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(54) **Device for interrupting a detonating cord and safe packaging method for such a cord**

Vorrichtung zum Unterbrechen einer Sprengschnur und Verfahren zum Verpacken einer solchen Sprengschnur

Dispositif pour couper un cordeau détonant et procédé pour emballer un tel cordeau

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(56) References cited:
EP-A- 0 602 470 **US-A- 4 432 268**

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Description

[0001] The invention relates to the transporting of textile sheathed detonating cord and more particularly to a detonating cord retention device comprising a block defining a channel, wherein a detonating cord is provided in slots to form loops arranged outwardly of an assembled device. Also the invention relates to the design of an explosive diode to restrict detonation transfer to one direction only.

[0002] Detonating cords typically contain a secondary high explosive core encased in an outer textile sheath and plastic jacket. Typical explosive materials used are PETN, RDX, HMX, HNS, and PYX. These textile wrapped detonating cords are used extensively in the petroleum exploration and production industry to initiate other explosive components used in various downhole tools. The textile wrapping provides a highly flexible structure that can be easily threaded through perforating guns. Some examples of components that textile detonating cords are used with are perforating shaped charges, setting tools, and similar items. The well locations where these components are used are widely scattered around the world sometimes in very remote locations. It is highly desirable to be able to ship detonating cord by air from a central store location to the remote field location needing the material. However the regulations governing the shipment of explosives by air are quite stringent.

[0003] Basically the regulations require that detonating cord explosive materials be packaged in such a manner that an ignition or detonation in one container shall be confined to that container and will not propagate to another container. In practical terms, this means that the maximum amount of detonating cord allowed to detonate in a package is 304,8 mm (twelve inches) to 914,4 mm (thirty-six inches).

[0004] The prior art has several examples of packaging methods that have been used to meet the air shipping regulations for explosive materials. US-A-4 586 602 discloses a detonating cord transport system where the detonating cord is wound on a plurality of separator support members that provide crossover locations at frequent intervals. At these crossover points, a severing means is wrapped around the cord so that the detonation of one cord portion will sever the continuing cord length at the crossover point without initiating the cord. The maximum length of cord that can detonate without encountering a crossover point is approximately 0,305 m (one foot). Packaging of detonating cord using this method is quite laborious and involves inserting severing means around the cord and cable ties to anchor the cord in position.

[0005] US-A-4 817 787 discloses a different packaging method where a mounting board of insulating material, such as expanded polystyrene, is used to hold the cord. Walled paths are molded into the mounting board through which the cord can be threaded. The cord path has a series of loop regions and adjoining parallel regions through which the parallel cord is separated by the wall. The purpose of the wall is to provide a safety distance where the detonation of a length of cord will cause the adjacent parallel length of cord to be severed without initiation. The minimum wall thickness required for the expanded polystyrene is about 5,2 mm (0.205") minimum.

[0006] US-A-4 895 249 discusses a packaging method that is claimed to be an improvement over the detonating cord transport system disclosed in the '602 patent. This patent discloses a method that increases the labor efficiency of packaging detonating cord and efficiencies in the quantity of detonating cord per package. In this patent, the detonating cord is also wound on a plurality of separator support members. The cord is wound in loops that cross over itself at frequent locations. At the crossover points a severing means is inserted which serves as a means of stopping the detonation at the crossover point. A preferred example of a severing means is a nylon-reinforced rubber hose that is slit and placed around one cord section at the crossover point. Each separator support layer can accommodate 7,62 m (25 feet) of detonating cord. Twenty stacked layers will therefore allow a total of 152,4 m (600 feet) of detonating cord to be shipped in one package.

[0007] The prior art disclosed in both US-A-4 586 602 and US-A-4 817 787 rely on a separate severing means to actually cut the detonating cord. For this system to work, the detonating cord must follow a path very close to the adjacent strand being actually severed. The detonation of the cord will accelerate the independent severing means at high velocity. The material being accelerated actually causes the severing of the detonating cord. According to US-A-4 895 249, the severing means is a metal foil sleeve placed over the detonating cord at an actual crossover point.

[0008] Both of these packaging methods require that the detonating cord be bent back to either cross over itself or pass close by in a parallel orientation to insure severing of the detonating cord. Placing severe bends in the detonating cord remains in this packaging orientation for an extended period of time.

[0009] US-A-4 432 268 which is considered as basis for the preamble of claim 1 discloses a detonation cut-off device comprising a body having two through holes and at least one blast hole connecting the through holes and extending from one of the trough holes to the outside of the body. A detonation cord is provided in said through holes to form a loop arranged outwardly of the body. The blast hole directs the detonation pressure of an accidentally detonating cord to the other through hole so as to sever the cord in the other trough hole and prevent further propagation of the detonation wave.

[0010] EP-A- 0 602 470 discloses a detonation cut-off device comprising a block having two through holes and a bore connecting the through holes. A striker is slidably arranged in the bore and a detonation cord is provided in said through holes to form a loop arranged outwardly of the body. The detonation pressure of an accidentally

detonating cord forces the striker towards the other through hole so that the cord in the other trough hole is cut by the striker and further propagation of the detonation wave is prevented.

