Sept. 4, 1956 W. G. SWEETMAN 2,761,383

NON-EXPENDIBLE GUN FOR USE IN JET PERFORATING

Filed Aug. 8, 1951

2 Sheets-Sheet 1

Fig. 1

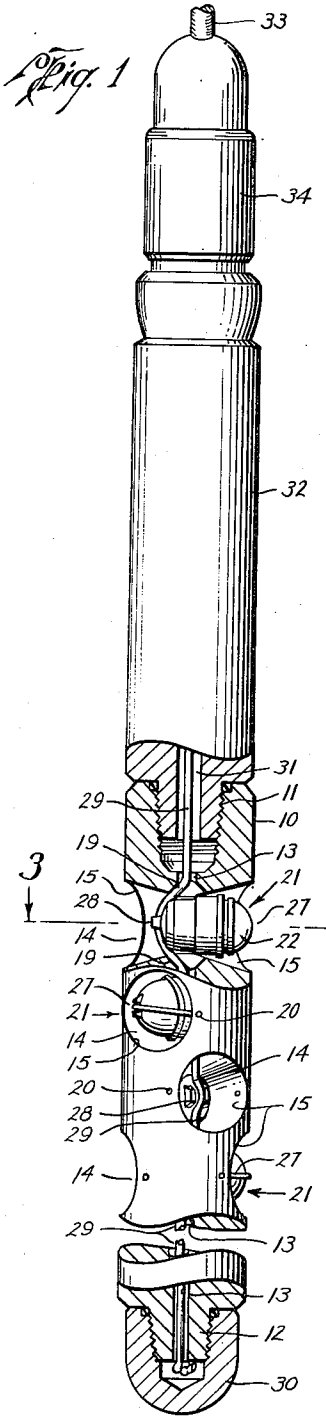


Fig. 2

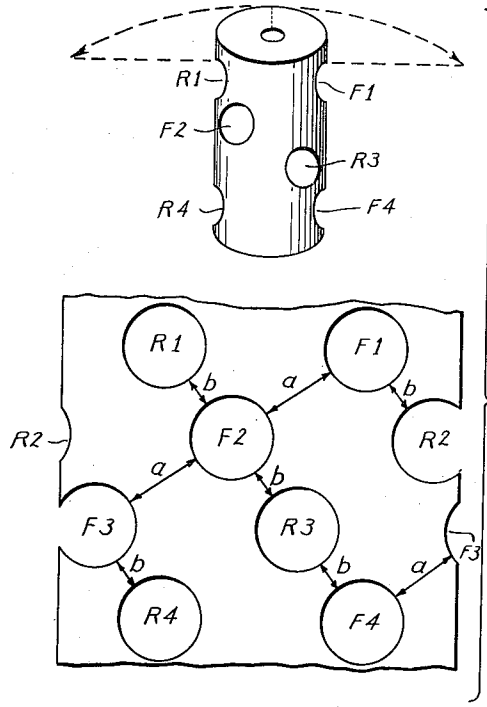
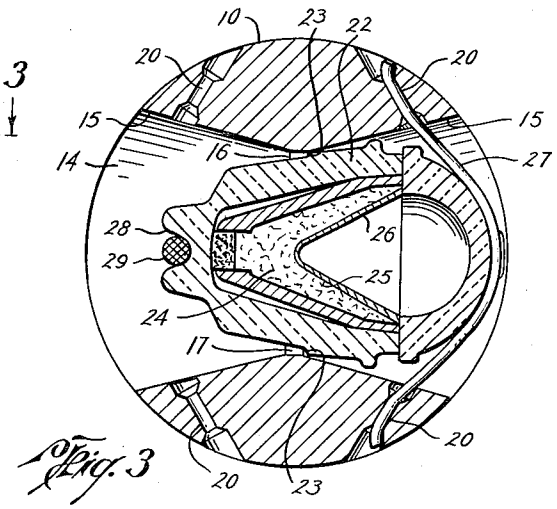


