Aug. 9, 1960 E. A. SMITH 2,948,122

COMBUSTIBLE FUEL OPERATED PILE DRIVING HAMMERS AND THE LIKE

Filed May 3, 1956 2 Sheets-Sheet 1

Fig. 1.

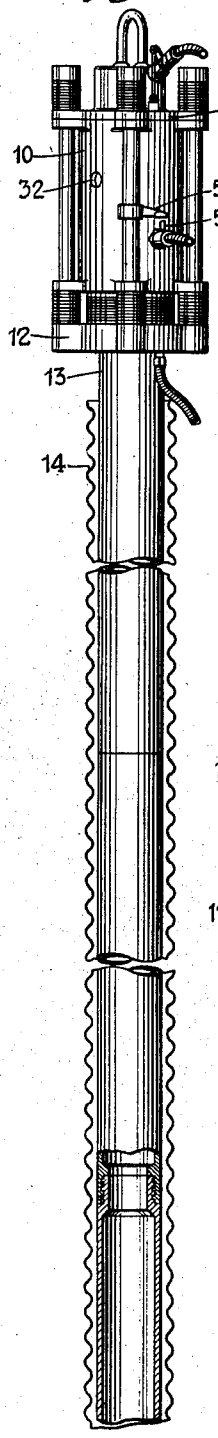


Fig. 2.

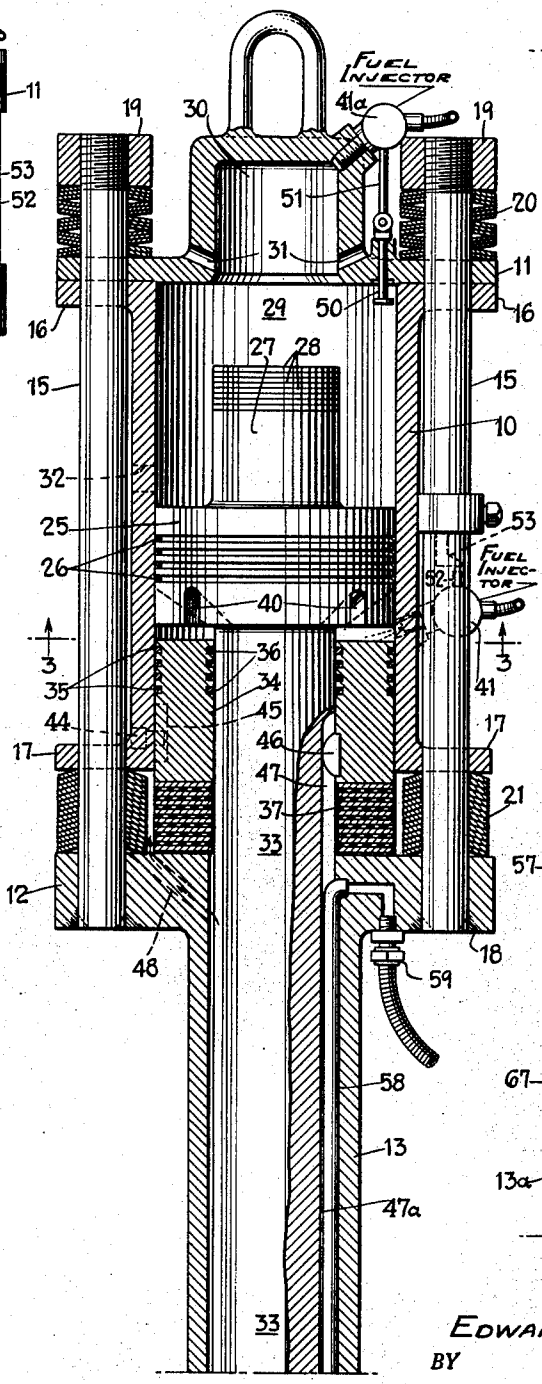
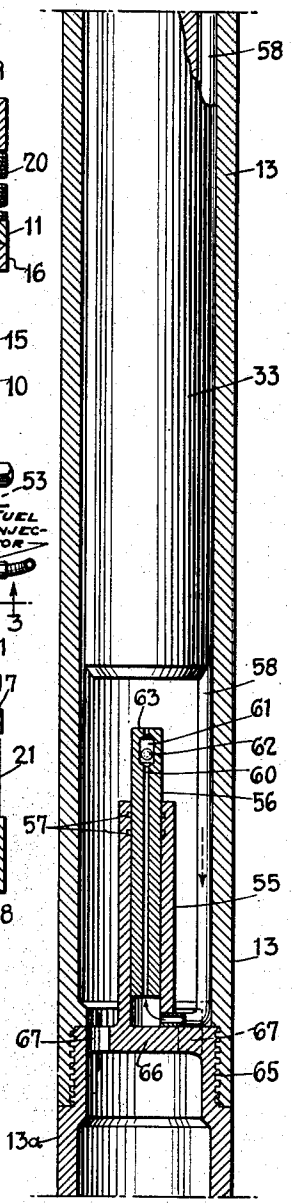


