

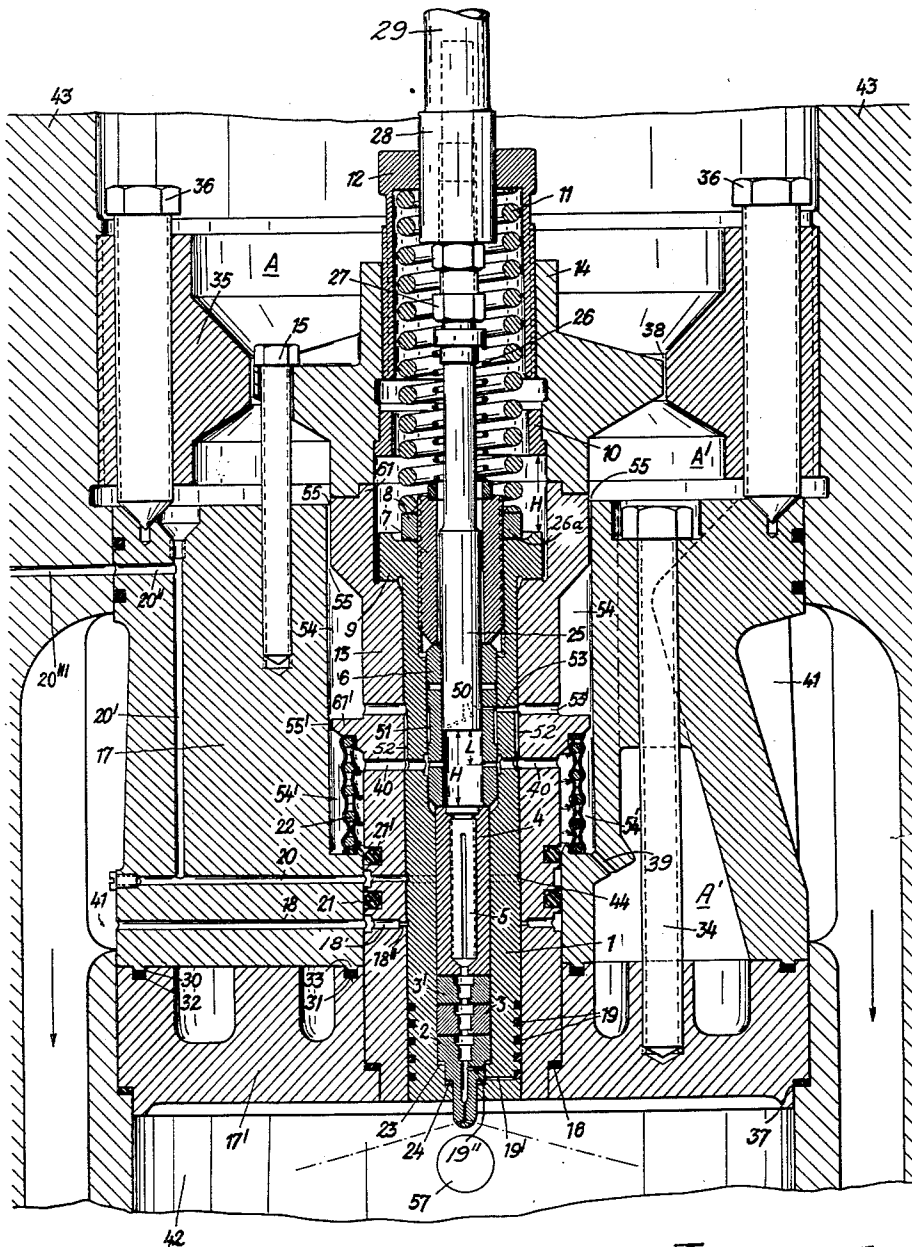
April 5, 1960

A. LANG

2,931,346

PILE HAMMER

Filed Feb. 21, 1958



Inventor
A. Lang

By *Glenn Downing Tebbels*
Attys

1

2,931,346

PILE HAMMER

Anton Lang, Hartberg, Steiermark, Austria, assignor to Delmag-Maschinenfabrik Reinhold Dornfeld, Esslingen (Neckar), Germany

Application February 21, 1958, Serial No. 716,744

13 Claims. (Cl. 123—7)

This invention relates to a known type of diesel hammer used for pile-driving and similar work.