[0011] It is the objective of the present invention to provide an improved detonating cord retention device, to obviate the need for a severing means, and to provide an explosive diode whereby the propagation of detonation is restricted to one direction only.

[0012] This objective is achieved by a detonating cord retention device comprising upper and lower retention device segments of complementary shape, said segments defining slots which are inclined relative to the axis of the channel, and communicate with said channel, said device segments further defining interlocking aperture and tab means for holding said device segments in assembled relationship.

[0013] The subject-matter of preferred embodiments of the present invention is defined in the dependent claims.

[0014] In the preferred embodiment of this invention, the detonating cord can be spaced apart at a greater distance that allows the radius of the loop to be increased to avoid damaging the detonating cord. Also the cord sections pass each other at the severing location in an arcuate configuration that avoids any sharp bends in the detonating cord. This packaging method allows the detonating cord to be stored in this configuration for an extended length of time. Also since no separate severing means is required, there will be a resultant reduction of material and labor costs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig 1 shows a diode cutoff block with a loop of detonating cord exiting the block.

Fig 2 shows a hinged diode cutoff block with a loop of detonating cord threaded through the base section of the block.

Fig 3 shows detonating cord assembled in a diode configuration such that a detonation is only allowed to propagate in one direction.

Fig 4 shows a transport packaging segment where detonating cord and diode blocks are aligned on a foamed polystyrene sheet in a series of loops to allow safe packaging of the detonating cord.

Fig. 5 shows a transport package comprising a stack of sheets such as that shown in Fig. 4.

Fig. 6 is a sectional view of the Fig. 5 package showing cardboard separators between the sheets.

[0016] A diode cutoff block is shown in Fig 1. In this drawing, the diode cutoff block 10 is shown. The block 10 has two through holes 16, 16 for detonating cord and a channel 18 through the block for focusing the air blast of the detonating cord. Detonating cord 12 passes through the diode block 10 and then forms a loop 14 before the cord passes through the diode block 10 in the opposite direction. The diode block 10 functions by focusing the air blast of the detonating cord 12 through the block 10 and severing the adjacent detonating cord section. The length of the loop 14 must be selected to allow the air blast to sever the adjacent detonating cord 12 before the detonation wave can travel around the loop 14 and pass through the block 10 again.

[0017] The block 10 can be made out of a variety of materials such as metal, wood, or plastic. From a cost and weight standpoint, the preferred material is usually plastic. The dimensions of the block 10 are determined by the quantity of explosive loading in the detonating cord 12. Typically textile detonating cords have an explosive loading ranging from 4 grains per foot to 400 grains per 0,305 m (foot). A typical textile detonating cord for the oil well servicing industry has a coreload of about 80 grains per 0,305 m (tool) With a higher coreload detonating cord, the distance between the thru holes 16,16 must be increased slightly and the block 10 made thicker. The actual dimensions are determined by evaluating the severing capabilities of various samples of detonating cord in different block dimensions. For an 80 gr/0,305 m (ft) detonating cord, the distance between thru holes 16,16 ranges from 6,35 mm (0.250") to about 31,75 mm (1.250"). The loop 14 needs to have a minimum detonating cord length of about 152,4 mm (6 inches) to allow adequate severing of the detonating cord 12.

[0018] The diode cutoff bloc 10 illustrated in Fig 1 is shown as a solid block. While a solid block performs well, it is difficult to attach and remove the block 10 from the detonating cord 12. An improved diode block is shown in Fig 2. A hinged plastic block 20 is shown in the open position. A length of detonating cord 12 is shown passing through the block 20. A slot 28 for the detonating cord 12 is molded into both the base 34 the hinged block 20 and the lid 22 of the hinged block 20. The lid 22 and the base 34 the block 20 are joined by a living plastic hinge 30 that allows the block portions to be flexed. Locking tabs 32 and interlocking apertures (24) hold the block 20 fixed in the closed position when the block 20 is shut. By pressing the locking tabs 32 together, the block 20 can be opened easily.

[0019] When the hinged block 20 is closed, an air blast channel 26 is formed similar to that in the one-piece block 10. The functioning of the block 20 is identical to the cutoff block 10 described earlier. When a length of detonating cord 12 detonates, the air blast from the cord 12 will sever the adjacent length prior to the detonation front passing around the loop 14 and back through the block 10, 20.

[0020] It is also possible to use a diode block as a directional cutoff device. Fig 3 shows an arrangement of a diode cutoff block that only permits one-way detonation transfer. The main detonating cord transmission line 40 goes from the top of the Fig. 3 drawing to the bottom of the drawing. A diode block 10, 20 is attached to webbing material 48 to hold the block 10, 20 in the correct position.

A jumper detonating cord 42 is secured to the main detonating cord 40 with hog rings 44. The other end of the jumper detonating cord 42 passes through the thru hole 50 in the diode block 10, 20. The main detonating cord 40 passes through the other thru hole 52 in the block 10, 20. Silicone rubber tubing 46 is placed over the jumper detonating cord 42 to prevent the detonation of the jumper cord 42 from damaging the main detonating cord length 40.