Fig. 3



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2 Sheets-Sheet 2

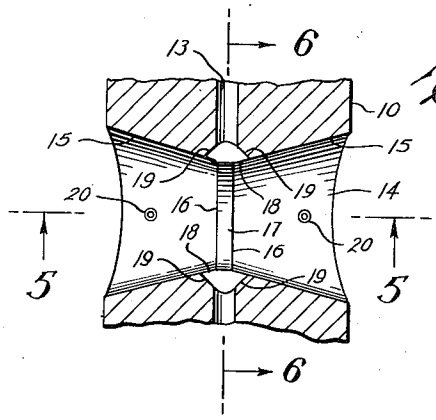

Fig. 4

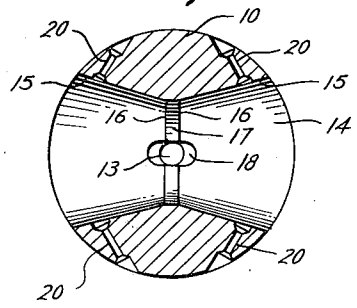

Fig. 5

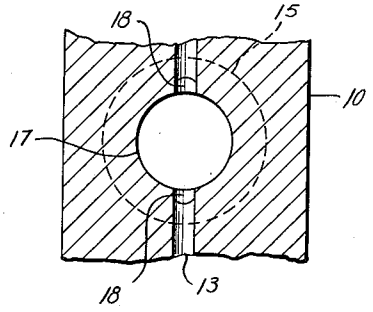

Fig. 6

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NON-EXPENDIBLE GUN FOR USE IN JET PERFORATING

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Application August 8, 1951, Serial No. 240,935

3 Claims. (Cl. 102—20)

This invention relates to carriers, or so-called "guns," employed in the art of perforating wells, which are adapted to support explosive perforating units of the hollowed type, commonly referred to in the art as "jet charges," the art itself being usually known as "jet perforating."

Various types of such carriers of "guns" have heretofore been designed which fall into two general classes, to wit: expendible and non-expendible types. The expendible types are normally constructed of shatterable materials, both metallic and non-metallic, which are designed to be disintegrated as completely as possible by the explosion of the charges. The non-expendible type is normally constructed in the form of a massive steel body provided with sockets or receptacles in which the charges are seated, and which, after firing of the charges, is withdrawn from the well for reloading and re-use. The present invention is directed particularly to the non-expendible type of carrier, which is advantageous for use in many instances where the use of expendible type carriers is found to be undesirable or unadapted for one reason or another.

Non-expendible guns are necessarily relatively expensive to construct, since they must normally be made of tough alloy steels and of massive construction in order to withstand the destructive forces resulting from the firing of the high explosive perforating charges. Moreover, the charge sockets and seating surfaces for the charges, and the various openings and sealing closures therefor, must ordinarily be machined to very close tolerances and these are particularly subject to the battering and destructive action of the forces released by the explosion of the charges. Present types of non-expendible guns, therefore, ordinarily require remachining, often after each run or, at best, after only a very few runs, and this is not only expensive but necessarily sharply limits the total number of times the gun may be re-used.

Accordingly, the principal object of the present invention is to provide an improved non-expendible type of carrier or gun for jet perforating which is relatively unaffected by the force of the exploding charges and which, therefore, is capable of re-use a much larger number of times than the more conventional forms of non-expendible guns.

A more specific object is to provide a gun having a cylindrical body of relatively massive construction provided with a series of longitudinally spaced passages extending transversely entirely through the body, the passages being angularly oriented with respect to each other about the longitudinal axis of the body; the opposite outer ends of each passage being shaped to form receptacles or seating sockets for individual perforating units, the sockets in each passage being in open communication with each other at their inner ends.

A further object is to provide a gun having the socket arrangement mentioned in which for each run only one charge is mounted in one socket of each pair, the other socket of each pair forming a vent for relief of pressure resulting from the firing of the charge.

A further object is to provide a gun having the socket arrangement mentioned in which the charges are selectively arranged in the sockets in such manner as to provide clockwise orientation of the series of charges along the gun body.

Other and more specific objects and advantages of this invention will become apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate a useful embodiment in accordance with this invention.

In the drawings:

Fig. 1 is an elevational view of the complete gun having some of the parts thereof broken away for purposes of illustration;

Fig. 2 is a diagrammatic representation of a planar development of a portion of the gun surface to illustrate the spatial relationships of the charge sockets;

Fig. 3 is a horizontal cross-sectional view taken along line 3—3 of Fig. 1;

Fig. 4 is a longitudinal sectional view of one of the charge-seating passages of the gun;

Fig. 5 is a transverse sectional view taken along line 5—5 of Fig. 4; and

Fig. 6 is a longitudinal sectional view taken along line 6—6 of Fig. 4.

As shown in the drawings, the gun comprises an elongated generally cylindrical body **10**, which is normally constructed from a solid billet of a suitable alloy steel. Body **10** is provided at its upper end with an internally threaded socket **11** and at its lower end with an externally threaded pin member **12**. An axial bore **13** extends entirely through the body, its upper end communicating with the bottom of socket **11** and its lower end opening through the outer end of pin member **12**.