A diesel hammer of this type comprises a hammer body in which a combustion cylinder is formed. A piston is slidably mounted in the combustion cylinder and adapted to rest on the pile or other object to be hammered. The hammer operates as a two-stroke diesel engine. During the expansion stroke, the piston is forced against the said object and the hammer body is driven upwards. Suitable abutment means limit the upward movement of the hammer body relatively to the piston, so that at the end of the expansion stroke the hammer body lifts the piston off said object. The piston and hammer body then fall back towards the object; the piston strikes the object and remains in contact with it while the hammer body continues to fall, thus producing the compression stroke in which air is compressed in the cylinder; against the action of a spring the pressure of this air actuates an injection pump which injects fuel into the compressed air, and the consequent ignition and combustion of this fuel produces the subsequent expansion stroke.

The above brief description is given merely to show the type of hammer to which the invention relates; this type is sufficiently well known to enable more detailed description of its general structure and manner of operation to be dispensed with.

The object of the invention is to provide means whereby ignition is automatically delayed to an extent depending on the distance through which the hammer body has fallen, which of course depends on various factors such as the resistance of the pile or other object to downward movement.

With this object in view the invention consists in a diesel hammer comprising a hammer body having a combustion cylinder and adapted to compress air in said cylinder by descending under the action of gravity, a fuel injection pump adapted to be actuated by the compressed air and thereby to inject fuel into the combustion cylinder, a compression spring adapted to resist the fuel-injecting movement of the pump, and a weight upwardly and downwardly slidable in the hammer body and adapted to descend with the hammer body and to assist the spring in resisting the fuel-injecting movement of the pump, whereby fuel injection is delayed to an extent depending on the kinetic energy acquired by the weight during the descent of the hammer body and consequently on the distance through which the hammer body has fallen.

This weight is preferably formed as a hollow piston surrounding the injection pump and closed by a nozzle at its bottom end; in deciding how heavy this weight should be made, it is necessary to take into consideration the greatest height of fall and the greatest degree of compression and on the other hand the pressure transmission ratio which is determined by the ratio of the cross sectional area of the hollow piston to the cross sectional area of the injection pump plunger. The spring load is thus more or less supported in its action by the

2

dynamic effect of the mass of the hollow piston falling with the hammer body, whereby the beginning of injection is not dependent merely on the respective compression pressure and the characteristic of the spring but also on the height of the fall of the hammer body; this offers exceptional advantages.

This dependency of the beginning of injection on the height of fall enables diesel hammers to be used for the most varying conditions; economic operation, great efficiency and also a high degree of reliability in operation are achieved, which was not the case in any of the internal combustion hammers used hitherto. With the abovementioned automatic regulation of the beginning of injection according to the height of fall, additional air storage chambers, for the purpose of additional adaptation of the method of operation of the hammer can be disposed externally on the combustion cylinder and communicate with the compression and combustion chamber of the cylinder by a connecting duct, in order to reduce the degree of compression and thus to induce a more extensive delay of the beginning of injection and therefore a maximum impact effect, as opposed to maximum pressure effect at the greatest degree of compression.

Concrete piles and concrete slabs do not stand up to hard impacts, for which reason in this case hammering is to be carried out economically with the highest possible pressure peak but with low impact effect, because the large quantity of padding for the driving cap, hitherto used as sole means of preventing the destruction of the concrete, has the effect of absorbing and wasting energy and thus impairs efficiency. Also there will be difficulties when hammering in soft ground at least at the start, if the diesel hammer is adapted to hard impacts, for which reason in this case also work must be done with higher pressure peaks and lower impact effect. When hammering in soft ground the resistance can moreover be so low at the beginning that the mere compression operation is sufficient to cause the pile to penetrate without injection taking place and causing the hammer body to be thrust upwards. This drawback can admittedly be met by already injecting part of the fuel into the compressed air before ignition limit is reached and gasifying it contrary to the diesel principle, so that when the necessary inflammation heat is reached it burns in an explosive manner while the hammer body continues to fall, the pressure thus increased causing further fuel to be injected which then burns as in a diesel motor. Admittedly operation in soft ground is thereby made safe, but at the cost of impact performance when high resistances occur. In those cases where soft earth lies on top of more resistant ground, when the more resistant layer is reached further hammering must be carried out with the greatest possible impact effect, which is achieved by the construction according to the invention which automatically greatly delays injection so that the latter, differing from the original pre-injection when operation is started, now takes place at approximately the time of impact and therefore of the reversal of the movement of the hammer body. Without this delay in injection the peak pressure would be increased at the cost of the impact to such an extent that this impact would be vary largely absorbed by the pressure peak, thus causing a corresponding reduction in performance. Since rebound height of the hammer body and penetration resistance are approximately in a linear ratio, this is also approximately valid with regard to the injection delay effected by the dynamic action of the mass. If this delay is still insufficient, the degree of compression can be reduced by connecting the air storage chambers, whereby the necessary adaptability to all imaginable conditions is made possible.

