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(54) Rotary cutter assembly.

(57) The application discloses a method and an apparatus for perforating thermoplastic tube (10), especially corrugated tube. The cutter includes one or more spindles (12) that carry punch-type cutters (14) and are revolved around the tube (10) so that the punches (14) follow epicycloids (E) with cusps (P) at the surface of the tube. The punches (14) thus penetrate the tube without tangential movement. The spindles are equipped with ribs (34) to engage the corrugations (11) of the tube (10) to advance the tube through the apparatus.

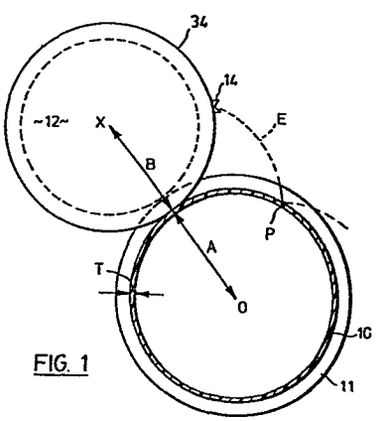

FIG. 1

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The present invention relates to the perforating of tubes, and particularly to the perforating of thermoplastic tubes at spaced points. The perforated tubes may be used in underground drainage applications. They may be formed with annular or helical corrugations.

According to one aspect, the present invention is concerned with a method of perforating a tube by advancing the tube along a feed path and perforating the tube at spaced points with a punch.

Punching methods of the type in question permit the production of perforations of various controlled shapes and sizes. However, the known punching methods, for example those disclosed in DE-OS 1778094 and 1779579 cannot work at high production speeds. This contrasts with methods in which circumferential slots are cut in the tube, as with rotary cutters. Reference may be made, for example to US-PS3824886, 3957386 and 4180357 for methods of this type. Slot cutting methods can be carried out at high speed, but cannot produce holes of varying shapes. Hole size control can also be a problem when pipe dimensions are not perfectly uniform.

According to this aspect of the present invention there is provided a method of perforating a tube comprising the steps of advancing the tube along a feed path and revolving a punch about the tube in an epicycloidal path such that the punch perforates the tube at cusps of the epicycloidal path.

According to another aspect, the present invention relates to an apparatus for perforating a tube according to the above method.

According to this aspect of the present invention, there is provided in an apparatus for perforating a tube, a punch and means for revolving the punch about the tube in an epicycloidal path such that the punch perforates the tube at cusps of the epicycloidal path.

In the accompanying drawings, which illustrate an exemplary embodiment of the present invention.

Figure 1 is a schematic illustration showing the position of a punch on a tool holder and a portion of the path of the punch with respect to a tube to be perforated;

Figure 2 is a sectional side elevation, taken on line 2-2 in Figure 3 of an apparatus for perforating corrugated tubing;

Figure 3 is a section on line 3-3 in Figure 2;

Figures 4 and 5, located on the same sheet on Figure 1, are of front and side views, partly in section, of a punch for use in the apparatus of Figures 1 and 2;

Figure 6, located on the same sheet as Figure 3, is a partly sectional schematic showing the punch as it perforates the wall of a tube; and

Figure 7, located on the same sheet as Figure 2, illustrates a length of corrugated tube after being perforated.

Referring to the drawings, Figure 1 illustrates a cross section of a tube 10 with a central axis O. The tube 10 is corrugated, having a wall thickness T in the troughs between the peaks 11. The external radius of the tube at the troughs is A.

A cutter for perforating the tube includes a tool holder in the form of a cylindrical spindle 12 with a portion 34 of radius B tangential to the tube 10 at the base of the illustrated trough. A punch 14 is mounted on the portion 34 and projects radially a distance slightly greater than the tube wall thickness T. The spindle 12 rotates about its axis X causing the punch 14 to rotate about the axis X. The spindle is in turn caused to revolve in a circular path about the central axis O of the tube. The ratio of the angular velocity of the toolholder about axis X to the angular velocity of axis X about axis O is A:B. This means that the portion 34 of the spindle 12 rolls about the tube 10 on a circle of radius A and the punch is caused to follow an epicycloidal path E having a cusp which engages the surface of the tube at point P.

At the point P, the punch 14 perforates the wall of the tube 10 to form an aperture without exerting a tangential force on the tube.

