US 20030155112A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2003/0155112 A1
Tiernan et al. (43) Pub. Date: Aug. 21, 2003

(54) MODULAR PROPELLANT ASSEMBLY FOR FRACTURING WELLS

(76) Inventors: **John P. Tiernan**, Newnan, GA (US); **Richard S. Passamaneck**, Golden, CO (US); **Lynn Frazier**, Robstown, TX (US); **Dany Normand**, Sharpsburg, GA (US)

Correspondence Address:
DORR CARSON SLOAN & BIRNEY, PC
3010 EAST 6TH AVENUE
DENVER, CO 80206

(21) Appl. No.: **10/340,393**

(22) Filed: **Jan. 10, 2003**

Related U.S. Application Data

(60) Provisional application No. 60/347,442, filed on Jan. 11, 2002.

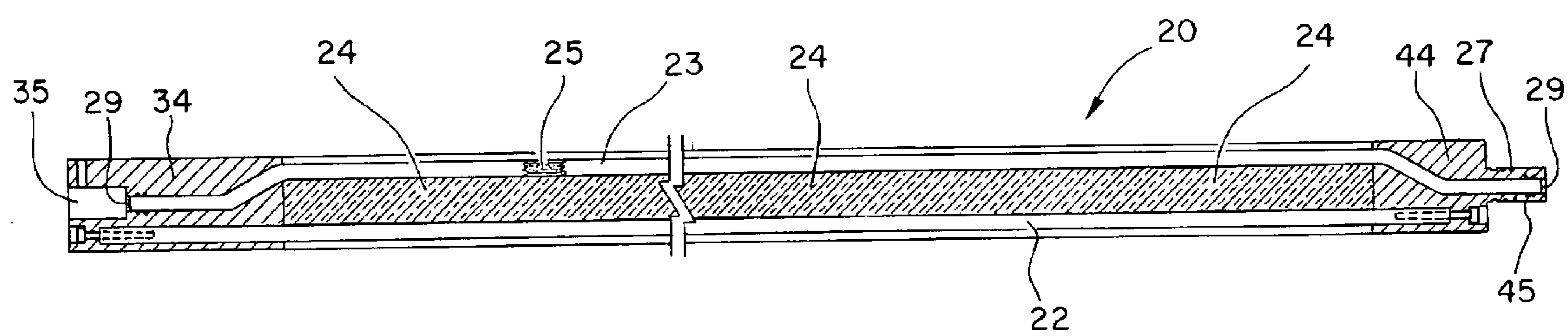
Publication Classification

(51) Int. Cl.^{7} **E21B 43/263**

(52) U.S. Cl. **166/63**; 166/308; 166/299

(57) **ABSTRACT**

A modular propellant assembly for fracturing wells has a propellant charge with a detonating cord extending along its length to ignite the propellant. Each propellant module also has end caps with male and female connectors that enable propellant modules to be connected in an end-to-end relationship to any desired length. These connectors align the ends of the detonating cords in adjacent propellant modules and are sealed with O-rings so that the detonating cords remains dry while submerged at high pressures. This enables the detonating cords to be ignited in series.