An embodiment of the invention chosen by way of example is illustrated in the accompanying drawing which is a vertical section through part of the hammer body of a diesel hammer of the type referred to, showing only those parts which need to be modified in order to carry the present invention to effect; other parts which are well known per se and require no modification, are omitted.

A combustion cylinder 42 is formed in the hammer body 43. A power piston not shown in the drawing is slidably mounted in the combustion cylinder 42 and adapted to rest on a pile or other object to be hammered. The hammer operates as a two-stroke diesel engine. During the expansion stroke, the power piston is forced against the said object and the hammer body 43 is driven upwards. Suitable abutment means known per se limit the upward movement of the hammer body relatively to the power piston, so that at the end of the expansion stroke the hammer body 43 lifts the power piston off said object. The power piston and hammer body 43 then fall back towards the object; the power piston strikes the object and remains in contact with it while the hammer body continues to descend in the direction shown by the arrow, thereby compressing air in the cylinder 42.

A weight 1 in the form of a hollow piston is slidably mounted in a guiding member 13 rigidly secured to a two-part cylinder head 17, 17' closing the combustion cylinder 42 at the top. Piston rings 19 are attached to the lower end of the piston 1. A compression spring 11 bears against a bushing 12 rigid with the hammer body 43, and urges the piston 1 downwards; the air compressed in the cylinder 42 by the descent of the hammer body 43 drives the piston 1 from the position shown in the drawing upwards in the hammer body 43, and compresses the spring 11.

The piston 1 encloses an injection nozzle 2, non-return valves 3 and 3', a tube filter member 4 with filter tube 5 and an injection pump cylinder 6. A pressure screw 7, screwed into the top of the piston 1 and secured by a lock nut 8, presses the parts 6, 4, 5, 3', 3 and 2 against one another and secures said parts rigidly in the piston 1.

The bottom end of injection pump plunger 25 is accommodated inside the pump cylinder 6. By means of a second compression spring 26 the top end of this plunger is pressed against a stop in the form of an adjusting screw 27 screwed into a tube 29 rotatably but non-slidably mounted in a cover which is secured to the top of the body 43 but is not shown in the drawing. The bottom end of this spring 26 bears against an abutment ring 26a supported on the pressure screw 7. The plunger 25 is thus held stationary with respect to the hammer body 43, while the pump cylinder 6 and the other parts rigid with the piston 1 participate in the movement of this piston relatively to the hammer body 43.

The piston 1 and the parts 2, 3, 3', 4, 5, 6, 7, 8, 19 and 26a are driven upwards relatively to the hammer body 43 by the air pressure in the cylinder 42, and during this movement the springs 11 and 26 are compressed, but all other parts shown in the drawing remain stationary with respect to the hammer body 43.

By means described hereinafter, fuel is admitted to the interior of the injection pump cylinder through ducts 40, and apertures in the piston 1 and cylinder 6 level with the ducts 40, and fills said cylinder. As the piston 1 and the pump cylinder 6 rigid therewith move upwards, relatively to the body 43, under the action of the pressure of the air in the cylinder 42, the volume of the pump cylinder space accommodating the fuel is reduced, since the plunger 25 remains stationary as aforesaid, and the fuel in said space therefore flows out of said space through the said apertures until these apertures are covered by the bottom edge of the plunger 25; further upward movement of the piston 1 and parts

rigid therewith causes further reduction in the volume of this space, whereby fuel is injected through the filter 5, the non-return valves 3 and 3' and the nozzle 2 into the compressed air in the cylinder 42, whereupon ignition and combustion of the injected fuel takes place in the manner well known per se in diesel engines.