Fig. 2a.



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Fig. 3.

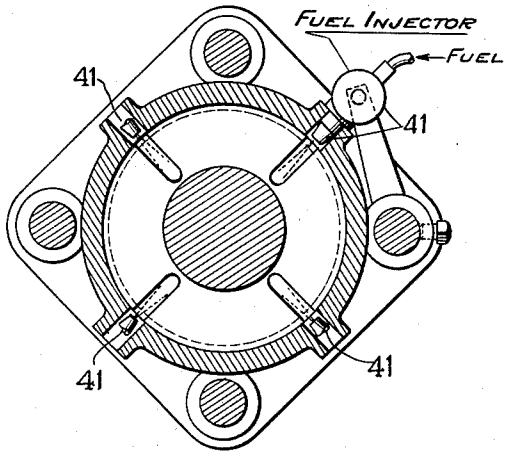
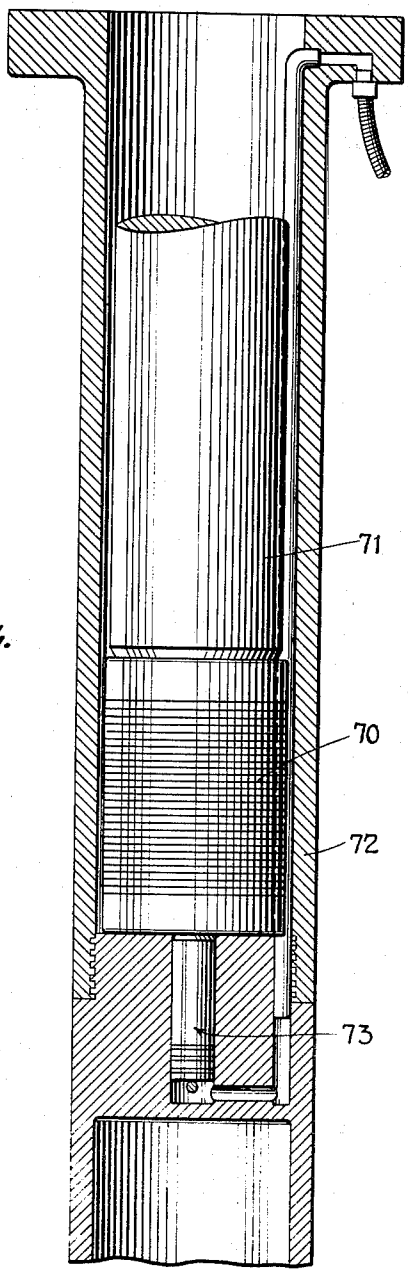


Fig. 4.