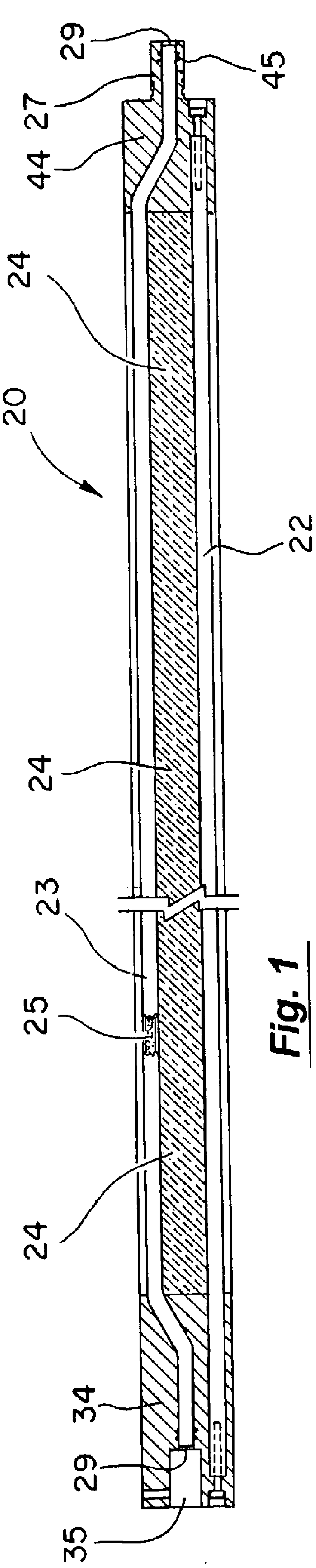

29
45
27
44
24
20
22
24
23
25
24
34
29
35

Fig. 1

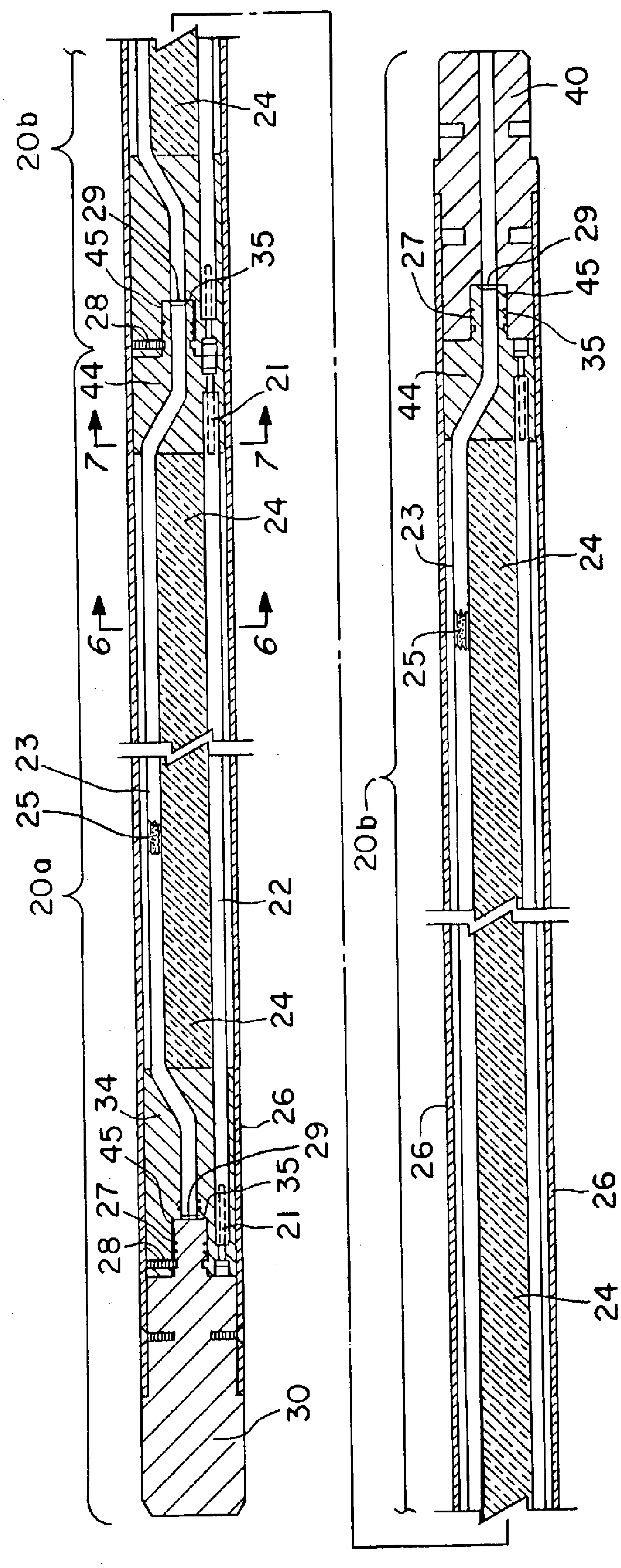

20b
24
29
45
35
28
44
21
7
24
6
23
25
20a
22
24
34
26
45
29
27
35
21
28
30
40
27
29
45
35
44
23
24
25
20b
26
26
24