The top of the piston 1 has a collar 9. When the piston 1 is in its lower extreme position shown in the drawings, the collar 9 bears against the guiding member 13. A stop 10 is rigid with a clamp 14 secured to the cylinder head. After the piston 1 has moved upwards through a distance H, the collar 9 bears against the stop 10. When the adjusting screw 27, which fixes the position of the plunger 25, has been adjusted to the position shown in the drawing, the distance H through which the piston 1 can move is equal to the distance between the bottom of the stationary plunger 25 and the lower extreme position of the bottom of the movable cylinder 6.

During the upward movement of the piston 1 and cylinder 6 through a distance H, a volume of fuel equal to that contained in the portion of the cylinder 6 above the ducts 40 in the position shown in the drawing, i.e. a volume having the height L, will be forced out through the aforesaid aperture, whereas a volume of fuel equal to that contained in the portion of the cylinder below the ducts 40 in the position shown, i.e. a volume having the height H—L, will be injected into the combustion cylinder 42 after the said apertures have passed the bottom edge of the stationary plunger 25 so as to be covered by that edge.

The starting run through the distance L ensures that injection starts abruptly, although the nozzle 2 is an open nozzle, because the piston 1 and the parts rigid therewith will have acquired a considerable upward speed, relatively to the hammer body 43 and plunger 25, when the bottom edge of the plunger 25 covers the aforesaid apertures, so that the pressure in the lower part of the cylinder 6 will rise abruptly.

In order to reduce the quantity of fuel injected, the position of the stationary plunger 25 is adjusted upwards from the position shown in the drawing. This is done by screwing the adjusting screw 27 further up into the pipe 29, so that the action of the compression spring 26 raises the plunger 25 through a certain distance. The bottom of the plunger 25 will then still be this distance above the bottom of the cylinder when the cylinder has completed its injection stroke. The quantity injected is then reduced by the amount of fuel remaining between the bottom of the plunger 25 and that of the cylinder 6 at the end of the injection stroke.

By means of the compression spring 11, which bears at the bottom against the lock nut 8 and at the top against the bushing 12, the hollow piston 1 is held in its initial position, shown in the drawing, by the initial stress in the spring 11. The bushing 14 is provided with a male thread engaging a female thread in the clamp 14, so that by rotating the bushing 12 it is possible to vary the initial stress in the spring 11 and thereby to adjust the injecting timing. This adjustment can be effected by rotating the pipe 29 of which the tip 28 is slidably but non-rotatably mounted in the bushing 12.

The guiding member 13 is supported on a sealing seat 16 resting on a shoulder in the lower portion 17' of the cylinder head, and is pressed against this seat by means of the clamp 14 and three screws 15, of which only one appears in the drawing, which pass through apertures in the clamp 14 and engage female threads in the upper portion 17 of the cylinder head.

The piston rings 19 are provided in order to avoid pressure losses while keeping sufficient clearance between the piston 1 and guiding member 13 to allow for thermal expansion. The rings 19 are supported in annular grooves in the piston 1. A duct 19' provided in the piston 1 and a further duct 19'' in the nozzle 2 provide communication between the interior of the nozzle

5

2 and the lowest piston ring groove, whereby a small quantity of fuel oil is forced into this groove during injection, so that the piston rings 19 are constantly cleaned and the slide path of the piston 1 in the guiding member 13 is provided with a film of oil. A bore 18 in the upper portion of the cylinder head communicates with a bore 18' and a narrow annular groove 18'' in the guiding member 13. Any exhaust gases which may pass the piston rings 19 are diverted through the groove 18'' and bore 18' and 18 into a scavenging air chamber 41 so that they cannot rise and reach the fuel. Alternatively, such gases may be led out into the open air instead of into the chamber 41. Bores 20, 20', 20'' and 20''' in the upper portion 17 of the cylinder head and in the hammer body 43 communicates with an annular recess 44 in the piston 1. Cylinder oil for additional lubrication of the piston 1 is supplied to the recess 44 through the bores 20, 20', 20'' and 20''', from a supply container (not shown in the drawings) in the hammer body 43. An oil-resistant rubber sealing ring 21 arranged above the bore 18 and below the bore 20, and a similar ring 21' arranged above the bore 20, prevent the exhaust gases, cylinder oil and fuel from coming into contact with one another.