[0021] The diode cutoff direction is illustrated by the arrow 56. If the main detonating cord lead 40 is initiated at the top of the figure, the detonation wave will progress towards the bottom of the Figure. The main detonating cord 40 will initiate the jumper detonating cord 42 at the hog ring connection 44. The jumper detonating cord is 42 much shorter than the main detonating cord lead 40 that has a series of loops 40a, 40b, 40c in it. Thus the detonation front from the jumper cord 42 will arrive at the diode block 10, 20 and sever the main detonating cord lead 40 at 50/52 before the detonation front from the main lead 40 arrives at the block 10, 20 . Thus the block 10, 20 will function as an explosive diode, permitting the detonation front to pass through the block only in one direction opposite that of the cutoff direction 56.

[0022] Fig 4 illustrates a packaging transport section for safe packaging of detonating cord. An expanded polystyrene tray 70 is formed with a series of detonating cord loops 72 molded into the surface of the plastic. The channel for the detonating cord 12 is slightly wider than the diameter of the detonating cord 12 and slightly deeper than the diameter of the detonating cord 12. This allows accurate positioning of the detonating cord 12 and makes the packaging easy to assemble. Cavities are molded into the tray and sized and dimensioned to receive diode cutoff blocks 74, 74. These blocks 74, 74 may be similar to those described above with reference to Figs. 1-3. If the detonating cord (12) were to be accidentally initiated in some fashion, the detonation would only propagate until it encounters the first cutoff block 74.

[0023] The length of each loop is about 304,8 mm (twelve inches). In this design the maximum length of detonating cord that may be detonated is about 457,2 mm (eighteen inches) before the detonating cord will be severed in a diode cutoff block. Each detonating cord transport section holds about 457,2 mm (eighteen feet) of detonating cord. By stacking multiple transport sections, larger quantities of detonating cord can be packaged. For example, stacking twenty-eight transport sections will allow packaging 152,4 m (500 feet) of detonating cord in an outer 4G fiberboard box.

[0024] Figs. 5 and 6 show a complete packaging for a stack of trays 70, 70 such as that shown in Fig. 4. Fig. 6 shows separator pads 75 between the foam sheets or trays 70, 70.

[0025] Thus, block 20 in Fig. 2 provides a slightly arcuate shape for the cord segments contained in the channels and this configuration avoids any necessity for separate severing means to act on the detonating cord when an unwanted percussive signal passes through the adjacent cord segment. The results for this geometry of the containment passageway and the channels has been verified in proprietary tests conducted by an independent testing laboratory. The recommendation of that laboratory was to classify the packaging described herein as meeting federal requirements for transporting by highway, by rail, and by civil aircraft in the USA.

[0026] The term "block" is intended to mean a three-dimensional elongated object with one or more flat faces, and otherwise of any convenient shape for defining the longitudinal blast passageway(s) and lateral channel(s) called for in the appended claims.

[0027] The foregoing disclosure and the embodiments shown in the drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense.

Claims

1. A detonating cord retention device comprising:

   a block (20, 74) defining
   a channel (26), wherein a detonating cord (12, 40) is provided in slots (28) to form loops (14, 40a, 40b, 40c) arranged outwardly of an assembled device, **characterised in that**
   upper and lower retention device segments of complementary shape are provided, said segments defining slots (28) which are inclined relative to the axis of the channel (26) and communicate with said channel (26) said device segments further defining interlocking aperture (24) and tab (32) means for holding said device segments in assembled relationship.

2. The device according to claim 1, wherein said device segments are fabricated in one piece from a polymeric material and define a hinge (30) along one side edge thereof.

3. The device according to claim 1 or 2, further **characterized by** a housing having a plurality of secondary channels including a shunt channel for accommodating a short segment of detonating cord (40) said shunt channel allowing an upstream end of a jumper detonating cord (42) to be attached to the detonating cord (40) in said secondary channels at an upstream side of the device, and said jumper detonating cord (42) having a downstream end provided in one of said secondary channels for severing a length of the detonating cord (40) in an adjacent secondary channel in response to a percussive signal carried along said jumper detonating cord (42) into said housing, whereby the device functions as a diode and is responsive to a directional percussive signal in said detonating cord (40).

4. The device according to any one of the claims 1 to 3, wherein said slots (28) are angled inwardly toward one another to minimize the spacing between the loop end portions of the detonating cord (12, 40) in said channel (26) so that the detonating cord loops (14) radiate outwardly away from the device.

5. The device according to any one of the claims 1 to 4, further **characterized by** trays (70) for accommodating a plurality of detonating cord loops (72), and a plurality of said blocks (74) arranged along a line to accommodate the detonating cord loops (72) so that the loops (14) extend outwardly from said line, said trays (70) being assembled so as to accommodate the loops (14) of detonating cord (12) in a stack of trays (70) for transportation of detonating cord (12).

6. The device according to any one of the claims 1 to 5, wherein said channel (26) has a height that corresponds closely to the outside diameter of the detonating cord (12, 40) and to the diameter (d) of the slots (28) that receive said loop end portions.