Fig. 2

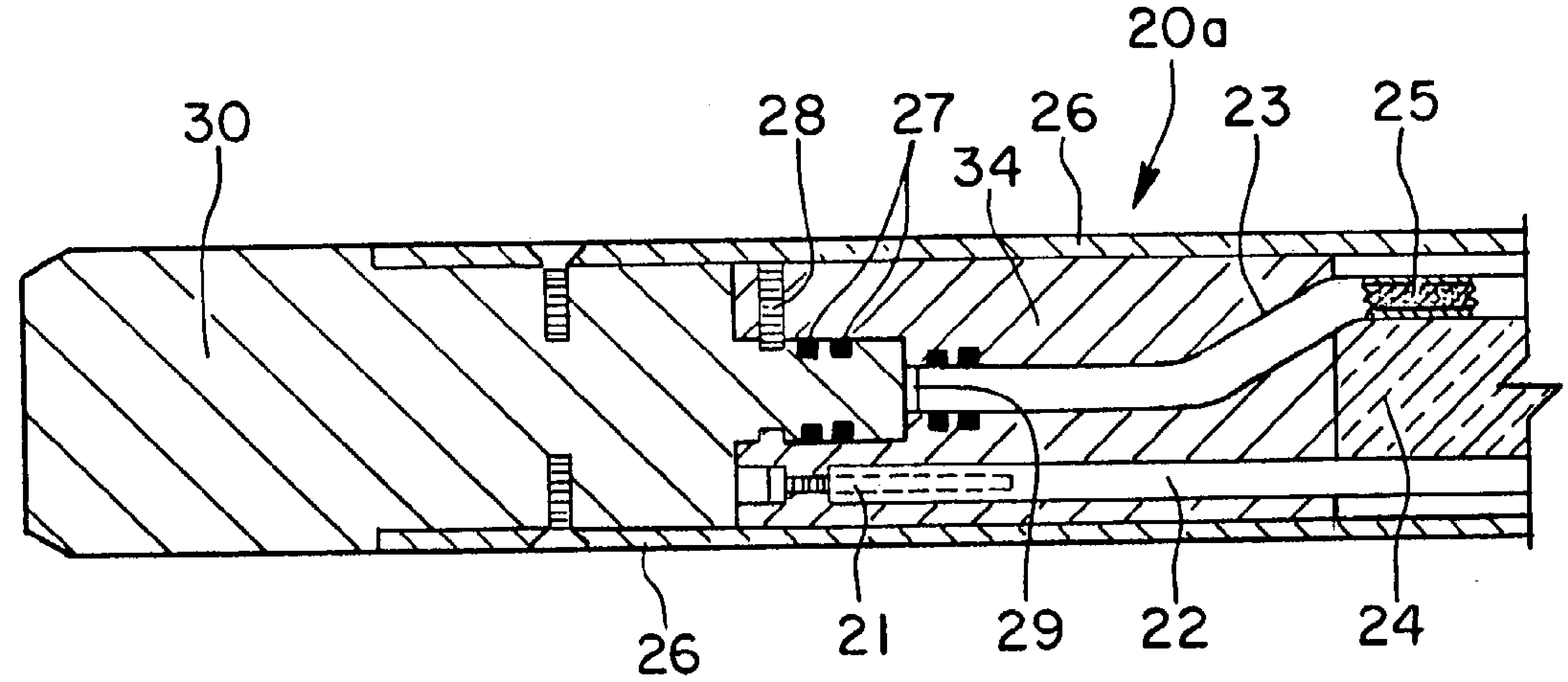


Fig. 3

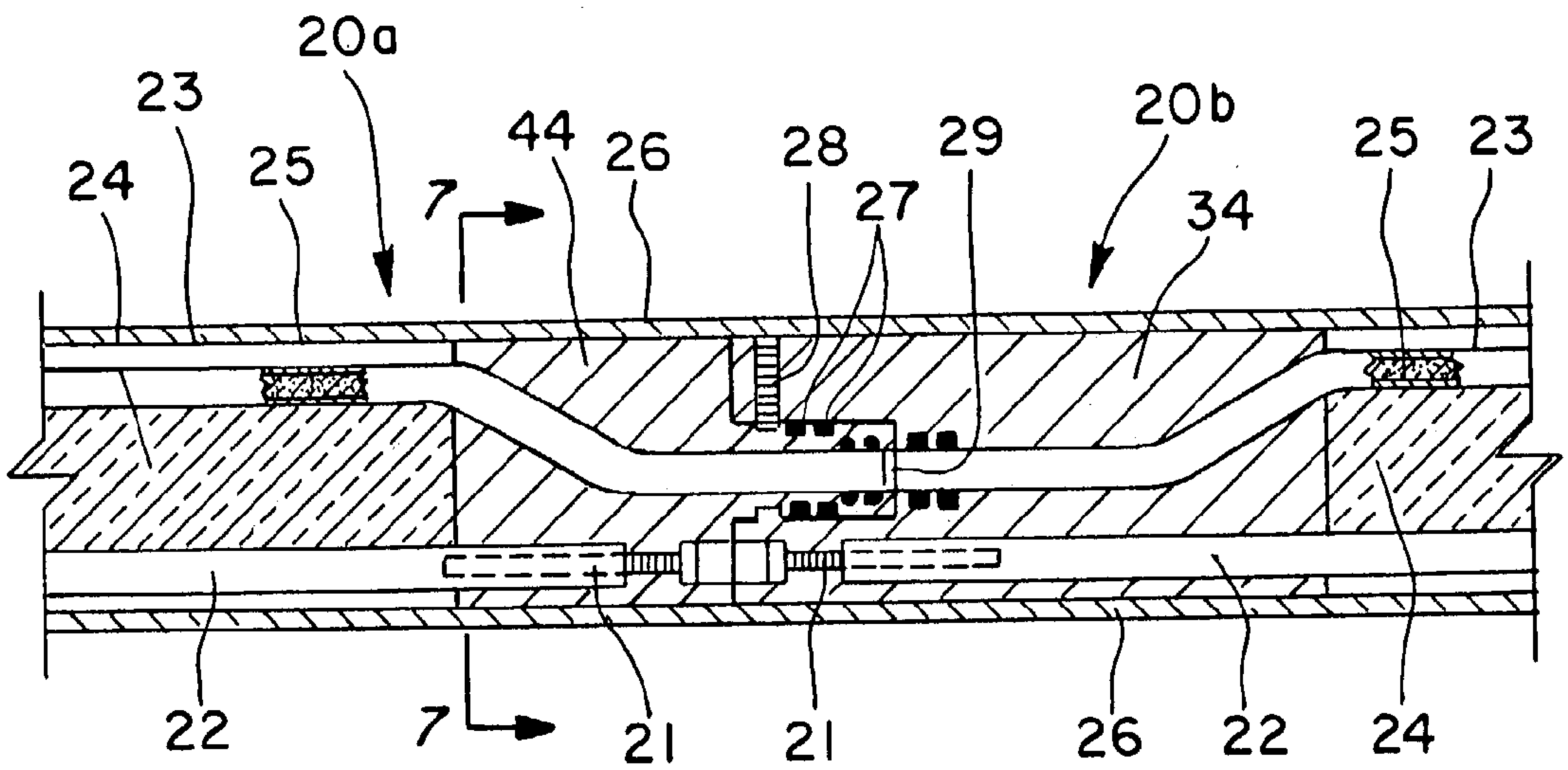