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COMBUSTIBLE FUEL OPERATED PILE DRIVING HAMMERS AND THE LIKE

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14 Claims. (Cl. 61—76)

This invention relates to pile driving hammers and the like and more particularly to hammers driven by the internal combustion of fuel, such as gasoline, or preferably by the combustion of fuel oil as in a diesel engine, although certain features of the invention are useful for other types of fluid pressure operated pile driving hammers.

For many years, it has been the general practice to drive piles and the like by the steam hammers. Yet such steam hammers have a number of disadvantages under some operating conditions. For example, the smoke from the necessary steam boiler and the escaping steam from the hammer may be objectionable. A boiler in conjunction with a steam hammer is very inefficient in the use of fuel and in some places the necessary water supply is not easily made available or the water sources and necessary water connections may become frozen. While a hydraulic type hammer has recently been developed which appears to have overcome many of the objections of steam pile driving hammers for some situations, yet hydraulic hammers require a separate and pump and considerable pressure control equipment, the expense, maintenance and operation of which is considerable, as well as involving added shipping expenses in cases of remotely located construction jobs. Furthermore, the fuel requirements for hydraulic hammers, although much less than required for steam hammers, leave room for improvement.

Another alternative for steam pile driving hammers has involved efforts to develop a diesel-operated hammer, but so far as is known, such efforts have not heretofore produced a diesel type hammer suitable for very extensive use, one reason being that the piston was necessarily of a long heavy construction such as to act also as a ram, but making necessary such a vertically elongated assembly as to unduly diminish the available headroom above the pile or pile core to be driven, and the matter of minimizing the necessary headroom is an important factor in the driving of long piles efficiently. Another difficulty with diesel or the like hammers, results from the fact that the periodic heavy shocks of the explosions present problems of providing a piston cylinder and heavy ram combination which will be able to withstand such shocks without soon being rendered inoperative or destroyed.

In accordance with the present invention, an improved hammer is provided of a type adapted for the internal combustion of fuel and preferably diesel operated, although the principal features of the invention may, if desired, be so designed as to utilize gasoline as the fuel. Diesel hammers in accordance with the invention may be constructed of a given size to utilize during a normal working day for example, 20 to 30 gallons of fuel oil, whereas for hydraulic hammers of equivalent size, the fuel requirements are substantially twice as great and in the case of steam hammers, the equivalent fuel requirement may rise from 200 to 300 gallons of fuel oil per day. Furthermore, with the diesel hammer construction

of the invention, no auxiliary engines, pumps, boilers or the like equipment and the necessary operating personnel therefor, are required. Thus such diesel hammers are self-contained and can be suspended and lifted about by the use of ordinary cranes.

The particular difficulties heretofore encountered with diesel hammers are, according to the invention, avoided by a construction in which the cylinder, which may be either single or double-acting, is yieldably held down upon the pile core or other element being driven thereby, thus minimizing the destructive effects of the impacts upon the cylinder. Also preferably the piston is made quite short, but is integral with or attached to an elongated heavy ram which may extend far down into the pile core or other member being driven and thus the headroom required for the cylinder and piston assembly is minimized. Furthermore, the construction is preferably so made that the explosions which act to raise the piston and ram are applied to a yieldably supported sleeve located beneath the piston and which sleeve is free to move somewhat with respect to both the ram which extends down therethrough and the cylinder which surrounds such sleeve, this feature preventing the possibility of the force of the explosions being transmitted directly to the cylinder.

Further objects, features and advantages of the invention hereof will appear from the detailed description given below, taken in conjunction with the accompanying drawings, which form a part of this specification and illustration by way of example the presently preferred embodiments of the invention.

In the drawings:

Fig. 1 is an elevational view showing one embodiment of a hammer in accordance with the invention, as associated with a pile driving core, the latter being surrounded by a pile shell in position to be driven into the earth;

Fig. 2 is a vertical sectional view of the upper portions of the assembly of Fig. 1;

Fig. 2*a* is a vertical sectional view of the lower portions of the assembly of Fig. 1;

Fig. 3 is a horizontal sectional view taken substantially along line 3—3 of Fig. 2; and

Fig. 4 is a vertical sectional view of the lower portion of another embodiment of a hammer assembly made according to the invention.