In the embodiment schematically illustrated in Figure 1, the radii A and B are equal so that the angular velocities of the tool 14 about axis X and of axis X about axis O are equal. The epicycloidal path E is a cardoid with a single cusp. In other embodiments, the radii A and B may not be equal. They are preferably in a simple whole number ratio e.g. 1:2, 2:1 or 3:1. In any event, even if the radii A and B are not in a simple whole number ratio, the angular velocities are in the ratio A:B to produce the desired epicycloidal path.

In Figure 1, a single cutter is shown for simplicity of illustration. In the apparatus illustrated in Figures 2 and 3, three cutters are disposed symetrically about the tube. In alternative embodiments, other numbers of cutters may be employed.

Referring more specifically to Figures 2 and 3, the apparatus illustrated includes a housing 15 with end walls 16 and 17. End wall 17 has a central circular opening 19 for receiving a pipe to be perforated. The end wall 16 has a larger circular opening that is aligned with the opening 19 and has a counterbore on the outside. A ball bearing 22 is fitted into the counterbore and is retained in position by an end cover 22a. The bearing 22 carries the cylindrical sleeve of an adaptor 20. The adaptor 20 also has a circular flange fastened to the side face of a sheave 29 by cap screws 29a. The adaptor 20 and sheave 29 have a through bore 18 that is the same size as the opening 19 in end wall 17 and aligns with that opening so that a tube 10 may pass into and out of the apparatus through the openings 18 and 19.

A stationary ring gear 21 is secured to the inside face of wall 17 by bolts 21a. The gear is aligned with the opening 19 so that the tube 10 can pass through the gear. The hub of the gear 21 carries a ball bearing 23,

which in turn supports a gear housing 25. The housing is sealed to the gear 21 by seals 25a and 25b.

The gear housing 25 carries three shafts 26a parallel to the gear 21. A pinion 26 is keyed to each of the shafts 26a and meshes with the teeth 24 of the ring gear 21. Each shaft 26a also carries a gear 26b.Three idler gears 28 carried by the housing 25 mesh with the gears 26b.

Three drive bars 30 (one shown) extend between the gear housing 25 and the sheave 29. The bars are secured to both the housing and the sheave so that these parts rotate as a unit.

Also extending between the gear housing 25 and the sheave 29 are three spindles 33. At one end each spindle shaft extends into the gear housing 25 and is keyed to a gear 27 meshing with a respective one of the idlers at 28. The other end of the spindle shaft is mounted on the sheave 29 by ball bearing 33A.

Between the gear housing 25 and sheave 29 each of the spindles 33 has an enlarged cylindrical section 34 that serves as a tool holder. This section 34 carries a helical rib 35 on its outer surface and a punch at the location indicated by the circle Y. The punch will be described in more detail in connection with Figures 4 and 5.

A drive shaft 32 extends through the housing 15, parallel to the tube 10. It is mounted in bearings 32a and 32b in the end walls 16 and 17 respectively. The shaft 32 carries sheave 40 aligned with sheave 29. Sheave 40 drives sheave 29 through a series of V belts 31.

As mentioned above, the punch is more clearly illustrated in Figures 4 and 5. As illustrated in those figures, the body 34 of the spindle 33 has a stepped bore 37a aligned with the rib 35. A cylindrical body 37 of the punch fits into the bore 37a and is held in place by a cap screw 38 extending into the bore 37a from the opposite side and threaded into a bore in the inner end of body 37. The

punch has a cutting head 36 with V shaped cutting edge for cutting rectangular slots in the tube. The punch is shown in Figure 6 engaged with the wall of the tube 10 and piercing the tube in the desired manner. Figure 7 illustrates an helically corrugated tube 10 with slots 40 produced by the punch.

In operation of the apparatus, the drive shaft 32 is driven from an external power source of any appropriate sort. This drives the sheave 40, the belts 31 and sheave 29. Rotation of sheave 29 acts through drive bar 30 to rotate the gear housing 25. As the sheave 29 and gear housing 25 rotate, the spindles 33 are revolved about the tube 10 extending through the housing. The gear train consisting of stationary gear 21, pinions 26 and 26b, idlers 28 and gears 27 rotate the spindles 33 about their respective axes. Appropriate selection of the gear ratios insures that the ribs 35 of the spindles 33 will roll on the surface of the tube 10 without slipping, so that the cutter will progress around the tube in an epicycloidal path.

The helical ribs 35 on the spindles 33 will engage with the corrugations of the corrugated tube to advance the tube through the cutter. With a tube having helical corrugations such as that shown in Figure 7, the ribs 35 may be annular rather than helical. Helical ribs are required for a pipe with annular corrugations.

