Feb. 2, 1960 H. H. MOHAUPT 2,923,204

PROPELLANT CHAMBER MEANS

Filed Oct. 8, 1954

FIG. 1.

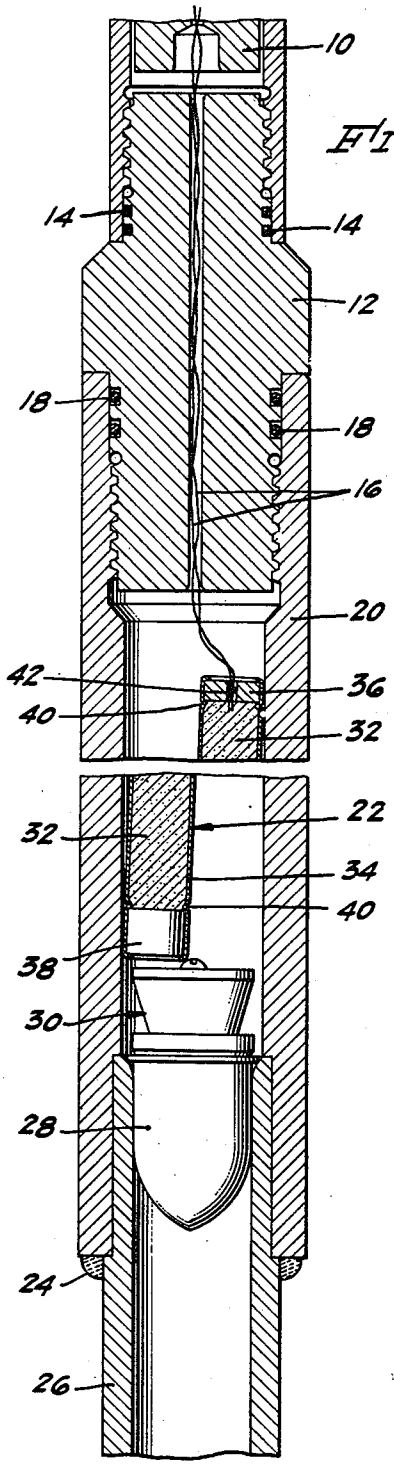
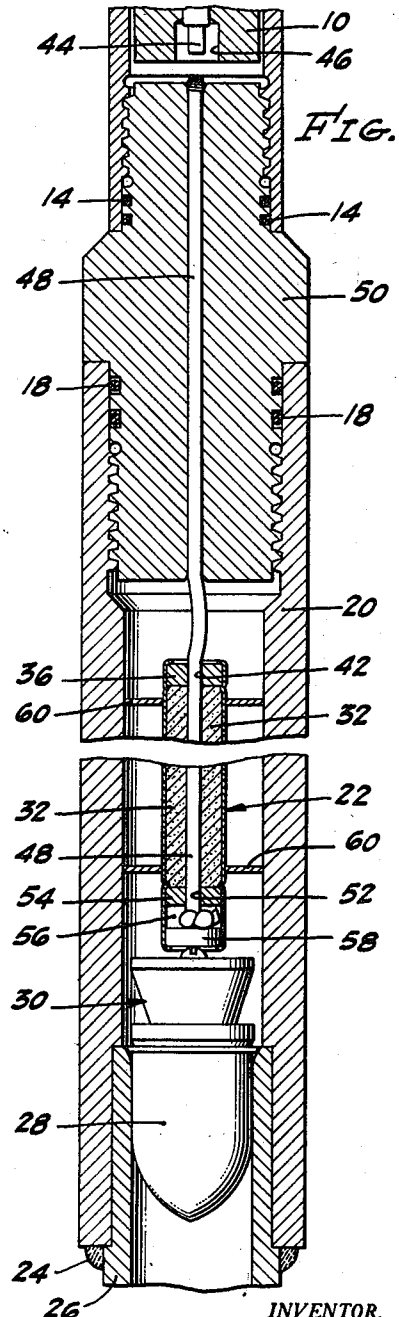


FIG. 2.