Fig. 4

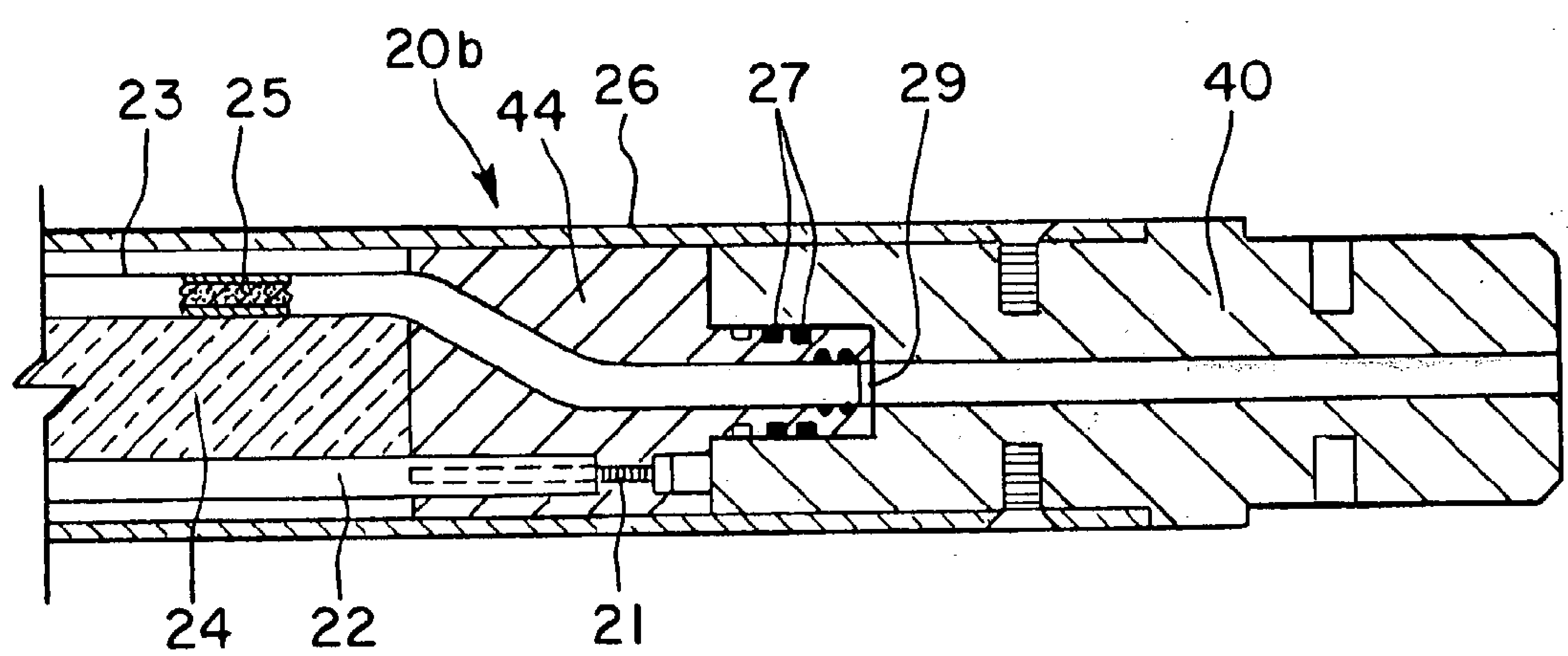


Fig. 5

Fig. 6