Before reaching the supply ducts 40 the fuel is cleaned by a filter cloth sewn over a strong helical spring 22. The cloth is cleaned by the vibrations of the spring during the operation of the hammer.

The upper portion 17 of the cylinder head is a casting. The lower portion 17' is made from alloyed steel with low heat conductivity so as to reduce the amount of heat radiated from the combustion cylinder 42 and thereby to increase the attainable pressure in the combustion chamber and obtain greater efficiency and reduce the heating of the hollow piston 1 and the parts surrounded by the hollow piston. The portions 17 and 17' of the cylinder head are interconnected by means of three screws 34 of which only one appears in the drawing. A flat bottom sealing surface of the part 17 is in contact with a flat top sealing surface of the part 17'. Soft metal rings 32 and 33 in grooves 30 and 31 in the top surface of the part 17' are deformed by annular projections from the bottom surface of the part 17 so as to produce a seal.

A ring 35 is disposed above the upper portion 17 of the cylinder head is provided with a male thread engaging a female thread in the hammer body 43. Pressure screws 36 engaging in female threads in the ring 35 press the cylinder head on to an annular sealing member 37 supported on an internal shoulder in the hammer body 43.

Between the ring 35 and the clamp 14 there is a narrow annular gap providing communication between an upper part A and a lower part A' of a fuel chamber. The lower part A' extends right through the top portion 17 of the cylinder head, as indicated in dotted lines in the right-hand side of the drawing, except in certain places at which radial ribs of the cylinder head top portion 17 extend through the part A', as in the plane of the drawing.

Two annular cavities in the guiding member form annular chambers 54 and 54' bounded on the outside by the wall of a bore in the cylinder head portion 17 in which the guiding member 13 is accommodated: the upper chamber 54 communicates with the top of the fuel chamber part A' by way of an annular gap 55 between the wall of said bore and a collar 61 formed on the guiding member and supporting the clamp 14; the lower chamber 54' accommodating the spring 22 and filter cloth communicates with the upper chamber 54 by way of a second narrow gap 55' between the wall of the aforesaid bore and a second collar 61' on the guiding member 13. Ducts such as 39 provide communication between the bottom of the part A' and the lower chamber 54'.

Fuel introduced into the upper part A of the fuel

6

chamber flows through the annular gap 38 into the lower part A' of the chamber. The fuel in the lower part A' can pass into the interior of the injection pump cylinder 6 through the duct 39, the lower chamber 54' and the ducts 40.

Bores 50 disposed above the level of the ducts 40 extend radially through the wall of the injection pump cylinder 6. These bores are arranged so that their inner ends lie on a helical curve, as shown in the drawing. The bores 50 communicate with an annular recess 51 in the outside of the cylinder 6; from the cavity 51, a bore 53 in the piston 1 leads to an annular recess 52 in the outside of the piston 1; bores 53' in the guide member 13 provide communication between the recess 52 and the upper chamber 54.

It should be noted that the recess 52 provides communication between ducts 40 and bores 53'.

It is not necessary to remove air from the injection pump before putting the hammer into operation; provided that the fuel level is above the gap 38, the pump will be completely filled with fuel, since all air escapes through the bores 50, 53 and 53', chamber 54, gap 55, the top of the fuel chamber part A', and annular gap 38 into the upper chamber part A.

By means of the annular gap 38, air bubbles are separated from the fuel in the lower chamber part A' under the influence of the accelerating and retarding forces acting on the fuel as a result of the movements of the hammer body, and pass into the upper chamber part A, so that the fuel below the gap 38 remains free from air bubbles while the hammer is in operation.

The gap 38 also prevents unchecked upward movement of the fuel relatively to the hammer body 43 when the upward movement of the hammer body produced by the expansion stroke is retarded as the power piston is lifted off the pile. The gap 38 also ensures that at this moment the injection pump is filled, through duct 39, chamber 54 and duct 40, under appropriate fluid pressure. While the hammer is in operation the fuel below and above the annular gap 38 transfers heat from the hot inner parts of the hammer to the air-cooled outer parts provided with cooling vanes.