Referring now to the drawings in further detail, a cylinder is shown at **10** having a cylinder head **11** and a base **12**, which, if desired, may be integrally formed as an outwardly protruding upper flange or so-called "core head" on a pile driving core **13**. As shown in Fig. 1, the core **13** extends down into a surrounding corrugated sheet metal pile shell **14** which is in a position to be driven by the hammer.

The cylinder **10** is retained between the head **11** (to which it may be affixed in any usual way) and the base **12** by a plurality of guide rods as at **15** which extend through aligned apertures in the head and base and through upper and lower flanges as at **16**, **17** formed on the cylinder. The rods **15** are suitably affixed at their lower ends as by welding as indicated at **18** in the base **12** and the upper ends of the rods are provided with threaded nuts as at **19** adapted to apply adjustable pressure to yieldable or resilient means such as groups of Belleville washers **20** and **21** located respectively just in under the nuts **19** and just above the base **12**. Thus when the interior of the cylinder head is subjected to upward pressure impacts, the Belleville washers **20** will yield somewhat and allow the cylinder to rise slightly with respect to the rods **15** and the base, thus avoiding excessive impacts on the cylinder and cylinder head. Also, as hereinafter explained approximately at the ter-

mination of the down-strokes, the base and core and the attached rods **15** will be driven downwardly and by reason of the yieldable washers **20**, the downward force against the cylinder assembly as applied by the nuts **19** will be cushioned. When the cylinder rebounds back to normal position with respect to the other parts after each compression of the Belleville washers **20**, then the washers **21** at the lower ends of the rods **15** will yield slightly so that the lower portions of the cylinder will not strike heavily against the base or core head.

In the form of construction shown in Fig. 2, the cylinder contains a main piston portion **25** bearing piston rings **26** and a smaller upwardly extending piston portion **27** bearing piston rings **28**. A main cylinder chamber is provided at **29** and a supplemental smaller cylinder chamber is provided at **30**, this being formed as a cavity within the cylinder headpiece **11**. During the upper part of the stroke of the piston, the smaller piston portion **27** extends up into the chamber **30**, which may have ports as at **31** for the intake of air and venting gaseous products of combustion. The main cylinder chamber is formed with one or more parts in its lower portion as at **32**.

A ram **33** is formed integral with, or is suitably secured to the lower surface of the piston **25** and may, if desired, extend far down into the pile core **13**, as indicated in Fig. 2*a*. The upper portion of the ram **33** is surrounded by a sleeve **34**, the external diameter of which is such as to fit within the cylinder and be sealed with respect thereto by piston rings **35**. The internal diameter of the sleeve **34** is such as to embrace the upper portion of the ram **33** and may be sealed with respect thereto as by piston rings **36**. As shown in Fig. 2, the equivalent of so-called "cap block" means is interposed as at **37** between the base or upper end of the pile core **13** and the lower surface of the sleeve **34**. This cap block-like means may be constructed of a series of superposed washers, for example formed of synthetic plastic material interposed with metal washers, such as of aluminum, if desired. Such construction may be similar to the cap block means disclosed in U.S. patent to Edward A. Smith, No. 2,723,532, granted November 15, 1955, reference to which is hereby made.

The undersurface of the piston **25** may be formed with a plurality of radially inwardly and downwardly directed slots as at **40**, each adapted to receive injections of fuel oil as from fuel injectors **41**, secured at angularly spaced positions upon the cylinder as best shown in Fig. 3.