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PROPELLANT CHAMBER MEANS

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7 Claims. (Cl. 89—1)

This invention relates to novel apparatus for propelling missiles in wells and particularly to apparatus wherein the ratio of length of propellant chamber to diameter is extremely large. The invention also relates to a novel propellant charge for use in such apparatus.

Recently there has been developed for use in oil, gas, or water wells a new process whereby the penetrability of producing or potential producing earth formations is increased. Such process includes the firing into the formation of a missile possessed of extremely high kinetic energy, such missile being fired from a tool barrel and prinicpally accelerating in a direction along the axis of the well bore, i. e., the barrel extends vertically down the well bore and the missile is fired therethrough. An application entitled "Penetrating and Fracturing Tool" and filed January 25, 1954, in the name of Henry H. Mohaupt and having Serial No. 405,823 describes and claims such a process wherein directing means is used at the end of the tool barrel to direct the missile into the formation.

Additional uses for a tool of the general nature described in the aforesaid application have been found, such uses for example comprising the destruction of objects within the well, such as tools dropped thereinto and the like, and the drilling of additional well bore by firing the missile through strata relatively impervious to ordinary drilling bits. In these applications the penetrating tool does not normally use missile-directing means.

The aforesaid tool is characterized by the presence of a long barrel, a relatively massive missile and an exceedingly large powder charge which missile, as stated above, upon being fired possesses tremendous kinetic energy. Inasmuch as strict limitations are imposed upon the design of such a tool by virtue of the relatively small well bore diameters in which the tool must be used, the capacity of the propellant chambers able to accommodate the necessarily large propellant volumes can only be achieved by a relative increase in the length of the propellant chamber as compared to the possible increase in propellant chamber diameter.

Workable maximum ratios of chamber length to diameter, however, have long been established and adhered to in the propellant art, as for example, in firearms. These ratios have not materially changed since the introduction of smokeless powder and are of the order of 5 to 1. On the other hand in practicing the aforesaid process in oil wells ordinarily restricted in diameter to about 7 inches or considerably less, in order to impart the necessary kinetic energy to the missile fired, the ratio of chamber length to diameter must frequently be as large as 30 to 1 or considerably higher.

Unfortunately, investigation of the behavior of propellants in propellant chambers having high ratios of length to diameter demonstrates that conventional propellant practice will not permit tool design compatible with the aforedescribed process in wells. As is well known the limitations imposed upon propellant chamber design by material strengths, shapes, thicknesses, and the like, make it mandatory that erratic or fluctuating, and particularly

high peak chamber pressures resulting from the burning of the propellant charges within the chambers be avoided. Otherwise, chamber failure must and does occur. Thus in tests conducted utilizing standard propellant practice and tools comprising barrels and standard propellant chambers, it has been determined that chamber pressures generated do not vary greatly as chamber length is increased from approximately one diameter to approximately five diameters. In these tests the weight of propellant is of course increased while the loading density kept constant and normal.

Further lengthening of the chamber beyond ratios of 5 to 1, however, appears first to increase the pressure in the entire chamber, but unpredictably such condition may suddenly yield to high magnitude localized pressures. For example, it appears that given a chamber length to diameter ratio of 9 to 1, the strongest steel chambers are swelled either at the ignition end or at the front end adjacent to the missile, pressures in excess of 100,000 lbs. (p.s.i.) being registered at these points. As the aforesaid ratio is further increased complete bursting of the chamber frequently takes place. A careful analysis of the resulting fragments shows that failure occurs at one or the other or both ends of the chamber and thereby demonstrates that the peak uncontrollable pressures occur at the ends of the chamber.

Furthermore, decreasing of the loading density of the propellant does not overcome, contrary to expectations, the erratic pressure conditions mentioned but seems to aggravate such conditions, it appearing that the disruptive effects at even the low loading densities are quite similar to the effects obtained at the higher normal loading densities.

While the explanation for the aforesaid phenomena must of course be theoretical, it appears that the excessive and destructive pressures in propellant chambers having abnormally high length to diameter ratios are caused by the acceleration of the propellant particles themselves and their consequent compression or impact against the ends of the chambers. This impact and resulting high compression of the propellant results in a vastly increased burning rate in the affected portions of the propellant and creates uncontrollable pressures at those points. These erratic pressures are not characteristic of any particular type or composition of propellant but occur in all types. Explanation of the fact that disruptive pressures have been found adjacent the igniting point of the propellant as distinguished from the opposite end of the chamber apparently resides in the fact of oscillation or rebound.