CLAIMS

1. A Method of perforating a tube as the tube is advanced along a feed path characterized by revolving a punch about the tube in an epicycloidal path such that the punch perforates the tube at cusps of the epicycloidal path.
2. A method according to claim 1 characterized in that at least three punches are revolved about the tube in respective epicycloidal paths with the cusps of the paths symetrically arranged around the tube.
3. A method according to claim 1 characterized in that the epicycloidal path has an integral number of lobes in one revolutaion about the tube.
4. A method according to claim 1, 2 or 3 characterized in that the tube is corrugated and the punch perforates the tube in troughs in the external surface of the tube.
5. An apparatus for perforating a tube with a punch, characterized by means (21,26,26b,27) for revolving the punch about the tube in an epicycloidal path such that the punch perforates the tube at cusps of the epicycloidal path.
6. An apparatus according to claim 5 characterized by a tool holder (12) on which the punch (14) is mounted, means (33a) for mounting the tool holder for rotation about an axis (x) thereof, and means (29,31,40) for revolving the axis (x) of the tool holder about the tube (10).
7. An apparatus according to claim 6 characterized in that the tool holder is a spindle (33) with the punch (14) projecting radially therefrom.
8. An apparatus according to claim 7 characterized in that the spindle (33) rolls about the surface of the tube.
9. An apparatus according to claim 8 characterized by a plurality of spindles (33) distributed symmetrically about the tube.

10. An apparatus according to claim 7, 8 or 9 characterized by a helical rib (35) on the spindle, engagable with the tube to advance the tube through the apparatus.
11. An apparatus according 7,8,9 characterized in that the spindle has a helical rib (35) and the punch (14) projects radially from the rib.

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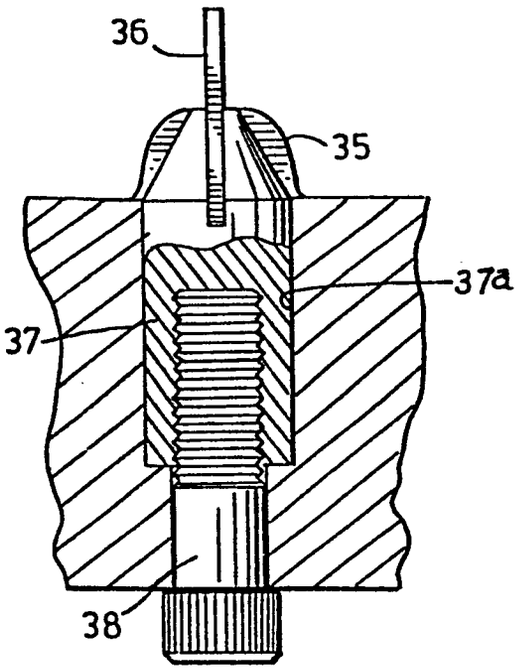