The sleeve **34** may be retained against rotation with respect to the cylinder as by a screw **44** positioned in the cylinder wall and protruding into a vertical slot **45** formed in the sleeve. The piston and ram may be retained against turning with respect to the sleeve **34** as by key means **46** mounted in the sleeve and adapted to engage a vertical slot **47** in the ram. One or more passages as at **48** may extend from the space about the ram upwardly and outwardly through the base **12** to the exterior of the hammer for equalizing the pressures internally and externally of the core **13**.

As above stated the hammer may be of either a single or double-acting type, and if of the latter type, then fuel injectors are provided not only as at **41** but also as at **41***a* for injecting fuel into the cavity **30** to provide diesel explosions of the gas and fuel as compressed within such chamber. It may be noted that the upper portion of the cylinder may be formed of uniform diameter, if desired, without an extension of smaller diameter as at **30**.

The fuel injectors **41**, **41***a* may be of suitable well known types and the timing of the operation thereof may be accomplished in various known ways, but with the particular example shown in Fig. 2, injectors such as at **41***a* may be actuated to inject fuel as by push rods **50** adapted to be engaged by the piston **25** when same approaches the upper end of its up-stroke. The push rods **50** may be connected as by connection rods **51** to actuate the mechanism of the injectors.

The injectors **41** may be actuated by protruding push-rod means thereon as at **52**, adapted to be engaged by lug-like members as at **53** affixed to one or another of the guide rods **15**.

In order to start the operation of the hammer, the ram and piston means are first elevated to their uppermost positions. This may be accomplished by the use of hydraulic cylinder and piston means located down in the pile core beneath the ram as shown in Fig. 2*a*. That is, a small cylinder **55** is provided containing a piston **56** sealed with respect to the cylinder as by piston rings **57**. A connection **58** for liquid pressure is provided extending from a suitable source through a coupling **59** at the base of the hammer and thence down into the lower end of the cylinder **55**. The connection or conduit **58** may be located in a keyway or slot **47***a* formed along the side of the ram **33**, and if desired, as a continuation of slot **47** above mentioned. Thus to raise the ram and piston means of the hammer, the operator injects liquid under pressure through the connections **58**, **59** to cause raising of the piston **56** and consequent raising of the ram **33** thereby. It may be desirable, in order to release any air contained under the piston **56**, to provide an air vent as at **60** connected with a small chamber **61** at its upper end containing a ball valve **62**. Thus when liquid is introduced under the piston **56**, any air contained under such piston will be forced up past the ball **62**, but when the hydraulic pressure becomes sufficient to raise this ball, it will engage a valve seat **63**, thus closing passage **60** against escape of liquid therethrough.

In order to gain ready access to this hydraulic jacking means for starting the hammer, the core **13** is preferably provided with a threaded or other form of detachable joint as at **65** for connecting a lower core section as at **13***a* to the upper core section **13**. The upper end of the core section **13***a* may be formed with a web **66** upon which the cylinder **55** is supported, or the cylinder, web and upper end of core section **13** may be formed integrally, as shown.

The web **66** may be apertured as at **67** to permit discharge of air from beneath the ram, thereby avoiding air compression below the ram, which would tend to check the downward movement of the ram.

The operation of the construction of Figs. 1–3 inclusive may be described as follows. Assuming first that the ram and piston assembly have been moved to their uppermost positions by the means above described and as shown in Fig. 2*a*, then the liquid pressure against the hydraulic piston **56** is released, thereby allowing the ram and piston **25** rapidly to fall and to apply an impact to sleeve **34**, which impact, through the cap block means **37**, is applied to the upper end of the core **13**. This impact will cause the nuts **19** on rods **15** to apply pressure to the Belleville washers **20** with sufficient abruptness to cause the washers to yield so that the cylinder **10** will lag in its downward movement as compared with the downward movement of the rods. This relative movement of the cylinder and rods **15** is utilized to then actuate the fuel injectors **41**. That is, the downward movement of the rods **15** will carry the lug-like means **53** downwardly to cause actuation of the push-rod means **52** on the fuel injectors. Thus charges of fuel will be injected substantially immediately after the initial impact of the piston **25** against the sleeve **34**, and since at this moment there will be heavy air pressure within the cavities **40**, the fuel charges will explode, thereby raising the piston **25** and ram **33** again toward their uppermost positions. The gaseous products of combustion from beneath the piston **25** may then escape through the port or ports **32**. The downward movement of the fuel injector operating lug means **53** with respect to the fuel injector push-rods **52**, will be only momentary and the parts **52**, **53** will promptly

move away from each other again upon completion of an injection of fuel.

