Dec. 19, 1961 E. W. SEXTON 3,013,492

EXPLOSIVE CARTRIDGE

Filed Jan. 21, 1959 2 Sheets-Sheet 1

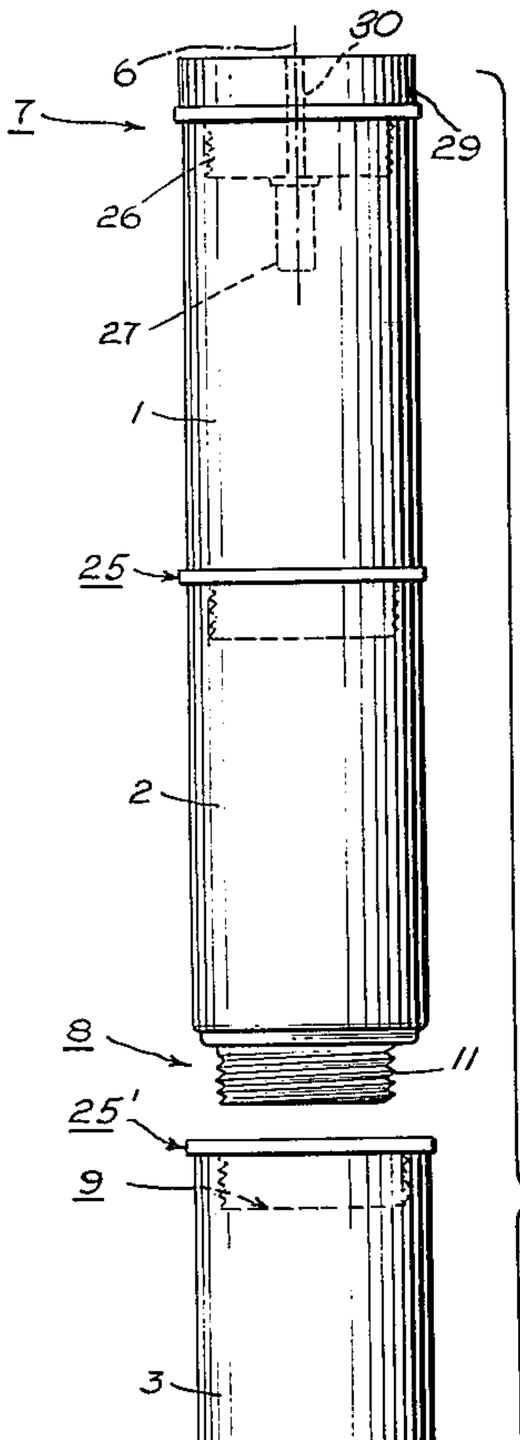

FIG. 1

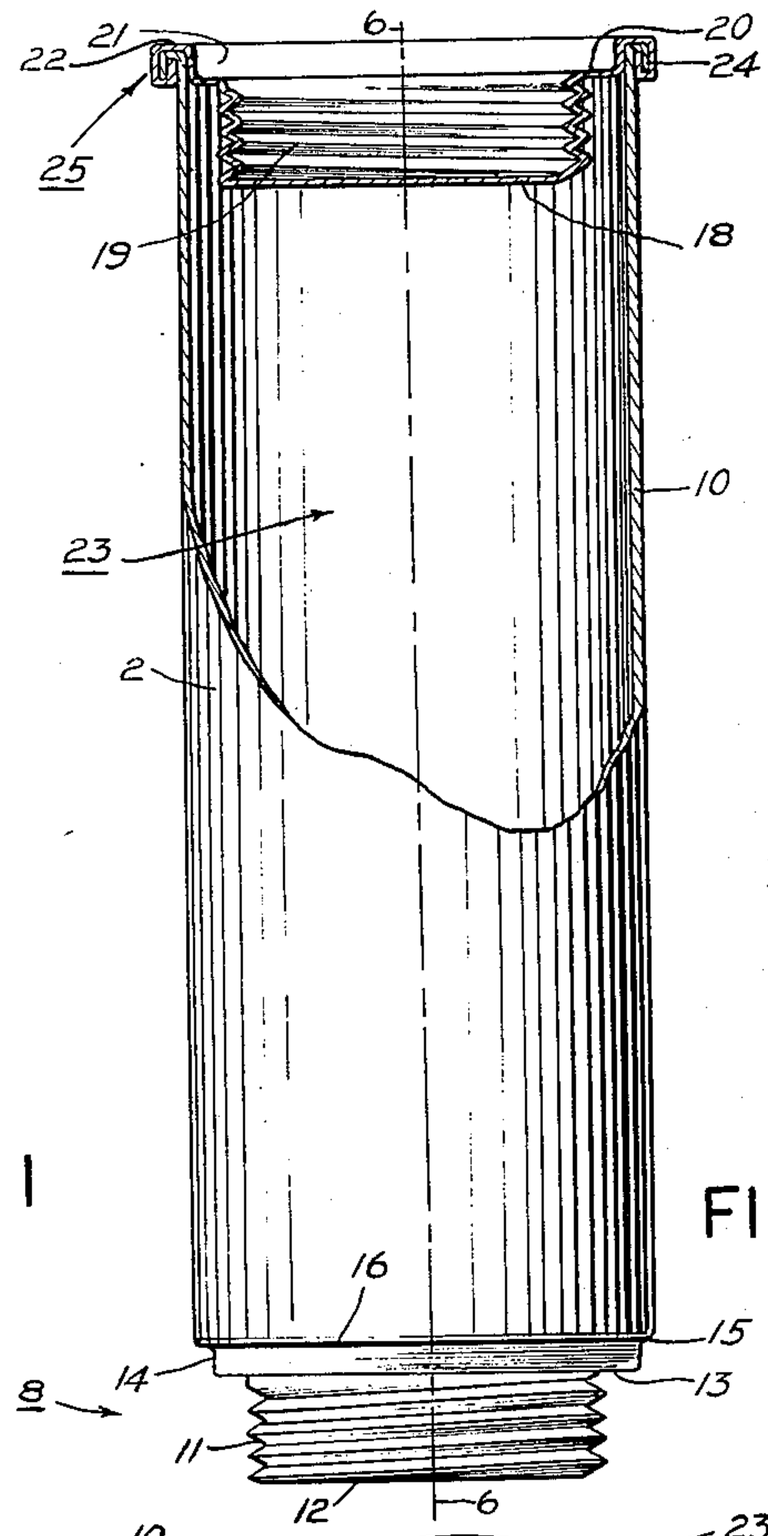

FIG. 2

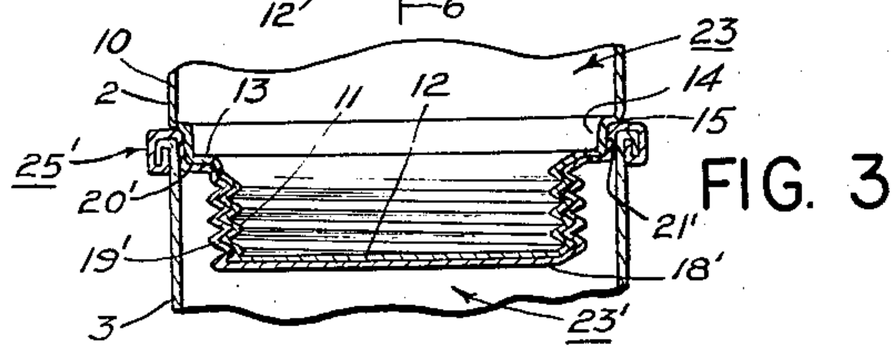

