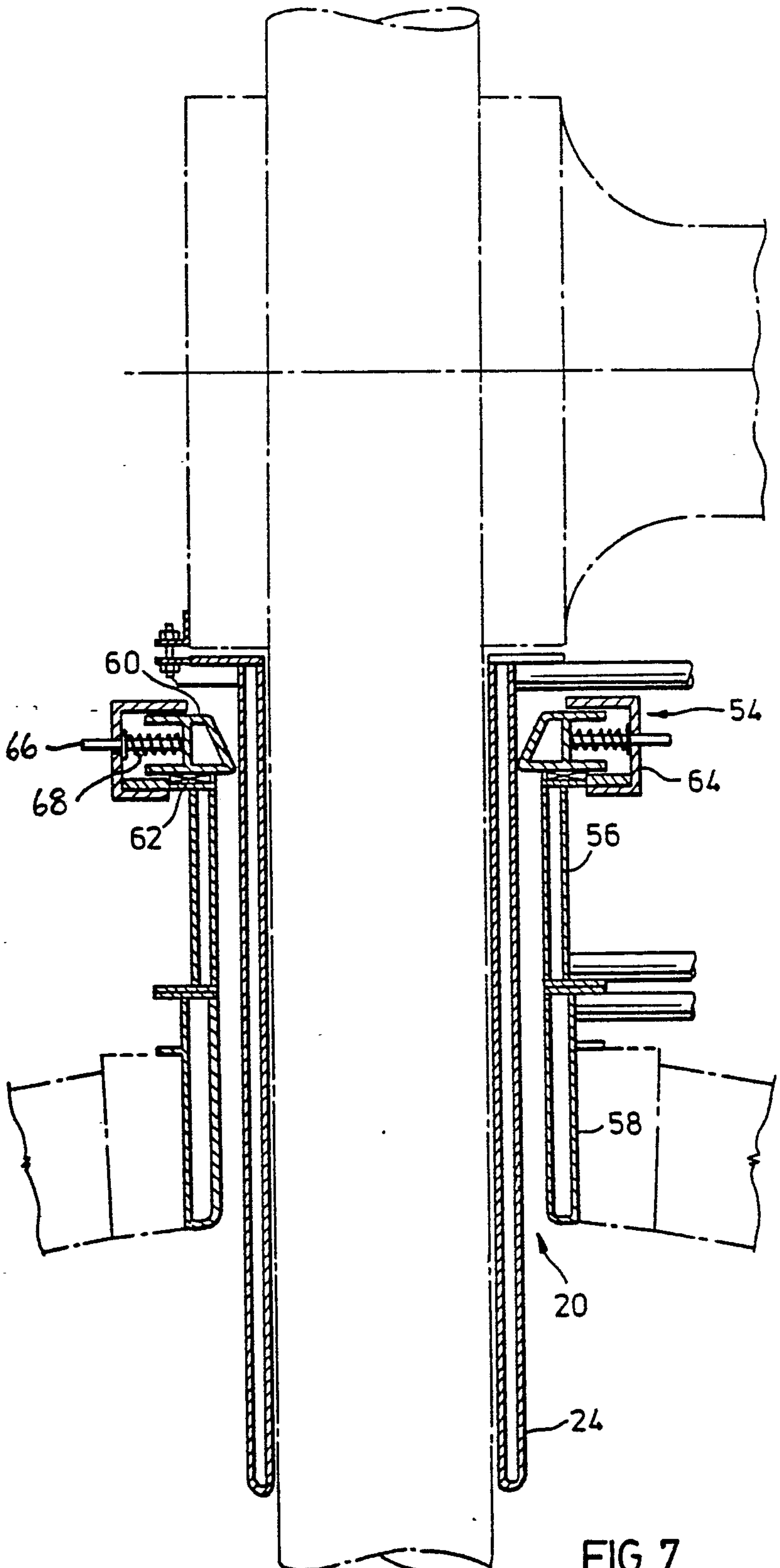

FIG. 7