Patentansprüche

1. Sprengschnurhaltevorrichtung mit:

einem Block (20, 74), der einen Kanal (26) aufweist,

wobei eine Sprengschnur (12, 40) in Schlitzen (28) so angeordnet ist, dass sie Schleifen (14, 40a, 40b, 40c) bildet, die außerhalb von einer zusammengebauten Vorrichtung angeordnet sind,
dadurch gekennzeichnet, dass ein oberer und ein unterer Haltevorrichtungsabschnitt von komplementärer Form vorgesehen sind, wobei die Abschnitte die Schlitze (28) aufweisen, welche gegen die Achse des Kanals (26) geneigt sind und mit dem Kanal (26) in Verbindung stehen, wobei die Vorrichtungsabschnitte weiter eine Verriegelungsöffnung (24) und einen Verriegelungslappen (32) haben, die dazu dienen, die Vorrichtungsabschnitte in zusammengebautem Zustand zu halten.

2. Vorrichtung nach Anspruch 1, wobei die Vorrichtungsabschnitte in einem Stück aus einem polymeren Material hergestellt sind und ein Scharnier (30) längs eines Seitenrandes derselben aufweisen.

3. Vorrichtung nach Anspruch 1 oder 2, weiter **gekennzeichnet durch** ein Gehäuse, das mehrere sekundäre Kanäle hat, welche einen Zweigkanal umfassen zum Aufnehmen eines kurzen Abschnitts der Sprengschnur (40), wobei der Zweigkanal erlaubt, ein stromaufwärtiges Ende einer Überbrückungssprengschnur (42) an der Sprengschnur (40) in den Sekundärkanälen auf einer stromaufwärtigen Seite der Vorrichtung zu befestigen, wobei die Überbrükkungssprengschnur (42) ein stromabwärtiges Ende hat, das in einem der Sekundärkanäle angeordnet ist, zum Durchtrennen eines Stückes der Sprengschnur (40) in einem benachbarten Sekundärkanal auf ein perkussives Signal hin, das über die Überbrückungssprengschnur (42) in das Gehäuse übertragen wird, wodurch die Vorrichtung als eine Diode arbeitet und auf ein perkussives Richtungssignal in der Sprengschnur (40) anspricht.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, wobei die Schlitze (28) einwärts zueinander hin abgewinkelt sind, um den Abstand zwischen den Endteilen der Sprengschnur (12, 40) in dem Kanal (26) zu minimieren, so dass die Sprengschnurschleifen (14) von der Vorrichtung aus nach außen wegstehen.

5. Vorrichtung nach einem der Ansprüche 1 bis 4, weiter **gekennzeichnet durch** Tabletts (70) zum Aufnehmen einer Vielzahl von Sprengstoffschleifen (72) und einer Vielzahl der Blöcke (74), die längs einer Linie angeordnet sind, um die Sprengschnurschleifen (72) so aufzunehmen, dass die Schleifen (14) sich von der Linie aus nach außen erstrecken, wobei die Tabletts (70) so zusammengebaut sind, dass sie die Schleifen (14) der Sprengschnur (12) in einem Stapel von Tabletts (70) zum Transportieren einer Sprengschnur (12) aufnehmen.

6. Vorrichtung nach einem der Ansprüche 1 bis 5, wobei der Kanal (26) eine Höhe hat, die dem Außendurchmesser der Sprengschnur (12, 40) und dem Durchmesser (d) der Schlitze (28), die die Schleifenendteile aufnehmen, eng entspricht.

Revendications

1. Dispositif de retenue de cordeau détonant comprenant:

un bloc (20, 74) définissant
un canal (26), dans lequel un cordeau détonant (12, 40) est placé dans des fentes (28) pour former des boucles (14, 40a, 40b, 40c) agencées vers l'extérieur d'un dispositif assemblé, **caractérisé en ce que** des segments de dispositif de retenue supérieur et inférieur de forme complémentaire sont prévus, lesdits segments définissant des fentes (28) qui sont inclinées par rapport à l'axe du canal (26), et communiquent avec ledit canal (26), lesdits segments de dispositif définissant, en outre, des moyens de languette (32) et ouverture (24) à verrouillage mutuel pour garder lesdits segments de dispositif assem-

blés.

2. Dispositif selon la revendication 1, dans lequel lesdits segments de dispositif sont fabriqués en une seule pièce à partir d'un matériau polymère et définissent une articulation (30) le long d'un bord latéral.

3. Dispositif selon la revendication 1 ou 2, **caractérisé en outre par** un boîtier comportant une pluralité de canaux secondaires comprenant un canal de dérivation pour loger un court segment de cordeau détonant (40), ledit canal de dérivation permettant à une extrémité d'amont d'un cordeau détonant de liaison (42) d'être fixée au cordeau détonant (40) dans lesdits canaux secondaires sur un côté d'amont du dispositif, et ledit cordeau détonant de liaison (42) ayant une extrémité d'aval disposée dans l'un desdits canaux secondaires pour sectionner une longueur du cordeau détonant (40) dans un canal secondaire adjacent en réponse à un signal de percussion transporté le long du cordeau détonant de liaison (42) dans ledit boîtier, grâce à quoi le dispositif sert de diode et est réactif à un signal de percussion directionnel dans ledit cordeau détonant (40).