FIG. 3

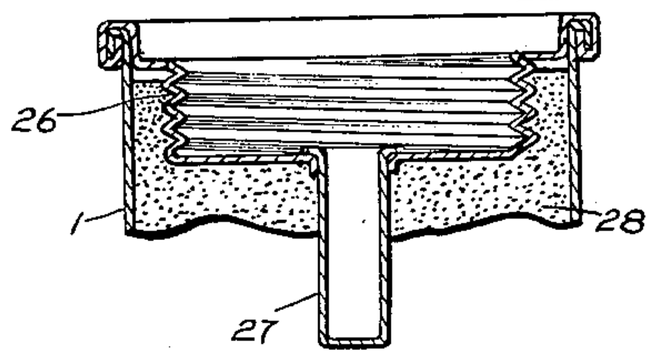

FIG. 4

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EXPLOSIVE CARTRIDGE

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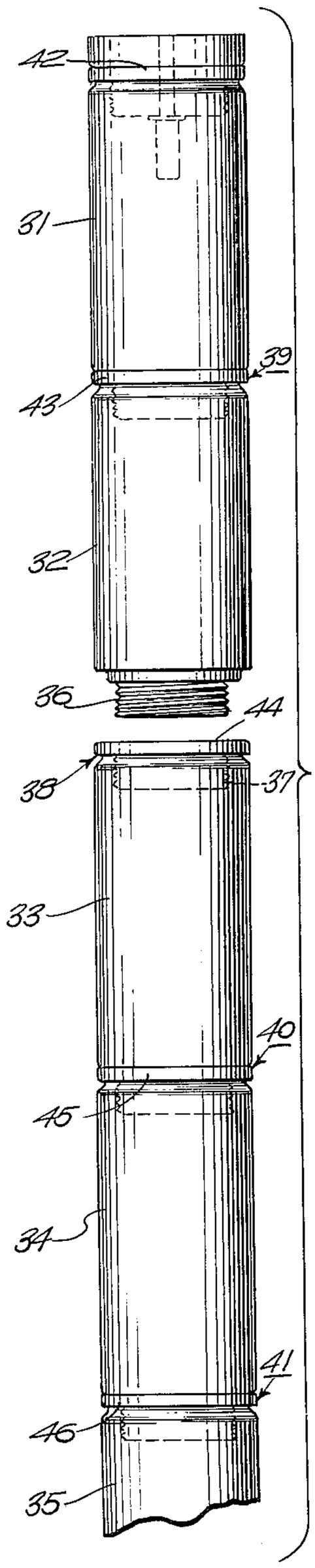