The basic cause, therefore, of the conditions described above may be theoretically summarized to the effect that flame propagation, the mode of combustion inherent and characteristic of propellants relies on an increasingly intense flame which sweeps around and past each grain of propellant as the flame progresses through the chamber charge. Such flame or incandescent gases necessarily carry along increasing numbers of propellant particles, thereby shifting the charge along the major axis of the chamber and drastically upsetting the uniformity of the loading density and the combustion rate.

As previously stated, limitations imposed by well diameters severely limit the permissible diameter of the tools used in the subject process, it being of course necesary to provide adequate clearance between the tool and the cased or uncased well bore. At the same time in order to impart sufficient kinetic energy to the missile to accomplish its purpose, propellant charges must be used which cannot be encompassed within propellant chambers at the one time adhering to diameter limitations imposed by the well bore and at the same time having the required volumetric capacities necessitated by the charge. For example, a large number of wells are provided with

a casing having a 5½" outside diameter and 4.9" inside diameter. This necessitates a tool having an outside diameter of not substantially greater than 4" and indeed in many cases, such as where heavy drilling mud is used, the clearance must be greater. It is likewise frequently desirable in such a tool that a missile having a diameter of 1.5" or greater be used. In order that the necessary several hundred thousand ft.-lbs. of kinetic energy be imparted to the missile, a propellant chamber of several feet of length must be used, but as is obvious that even were the diameter of the chamber to be held to 1½" the ratio of chamber length to diameter will be manyfold that of 5 to 1. The wall thickness of the propellant chamber cannot exceed about 1" at its thicker sections and may only be about ½" at its weaker sections. Such wall thickness allows no safety margin whatsoever for erratic or fluctuating pressures but in view of the principles above set forth the chamber length to diameter ratio will ensure destructive pressures. Complicating the situation is the fact that given the slight clearance present in the well even a slight swelling of the tool cannot be tolerated because of the likely lodging of the tool within the well bore and consequent possible loss of the well.

In the light of the conditions under which the subject process must be practiced and the problem posed by the theory set forth above, the basis of the instant invention is found in the conception that mass movement of the propellant particles along the axis of the chamber must be avoided and with this in mind the object of this invention is to provide novel propellant chamber means for use in wells whereby erratic, fluctuating and high peak pressures are not developed in the chamber even though it has an abnormally high length to diameter ratio. It is also an object of this invention to provide a novel propellant charge for use in accomplishing the aims of the invention.

Other objects and advantages of the instant invention will be apparent from the following description.

In the drawings:

Fig. 1 shows a longitudinal sectional view of propellant chamber means incorporating the instant invention; and

Fig. 2 shows in the same view a different embodiment of chamber propellant means incorporating the instant invention.

As stated before, the basis of the instant invention is the conception that extreme axial acceleration of the charge particles must be avoided. This concept is carried into effect, first, by means comprising an annular expansion space within the propellant chamber, and second, by means ensuring a substantially instantaneous ignition over the entire length of the charge.

Referring to the embodiment of the invention shown by Fig. 1, it will be seen that a contact sub **10** suspended from the usual conductor cable not shown is threaded to an adapter **12**, sealing rings **14** being provided to provide a safety seal between the sub and the adapter. Extending from the conductor cable through bores in the sub and adapter are ignition wires **16**. Threaded to the adapter **12** and sealed by sealing rings **18** is an elongated propellant chamber **20** which propellant chamber carries an elongated propellant charge generally designated as **22** and which propellant chamber is welded by the weld **24** to the barrel **26**. It will be noted that the propellant chamber **20** and propellant charge **22** are shown as foreshortened, the actual ratios of length to diameter of these elements being considerably in excess of 10 to 1. A missile **28** is shown carried by the barrel **26**, said missile being provided with gas check means **30**.

