April 28, 1953 H. W. HARRISON 2,636,561

WELL GUN

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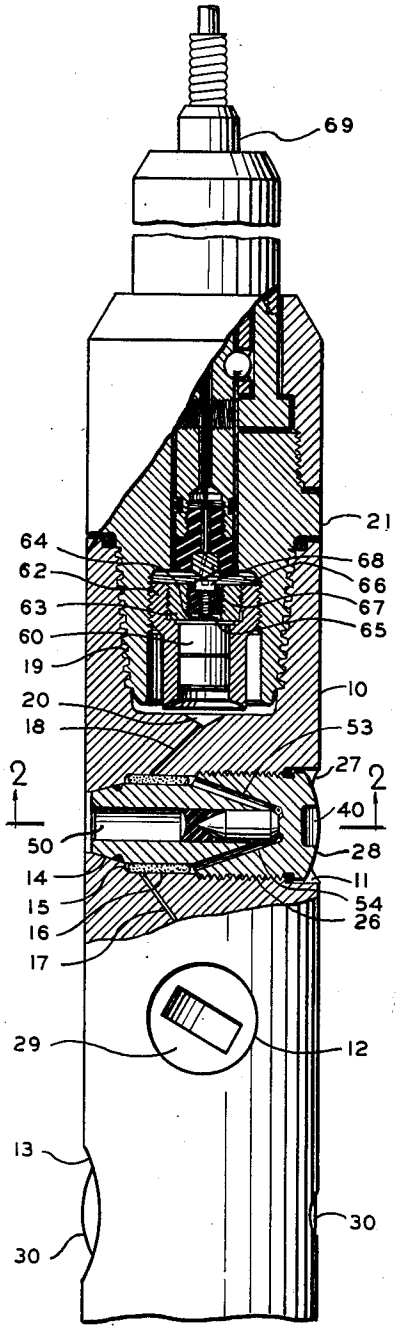


FIG. 1

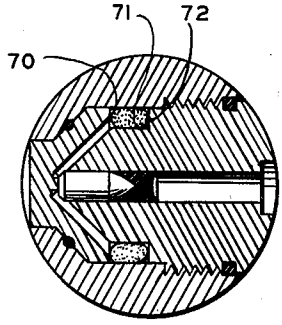


FIG. 4

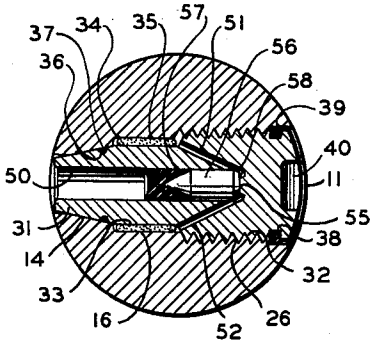


FIG. 2

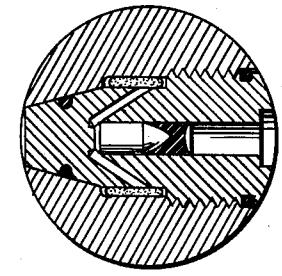


FIG. 3

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WELL GUN

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21 Claims. (Cl. 164—0.5)

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This invention pertains to well guns and more particularly to a gun for perforating the casing of petroleum wells.

A principal object of the invention is to provide a gun of such simple construction that it can be easily and inexpensively manufactured.

An equally important object is to provide a gun that will be strong and durable so that it will stand up under repeated use.

Perhaps the chief object of the invention is to provide a gun having the above set forth desirable qualities which will also have a maximum perforating power for a minimum size.

Further objects of the invention are to provide a gun that will be safe, reliable, simple, and economical to operate.

Other objects and advantages of the invention will be apparent from the description thereof hereinafter. Before describing the invention, however, certain of the problems to be overcome will be mentioned.

Petroleum wells are necessarily of rather small diameter due to the great depths to which they are carried. This places a limitation on the diameter of any gun used to perforate the well casing. The bore of the gun must be perpendicular to the axis of the well since to be most effective the bullet must strike the casing perpendicularly and since only a straight bore is practical. The length of the bore of the gun must therefore be less than the diameter of the gun. In addition, the diameter of the gun places a limitation on the size of the explosive charge since the walls of the chamber for the explosive charge must be strong enough to withstand the force of the explosion. Since the energy of a projectile leaving the gun, which is a prime factor in determining its penetration power, is directly proportional to the product of the length of the bore and the average force acting on the projectile, it is apparent that the limited diameter of a gun suitable for use in a petroleum well poses a difficult problem.