At this point, it should be noted that, with the above-described method of timing the operation of injectors **41**, the injections of fuel beneath the piston **25** cannot possibly occur until after the piston **25** has applied its impact to the sleeve **34**. Thus the possibility of premature explosions beneath the piston **25** is eliminated. Heretofore, in attempted diesel hammer constructions, one of the difficulties has been that of insuring proper timing of the explosions. If the explosions occurred just before the downward impact, for example, then the piston would be forced upwardly without having an opportunity to deliver its impact, and then the only driving force would be that of the reaction of the explosion against whatever member is being driven, and such reaction would be relatively small as compared with the driving force capable of being imparted by the rapid downward travel of the heavy ram and piston assembly. If the timing of the fuel injection is such that the downward movement of the heavy ram is prematurely checked by the explosions, then the hammer may give the appearance of operating satisfactorily, when in fact it is not delivering any heavy impacts.

As the piston **25** and its extension **27** move upwardly, the port or ports **32** will be closed. Gaseous products of combustion will first be blown out through ports **31**, whereupon piston extension **27** will then close these ports and cause the gases in the chamber **30** thereafter to be placed under heavy compression. Then the push-rods **50** for fuel injectors **41***a* will be engaged by piston **25**, causing injections of fuel into the gases under high pressure in the chamber **30**. The fuel therein will then explode, causing the piston and ram assembly forcefully to start the downward stroke, which, supplemented by gravity on the heavy ram, will insure delivery of the necessary heavy impact at the end of the downward stroke.

It should be noted that the compression of the Belleville washers **20**, **21** on the rods **15** should be so adjusted that there will be only a relatively small or negligible movement of the cylinder **10** with respect of the rods **15** at the times when fuel explosions occur, both at the upper and lower ends of the strokes. Thus the explosions will not cause actuation of the fuel injectors **41**, but the washers **20**, **21** are so designed, or their normal compression is so adjusted, that when the impacts of the heavy weight of the ram occur at the end of the downward stroke, the washers **20** will yield and cause the necessary relative movement of the cylinder **10** and rods **15** to bring about actuation of the fuel injectors **41**.

With the embodiment of the invention shown in Fig. 4, the upper portions of the hammer (not shown in Fig. 4) may be the same as those of Fig. 2, except the cap block means **37** is omitted. Instead, as shown in Fig. 4, cap block means as at **70** may be provided beneath the ram **71** and down within the core **72**. This cap block means may be of a construction similar to that disclosed in the above-mentioned Patent No. 2,723,532. Hydraulic cylinder and piston means as indicated at **73** may be provided for a purpose similar to that shown in Fig. 2*a*, that is, for the purpose of starting the hammer, but in this case it will be understood that the hydraulic piston acts to engage the underside of the cap block **70**, which in turn engages the lower end of the ram **71** to raise the latter for starting the hammer. When the arrangement of Fig. 4 is used, it will be understood that the main impacts of the piston and ram assembly will be applied to the cap block **70** at the termination of the down-stroke. The sleeve **34** will be made of a height sufficient to occupy the space containing the cap block means **37** above described, and thus the explosions which occur at the start of the up-stroke of the piston, will react between the upper surface of the sleeve **34** and the undersurface of the piston **25** as in the case of the first embodiment of the invention above described.

It will be understood that suitable cooling fins may be provided on the exterior of the cylinder **10**, but these, for convenience and simplicity of the drawings, have been omitted.