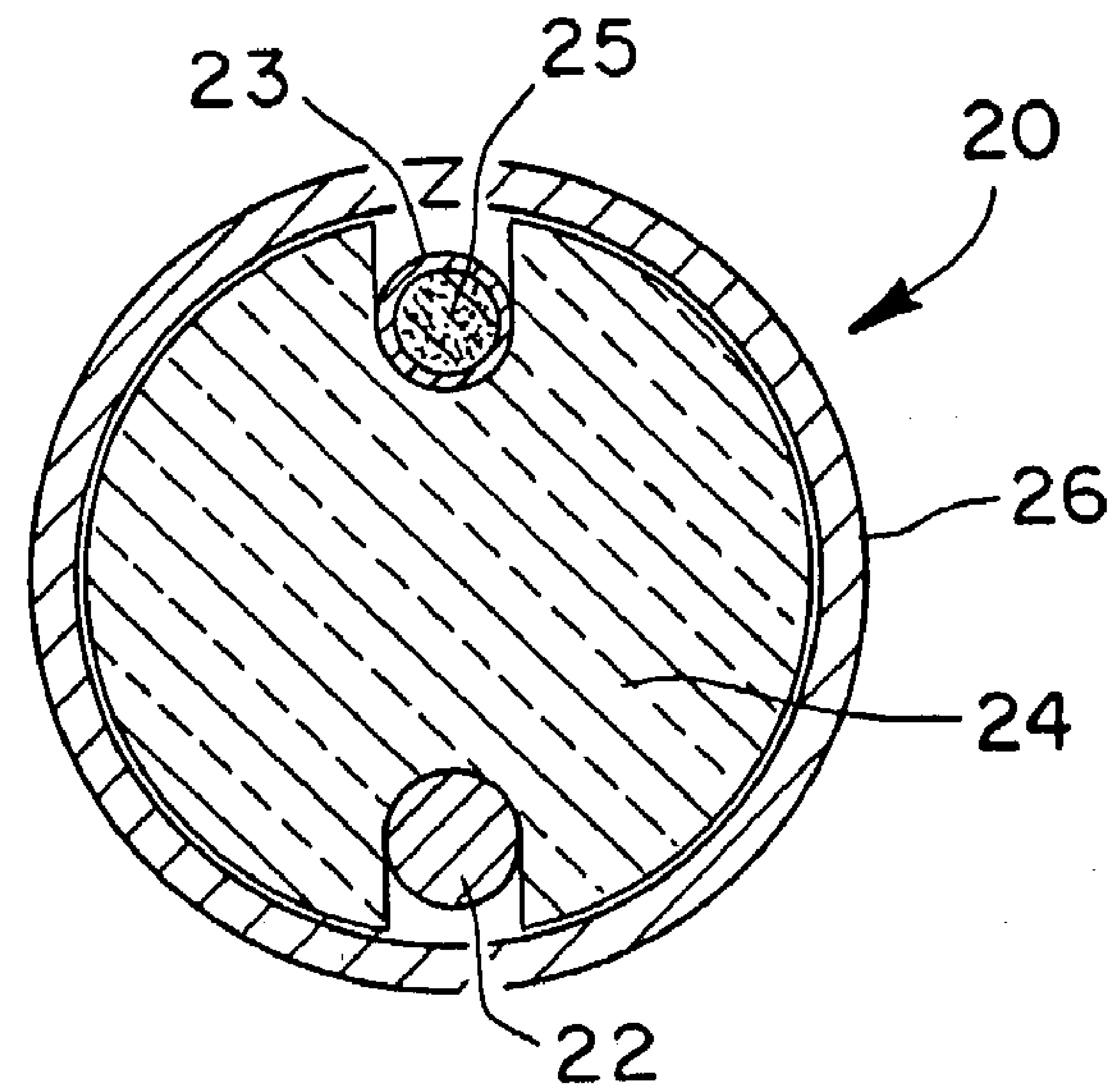
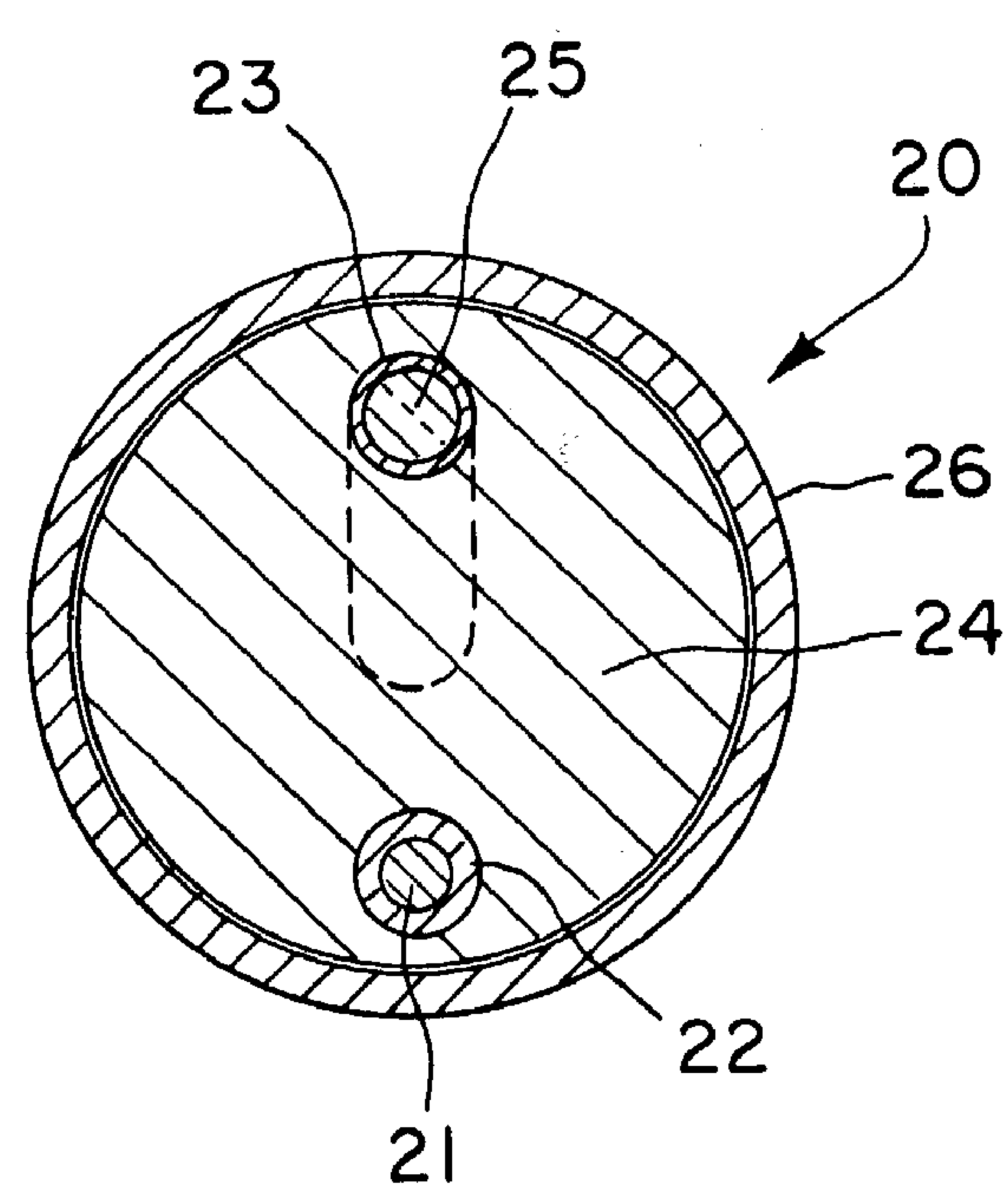