In perforating a petroleum well casing it is desirable to be able to make all the perforations at once. There are a number of reasons for this. For one thing, due to the great depths at which the perforations are usually made, there is considerable time and labor involved in lowering and raising the gun from top to bottom and back again. In addition it is difficult to locate a perforating tool twice at exactly the same depth, this being due to the change of length on any supporting pipe or cable on which the tool is lowered owing to its stretch over the great distances from the top to the bottom of a typical petroleum well. Another factor is the desirability of having the perforations made around the complete periphery of the casing. To accomplish this with a single shot gun would require some means for orienting the gun in the casing.

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A perforating gun for making a plurality of perforations in one trip into a well must have a plurality of projectiles and means for igniting the explosive charges for each. Various means have been proposed for this purpose including electric connections, flame passages, and mechanical linkages for operation of firing pins, but all of them have the common requirement of passageways interconnecting the several charges. Due to the nature of the medium in which the gun must operate, which is usually a mixture of oil, water, mud, and sand, coupled with the fact that the ignition means must be protected against damage by abrasion against the walls of the well during raising and lowering of the gun, it is almost a positive requirement that the ignition passages lie wholly inside the gun sealed from the outside. The provision of such passages is another difficult problem in the construction of a gun for perforating the casing of a petroleum well.

The requirement that a gun be capable of firing a plurality of projectiles in one trip into the well plus the limitation on the length of the bore of each barrel of the gun necessitates the use of quite a number of relatively large explosive charges. The simultaneous or nearly simultaneous explosion of all of the charges imposes great stress on the gun in each operation. To fashion the gun so as to stand up under repeated use is a further problem encountered in the construction of a petroleum well casing perforating gun.

Since a perforating gun uses a plurality of projectiles and large quantity of explosive, making a gun that can be loaded and handled safely is another important problem. Not only must the personnel operating the gun be protected but the well itself must be considered since preignition of the gun before it is lowered to the right level in the well would require a very expensive operation to eliminate unwanted perforations. Protection of the well also requires that in case of failure of the gun by rupture of some part thereof due to the forces of an explosion, there be no part of the gun which will completely separate and fall into the well or jam against the side of the casing, for all parts of the gun are made of hardened steel which cannot easily be removed by drilling as can other junk metal.

The foregoing problems as well as others not discussed in detail have been solved and the objects of the invention attained through the construction hereinafter described.

Briefly stated, the invention comprises a cylindrical body of metal into the side of which transverse to its axis are a plurality of apertures passing completely through the body and disposed so as to open at different points angularly displaced around the periphery of the body. Within each aperture there is a space to receive a hollow cylindrical molded explosive charge. The aperture is also threaded at one end to hold a removable plug that constitutes a combination barrel and breach block which is screwed into the aperture. The opposite end of the aperture is inwardly flared and the corresponding end of the plug is tapered to seat therein. Gas ports in the plug connect the rear of the bore thereof with the annular explosive chamber. A plurality of gas passages connect the explosive chambers with each other and with the ends of the gun body. The ends of the gun body can be connected onto other similar gun bodies in series to form a gun unit. One end of the unit is closed by a tail piece and the other end is connected to a suitable ignition head which may comprise an electrically fired ignition charge communicating with the gas passage at the end of the gun unit. Explosion of the ignition charge causes an exploding gas flame to travel through the gas passages serially igniting the explosive charges. The gas of the explosion of each charge passes through the gas ports in each plug to expel the projectiles.

Due to the fact that the chamber for the explosive charge is annular in form with the gun bore as an axis, the forces of the explosion acting on the gun body and plug are better distributed. Thus, much of the force is directed radially against the plug and only a small amount is directed axially tending to blow the plug out of the gun body. The forces against the plug due to the gas in the ports connecting the gun bore with the explosive charge chamber are all balanced so that they add nothing to the forces tending to blow out the plug. This is extremely important since one of the most common types of failure in a perforating gun is in the threaded connection between the barrel and body. The flared end of the plug provides for the possibility of the plug rupturing across the section through which pass the gas ports, so that in case of such failure the unthreaded end of the plug cannot be blown out of the gun body. By suitable modifications which will be described it is possible to balance out not only the forces in the gas ports but also those in the explosive chamber and in the gun bore so that there is little or no force tending to blow out the plug.