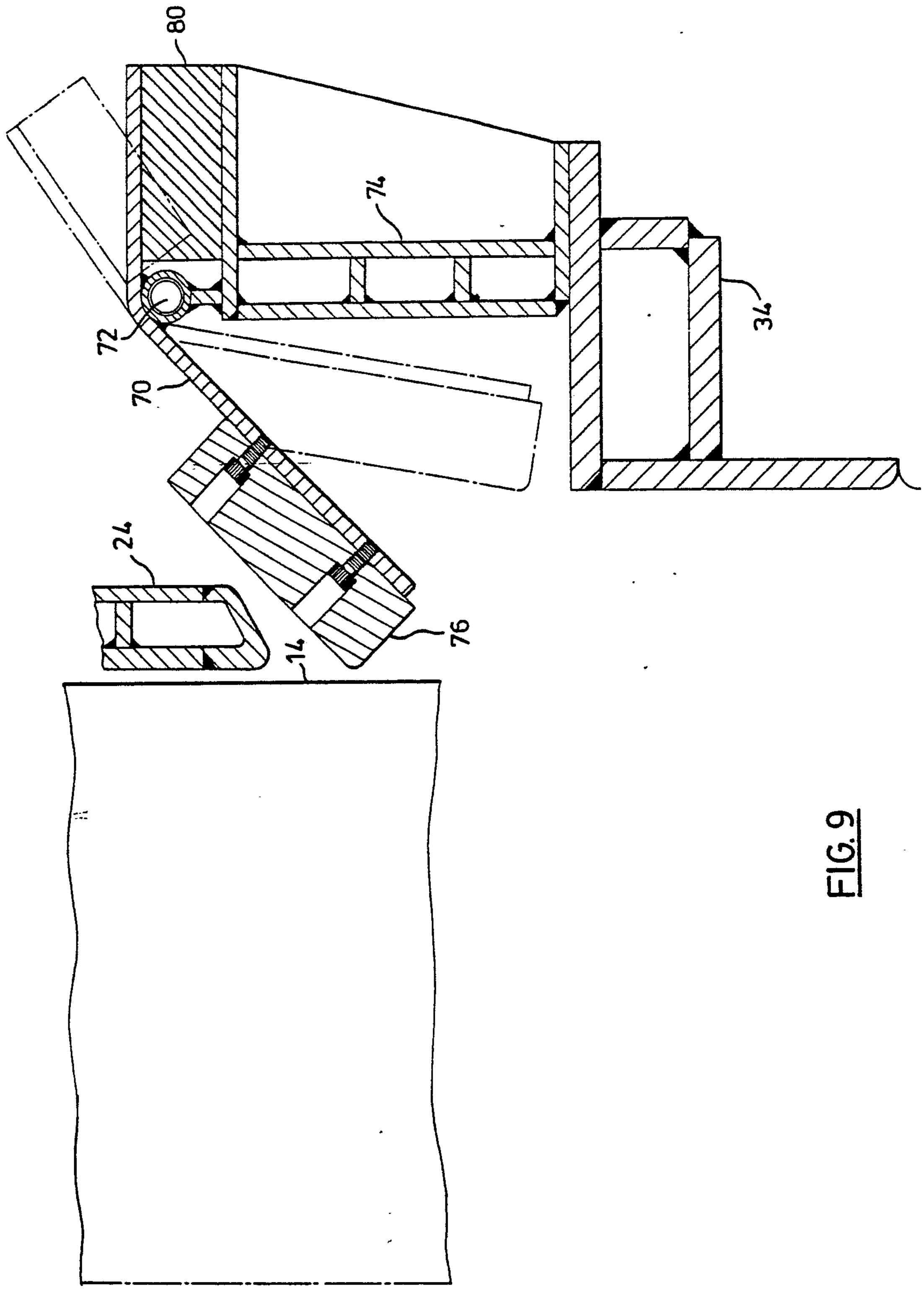

FIG.9