FIG. 5

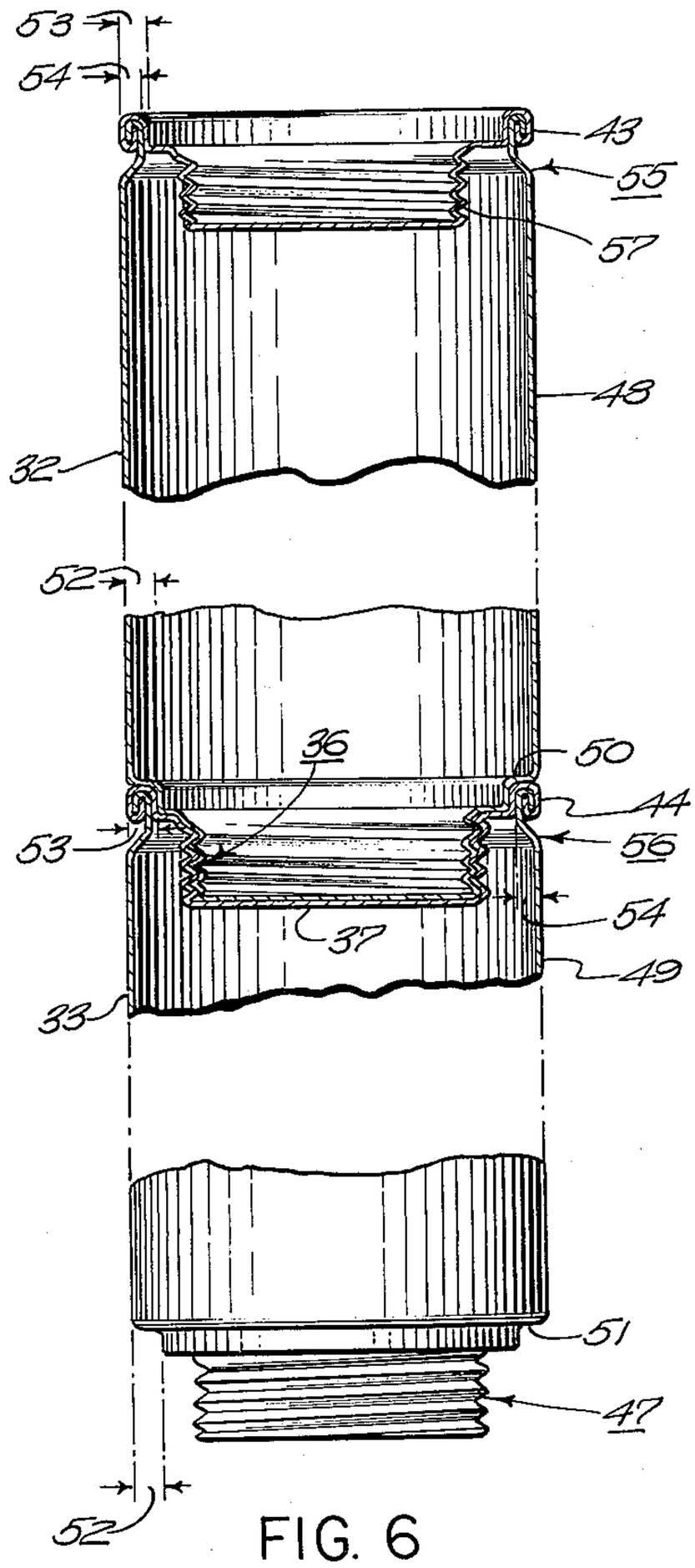

FIG. 6

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EXPLOSIVE CARTRIDGE

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Filed Jan. 21, 1959, Ser. No. 788,070
5 Claims. (Cl. 102—24)

The present invention is concerned with improvement of columnar assemblies of explosive cartridges and, in one particular aspect, with explosive container units of improved construction and form which interconnect to produce highly rigid unitary columns having positive and accurately predictable detonating characteristics.