The annular explosive chamber has an additional advantage when a molded or otherwise pre-shaped charge is used. This is the fact that it has a large surface area so that more of the charge burns simultaneously thereby building up the desired pressure more quickly. The explosives used in perforating guns are of the relatively slow burning type as distinguished from the more dangerous materials which detonate substantially instantaneously such as TNT. For this reason there is a possibility that the projectile may be discharged before the pressure builds up to its maximum, with consequent loss

of penetrating power. Therefore anything which speeds up the pressure buildup is desirable.

The use of a preshaped charge is advantageous since it speeds up the operation of loading the gun. It also increases the degree of safety in the loading and handling of the gun since there is not the constant fire hazard and preignition danger that is present when loose powder is used. A further advantage lies in the fact that preshaping of the charge adapts it to the use of a waterproof covering or coating which reduces or eliminates the possibility of the charge failing to explode due to contact with rain, well fluid, or other liquid. Whatever disadvantage there is due to compacting of the powder which tends to reduce the rate of burning is largely offset by the annular shape as noted on the preceding paragraph.

The construction of the present invention in which the combined barrel and breech plug passes completely through the gun body and gas ports connect the gun bore with the explosive charge chamber is to be contrasted with previously known constructions wherein the gun barrel extends only part way through the gun body. The longer barrel admits of a longer bore which increases the energy of the projectile shot from the gun for a given explosive pressure. In addition, there is no possibility of explosive gas pressure building up behind the end of the gun barrel tending to blow it out as is the case where the aperture for the gun barrel does not extend clear through the gun body.

The large size of the apertures in the gun body required to accommodate the gun barrels and explosive charges makes it possible to bore the gas passages that interconnect the explosive charge chamber by means of a drill entering the gun body at an angle through one of the apertures. This means that there can be as many gun barrels in a single gun body as desired. This is a great advantage over certain known constructions wherein but a single barrel is provided in each gun body and many sections must be joined together to provide a unit having the desired number of barrels. The construction of the invention also compares favorably with previously known constructions having a plurality of gun barrels in each section wherein it is necessary either to use an extremely long drill to bore a single passage axially of the gun body or else to provide means for sealing special drill openings along the side of the gun body. The construction according to the invention requires only a relatively short drill to bore the gas passages and since the drill enters through the aperture for the combination gun barrel and breech block, the opening is automatically sealed from the outside when the plug is in place. Because of this simplicity of construction, it becomes economical to discard a gun body entirely whenever it becomes damaged or worn rather than attempt to make certain of the parts such as the gas passages replaceable.

For a detailed description of a preferred embodiment of the invention and a number of modifications thereof reference will now be made to the accompanying drawing in which

Figure 1 is an elevation, partly in section, showing a portion of a perforating gun constructed according to the invention;

Figure 2 is a transverse section taken along line 2—2 of Figure 1;

Figure 3 is a view similar to Figure 2 showing a modification, and

Figure 4 is a view like Figure 2 showing a further modification.

In Figure 1 there is shown a gun body 10 having a plurality of transverse apertures such as those shown at 11, 12, and 13 which pass completely through the gun body from one side to the other. The axes of the apertures are angularly disposed with respect to each other, in the particular case shown the angle between each adjacent pair of apertures being 90 degrees and every other aperture having its axis lying in the same plane but alternately pointed in opposite directions. The apertures are of a circular section throughout being of varying diameter. Starting at the left hand side of aperture 11 it is tapered for a short distance so as to make the aperture flare inwardly as indicated at 14. Adjacent to the flared portion 14 there is a shoulder 15. Next to shoulder 15 there is a smooth cylindrical portion 16 followed by a threaded cylindrical portion 26. The right hand end of aperture 11 is constituted by a counterbore 27 which is of slightly larger diameter than the cylindrical portion 16.