Fig. 7



MODULAR PROPELLANT ASSEMBLY FOR FRACTURING WELLS

RELATED APPLICATION

[0001] The present application is based on, and claims priority to U.S. Provisional Patent Application Ser. No. 60/347,442, filed on Jan. 11, 2002.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to the field of fracturing the formation surrounding a well. More specifically, the present invention discloses a modular propellant assembly for fracturing the strata surrounding a well.

[0004] 2. Statement of the Problem

[0005] Hydraulic fracturing has been used in the oil and gas industries for many years to stimulate production from wells. The prior art also includes several examples in which gases generated by combustion of propellants have been used for fracturing wells (e.g., U.S. Pat. Nos. 4,633,951 and 4,683,943 of Hill et al. and U.S. Pat. No. 5,295,545 of Passamaneck). The amount, type, and configuration of the propellant charge must be carefully selected for each well using sophisticated modeling techniques to optimize the effectiveness of the fracturing process.

[0006] This creates a need for customized propellant charges for each well, which adds significantly to manufacturing and inventory costs for these assemblies. Therefore, a need exists for a propellant assembly that can be readily customized to meet the specific needs of a particular well.

[0007] 3. Solution to the Problem

[0008] The present invention addresses the shortcomings associated with conventional propellant fracturing systems by providing a modular propellant assembly that can be readily customized and assembled in the field to meet the requirements for a specific well. This modular approach reduces costs and results in a safer, more reliable application.

[0009] In addition, the modular propellant design allows easy assembly prior to transporting the propellant to the well site. A simple and quick procedure can be employed at the well site to ready the system to go down hole. Furthermore, reliability is dramatically improved because the system's integrated ignition components can be factory assembled and tested prior to application in the field.

SUMMARY OF THE INVENTION

[0010] This invention provides a modular propellant assembly for use in fracturing wells. Each propellant module contains a propellant charge with a detonating cord extending along its length and end boosters to ignite the propellant. Subsequent propellant grains are ignited by an ignition booster-to-booster transfer. Each propellant module also has male and female connectors that are sealed with O-rings so that the ignition system remains dry while submerged at high pressures. These connectors enable propellant modules to be connected in an end-to-end relationship to any desired length, so that their detonating cords will be ignited in series. Each propellant module can also be provided with a steel rod extending between the end connectors for structural support and rigidity.

[0011] These and other advantages, features, and objects of the present invention will be more readily understood in view of the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention can be more readily understood in conjunction with the accompanying drawings, in which:

[0013] **FIG. 1** is a side cross-sectional view of a propellant module **20**.