Extending entirely through body **10** at right angles to its longitudinal axis are a plurality of longitudinally spaced passages **14** which are angularly oriented with respect to each other about the longitudinal axis of the body. As shown in detail in Figs. 4, 5 and 6, the outer ends of each passage **14** are machined or otherwise shaped to form outwardly flaring generally conical sockets **15**, the taper of each socket extending outwardly from points immediately adjacent bore **13** and on the respective opposite sides thereof, thereby forming an internal shoulder **16** at the inner end of each socket and defining a narrow annular wall **17** between the shoulders **16** which extends circumferentially of passage **14**. At the inner end of each socket, at the upper and lower sides thereof, short notches **18** are cut radially through the wall of the socket into communication with bore **13**, each notch extending into bore **13** at an angle to the wall of the socket to thereby provide a sloping wall **19** extending between the wall of the socket and bore **13**. Each socket is provided adjacent its outer end, and on opposite sides thereof with a pair of holes **20—20** which extend from the wall of the socket through body **10** to the exterior thereof. It will be seen that the sockets **15** in each passage are substantially identical in form and symmetrical with respect to the longitudinal axis of the body.

Mounted in one of the sockets **15** of each of the passages **14** is a hollowed high explosive perforating unit, designated generally by the numeral **21**. Perforating units **21** are of the self-contained hermetically sealed type, described in detail in my co-pending application Serial No. 163,146, filed May 20, 1950, now Patent No. 2,629,325, dated February 24, 1953. As shown in Fig. 3, perforating unit **21** comprises a glass casing **22** of generally ovoid or egg-shape, the larger end being directed toward the outer end of the socket. Casing **22** is provided near its smaller end with an external annular shoulder **23** adapted to be engaged by shoulder **16** when the unit is inserted in socket **15** to thereby form an internal

stop for the unit and to position the perforating unit with its outer end substantially flush or slightly inside the outer end of socket **15**. A charge of high explosive **24** is completely enclosed within casing **22** and is provided at its outer end with a generally conical hollow **25** facing toward the outer end of socket **15**, and with a thin metallic liner **26** conforming in shape to, and seated within, hollow **25**. The perforating unit is held in place in socket **15** by means of a wire keeper **27** which passes transversely over the outer end of casing **22** and has its opposite ends threaded through holes **20—20** on opposite sides thereof and crimped over the outer edges of holes **20**, or otherwise suitably fastened, to hold the perforating unit in place in socket **15** against shoulder **16**.

The inner end of casing **22**, adjacent the inner end of charge **24**, is provided with a notch **28** for the reception of a suitable detonating element **29**, such as the well known "Primacord", which passes transversely across the inner end of casing **22** and through notch **18** into bore **13** on opposite sides of socket **15**. The sloping surfaces provided by walls **19** of notches **18** allows the detonating cord to enter bore **13** without forming sharp bends or creases therein which would otherwise interfere with the effective transmission of detonating shock along the detonating cord to the series of perforating units over which the detonating cord is trained.

Detonating cord **28** is threaded through bore **13** and passes successively over the inner ends of each of the series of perforating units mounted in body **10**. The lower end of the detonating cord is suitably anchored to the lower end of threaded pin **12** which is enclosed by a threaded cap **30**. The upper end of the detonating cord extends into socket **11** and passes into the bore **31** of a firing head **32** which is threadedly connected into socket **11**. Firing head **32** is of a generally conventional form, the details of which do not form a part of this invention. As is well understood in the well-perforating art, firing head **32** will contain an electrically fired initiator which is connected to a suitable source of electric current through a conducting cable **33** which extends to the surface and is connected to firing head **32** by means of a conventional connector or so-called "rope-socket" **34**, by which electric current is transmitted from the cable to the initiator, the cable being also used to lower the gun into a well.

When a hollowed explosive charge, such as that employed in a perforating unit **22**, is fired, it is characteristic of such charges that a portion of the explosive forces will be concentrated into a narrow perforating jet or column which will be projected from the hollowed end of the charge along its longitudinal axis. At the same time the remainder of the explosive force generated by detonation of the charge will discharge in random manner in all directions about the charge and unless suitably controlled or directed, will tend to produce severe battering and other destructive action on the surrounding parts of the gun. By mounting only a single perforating unit in only one of the sockets of each pair formed in each passage **14**, it will be seen that the unoccupied socket will form an outwardly flaring vent of relatively large diameter through which the random explosive forces may be channeled and directed to the exterior of the gun. As a result of so confining and directing the random forces, their normally destructive action on the adjacent parts of the gun body will be very largely obviated so that the sockets will remain substantially undamaged and the gun may be reloaded and re-used a very large number of times.

Ordinarily, after firing one series of charges, the next series will be loaded in the sockets in the opposite ends of the passages **14** so that successive firings will take place in alternate ends of the passages. This further tends to protect the gun and of itself doubles the number of times the gun may be run.

A very important factor in greatly lengthening the life of the gun is provided by means of a novel loading arrangement in which the shots of each series are mounted in selected ones of the sockets in such a manner that the shots will be oriented with respect to each other in the clockwise direction about the longitudinal axis of the gun.