Angularly disposed ignition passages such as that shown at 17 connect the cylindrical portions 16 of the various apertures with each other. A similar ignition passage 18 connects the cylindrical portion 16 of the top aperture 11 with the interior of a threaded box 19 at the center thereof, the entrance of passage 18 into the box being chamfered as shown at 20. At the lower end of the gun body 10 which is not shown another ignition passage similar to passage 18 connects the cylindrical portion 16 of the lowermost aperture with the center portion of a pin member formed on the lower end of the gun body. This pin member may be screwed into the box at the top of another similar gun body or may be closed with a suitable streamlined tail-piece. The box member 19 at the top of gun body 10 may be screwed onto the pin member at the bottom of another similar gun body or, as shown in Figure 1, may be connected to a firing head 21. If two gun bodies are screwed together the passage 18 at the top of one will register with the corresponding passage at the bottom of the other so as to provide a continuous path. All of the passages such as that shown at 17 between the apertures in the gun body as well as the passage 18 at the top are disposed at such an angle that they can be drilled through the opening in the side of the gun body provided by the small ends of the apertures. The passage connecting the lowermost aperture with the pin on the bottom end of the gun body may be drilled from the pin end.

Within each of the apertures in the gun body there is received a plug constituting a combination gun barrel and breech block such as those shown at 28, 29, and 30. The plug is of circular cross section and of varying diameter conforming generally to the shape of the aperture in which it is received. Referring to Figure 2 the plug has a tapered end at 31 conforming to the taper 14 of the aperture 11 and a threaded portion 32 which fits the threaded portion 26 of the aperture. The middle portion 33 of the plug 28 opposite the cylindrical portion 16 of the aperture is also cylindrical but of a smaller diameter than portion 16, leaving an annular space 34 therebetween. This annular space is adapted to receive a pre-formed annular charge of explosive 35. On the tapered portion 31 near the cylindrical portion 33 there is an annular recess 36 adapted to receive a seal ring 37 which may be made of neoprene. The large end of plug 28 adjacent the threads 32 is provided with an annular recess 38 adapted to receive a similar seal ring 39. The end of the plug near the threaded portion 32 is also provided with a square socket 40 to receive a wrench for screwing the plug into position.

The plug 28 is provided with a cylindrical gun bore 50 extending from the tapered end of the plug well into the threaded portion thereof. A plurality of gas ports, preferably eight in number, such as those shown at 51 and 52 in Figure 2 and 53 and 54 in Figure 1, equally spaced around the axis of plug 28, connect the annular explosive chamber 34 with the inner end of gun bore 50. A protuberance 55 is left at the inner end of the gun bore surrounded by the ends of the gas ports. A projectile such as that shown at 56 may be placed in the end of the gun bore against protuberance 55 and held in position by means of a rubber cork 57. Preferably the end of projectile 56 is provided with an annular bevel as shown at 58 so as to provide ample space for explosive gas traveling from chamber 34 through the gas ports to get behind the projectile 56.

Referring once more to Figure 1, the ignition head 21 may comprise an ignition charge received within a cartridge 60 which is removably positioned within the head 21 by means of screw plugs 62 and 63. The cartridge may be provided with a filament wire, one end of which connects to a circular contact 64 on the top end of the cartridge and the other end of which connects to the rim 65. Rim 65 is grounded while contact 64 is connected through a pin 66 in insulating bushing 67 to a contact 68 extending from electric rope socket 69.

In operation of the construction above described a number of gun bodies 10 sufficient to hold the number of gun barrels necessary to provide the required number of well perforations are screwed together and connected to the firing head 21. The assembled unit is then lowered into the well and when the gun reaches the desired level it is fired by closing a switch at the surface which sends an electrical current through the filament in the cartridge 60. The flame and exploding gas from cartridge 60 pass through ignition passage 18 to the annular explosive chamber around the top gun barrel exploding the charge therein. The gas from this explosion passes largely through the gas ports in the plug 28 to the rear end of the gun bore and ejects the projectile 56. The initial expulsion of the projectile is prevented by the pressure of the well fluid against the cork 57 so that there is sufficient time for the gas pressure to build up to its peak before the projectile is completely expelled. The plug 57 also serves to seal the gun barrel so as to keep well fluids from entering the gas ports, the explosive chamber and the ignition passages. Well fluids would be harmful to the explosive charge unless properly waterproofed, and sand in the fluid would have a detrimental abrasive action on the gas ports and ignition passages. Some of the gas from the explosion passes through the ignition passage 17 and ignites the explosive charge around the next plug 29. The ignition proceeds serially down the gun until all of the explosive charges have been fired.