4. Dispositif selon l'une quelconque des revendications 1 à 3, dans lequel lesdites fentes (28) sont inclinées vers l'intérieur l'une vers l'autre pour ramener à un minimum l'espace entre les parties d'extrémité de boucle du cordeau détonant (12, 40) dans ledit canal (26) de manière que les boucles de cordeau détonant (14) rayonnent vers l'extérieur du dispositif.

5. Dispositif selon l'une quelconque des revendications 1 à 4, également **caractérisé par** des plateaux (70) pour loger une pluralité de boucles de cordeau détonant (72), et une pluralité de dits blocs (74) agencés le long d'une ligne pour loger les boucles de cordeau détonant (72) de manière que les boucles (14) s'étendent vers l'extérieur depuis ladite ligne, lesdits plateaux (70) étant assemblés afin de loger les boucles (14) de cordeau détonant (12) en une pile de plateaux (70) pour le transport du cordeau détonant (12).

6. Dispositif selon l'une quelconque des revendications 1 à 5, dans lequel ledit canal (26) a une hauteur qui correspond étroitement au diamètre extérieur du cordeau détonant (12, 40) et au diamètre (d) des fentes (28) qui reçoivent lesdites parties d'extrémité de boucle.

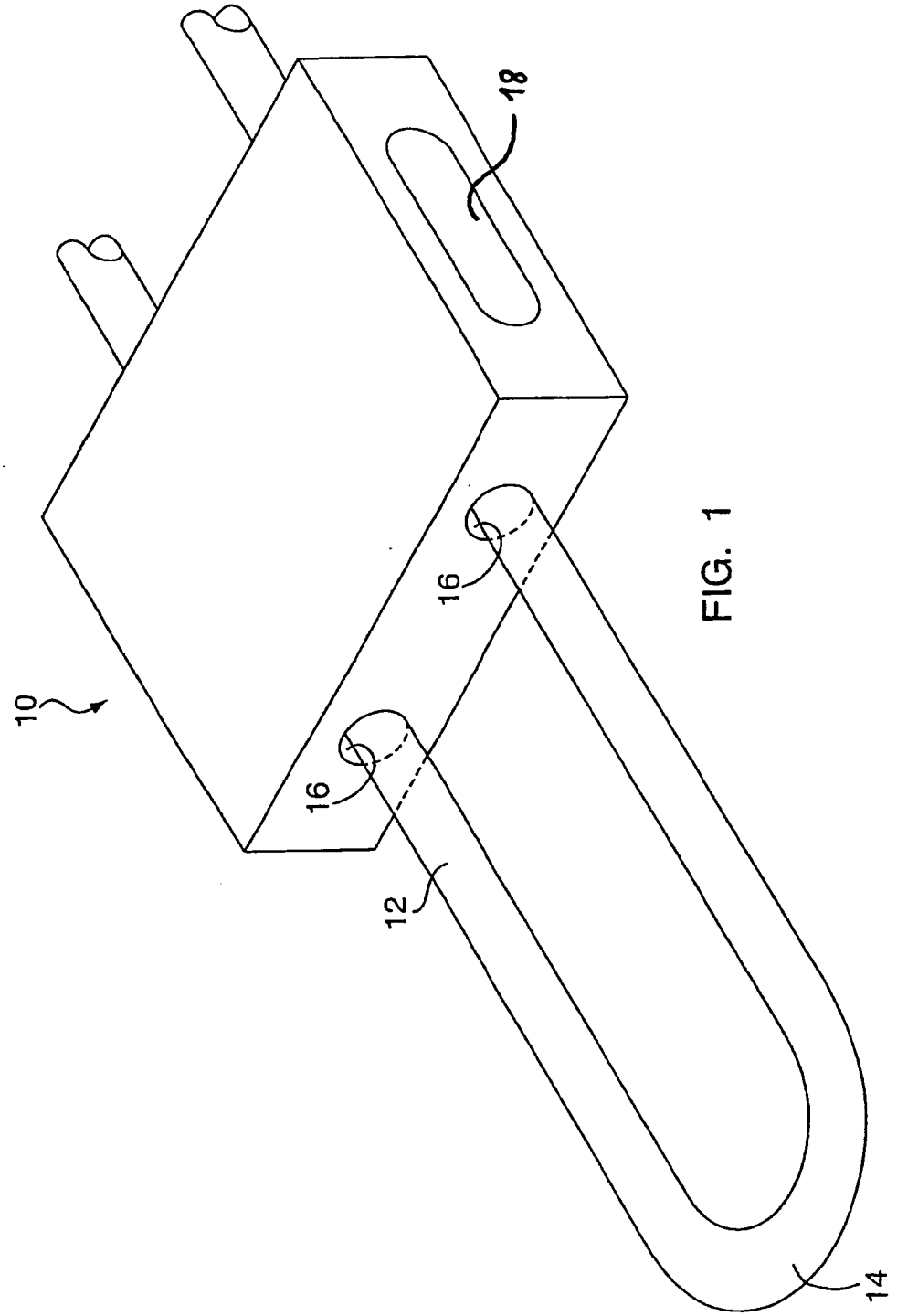


FIG. 1

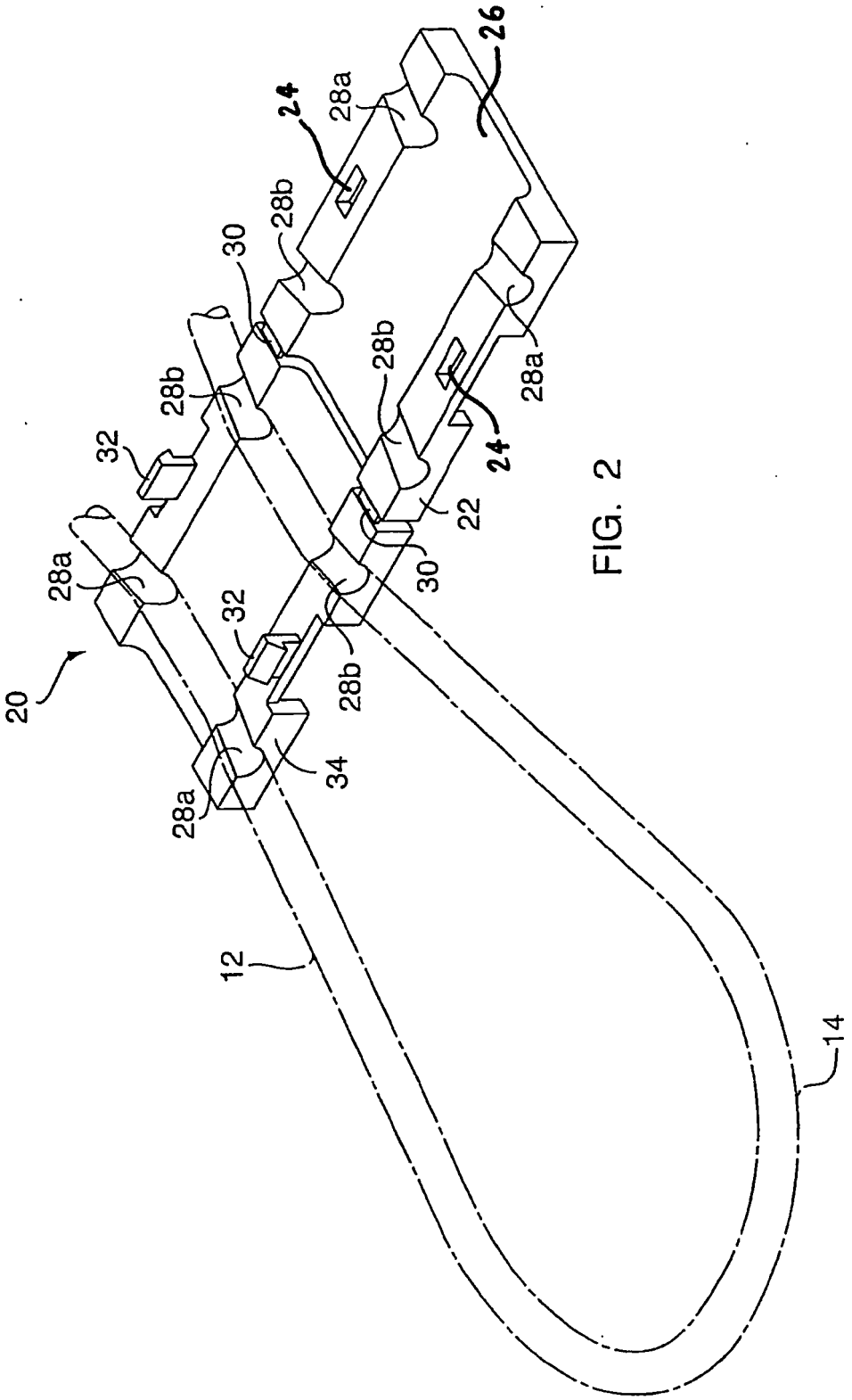