It is possible to alter the degree of compression by providing additional storage chambers communicating with the combustion cylinder 42 through a connecting duct 57. These chambers are preferably screwed on to the outside of the hammer body at the same level as the combustion cylinder 42. By using such chambers it is possible to reduce the degree of compression in the cylinder 42 and thereby to increase the delay in injection. When such chambers are not being used, the duct 57 is closed for instance by means of a flange.

I claim:

1. A diesel hammer comprising a hammer body having a combustion cylinder and adapted to compress air in said cylinder by descending under the action of gravity, a fuel injection pump adapted to be actuated by the compressed air and thereby to inject fuel into the combustion cylinder, a compression spring adapted to resist the fuel-injecting movement of the pump, and a weight upwardly and downwardly slidable in the hammer body and adapted to descend with the hammer body and to assist the spring in resisting the fuel-injecting movement of the pump, whereby fuel injection is delayed to an extent depending on the kinetic energy acquired by the weight during the descent of the hammer body and consequently on the distance through which the hammer body has fallen.

2. A diesel hammer as claimed in claim 1, which comprises a cylinder head closing the combustion cylinder at the top and formed with an aperture and in which the weight is hollow, and is mounted in said aperture whereby the weight is adapted to be driven upwards in the hammer body by the compressed air in the combustion

cylinder, and in which the compression spring is adapted

to urge the weight downwards, and which further comprises bottom abutment means adapted to limit the downward movement of the weight, a downwardly extending fuel pump plunger fixed relatively to the hammer body and accommodated inside the weight and having a cross-sectional area less than that of the bottom end of the weight, a fuel pump cylinder accommodated inside the weight and closely surrounding the plunger and rigidly secured to the weight, an injection nozzle mounted at the bottom of the weight and communicating with the interior of the fuel pump cylinder, and means adapted to supply fuel to the fuel pump cylinder.

3. A diesel hammer as claimed in claim 2, which comprises top abutment means adapted to limit the upward movement of the weight, and in which the wall of the fuel pump cylinder is apertured at a distance from the bottom of the cylinder less than the total distance of movement of the weight permitted by said top and bottom abutment means.

4. A diesel hammer as claimed in claim 3, comprising two non-return valves arranged inside the weight between the nozzle and the pump cylinder, a tubular filter holder between said valves and the injection pump cylinder, a filter inside said holder, and a pressure screw screwed into the top of the weight and maintaining the pump cylinder, the filter holder, the valves and the nozzle in sealing contact with one another.

5. A diesel hammer as claimed in claim 2, comprising means permitting the position of the pump plunger to be upwardly and downwardly adjusted.

6. A diesel hammer as claimed in claim 2, comprising means whereby the stress in the compression spring is adjustable from outside.

7. A diesel hammer as claimed in claim 2, comprising

a guiding member mounted in the cylinder head and slidably supporting the weight, piston ring grooves in the lower end of the weight, piston rings mounted in said grooves and in contact with said guiding member, and duct means providing communication between the interior of the nozzle and the lowest of the piston ring grooves.

8. A diesel hammer as claimed in claim 7, comprising means for removing any combustion gases that may pass the piston rings, and means for supplying lubricant to the interior of the guide member above the piston rings.

9. A diesel hammer as claimed in claim 2, comprising two fuel chambers arranged one above the other and communicating with one another through a narrow gap, and means providing communication between the lower fuel chamber and the fuel pump cylinder.

10. A diesel hammer as claimed in claim 2, comprising means for removing air bubbles from the fuel in the fuel pump cylinder.

11. A diesel hammer as claimed in claim 2, in which the cylinder head comprises a first part which is a casting and a second part which is made of alloy steel with low heat conductivity and is disposed underneath the casting.

12. A diesel hammer as claimed in claim 2, comprising means whereby the fuel is filtered before entering the fuel pump cylinder.

13. A diesel hammer as claimed in claim 12, wherein said means comprise a helical spring and a filter cloth sewn over the spring.

References Cited in the file of this patent

UNITED STATES PATENTS

1,917,066 Schalscha ----- July 4, 1933