Important industrial and scientific uses of explosives involve sub-surface location and detonation of charges, as, for example, in geophysical sounding and well shooting operations. Commonly, the charge must be accurately of predetermined explosive effect, and must also be capable of being thrust very forcibly to desired levels below the earth's surface through mud or other obstructions without premature and hazardous explosion.

Where the charge is to be placed at some depth, or where an existing well is involved, the accommodating opening in the earth assumes the general form of an elongated drill hole, and the charge itself has customarily assumed a complementary cylindrical columnar shape. However, the required lengths of such cylindrical charges are variable with the different exposive effects needed, and common lengths are so large as to be unwieldy. Consequently, manufacturers have sought to provide convenient stiff sub-sections or cartridges which would lend themselves to "stringing" or mating into columns at the work site in optimum total lengths for the operations being performed, and which would yet be as effective, explosively, as a unitary charge. The matter of merely physically joining the rigid sub-sections in end-to-end relationship can be overcome routinely through provision of appropriate screw threads, plugs, lock couplings, and the like, but prior efforts along these lines have nevertheless failed to satisfy several further objectives of primary importance. Some of these unsatisfied objectives concern improved hermetic sealing of the explosive under all expected environmental and handling conditions, more complete isolation of the explosive from loadings applied to the column as it is thrust into operating position, elimination of such voids in each cartridge as may tend to make its charge inaccurate, elimination of external irregularities which would interfere with pentration of the column into rough or somewhat obstructed passageways, improved rigidity and straightness of the cartridges themselves and the columns they form when interconnected, and interconnections between cartridges which will efficiently propagate detonating effects without permitting them to become damped and will preclude the possibilities of incomplete firing. Teachings of the present invention enable these further objectives to be met in uncomplicated constructions which are of economical manufacture.

It is one of the objects of this invention to provide explosive-filled cartridges of generally cylindrical configuration each drawn of metal to present both exterior and interior surfaces of improved smoothness, regularity and sealing characteristics, and to provide an end closure

and coupling of improved shape for rigid mating with like cartridges without voids therebetween.

It is also an object to provide explosive cartridges having improved couplings for interconnection in columnar assemblies and in which seamless drawn metal containers establish substantially exact volumes for filling with predetermined amounts of explosive without occasioning excess voids in the completed cartridges.

Another object is to provide drawn steel cartridges which are adapted for substantially voidless interconnection and maximum propagation of detonating forces and in which encased explosives remain hermetically sealed and undetonated under adverse environmental and installation conditions.

By way of a summary account of practice of this invention in one of its aspects, a thin impervious steel cylindrical container having an integral seamless end closure projecting axially outward from one end thereof is formed without seams by smooth drawing of the metal, the opposite end being left open for closure by a separate capping member. The outwardly projecting integral end closure is formed with threads having an outer diameter which is smaller than the diameter of the main body of the cartridge and is joined with the main body by a slightly tapered section, such that it serves as a male coupling portion. The capping member is of thin sheet metal formed with a threaded recessed center part complementing the configuration of the end closure and thereby forming a female coupling portion. Explosive charge material, such as a known gelatinous explosive, is deposited in the cartridge up to a predetermined level which may be taken to represent a predetermined explosive potential because of the smooth and regular cartridge interior which eliminates voids. The peripheral edges of the capping member recessed into the open end of the filled cartridge are rolled together with end edges of the main body of the cartridge to form a single thin annular seam and seal substantially aligned with the cylindrical body. Juncture of one such cartridge with others is accomplished by fully mating the complementary-shaped threaded sections, whereby tight sealing, precise rigid axial alignment and abutment of end surfaces are assured.

Although the features of this invention which are believed to be novel are set forth in the appended claims, additional and preferred constructional details and further objects and advantages may be most readily perceived through reference to the following description taken in connection with the accompanying drawing, wherein:

FIGURE 1 depicts a columnar arrangement of like explosive cartridges, with the assembly interrupted at one position to expose the drawn sealed end of one element in which teachings of this invention are practiced;

FIGURE 2 is a detailed illustration, partly in cross-section, of one explosive cartridge of the FIGURE 1 assembly;

FIGURE 3 provides a vertical cross-section of united end couplings of improved cartridges;

FIGURE 4 is a cross-section taken at one end of a detonating cartridge for the firing of a columnar assembly of explosive elements;

FIGURE 5 is a view like that of FIGURE 1 showing explosive cartridges in which the seals of the capping

members are located in slightly different position from that of the embodiment of FIGURES 1 to 3; and

FIGURE 6 illustrates details of end couplings of cartridges of the FIGURE 5 assembly, certain of the parts being shown in vertical cross-section.