The propellant charge **22** constitutes a load of ordinary smokeless powder **32** cylindrically encompassed within a thin walled frangible tube **34**. The tube **34** need have merely the strength to retain the powder in transport and may, for example, be composed of aluminum. End plugs **36** and **38** are utilized in conjunction with the tube and the tube is crimped as at the points **40** to retain the powder in place. The aforesaid plugs **36** and **38** may be composed of wood, aluminum, plastic or other frangible material. The ignition wires **16** extend into the powder **32** through a close-fitting bore **42** in the plug **36**.

In operation the tool is lowered into the well on the usual wire line to the firing zone, and the ignition wires **16** energized. By virtue of the extreme length to diameter ratio of the propellant chamber **20**, were such chamber filled with powder in the usual manner, propellant combustion would commence at the upper end of said chamber and burning would be progressive downward. The hot gases generated, however, would rush past and around the propellant particles towards the lower end of the propellant chamber and in so doing sweep with them unburned particles, thereby impacting and highly compressing the powder at the end of the chamber. As a result of this, the burning rate of the powder would greatly increase and would cause an excessive pressure peak, resulting in bulging, splitting, and even destruction of the chamber in that vicinity. The consequence of this would not only be failure and destruction of the tool, but additionally, damage to the well and casing and likely lodging of the tool in the well.

It will be noted, however, that the diameter of the thin walled tube **34** is considerably less than the inside diameter of the propellant chamber, providing thereby an annular expansion space within the chamber. In operation, therefore, as soon as propellant ignition at the upper end of the tube is effected, the tube bursts in that vicinity and such bursting continues progressively along the tube and within the propellant chamber as burning itself progresses. This affords continuous pressure release for the incandescent gases which are enabled to rush substantially unimpeded into the expansion annulus and proceed therealong parallel to the major axis of the chamber in such way as not to sweep before them the propellant particles. The incandescent gases envelop the tube progressively forwardly and laterally ignite the propellant as it becomes exposed as a result of the downward progressive bursting of the tube.

By this means axial acceleration and consequent impacting and compressing of the propellant particles at one end of the tube is avoided and likewise excessive pressures are substantially eliminated. Propelling of the missile **28** through the barrel **26** therefore takes its normal course without damage to propellant chamber, tool or well.

Referring now to Fig. 2 wherein like parts are given like numerical designations, it will be seen that rather than providing ignition wires, a blasting cap **44** electrically exploded in the usual way is provided within a recess **46** in the contact sub **10**, such blasting cap being adapted to detonate the detonating fuse **48** which passes through a bore in the adapter **50**. The detonating fuse, for example, may be Primacord, marketed for many years by the Ensign Bickford Company of Simsbury, Connecticut. Such detonating fuse **48** includes a relatively small column of fast-acting detonating explosive encased in impregnated fabric, plastic, or the like, and the fuse extends through the close-fitting bore **42** in the plug **36**, lengthwise through the propellant charge **22**, through a close-fitting bore **52** in a retainer ring **54** which may also be composed of wood, aluminum, or the like, and is knotted or otherwise retained in a space **56** defined by the ring **52** and a plug **58**, which again may be composed of wood, aluminum or the like. Centralizers **60** which may comprise annular rings or spiders made of asbestos or similar material are provided which hold the propellant charge **22** centrally in the powder chamber **20**.

The operation of the aforedescribed embodiment of the invention is similar to that of the previously described embodiment, provided, however, that due to the speed of propagation of the detonating fuse, ignition of the powder **32** along the axis of the propellant chamber is substantially instantaneous, said propagation approximating

20,000 ft. per second. This is greatly in excess of the propagation rate of the propellant and thus the entire length of the propellant charge is ignited before the unburned propellant particles may be axially accelerated due to the sweeping action of the incandescent gases.