FIG. 4

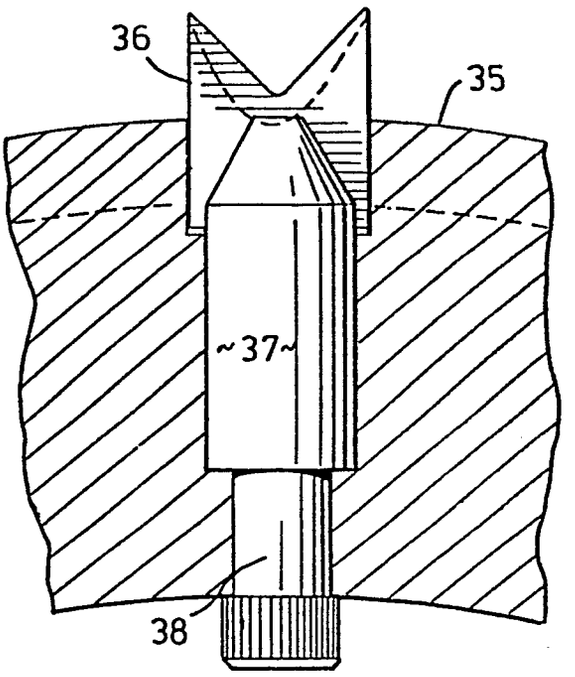


FIG. 5

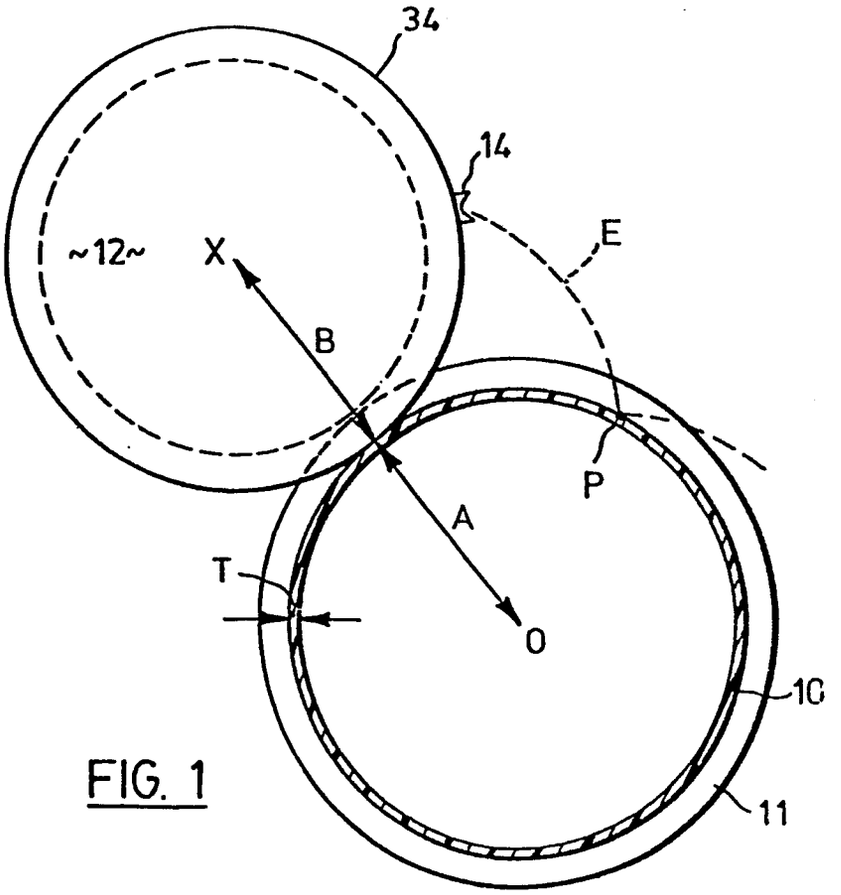
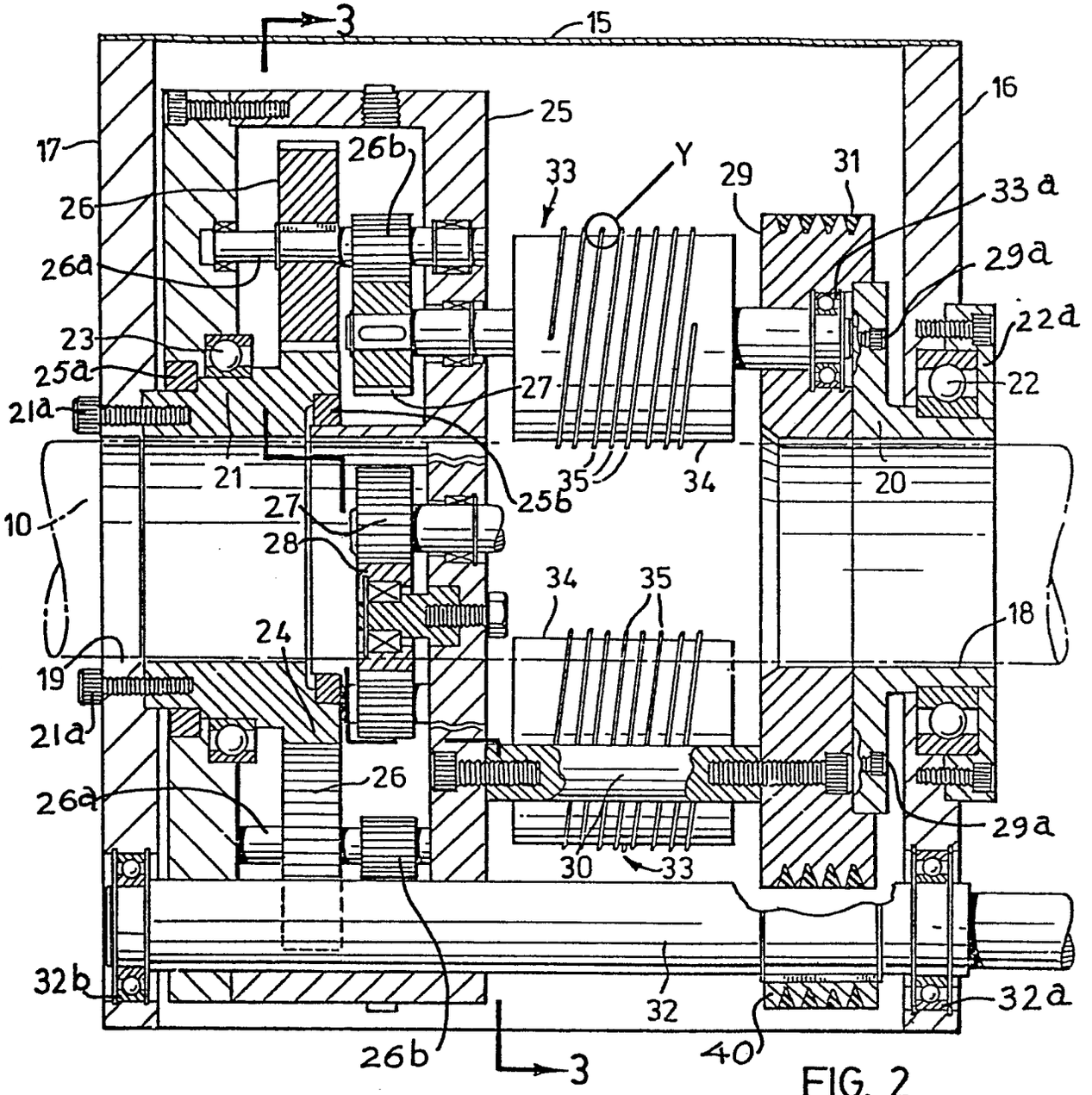