The assembly of individual explosive cartridges 1 through 5 in FIGURE 1 forms part of an elongated rigid columnar charge which extends along the accurately linear axis 6—6 and lends itself to being thrust into a drill hole or other opening by forces applied downwardly upon it near the top part 7. The sub-surface environments in which such elongated charges are to be fired may include water, oil, mire, and dirt particles of various sizes, all of which must be prevented from reaching the explosive material in the individual cartridges and from becoming deposited between mated end surfaces of the cartridges. For these reasons the generally cylindrical cartridges are in the form of drawn hollow steel containers which are entirely seamless at one end and fully along the cylindrical sides. An externally-threaded male coupling, such as coupling 8 of cartridge 2, appears at the closed seamless end of each cartridge and cooperates with a complementary-shaped internally-threaded coupling element sealed with an end of the adjoining cartridge, such as element 9 of cartridge 3. Simple manipulations of the couplings are effective to join the cartridges in the desired end-to-end relationship.

The FIGURE 2 portrayal of cartridge 2 shows the relatively thin sheet-like thickness of the side walls 10 thereof resulting from drawing of a steel blank in a well-known manner. These side walls do not possess the usual longitudinal seam found in cylindrical containers, and they are thus entirely impervious to moisture and dirt and remain so despite pressure, shock and abrasion which are to be experienced. Coupling end 8 is drawn integral with the side walls, such that its surfaces are likewise fully sealed and cannot be interrupted without tearing or puncturing such as could be produced by only the most extreme forces. None of the surfaces of coupling 8 extend radially outward beyond the diameter of the cylindrical side wall 10, and, the threaded cylindrical end 11 is less than this same diameter. Lower end surface 12 is planar and fully closed, and, at the top of the threaded part 11, a narrow annular shoulder 13 extends radially outward to merge with a short, slightly tapered, generally cylindrical section 14 which is, in turn, connected with the side wall 10 by way of a yet narrower shoulder 15. It is important that the lower edge 16 of container 2 which is defined near shoulder 15 lie in a plane which is accurately perpendicular to the longitudinal axis 6—6, and it is found that the drawing operation employed in forming the integral end closure and coupling 8 permits this perpendicularity to be established simply and with a high degree of precision. The wall of the generally cylindrical section 14 tapers downwardly and inwardly, preferably at an angle of about one degree to the longitudinal axis 6—6.

While the cartridge is formed with one integrally closed, the opposite end must remain open to admit explosive filler up to a high level so that there is no void or substantially no void after the cartridge has been completed by closing this end. This open end is subsequently closed by a cap and female coupling member 18. The drawn seamless body portion of the cartridge is of highly accurate dimensions and is known to accommodate a predetermined amount of explosive filler. Accordingly, the cartridge may be filled, as by an automatic loading machine, and it is assured that substantially no void or only a small predetermined void will remain in the cartridge when the capping member has been fixed in place. The close tolerances realized in this way enable the individual cartridges and columnar assemblies of them to accommodate maximum explosive charges.

The internal contours of the closure member 18 complement the aforementioned external contours of the opposite coupling end 8, and include internal threading 19,

a narrow annular shoulder 20, and a short generally cylindrical section 21, the inner side walls of which are slightly tapered inwardly in the downward direction so as to match the inward taper of the section 14 of coupling 8. A taper angle of but one degree in relation to axis 6—6 suffices to produce a tight friction fit with said section 14 to promote the desired moisture-proof seal.

Cap member 18 is initially prepared with an annular peripheral flange 22 which is of greater diameter than that of the cartridge body 2, and this cap is set into the open end of the cartridge in the illustrated position when the explosive has been placed within the hollow interior 23 up to a desired level. At this end, the cartridge itself is also provided with an integral outwardly-extending annular flange 24, and a rolling operation of a known type causes this flange 24, to become tightly rolled together with the cap flange 22 to form a rolled and generally flattened peripheral seam 25, which is of exaggerated lateral dimensions in the illustrations. A sealing material may be interposed between adjoining surfaces of the rolled seam, although it will be understood that the pressurized rolling is alone sufficient to establish a satisfactory seal. In forming the seam 25, a chuck is disposed inside the portion 21 of the cap member 18 while a cooperating tool applies rolling pressures to the flanges from the outside, and the substantial diameter of the generally cylindrical depression 21 readily accommodates a solid chuck element having an external configuration which conforms to the slight inward taper of the section 21. If the male coupling 8 were also made as a separate cap and secured to the lower end of the cylindrical side wall 10 by a rolled seam, it would be necessary to extend the portion 14 upwardly in contact with the inside surface of the cylindrical wall 10 and to cause the horizontal section 13 to extend inwardly therefrom a substantial distance to provide a groove of substantial depth and width between the upper portion of the threaded portion 11 and the side wall 10 to receive an annular chuck of a substantial radial thickness to support the cap and the side wall 10 during the operation of rolling their flanges to provide the connecting seam. This would result in the provision of an annular chamber of substantial volume between the section 20 of the female coupling and the thuse elevated section 13 of the male coupling when two such cartridges were assembled reducing the structural strength of joined cartridges, and also creating a void in this annular chamber which cannot be filled with explosive. This is an important reason for locating the female coupling at the separately-capped end of the cartridge and for not utilizing a separate male coupling connected to the side wall by a rolled seam.