Although preferred embodiments of the invention are herein disclosed for purposes of explanation, various modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A hammer construction for driving piles and the like and operating by internal combustion of fuel, comprising in combination: a cylinder; a hammer base means beneath said cylinder; a piston contained in said cylinder and having a ram secured as a unit therewith and to the underside thereof; a sleeve surrounding said ram beneath the piston located at a position to receive driving impacts from the piston and ram unit; slidable sealing means between said sleeve and the cylinder walls and also between said sleeve and the ram; resilient cap block means surrounding the ram and interposed between said sleeve and the hammer base means for transmitting the impacts to the latter from the sleeve; and means for injecting fuel into said cylinder between said piston and sleeve.

2. A hammer construction for driving piles and the like and operating by internal combustion of fuel, comprising in combination: a cylinder; a hammer base means beneath said cylinder; a piston contained in said cylinder and having a ram secured as a unit therewith and to the underside thereof; a sleeve surrounding said ram beneath the piston located at a position to receive driving impacts from the piston and ram unit; resilient cap block means interposed between said sleeve and the hammer base means; means for injecting fuel into said cylinder between said piston and sleeve; and means resiliently connecting said cylinder and base means to permit relative vertical movement therebetween upon delivery of impacts from the piston.

3. A hammer construction for driving piles and the like and operating by internal combustion of fuel, comprising in combination: a cylinder; a hammer base means beneath said cylinder; a piston contained in said cylinder and having a ram secured to the underside thereof; a sleeve surrounding said ram between the piston and said base means; slidable sealing means between said sleeve and the cylinder walls and also between said sleeve and the ram; means for injecting fuel into said cylinder between said piston and sleeve; and means resiliently holding said cylinder down with respect to said base means and permitting relative vertical movement therebetween upon delivery of impacts from the piston.

4. A power hammer operated by internal combustion of fuel and comprising in combination: a cylinder; a hammer base means beneath said cylinder; guide rods fixed in respect to said base means and extending up along the sides of the cylinder; compressible means on said guide rods interposed between said base means and the lower portion of the cylinder; additional compressible means at the upper ends of said guide rods for applying pressure to the upper end of the cylinder, the cylinder and guide rods by reason of said compressible means being relatively movable vertically upon actuation of the hammer; piston means within the cylinder; a ram connected to said piston means and extending downwardly therefrom; and means for injecting fuel into the cylinder for operating the piston means.

5. A power hammer operated by internal combustion of fuel and comprising in combination: a cylinder; a hammer base means beneath said cylinder; guide rods

fixed in respect to said base means and extending up along the sides of the cylinder; compressible means on said guide rods interposed between said base means and the lower portion of the cylinder; additional compressible means at the upper ends of said guide rods for applying pressure to the upper end of the cylinder, the cylinder and guide rods by reason of said compressible means being relatively movable vertically upon actuation of the hammer; piston means within the cylinder; a ram connected to said piston means and extending downwardly therefrom; means for injecting fuel into the cylinder beneath said piston to raise the piston and ram following each impact of the hammer; and means actuated in response to the relative movement of the cylinder and hammer base means for actuating said injector means at the result of such impacts.

6. A hammer construction in accordance with the foregoing claim 5 and in which said compressible means comprises Belleville washers surrounding said rods.

7. A power hammer construction operable by internal combustion of fuel, comprising in combination: a cylinder; a hammer base means beneath said cylinder and adapted to receive and transmit driving impacts; means resilient longitudinally of the cylinder for holding same down with respect to said base means; a piston contained in said cylinder and an associated ram extending from the piston means down through the base means; a sleeve means under the piston means and surroundig the upper portion of said ram; cap block means interposed between said sleeve means and the hammer base means; injector means for injecting fuel in between said piston means and sleeve means, said sleeve means being constructed and positioned to receive impacts from the piston means and to transfer same to said base means through said cap block means, said sleeve means being slidable in said cylinder upon receiving said impacts, by reason of said resilient holding means; and means controlling said injector means to actuate the same for injection of fuel substantially immediately following delivery of an impact by the piston means to said sleeve means.