[0014] **FIG. 2** is a side cross-sectional view of an assembly consisting of two propellant modules **20***a* and **20***b*.

[0015] **FIG. 3** is a detail side cross-sectional view of the left end of the assembly in **FIG. 2**.

[0016] **FIG. 4** is a detail side cross-sectional view of middle portion of the assembly in **FIG. 2** showing the male connector of the first propellant module **20***a* inserted into the female connector of the second propellant module **20***b*.

[0017] **FIG. 5** is a detail side cross-sectional view of the right end of the assembly in **FIG. 2**.

[0018] **FIG. 6** is a cross-sectional view of the propellant module taken along lines **6-6** in **FIG. 2**.

[0019] **FIG. 7** is a cross-sectional view of an end of the propellant module taken along lines **7-7** in **FIG. 2**.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Turning to **FIG. 1, a** side cross-sectional view is provided showing one possible embodiment of the propellant module **20**. **FIG. 6** is a cross-sectional view of the propellant module taken along lines **6-6** and **FIG. 7** is a cross-sectional view of an end of the propellant module taken along lines **7-7** in **FIG. 2**. The major components of the propellant module **20** include a propellant charge **24**, a tube **23**, and a detonating cord **25** that is housed inside the tube **23**. Each propellant module **20** also includes a lower end connector **35** and an upper end connector **45** that can engage complementary end connectors on adjacent propellant modules in an end-to-end relationship. This enables any number of propellant modules to fastened together in series (male end connector **45** into female end connector **35**) to form an assembly having the desired gas-generation characteristics tailored for a particular job.

[0021] In the preferred embodiment of the present invention, the end connectors **35** and **45** are male and female connectors. However, other types of connectors could be readily substituted. The propellant modules can be secured together with set screws **28**, as shown in the drawings. Alternatively, the male and female end connectors **45, 35** can be threaded together, attached by a bayonet connection, bonded by an adhesive, or secured by a frictional fit between the end connectors **35**, **45**.

[0022] A mild detonating cord **25** within a tube **23** extends along the length of the propellant charge **24**. The tube **23** should be made of a high-strength, corrosion-resistant material, such as stainless steel, to protect the detonating cord **25** and to keep the detonating cord dry. For example, the tube **23** and detonating cords can be placed in a groove extended from end to end on the propellant charge **24**, as shown in **FIG. 6**.

[**0023**] After the propellant module assembly has been fabricated and placed in the well, the detonating cord **25** is used to ignite the propellant charge **24**. The end connectors **35**, **45** have openings that serve to align and maintain the water-tight seal between the ends of the tubes **23** in adjacent propellant modules **20***a* and **20***b*, as illustrated in **FIGS. 2***a* and **4**. This enables the detonating cords **25** in all of the propellant modules to be ignited in series. When ignited, the detonating cord **25** ruptures the tube **23** and ignites the main propellant charge **24** of each module. In addition, boosters can be included at the ends of the propellant cords **25** to help light the detonating cords **25** in series. O-rings **27** also help to keep the boosters **29** and detonating cord **25** dry prior to ignition.

[**0024**] The propellant charge **24** can be any solid propellant having suitable burn-rate characteristics. In the preferred embodiment, each propellant charge **24** has a length of 60 inches, but this could be of any length that is practical. The diameter of the unit can be any value since it depends on the size of the well being treated.

[**0025**] The propellant charge **24**, tube **23**, and detonating cord **25** can be placed in a carrier **26** having perforations to allow combustion gases to escape from the propellant charge **24**. The carrier provides structural support and helps to protect the assembly from damage in transit and while the propellant module is being lowered into the well. For example, the carrier **26** can be a perforated steel tubing similar to those used in propellant fracturing and perforation-gun systems.

[**0026**] A threaded steel rod **22** extends between the upper and lower end caps **34** and **44** for structural support. Cap screws **21** are threaded into the ends of the steel rod **22** to tension the rod **22** and thereby pull the unit together creating a structurally stable unit.

[**0027**] The following is a description of the assembly process for the propellant modules **20**. The detonating cord **25** is cut to the proper length and boosters **29** are placed on each end and crimped in place. The detonating cord **25** is placed into the tube **23** and bent to conform to the geometry of the male and female end connectors **45**, **35**. The tube **23** with the detonating cord **25** and boosters **29** is placed in a groove in the propellant **24** that runs from end to end to receive the tube **23**. A second groove, placed 180 degrees from the previously mentioned groove, receives the steel rod **22**. Interior O-rings **27** are inserted into the O-ring grooves on both the male and female end connectors **45**, **35** to keep well bore fluids from getting to the boosters **29** and detonating cord **25** from the propellant side of the end connectors **45**, **35**. The male and female end caps **44**, **34** are placed over the ends of the propellant **24**. Cap screws **21** are placed in the ends of the steel rod **22** to tension the rod **22**. External O-rings **27** are placed on the male end cap **44** to complete the module. With this arrangement, the system is totally well bore fluid proof. The male and female end caps **44**, **34** have complementary male and female end connectors **45**, **35** that enable a series of propellant modules **20** to connect together in an end-to-end manner.