FIG. 1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26b
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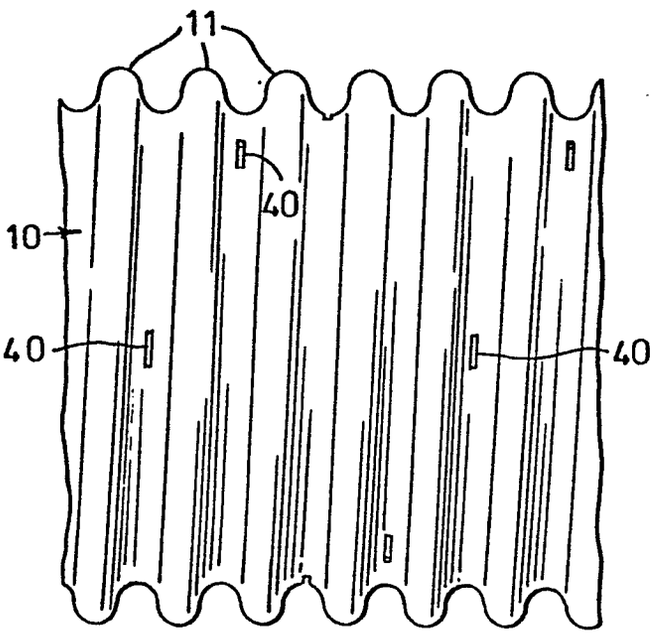
FIG. 2


11
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10
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40