8. A power hammer construction for driving piles and the like and operable by internal combustion of fuel, comprising in combination: a cylinder; a hammer base means beneath said cylinder and connected to a pile driving core; a piston contained in said cylinder and an associated ram extending down therefrom into said core; a cap block located in said core beneath said ram and adapted to apply impacts from the ram to the core; means resiliently holding said cylinder down with respect to said hammer base means and permitting relative movement therebetween upon delivery of impacts by the ram; means for injecting fuel beneath the piston; and means actuatable in response to said relative movement for causing actuation of said injection means to inject fuel substantially immediately following delivery of an impact by the ram.

9. A power hammer construction for driving piles and the like and operable by internal combustion of fuel, comprising in combination: a cylinder; a hammer base means beneath said cylinder and mounted on a pile driving core means; a piston within said cylinder and having connected thereto a ram extending down into said core means; means for injecting fuel into the cylinder for operating the piston; and means for starting the operation of the hammer, comprising a hydraulically operable cylinder and piston means located in the core beneath the ram for elevating the ram and piston to their upper positions.

10. A double-acting power hammer construction operating by internal combustion of fuel, comprising in combination: a cylinder; piston therein; a ram suspended from the lower side of the piston; hammer base means mounted upon a hollow core member surrounding said ram; compressible connection means between said base means and the cylinder permitting relative movement therebetween upon delivery of impacts by the piston; means for injecting fuel into the cylinder beneath the piston; means acting in response to said relative movement for timing the operation of said injector means to actuate the same subsequent to delivery of each such impact; means for injecting fuel above the piston; and means for actuating the latter injector means responsive to upward movements of the piston.

11. A power hammer operated by internal combustion of fuel and comprising in combination: a cylinder; a hammer base means beneath said cylinder; guide rods fixed in respect to said base means and extending up along the sides of the cylinder; compressible means on said guide rods interposed normally under compression between said base means and a portion on the cylinder; additional compressible means on said guide rods and interposed normally under compression between a portion of the cylinder and portions on the ends of the guide rods opposite from the base means, the cylinder and guide rods by reason of said compressible means being relatively movable vertically upon actuation of the hammer; piston means within the cylinder; a ram connected to said piston means and extending downwardly therefrom; and means for injecting fuel into the cylinder for operating the piston means.

12. A power hammer construction operable by internal combustion of fuel, comprising in combination: a cylinder; a hammer base means beneath said cylinder; means resilient longitudinally of the cylinder for holding same down with respect to said base means; piston means contained in said cylinder and an associated ram extending from the piston means down through the base means; a sleeve means slidably disposed in said cylinder between said piston means and said base means and surrounding the upper portion of said ram; and injector means for injecting fuel in between said piston means and said sleeve means, said sleeve means sliding in said cylinder and said base means and cylinder moving longitudinally relatively to one another when the piston means and ram act to deliver an impact, said holding means resilient longitudinally of the cylinder being stressed by said relative movement of said base means and cylinder.

13. A power hammer construction according to claim 12, wherein means are provided controlling said injector means to actuate the same for injection of fuel substantially immediately following delivery of an impact to said sleeve means.

14. A power hammer construction according to claim 12, wherein timing means are provided controlled by the relative movement of the base means and cylinder for causing said injector means to actuate for injection of fuel substantially immediately following delivery of an impact to said sleeve means.

References Cited in the file of this patent

UNITED STATES PATENTS

929,696	Oberly	Aug. 3, 1909
2,598,455	Smith	May 27, 1952

FOREIGN PATENTS

435,183	Great Britain	Sept. 17, 1935
679,147	Germany	July 29, 1939
739,518	Great Britain	Nov. 2, 1955