The nesting of cooperating coupling ends of adjoining cartridges appears in the cross-sectioned fragmentary views of joined cartridges 2 and 3 in FIGURE 3, the elements of cartridge 3 which correspond to those of cartridge 2 in FIGURE 2 being identified by the same reference characters with distinguishing single-prime accents added. Threading together of the portions 11 and 19′ of cartridges 2 and 3 causes their bottommost surfaces to abut one another. Similarly, the annular adjoining shoulders 13 and 20′ engage one another, without leaving any voids whatsoever between the two cartridges. The cooperating short cylindrical sections 14 and 21′ are in a tight coaxial fitted relationship, the locking tightness of which is promoted by the aforesaid slight taper of the generally cylindrical surfaces 14 and 21′. Shoulder 15, which lies accurately perpendicular to the longitudinal axis of the cartridge 2, abuts the top surface of the rolled seam 25′, without voids therebetween, and brings the side wall 10 of cartridge 2 into alignment and rigid interconnection with the side wall of cartridge 3. These relationships insure that the assembly is strong, rigid, and locked, that surfaces of the couplings fully abut one another, and that contaminants cannot be admitted into the site of juncture between the cartridges.

Rolled seam 25' tends to remain tight and sealed due to the pressures exerted upon it by the shoulder 15. While such seams cannot be as readily made accurately perpendicular to the longitudinal axes of cartridges as can the integral end edges 15, the present construction involves only half the number of such seams as have been used heretofore, and the columnar assembly of a number of such improved cartridges thus tends to be advantageously straighter.

The FIGURE 3 cross-section of the lower part of cartridge 2 reveals that the interior surfaces of this cartridge are regular and involve no pockets which would not readily become filled by the explosive material. Accordingly, the filling of each cartridge to a predetermined level at or near the top is sufficient to establish that the cartridge will have a predetermined maximum explosive potential, and useless voids between the ends of assembled cartridges are eliminated. Junctures involving two seamed cartridges necessarily occasion an annular void between cartridges, since both rolled seams must have annular recesses accommodating chucks used during rolling, and this condition is highly undesirable.

The disadvantage in having even small voids of this type is best understood by first recognizing that in a columnar assembly such as that of FIGURE 1, only one of the cartridges, such as the topmost section 1, is fired by electrically exciting a blasting cap within it. The explosion is efficiently propagated from cartridge to cartridge throughout the full length of the assembly, provided there are no voids or collections of damping material such as mud to prevent the assembly from behaving as one single charge. FIGURE 3 illustrates that such voids and traps for mud and the like are absent from the improved construction. Incomplete detonation not only fails to produce the desired explosive effects but results in hazard in subsequent operations at the same site. Also, the greater the diameter of the threaded portion of the joints in relation to the diameter of the cartridges, the greater is the amount of explosive composition at the bottom of one cartridge which is actually recessed directly into the exposive composition near the top of the other for good firing effects, and the detonating characteristics are bettered through this improvement of the present invention.

For the aforementioned detonation purposes, it is preferred to provide the cartridge which is to be used at the top of the column with a well in its upper coupling and designed to receive a detonator such as a commercial blasting cap. Such an arrangement is depicted in FIGURE 4, the cartridge 1 having the usual form of roll-seamed female coupling 26 at its upper end and further having a smaller hollow cylindrical well 27 projecting axially downward from the bottom of the coupling to which it is soldered or otherwise fastened. Well 27 receives a blasting cap and serves to dispose it deeply within the explosive filler 28 of this cartridge where it will efficiently communicate the explosive effects to the filler. This cartridge may then be closed by a suitable rigid cap or cover 29 (FIGURE 1) provided with a groove or passage 30 adapted to permit passage of detonation wires to the blasting cap.

Inasmuch as the peripheral seams are few in number, and there are no longitudinal seams, the very straight columnar assembly presents a highly smooth and regular exterior which does not tend to catch upon well hole obstructions. Each joint is tightly locked because of the fit between tapered and untapered surfaces, such that rough handling during positioning does not result in accidental disassembly or openings which would admit mud, water, and so forth. Side walls of the joined cartridges are aligned and in firm abutting end-to-end relationship which insures that compressive loadings of the column will not stress the internal explosive charges.