FIG. 7

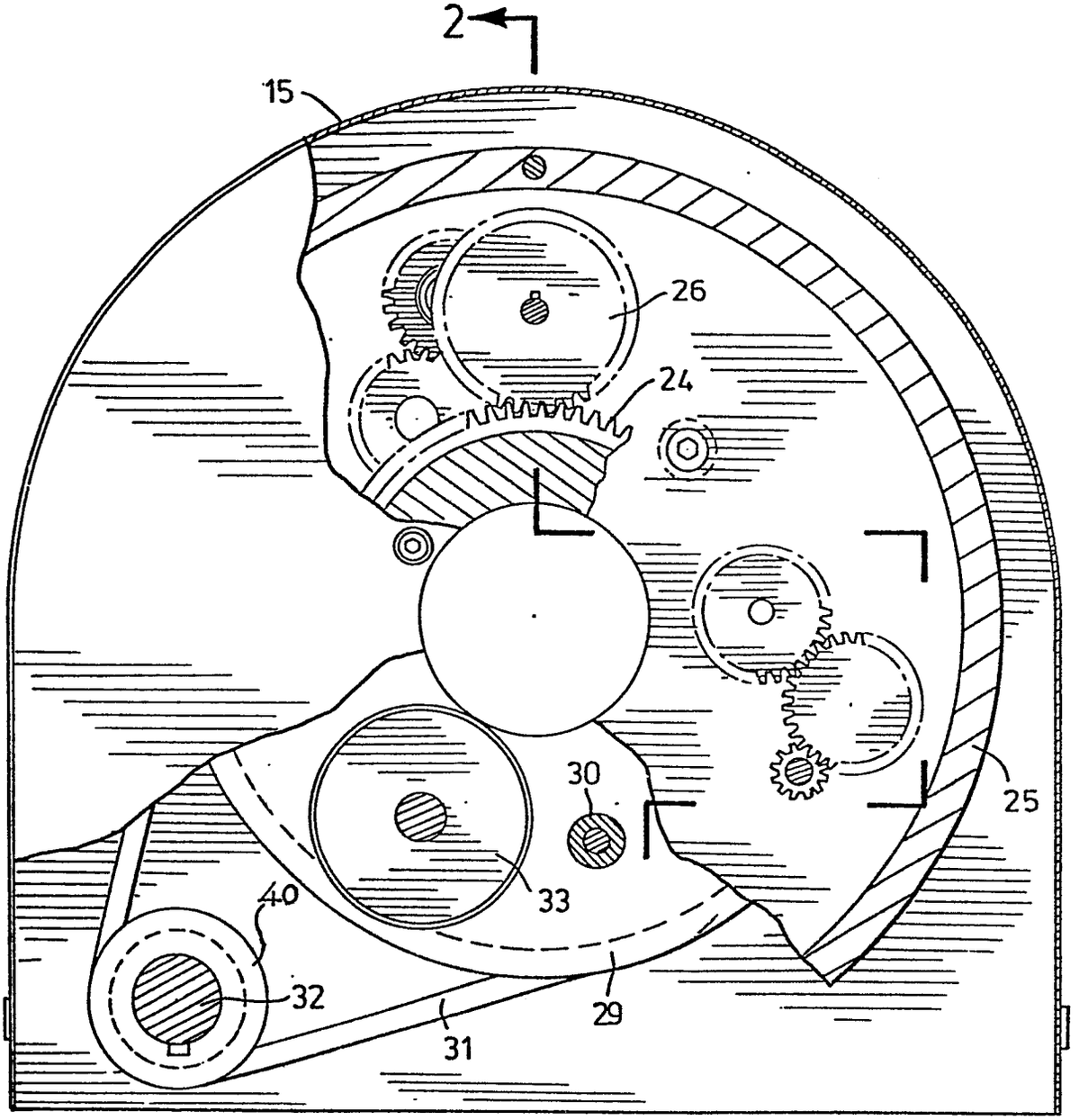

FIG. 3

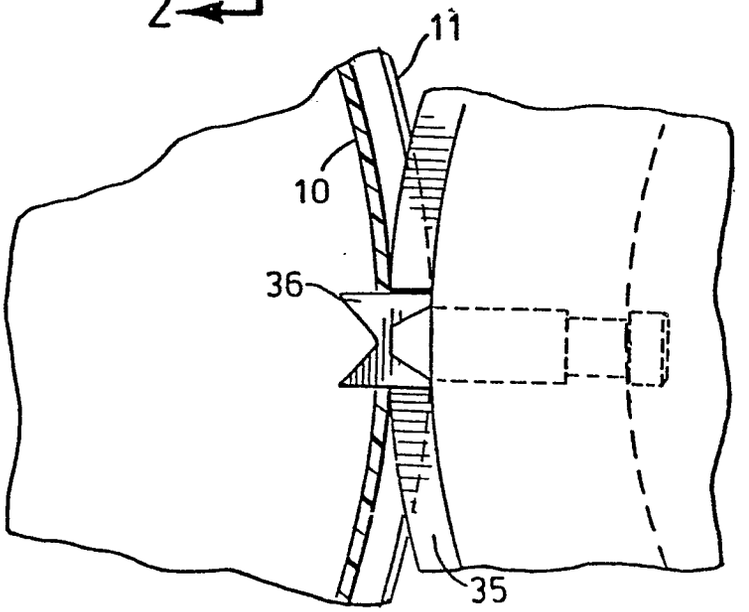

FIG. 6

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EUROPEAN SEARCH REPORT

Application number

EP 82 30 6521

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
X	DE-A-2 262 231 (HERMANS) *Figures; claims*	1,2,4	B 29 C 17/10
D,X	US-A-3 824 886 (HEGLER) *Figures*	1-11	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

B 29 C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10-03-1983	CORDENIER J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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