Fig. 2 illustrates schematically the desirable orientation arrangement for a series of four passages corresponding to a one-foot length of the gun, it being assumed for purposes of illustration that passageways **14** are longitudinally spaced on three-inch centers and are oriented at 120° with respect to each other. One end of each passageway is designated by the letter F and the opposite end by the letter R, the sub-scripts **1**, **2**, **3** and **4** designating the corresponding ends of the successively lower passages. In the development shown in the lower diagram of Fig. 2, the ends of all four passages are shown in their relative spatial positions. It will be seen that viewed in the clockwise direction around the gun, ends F_1, F_2, F_3 and F_4 of the successive passages **14** will be spaced from each other by the distance *a* which is substantially greater than the distance *b* which is the distance between an end F of one passage and an end R of the next lower passage, considered in the anti-clockwise direction. Accordingly, by inserting the perforating units of a series of shots only in ends F_1, F_2, F_3 and F_4, a maximum thickness of metal will be provided between each pair of shots thereby greatly increasing the degree of protection of each socket and the adjacent parts of the body from the effect of explosion of the charge in the next succeeding socket in the series. The next series of shots may then be installed only in the ends R_1, R_2, R_3 and R_4, again in the clockwise direction and the same maximum spacing between shots will be provided.

From the foregoing it will be seen that a gun body is provided which requires a minimum amount of machining, since no carefully machined sockets or charge seating surfaces are required, and by reason of the employment of hermetically sealed, self-contained perforating units, the need for carefully machined sealing surfaces and closures for the gun openings is eliminated. The cost of the gun is thereby greatly reduced. Moreover, the construction and loading arrangement described assures maximum protection of the parts of the gun against the normally destructive action of the explosive forces resulting from detonation of the perforating units thereby permitting re-use of the gun a much larger number of times than has heretofore been possible with the more conventional designs of non-expendible perforating guns.

It will be understood that various changes and modifications may be made in the details of the illustrative embodiment within the scope of the appended claims without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent:

1. In a perforating gun for use in jet perforating, a non-expendible carrier, comprising, an elongated cylindrical body of relatively massive metallic construction, an axial bore relatively small in cross-section extending through said body, a plurality of longitudinally spaced passages extending diametrically through said body intersecting said bore and angularly oriented with respect to each other about the longitudinal axis of said body, each of said passages including a pair of oppositely directed generally conical sockets each flaring outwardly at a substantial angle, the taper of each socket extending outwardly from points immediately adjacent said axial bore, said sockets being substantially identical in shape and symmetrical with respect to said longitudinal axis and in open communication with each other through their inner ends, a self-contained hermetically sealed hollowed high explosive perforating unit including a frangible case mounted in one of the sockets in each passage with its hollowed end directed outwardly of said one socket and with its opposite end extending within the socket at the opposite side of said passage, an internal annular shoulder formed at the inner end of each socket adjacent said bore adapted to engage an enlarged portion of the unit to form a supporting stop for the unit, means for retain-

ing each unit in engagement with its respective supporting stop, a cord-type detonating element extending through said bore into successive detonating relation with the inner ends of said series of units, and means connected to said body for firing said detonating element.

2. A non-expendible perforating gun for use in jet perforating, comprising, an elongated cylindrical body of relatively massive metallic construction, an axial bore relatively small in cross-section extending through said body, a plurality of longitudinally spaced passages extending diametrically through said body intersecting said bore and angularly oriented with respect to each other about the longitudinal axis of said body, each of said passages including a pair of oppositely directed generally conical sockets each flaring outwardly at a substantial angle, the taper of each socket extending outwardly from points immediately adjacent said axial bore, said sockets being substantially identical in shape and symmetrical with respect to said longitudinal axis and in open communication with each other through their inner ends, a self-contained hermetically sealed hollowed high explosive perforating unit including a frangible case mounted in one of the sockets in each passage with its hollowed end directed outwardly of said one socket and with its opposite end extending within the socket at the opposite side of said passage, the sockets in which said units are mounted being selected to provide clockwise orientation of the series of units along said body, means for retaining each unit in its socket, a cord-type detonating element extending through said bore into successive detonating relation with the inner ends of said series of units, and means connected to said body for firing said detonating element.

3. In a non-expendible perforating gun according to claim 2, wherein said means for retaining each charge in its socket comprises a reduced passage formed by the conical inner end of the socket adjacent said bore adapted to engage an enlarged portion of the unit to form a supporting stop for said unit, a pair of holes in said body on opposite sides of said socket extending from the exterior of said body to the interior of said socket adjacent its outer end, and a keeper wire extending transversely over the outer end of said unit and having its opposite ends anchored in said holes.

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