In the above described construction it will be noted that the threaded end of the plug con-

stitutes a breech block closing the end of the annular explosive chamber 34 and that there will be a pressure against the annular shoulder of the breech block tending to blow out the plug. The total force, however, will be relatively small due to the small area thus exposed. Inside the gas ports 51, 52 etc. the gas pressures in the plug will balance each other since a portion of the pressure will be directed rearwardly against the breech block portion of the plug while the remainder will be directed against the forward, or gun barrel portion of the plug. The web left between the gas ports 51, 52 etc. ties the gun barrel and breech block into one unitary plug so that the force of the gas pressure in the gas ports tending to blow out the plug is zero. However, should this web for some reason rupture, the gun barrel cannot be blown out of the gun body due to the taper of the nose thereof. The breech block portion will, of course, be held in the gun body by the threads thereon.

In addition to the force on the breech block around the annular shoulder closing the explosive chamber there is also an unbalanced force on the plug due to the pressure over the area closing the end of the gun bore 50. These two forces may be made to balance each other at least to some extent by reversing the direction of the gun barrel with respect to the plug as shown in Figure 3. The Figure 3 construction may be preferred for large guns where the explosive pressures are high and the resulting unbalanced force will be large. However, in smaller guns the construction shown in Figures 1 and 2 is preferred since it positions the gas ports in the large threaded portion of the plug rather than near the small tapered portion. Where the gun is small there may not be too much metal in the plug 28 so that if the gas ports are in the small end of the plug the web therebetween may crack when the plug is quenched during heat treatment.

Where a more complete balance of pressures is desired in a small diameter gun the construction of Figure 4 may be used in which the tapered portion of the plug is made of a larger average diameter thus providing more metal around the gas ports. This results, however, in a shoulder 70 between the tapered portion and the smooth cylindrical portion 71 of the plug instead of the shoulder 15 between the tapered portion 14 and smooth cylindrical portion 16 of the aperture 11 as in the previous construction. Shoulder 70 and the annular shoulder 72 around the breech block portion of the plug form an annular groove around the plug constituting the explosive charge chamber. In order to place the charge in this groove it must be split into at least two parts, say, diametrically across the charge. With this construction there is a complete balance of forces on the plug due to the pressures existing within the explosive chamber since the effective area of shoulders 70 and 72 are equal. The remaining unbalanced force due to the pressure against the closed end of the gun bore is in a direction such as to force the tapered end of the plug further into the taper in the aperture in the gun bore so that there is no force at all tending to strip the threads on the plug.

While a preferred embodiment and two modifications of the invention have been shown and described it is obvious that many other modifications thereof can be made without departing from the spirit of the invention thus, for example, instead of serially igniting the explosive charges by means of flame and exploding gas traveling through the ignition passages 17 and 18 the charges could equally well be ignited electrically by means of conductors placed in the ignition passages. Also, if it is desired to use flame ignition but to provide a longer interval between ignition of successive charges the ignition passages may be filled with some slow burning material either in the form of a free gas, liquid or powder, or in the form of a fuse. Furthermore, where flame ignition is used the ignition charge may be ignited by other than electrical means, for example, by percussion. It is intended to cover by Letters Patent all forms of the invention falling within the scope of the appended claims.

I claim:

1. A well gun comprising a body having an aperture therein having an opening to the exterior of the body on at least one side thereof, an integral plug disposed in said aperture, means to secure said plug in said aperture, an annular space around said plug between said plug and said aperture, said space being closed at both ends, a bore in said plug extending only part way therethrough, the open end of said bore facing the same direction as the opening in said aperture, at least one passage in said body leading to said annular space, and at least one port in said plug leading from said annular space to the closed end of said bore.

2. A well gun comprising a body having an aperture extending entirely therethrough opening at its ends on different sides of the body, an integral plug disposed in said aperture, means to secure said plug in said aperture, an annular space around said plug between said plug and said aperture, means sealing between said plug and said aperture at both ends of said space, a bore in said plug extending only part way therethrough, the open end of said bore facing the same direction as an opening in said aperture to the exterior of the body, at least one passage in said body leading to said annular space, and at least one port in said body leading from said annular space to the closed end of said bore.

3. A well gun comprising a body having an aperture entirely therethrough opening at its ends on different sides of the body, an integral plug disposed in said aperture, an annular space around said plug between the middle portion of the plug and the central portion of said aperture, one end of said plug adjoining said middle portion flaring inwardly and the adjacent portion of said aperture also flaring inwardly and at the same angle, said flaring end and flaring portion being in engagement, the other end of said plug being screw threaded and the adjacent portion of said aperture being correlatively threaded and engaged therewith, a bore in said plug extending only part way therethrough, the open end of said bore facing the same direction as one of the openings in said aperture to the exterior of the body, at least one passage in said body leading to said annular space, and at least one port in said plug leading from said annular space to the closed end of said bore.