FIG. 2

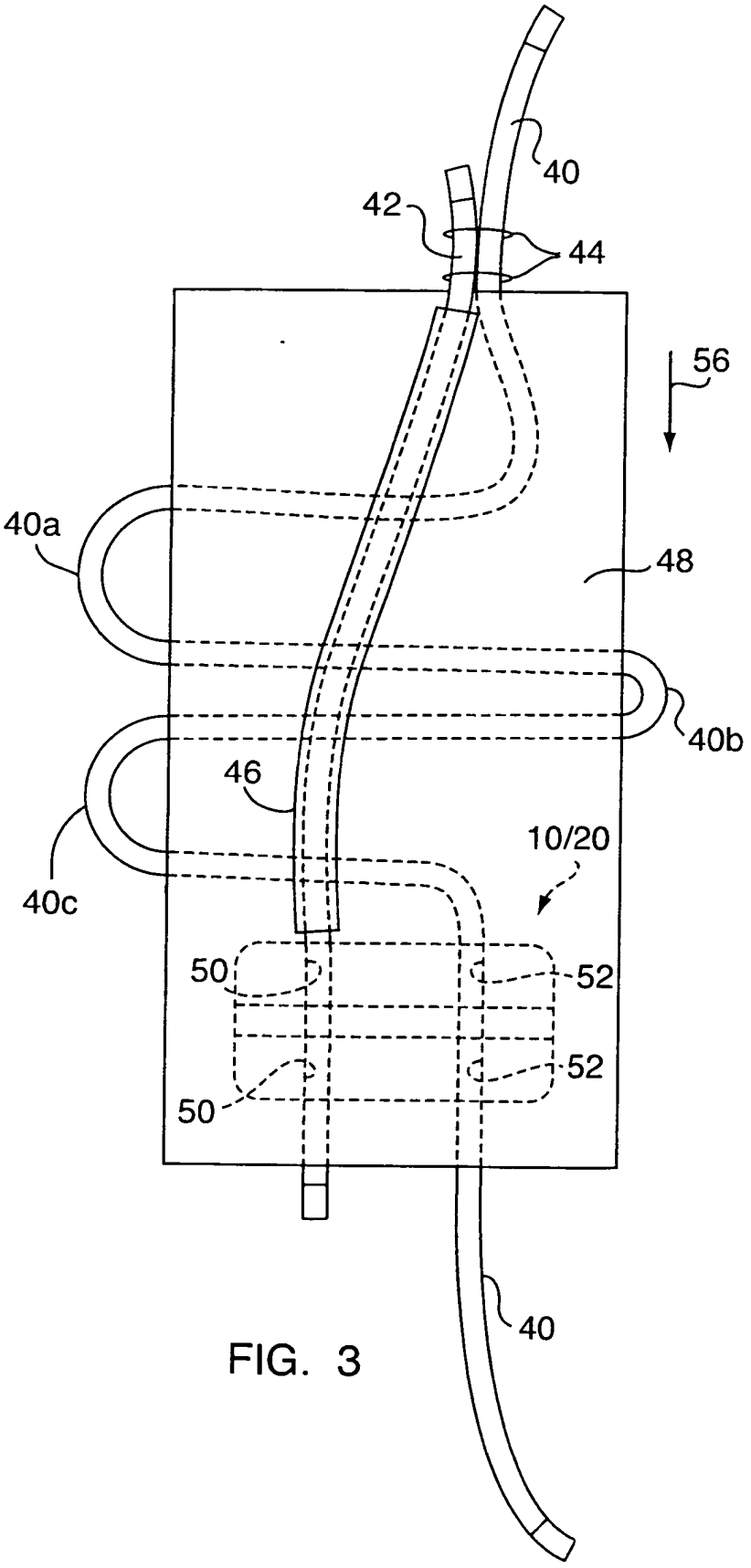


FIG. 3

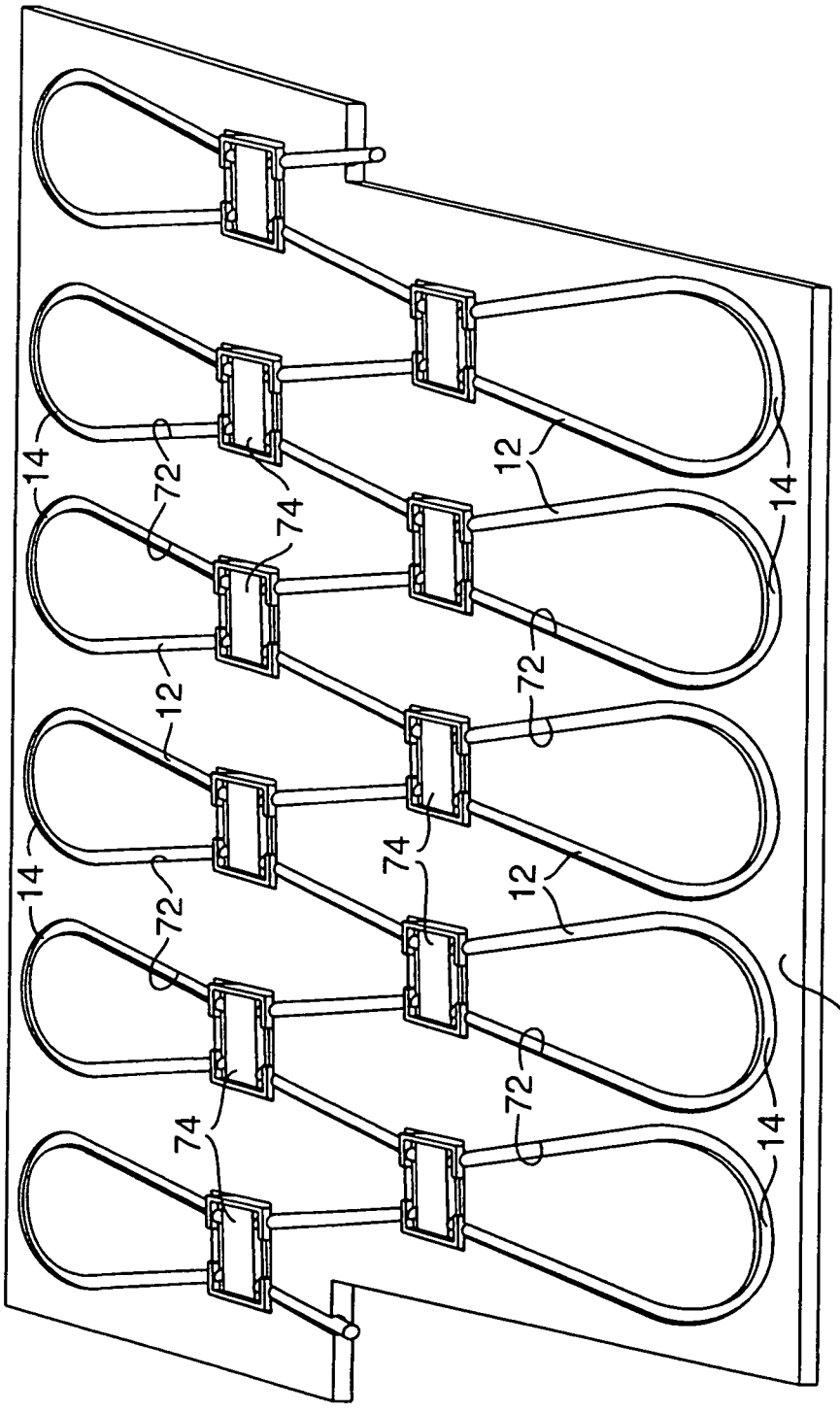


FIG. 4

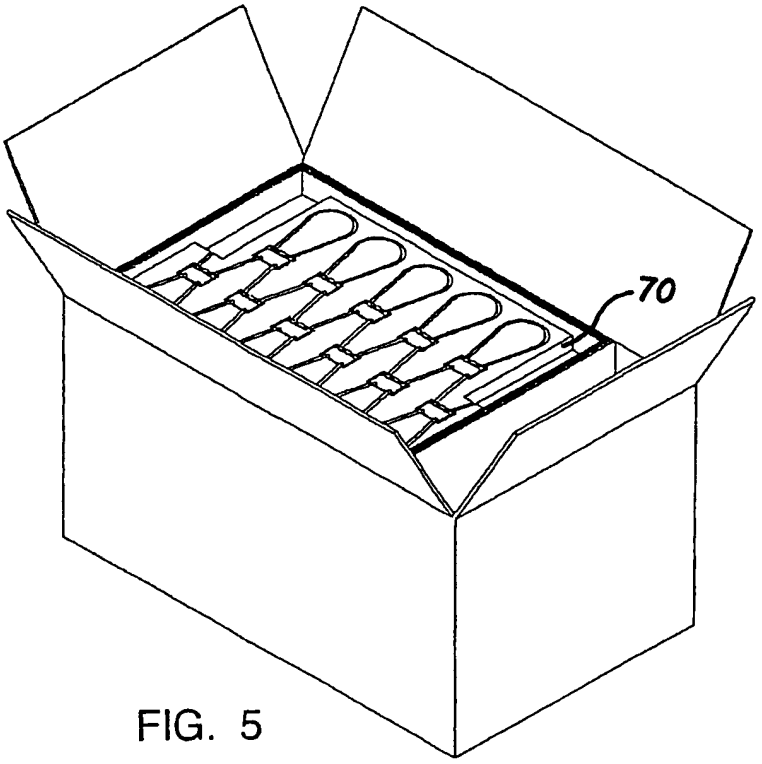


FIG. 5

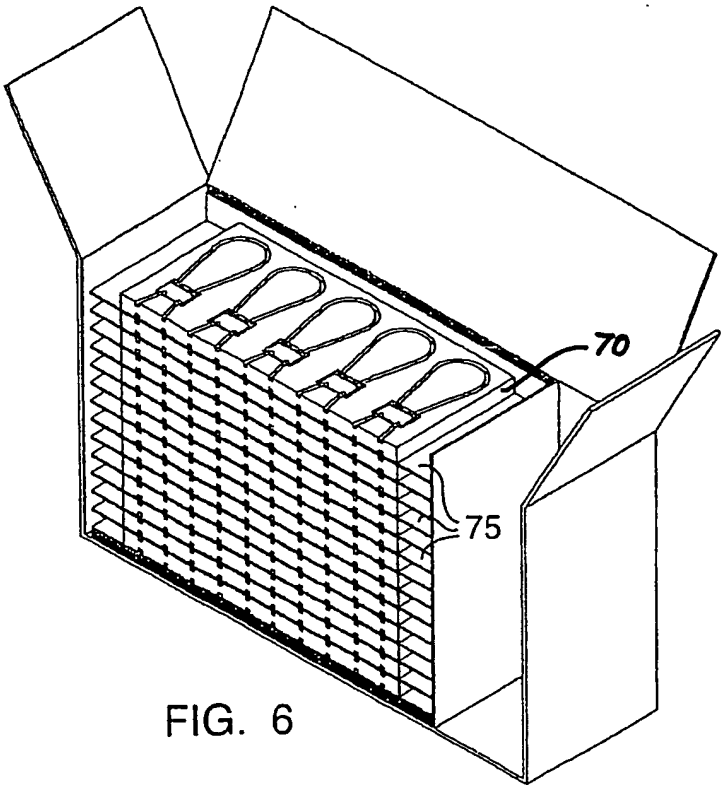


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 4817787 A **[0005] [0007]**
- US 4895249 A **[0006] [0007]**
- US 4432268 A **[0009]**
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