The assembly of explosive cartridges 31 through 35 in FIGURE 5 also constitutes a rigid columnar charge of the type portrayed in FIGURE 1, although the individual

steel cartridges are of modified construction which entirely avoids peripheral projections in the columnar assembly. Each of these cartridges is generally cylindrical in outer configuration and is entirely seamless along the sides and at the lower end, the seamless lower end 36 of cartridge 32 being illustrated in full as an externally-threaded male coupling. An internally-threaded coupling 37 of complementary shape appears at the top end 38 of the adjoining cartridge 33, whereby the two couplings may be readily manipulated into tightly joined end-to-end relationships such as appear at junctures 39 through 41. At the upper end of each cartridge, the female coupling and closure member is fastened and sealed with the cylindrical body portion in a rolled seam of the form described in connection with the embodiment of FIGURES 1 through 4, although such seams, 42 through 46, each have an outer diameter which is not in excess of the body portions of the cartridges.

For the purpose of accommodating the rolled seams wholly within peripheral limits of the cylindrical exteriors of the cartridges, at which positions they cannot become snagged with obstructions in the earth into which the assembly is thrust, each drawn container is slightly reduced in diameter at its upper end where the rolled seam is created. The enlarged and partly sectioned view of assembled cartridges 32 and 33 in FIGURE 6 displays this construction in detail. Each of these cartridges is drawn from a steel blank in a known type of drawing process, and their lower male coupling ends 36 and 47 are formed integral with the hollow cylindrical body portions 48 and 49, respectively, as seamless impervious units. While these coupling ends are in general similar to coupling end 8 depicted in FIGURES 1 and 2, they are distinguished in that their annular shoulders 50 and 51 are of a radial thickness 52 which is at least as great as the radial thickness 53 of the rolled seams 43 and 44 at the upper ends of the cartridges. These seams in turn are disposed in radial alignment with the cooperating annular shoulders of the cartridges with which they mate. The body portions 48 and 49 of these cartridges are reduced in diameter near their upper ends by radial amounts 54 which are less than the shoulder thickness 52, and this reduction is preferably formed with smooth outer contouring such as that designated by reference characters 55 and 56. In the axial direction, the length of each reduced section is sufficient to provide the material which is rolled into the seam, and is further sufficient to accommodate the chuck and cooperating rolling tool used to produce the rolled seam. Referring to the cartridge union in FIGURE 6, for example, the cylinder reduction at position 56 appears just short of the position of seam 44, whereby the edges of capping member 37 and upper end of container 49 may be rolled tightly together using such tools without interfering with other parts of cartridge 33. Upper capping members 37 and 57 are generally like female coupling member 18 in FIGURE 2, and preferably have the same slight inward taper of corresponding sections, although diameters are appropriately reduced because of the reductions in diameters of the upper ends of the cartridges.

Straight, secure and full abutment of upper surfaces of rolled seams with cooperating lower surfaces of outer annular shoulders of the united couplings is assured when these surfaces are designed to meet before the male and female threads are fully engaged. Further screwing of the containers to the point of full threaded engagement then forces these surfaces into a desired tight sealed relationship. In connection with both embodiments, this result is realized by making the rolled seam portion at the top of each cartridge slightly longer than the corresponding part of the male coupling of like cartridges.

The specific embodiment of this invention herein disclosed is intended to be of a descriptive rather than a

limiting nature, and various changes, combinations, modifications and substitutions may be employed in practice of these teachings without departing either in spirit or scope from this invention in its broader aspects.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An explosive cartridge adapted for interconnection with like cartridges in an explosive columnar assembly, comprising an elongated drawn seamless tubular sheet metal member charged with explosive material and having metal thereof extending across one end to form an end closure and male coupling which is an integral part of said seamless member, said end closure and male coupling comprising a wall portion extending inwardly forming a reduced diameter and then downwardly and then inwardly again and then downwardly into a portion having external thread means, a metal cap closing the other end of said tubular member and having a peripheral edge sealed with the peripheral edge of said tubular member in a rolled seam at said other end, said metal cap being recessed axially into said tubular member and having internal thread means proportioned to mesh with thread means of the proportions of said external thread means to form a female coupling, said end closure and said metal cap having surfaces of complementary shape and each being proportioned to abut with and to fit in coaxial peripheral relationship with surfaces of an opposite coupling with substantially no voids between said surfaces upon mating of male and female couplings, whereby said cartridge is fully sealed and is seamless along the sides and said end closure and may be assembled in end-to-end relation with like cartridges by threading of male and female couplings thereof.