4. A well gun comprising a body having an aperture therethrough from one side to the other and a plug adapted to be received in said aperture having a bore in one end forming a gun barrel opening out through said aperture to one side of said body, the outside of the middle portion of said plug and the inside of the middle portion of said aperture being formed so as to

provide an annular explosive charge chamber, the other end of said plug being of larger cross section than said middle portion of the plug and of about the same cross section as said middle portion of the aperture, the last said end of the plug constituting a breech block to close the end of said chamber through which a one-piece annular charge may be inserted, and at least one gas port in said plug connecting said bore with said chamber.

5. A well gun comprising a body having an aperture therethrough from one side to the other and a plug adapted to be received in said aperture having a bore in one end forming a gun barrel opening out through said aperture to one side of said body, the outside of the middle portion of said plug and the inside of the middle portion of said aperture being formed so as to provide an annular explosive charge chamber, the other end of said plug being of larger cross section than said middle portion of the plug and of about the same cross section as said middle portion of the aperture, the last said end of the plug constituting a breech block to close the end of said chamber through which a one-piece annular charge may be inserted, and a plurality of gas ports in said plug connecting said bore with said chamber, said parts being at acute angles to the axis of the barrel converging from said chamber in a direction opposite to that through which a projectile can leave said bores, said gas ports lying at least in large part in the breech block end of the plug.

6. A well gun comprising a body having an aperture therein and a plug adapted to be received in the aperture, the exterior of the plug and the interior of the aperture being formed to provide an explosive charge chamber therebetween, the plug having an opening constituting a gun barrel and at least one gas port connecting the inner end of the bore of the barrel with said chamber, said port lying at an acute angle to the axis of the barrel and having its end connecting to said chamber directed generally to the same end of the plug as the mouth of the barrel.

7. A well gun comprising a body having an aperture therein and a plug adapted to be received in the aperture, the exterior of the plug and the interior of the aperture being formed to provide an annular explosive charge chamber, the plug having an opening constituting a gun barrel and a plurality of gas ports connecting the inner end of the bore of the barrel with said chamber, said ports lying at acute angles to the axis of the barrel and converging in a direction opposite to that through which a projectile can leave the barrel.

8. A well gun comprising a body having an aperture therein, an integral plug adapted to be received in the aperture, the exterior of the plug and the interior of the aperture being formed to provide a chamber to receive a charge of solid explosive material, an opening in one end of the plug extending only part way therethrough forming a gun barrel, and at least one gas port interconnecting the bore of the barrel adjacent the closed end thereof with said chamber, the projected area of the exterior of the plug perpendicular to the axis of the barrel and exposed to the interior of said chamber and facing the closed end of the barrel being greater than the like area facing the mouth of the barrel.

9. A well gun comprising a gun body having an aperture therethrough from one side to the other transverse to the length of the body, said aperture being of circular cross-section substantially throughout and having a central portion of uniform diameter adjacent on one end to a threaded portion having a minimum inside diameter not smaller than the diameter of said central portion and adjacent on the other end to an inwardly directed shoulder, a plug adapted to be received in said aperture having a middle portion of smaller cross-section than said central portion of the aperture to provide an explosive charge chamber, said plug having a threaded portion adjacent one end of said middle portion adapted to fit the thread on said aperture, there being a shoulder between said middle portion and said threaded portion of the plug, said plug having a portion adjacent said middle portion that cooperates with the shoulder in the aperture to close said chamber, a bore in said plug inwardly from the threaded end thereof, and at least one gas port connecting said chamber and said bore.

10. A well gun comprising a gun body having an aperture therein, an integral plug adapted to be received in said aperture, said plug having an opening at one end extending only part way therethrough forming a gun barrel and having an opening in its side forming a chamber for a solid explosive charge, said chamber having equal projected areas perpendicular to the axis of the barrel facing respectively towards and away from the closed end thereof, and a gas port connecting said chamber and said barrel near the closed end thereof.