It will be noted that an expansion annulus is provided in this embodiment of the invention as with the former embodiment, but it is to be understood that by virtue of the use of the detonating fuse, such annulus can under some conditions be dispensed with, as for example, if coarse, slow-burning powder be used under optimum tool and well conditions. On the other hand, it is recommended that the annulus be provided as a safety factor and to accommodate the tool to varying conditions of use. Thus, through utilization of the annulus relatively faster-burning, less coarse powder can be used. Similarly, detonating fuse failure can be protected against, for were the detonating fuse to effect propellant ignition at the upper end of the propellant charge but fail thereafter, lacking the annulus axial acceleration of the propellant particles would inevitably occur. Again, the effect of friction, barrel obstructions, and the like on the missile are diminished and varying weights of missiles may be used, an expedient which would be highly dangerous were the annulus safety factor disregarded. Again, provided the annulus is used, the tool may be operated in wells having extremely high temperatures, the annulus providing first, an insulation against auto-ignition of the propellant charge, and second, a space into which products of decomposition of the hot propellant may dissipate. In this latter regard, the provision of the propellant charge centralizer **60** will also be noted. Such centralizers provide the purpose of insulation of the charge. It will be appreciated that absent high temperature wells the centralizers may be dispensed with as is shown in the first embodiment of the invention. It will also be understood that in operating said first embodiment in high temperature wells, centralizers should be utilized.

It is apparent that other modifications may be devised incorporating the spirit and substance of the inventive features hereinabove disclosed, and it is understood that as to such modifications, applicant is entitled to the full breadth and scope of the appended claims.

I claim:

1. The combination with a barrel adapted for propelling a high energy missile of an elongated rigid propellant chamber having a length to diameter ratio of at least 9 to 1; an elongated propellant charge in said chamber and extending throughout the major portion of the length thereof; and firing means for said propellant, said firing means including a detonating fuse extending lengthwise through said propellant charge, said detonating fuse being adapted to ignite said propellant substantially instantaneously over its entire length.

2. The combination with a barrel adapted for propelling a high energy missile of an elongated rigid propellant chamber having a length to diameter ratio of at least 9 to 1; an elongated propellant charge in said chamber and extending throughout the major portion of the length thereof; and firing means for said propellant, said firing means including a detonating fuse extending lengthwise through said propellant charge having a propagation rate substantially higher than that of said propellant, said detonating fuse being adapted to ignite said propellant substantially instantaneously over its entire length.

3. The combination with a barrel adapted for propelling a high energy missile of an elongated rigid propellant chamber having a length to diameter ratio of at least 9 to 1; an elongated propellant charge therein of less diameter than said chamber and extending throughout the major portion of the length thereof; and firing means for said propellant, said firing means including a detonating fuse extending lengthwise through said propellant charge, said detonating fuse being adapted to ignite said propellant substantially instantaneously over its entire length; and said propellant chamber defining an expansion annulus about said propellant charge.

4. The combination with a barrel adapted for propelling a high energy missile of an elongated rigid propellant chamber having a length to diameter ratio of at least 9 to 1; an elongated propellant charge in said chamber and extending throughout the major portion of the length thereof; and firing means for said propellant, said elongated propellant charge being of substantially less diameter than said chamber whereby said chamber defines an expansion annulus about said propellant charge.

5. The combination defined in claim 4 including centralizing means engaging said propellant and the walls of said chamber and holding said propellant axially centered in said chamber and spaced from the sides thereof.

6. The combination with a barrel adapted for propelling a high energy missile of an elongated rigid propellant chamber having a length to diameter ratio of at least 9 to 1; an elongated propellant charge therein; and firing means for said propellant, said propellant being of less diameter than said chamber and encompassed within a frangible tube, said propellant chamber defining an expansion annulus about said tube, and said firing means including a detonating fuse extending lengthwise through said tube, said detonating fuse being adapted to ignite said propellant substantially instantaneously over its entire length.

7. The combination with a barrel adapted for propelling a high energy missile of an elongated rigid propellant chamber having a length to diameter ratio of at least 9 to 1; an elongated, frangible, propellant-containing tube therein of less diameter than said chamber and extending throughout the major portion of the length thereof; centralizers positioning said tube within said chamber spaced from the walls thereof, said propellant chamber defining an expansion annulus about said tube; a propellant charge encompassed within said tube; and firing means for said propellant, said firing means including a detonating fuse extending lengthwise through said tube in igniting relation to said propellant, said detonating fuse being adapted to ignite said propellant substantially instantaneously over its entire length.

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