2. An explosive cartridge adapted for interconnection with like cartridges in an explosive columnar assembly, comprising an elongated drawn seamless hollow sheet metal cylinder charged with explosive material and having metal thereof extending across one end to form an end closure and male coupling the material of which is integral with the cylindrical side walls of said seamless cylinder, said end closure and male coupling comprising a wall portion extending inwardly forming a reduced diameter and then downwardly and then inwardly again and then downwardly into a portion having external thread means, a metal cap and female coupling member closing the other end of said cylinder and having a peripheral edge sealed with the peripheral edge of said cylinder in a rolled seam at said other end, said member being recessed axially into said cylinder and having internal thread means for meshing with thread means of the proportions of said external thread means, said end closure and said metal cap having surfaces of complementary shape and each being proportioned to abut with and to fit in coaxial peripheral relationship with surfaces of an opposite coupling with substantially no voids between said surfaces upon mating of male and female couplings, whereby said cartridge is sealed and is seamless along said side walls and said end closure and may be assembled in end-to-end relation with like cartridges by threading of male and female couplings thereof.

3. An explosive cartridge adapted for interconnection with like cartridges in an explosive columnar assembly, comprising an elongated drawn seamless tubular sheet metal member charged with explosive material and having metal thereof extending across one end to form an end closure of slightly lesser cross-section than that of the body of said member and projecting axially outward therefrom, said closure merging with said body of said member to form an annular shoulder which is accurately perpendicular to the longitudinal axis of said member, said shoulder extending into a downwardly extending reduced diameter portion which in turn extends into an inwardly extending second shoulder and then downwardly into a portion of further reduced diameter

having coupling threads on the exterior thereof, a metal cap closing the other end of said tubular member and having a peripheral edge sealed with the peripheral edge of said tubular member in a rolled seam at said other end, said rolled seam including overlapping material of said edges aligned with said shoulder at said one end, said cap being centrally recessed axially into said member and having coupling threads on the interior thereof for mating with threads of the proportions of said threads on the exterior of said end closure, said end closure and said cap being of complementary shape and proportioned to abut with and to fit in coaxial relation with a like cap and end closure, respectively, of like cartridges, whereby said cartridge may be assembled in rigid and sealed end-to-end connection with like cartridges to form an accurately linear columnar assembly with substantially no voids between the end closures and caps.

4. An explosive cartridge adapted for interconnection with like cartridges in an explosive columnar assembly, comprising an elongated drawn seamless hollow sheet metal cylinder substantially filled with explosive material and having metal thereof extending across one end to form an end closure projecting axially outward therefrom, said closure having a short cylindrical section of a first diameter slightly less than the diameter of the body of said cylinder and merging at one end with said body of said cylinder to form an annular shoulder which is perpendicular to the longitudinal axis of said cylinder, and said closure having an externally-threaded projection from the other end of said short cylindrical section which is of less diameter than said section, a metal cap closing the other end of said cylinder and having a peripheral edge sealed with the peripheral edge of said cylinder in a rolled seam at said other end of said cylinder, said rolled seam including overlapping material of said edges aligned with said shoulder at said one end, said cap having a short cylindrical section recessed into said cylinder near the inner periphery thereof and tapering inwardly from said one end of said cylinder to a diameter slightly less than said first diameter, and said cap having an internally-threaded center section further recessed into said cylinder, said projecting end closure and said recessed cap being of complementary shape to abut with a like cap and end closure, respectively, of like cartridges, whereby said cartridges may be assembled in rigid and sealed end-to-end connection with like cartridges to form an accurately linear columnar assembly in which said short cylindrical sections are in coaxial locking engagement with cooperating short cylindrical sections of adjoining cartridges with substantially no voids between the end closures and caps.

5. An explosive cartridge adapted for interconnection with like cartridges in an explosive vertical columnar assembly, comprising an elongated seamless hollow sheet metal cylinder substantially filled with explosive material and having an integral axial projection closing the bottom thereof, said projection having a short cylindrical section of a first diameter slightly less than the diameter of the body of said cylinder merging at one end with said body of said cylinder to form an annular bottom shoulder which is accurately perpendicular to the longitudinal axis of said cylinder, and said projection having an externally-threaded section of a second diameter slightly less than said first diameter projecting from the other end of said short cylindrical section, a thin metal cap closing the top of said cylinder and having a peripheral edge sealed with the peripheral edge of said cylinder in a rolled seam at said top substantially perpendicular to said axis, said rolled seam including overlapping material of said edges aligned with said bottom shoulder, said cap having a short cylindrical section recessed into said cylinder near the inner periphery thereof and tapered radially inward in the downward direction from said top to a diameter slightly less than said first diameter, and said cap having an

internally-threaded center section further recessed into said cylinder and projecting downwardly below the level of said explosive material in said cylinder, said integral axial projection closing the bottom of said cylinder and said cap closing the top of said cylinder being of complementary shape to abut with a like cap and integral axial projection, respectively, of like cartridges with substantially no voids between them, whereby said cartridge may be assembled in rigid and sealed end-to-end connection with like cartridges to form an accurately linear columnar assembly in which said short cylindrical sections are in coaxial locking engagement with cooperating short cylindrical sections of adjoining cartridges.

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