11. A well gun comprising a gun body having an aperture therein, an integral plug adapted to be received in said aperture, said plug having an opening at one end extending only part way therethrough forming a gun barrel and having an opening in its side forming a chamber for solid explosive charge, said chamber having equal projected areas perpendicular to the axis of the barrel facing respectively towards and away from the closed end thereof, and a gas port connecting said chamber and said barrel near the closed end thereof, said plug having a shoulder on its exterior facing in the opposite direction from said gun barrel adapted to seat against a shoulder in the aperture to take the force on the plug due to pressure in the gun barrel.

12. A well gun comprising a body having an aperture therethrough from one side of the body to the other, said aperture having an inwardly facing shoulder adjacent one end and a threaded portion adjacent its other end, an integral plug adapted to be received in said aperture having an outwardly facing shoulder adjacent one end and a threaded portion adjacent its other end, said shoulder and threaded portion of the plug being adapted to fit the corresponding portions of the aperture to hold the plug in the aperture, said plug having an annular channel thereabout between said shoulder and threaded portion constituting a chamber for a charge of solid explosive material and having an opening in the threaded end forming a gun barrel, and a plurality of gas ports connecting said chamber with the inner end of said barrel.

13. A well gun comprising a gun body having a plurality of apertures therein, a plurality of integral plugs each adapted to be received within one of said apertures, said cooperating plugs and apertures being formed to provide a chamber around each plug for a charge of solid explosive material, a bore in each plug extending only part way therethrough forming a gun barrel, at least

one gas port in each plug connecting the barrel adjacent the closed end thereof with the chamber around the plug, and a plurality of ignition passages interconnecting said chambers.

14. A well gun comprising a gun body having a plurality of apertures therein spaced apart along the longitudinal axis thereof, a plurality of plugs each adapted to be received within one of said apertures, said cooperating plugs and apertures being formed to provide an annular explosive charge chamber around each plug, a bore in each plug extending only part way therethrough forming a gun barrel, at least one gas port in each plug connecting the barrel adjacent the closed end thereof with the chamber around the plug, and a straight ignition passage interconnecting each adjoining pair of said chambers, each of said ignition passages being angularly disposed relative to the longitudinal axis of the body with the projection of its own axis from one end passing out of the gun body through one of said apertures without thereafter again intersecting the material of the gun body.

15. A well gun comprising a gun body having a plurality of apertures therein, a plurality of integral plugs each adapted to be received within one of said apertures, said cooperating plugs and apertures being formed to provide an annular chamber around each plug, a charge of solid explosive material in each of said chambers, a bore in each plug extending only part way therethrough forming a gun barrel, at least one gas port in each plug connecting the barrel adjacent the closed end thereof with the chamber around the plug, and a plurality of ignition passages interconnecting said chambers.

16. A barrel for a well gun comprising an integral metal body having a smooth cylindrical bore extending from a surface of the body part way therethrough, said body having an outwardly converging conical exterior surface concentric with said bore adjacent one end of the bore and a threaded exterior surface concentric with said bore adjacent the other end thereof and a cylindrical exterior surface concentric with said bore between said conical and threaded surfaces, said body having a plurality of relatively large gas ports extending from said cylindrical exterior surface to the closed end of said bore, said ports being angularly disposed relative to the axis of said bore and converging toward the closed end of said bore.

17. The combination of claim 16 in which the open end of said bore is adjacent said conical exterior portion of said body.

18. The combination of claim 16 in which the open end of said bore is adjacent said threaded exterior portion of said body.

19. The combination of claim 18 in which said cylindrical exterior surface has a smaller diameter than both said conical and threaded surfaces adjacent thereto.

20. The combination of claim 18 in which said cylindrical surface has the same diameter as that part of said conical surface adjacent thereto but a smaller diameter than said threaded surface adjacent thereto.

21. A well gun comprising a body having an aperture therein having an opening to the exterior of the body on at least one side thereof, an integral plug disposed in said aperture, means to secure said plug in said aperture, an annular space around said plug between said plug and said aperture, the outer diameter of said space being no larger than the diameter of said opening in said aperture, one end of said plug closing the end of said space adjacent said opening, the other end of said plug being no larger in diameter than the inside diameter of said space, said body closing the other end of said space, a bore in said plug extending only part way therethrough, the open end of said plug facing the same direction as an opening in said aperture to the exterior of the body, at least one passage in said body leading to said annular space, and at least one port in said plug leading from said annular space to the closed end of said bore.

HARRY W. HARRISON.

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