[**0028**] Additional propellant modules are prepared consistent with the number of modules needed for the job. These propellant modules can be identical to one another, or customized to meet the specific needs of a particular job. For example, **FIG. 2** is a side cross-sectional view of an assembly consisting of two propellant modules **20***a* and **20***b*. **FIGS. 3 through 5** are corresponding detail side cross-sectional views of the left, middle, and right connections of this assembly, respectively. In particular, modules can be assembled by mating the male end connector **45** from one module **20***a* with the female end connector **35** from a second module **20***b* and placing a set screw **28** to hold them together. **FIG. 4** is a detail side cross-sectional view showing the male connector **45** of a first propellant module **20***a* inserted into the female connector **35** of a second propellant module **20***b*.

[**0029**] The last or bottom module in the string of propellant modules has a plug **30**, which can be identical to the male connector **45** on the male end cap **44**. The plug **30** is secured to the bottom of the last propellant module with a set screw **28** to keep the lower end of the ignition system dry. The first or top module in the string inserts into a cross-over **40** which has the female geometry to complete the top seal for the ignition system. The cross-over **40** can be equipped to fire the system using either a conventional tubing-conveyed system, a coiled tubing system, or a wireline system.

[**0030**] The above disclosure sets forth a number of embodiments of the present invention. Other arrangements or embodiments, not precisely set forth, could be practiced under the teachings of the present invention and as set forth in the following claims.

We claim:

1. A modular propellant assembly for fracturing wells comprising:

a propellant charge;

a detonating cord extending along the propellant charge and having an upper end and a lower end;

an upper end connector for engaging a complementary end connector on an adjacent propellant module to align and seal the upper end of the detonating cord with the lower end of the detonating cord of an adjacent propellant module; and

a lower end connector for engaging a complementary end connector on an adjacent propellant module to align and seal the lower end of the detonating cord with the upper end of the detonating cord of an adjacent propellant module.

2. The modular propellant assembly of claim 1 further comprising a carrier containing the propellant charge and having perforations allowing combustion gases to escape from the propellant charge.

3. The modular propellant assembly of claim 1 further comprising a tube containing the detonating cord.

4. The modular propellant assembly of claim 1 further comprising a rod extending between the upper end connector and the lower end connector.

5. The modular propellant assembly of claim 1 further comprising a booster adjacent to an end of the detonating cord to ignite the detonating cord.

6. The modular propellant assembly of claim 1 wherein the propellant charge further comprises a groove holding the detonating cord.

7. The modular propellant assembly of claim 1 wherein one of the end connectors is a male connector and the other end connector is a complementary female connector.

8. The modular propellant assembly of claim 7 further comprising an O-ring creating a seal between the male and female connectors.

9. A modular propellant assembly for fracturing wells comprising:

a propellant charge;

a tube extending along the propellant charge and having opposing ends;

a detonating cord within the tube; and

end connectors for engaging complementary end connectors on adjacent propellant modules and for aligning and sealing the ends of the tube with the ends of the tubes of adjacent propellant modules, so that the detonating cords of each propellant module can be ignited in series.

10. The modular propellant assembly of claim 9 further comprising a carrier containing the propellant charge and having perforations allowing combustion gases to escape from the propellant charge.

11. The modular propellant assembly of claim 9 further comprising a rod extending between the end connectors.

12. The modular propellant assembly of claim 9 further comprising a booster adjacent to an end of the detonating cord within the tube to ignite the detonating cord.

13. The modular propellant assembly of claim 9 wherein one of the end connectors is a male connector, and the other of the end connectors is a complementary female connector.

14. The modular propellant assembly of claim 13 further comprising an O-ring creating a seal between the male and female connectors.

15. The modular propellant assembly of claim 9 wherein the propellant charge further comprises a groove holding the tube and detonating cord.

16. A modular propellant assembly for fracturing wells comprising:

a propellant charge;

a carrier containing the propellant charge and having upper and lower ends, and perforations allowing combustion gases to escape from the propellant charge;

a tube extending along the propellant charge inside the carrier;

a detonating cord within the tube; and

end connectors at the ends of the carrier for engaging complementary end connectors on adjacent propellant modules in an end-to-end relationship, wherein one of the end connectors is a male connector and the other end connector is a female connector, with both end connectors having openings for aligning and sealing the ends of the tube with the ends of the tubes of adjacent propellant modules, so that the detonating cords of each propellant module can be ignited in series.

17. The modular propellant assembly of claim 16 wherein the propellant charge further comprises a groove holding the tube and detonating cord.

18. The modular propellant assembly of claim 16 further comprising an O-ring creating a seal between the male and female connectors.

19. The modular propellant assembly of claim 16 further comprising a booster adjacent to an end of the detonating cord within the tube to ignite the detonating cord.

* * * * *