April 18, 1944. L. A. TROFIMOV 2,346,877

GUN RAMMER

Filed Dec. 4, 1942 2 Sheets-Sheet 1

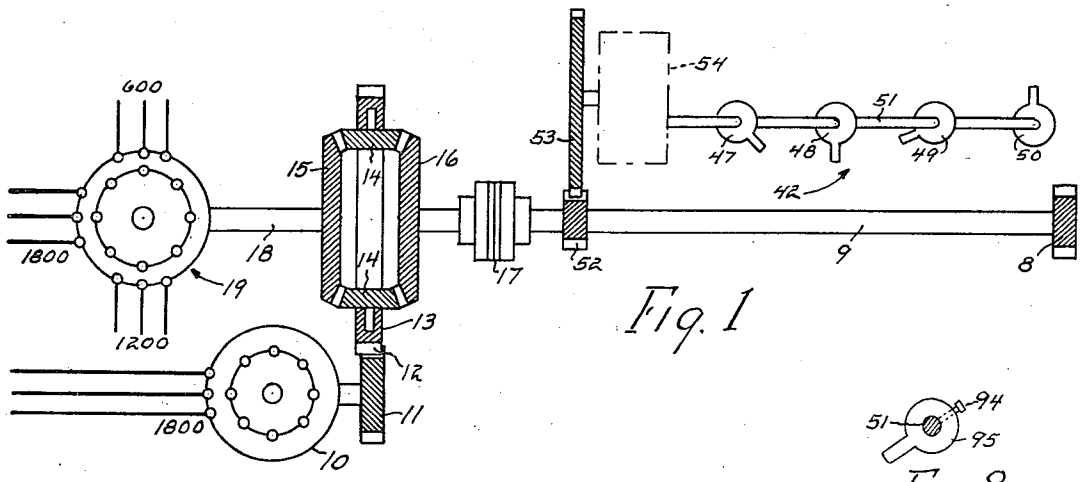


Fig. 1

Fig. 8

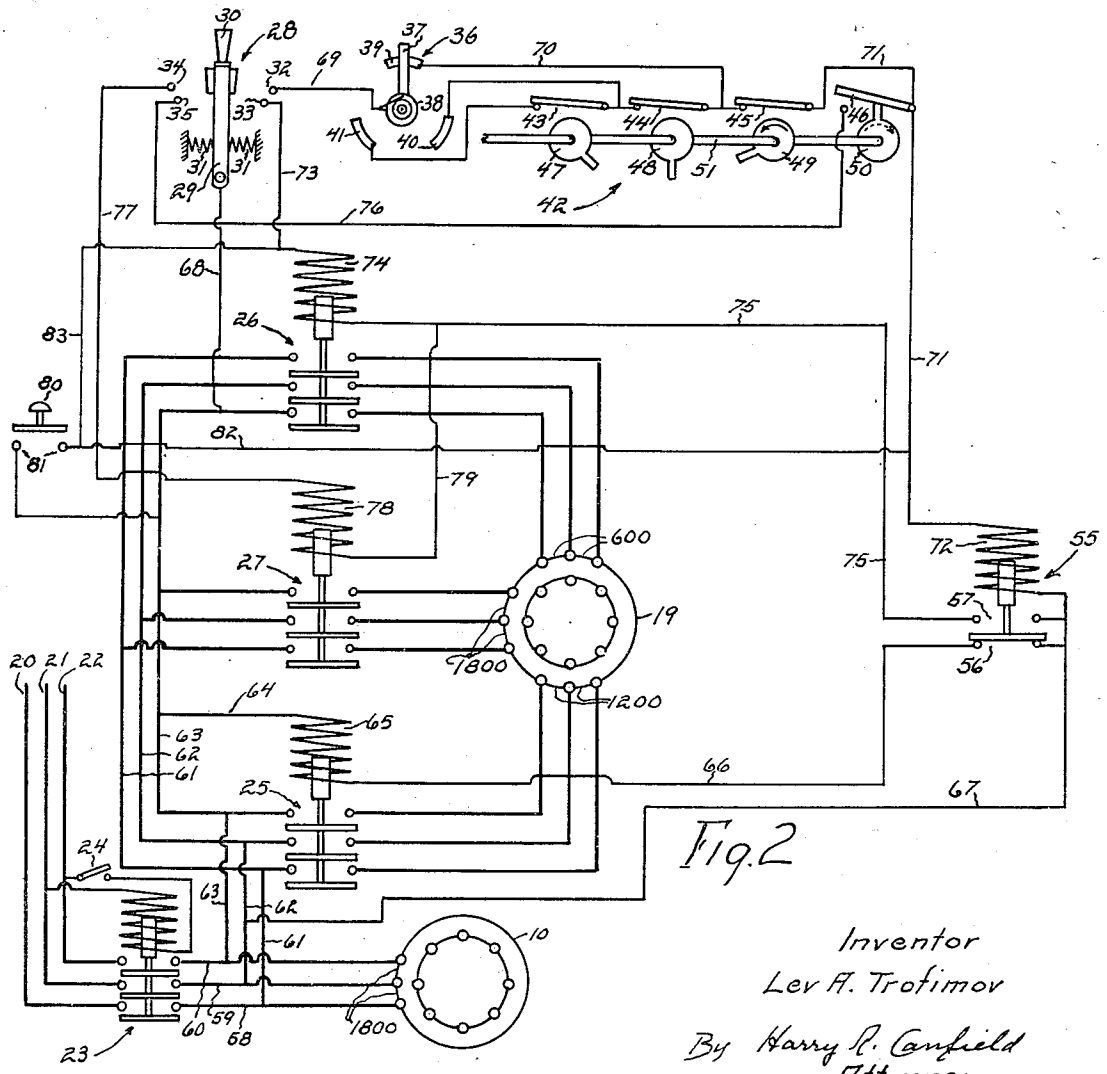


Fig. 2

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GUN RAMMER

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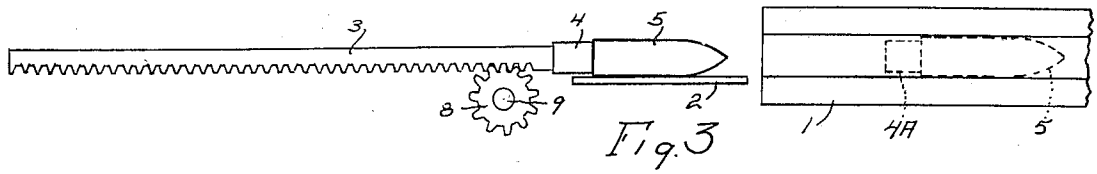


Fig. 3

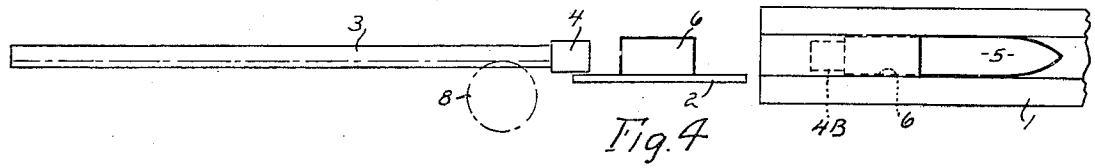


Fig. 4

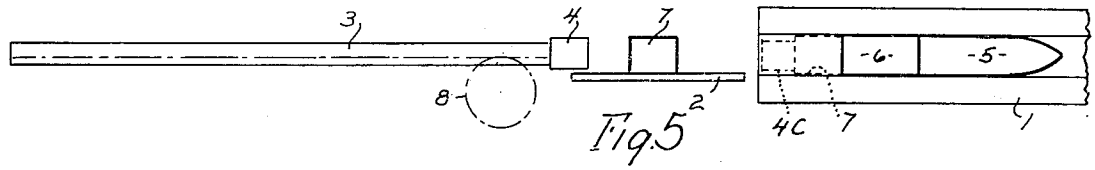


Fig. 5

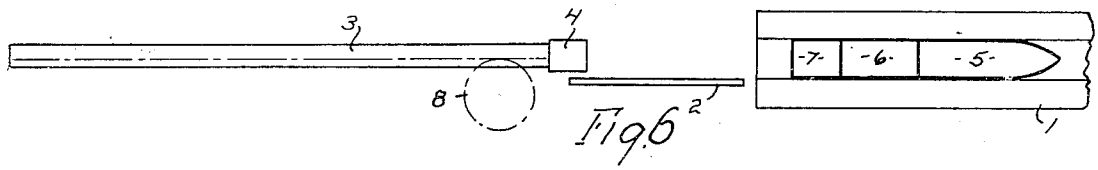


Fig. 6

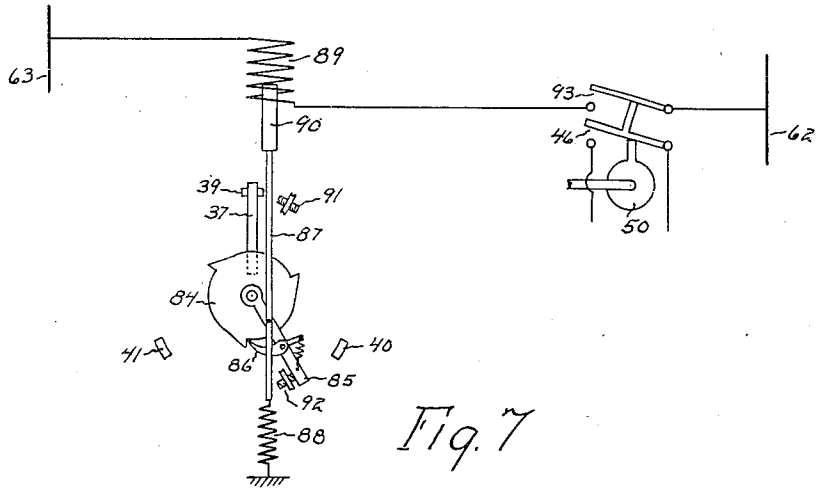


Fig. 7

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GUN RAMMER

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3 Claims. (Cl. 39—47)

This invention relates to power apparatus for reciprocating the rammer of a gun to successively charge the projectile and the powder into the breech of the gun.

Such power operated rammers are well known. Heretofore hydraulic power has been considered as the most practicable for this purpose, notwithstanding that it has certain inherent disadvantages. Electric motor power has been proposed to overcome these disadvantages of hydraulic power, but the reciprocatory character of the load, that is to say the driving of the reciprocatory rammer, has introduced problems in the application of electric power that have not been satisfactorily solved. Furthermore, it is recognized that alternating current motor power would be preferable to direct current motor power, but the problem of applying electric motor power to operate the rammer has heretofore been found to be even more difficult of solution with alternating than with direct current.

It follows that a complete solution of the problem calls for the application of alternating current motor power to the reciprocation of the gun rammer, and in the following is described such a solution to this problem.

It is therefore the primary object of this invention to provide a power apparatus for reciprocating a gun rammer in the forward and reverse directions, and with different lengths of stroke of the rammer to suitably and successively position the projectile and one or more charges of powder in the breech of the gun, utilizing electric motor power therefor.

Another object is to provide such a power apparatus as that referred to above in which the electric motor power may be that derived from alternating current.

Another object is to provide such a power apparatus having improved means for controlling the movements of the reciprocatory rammer.

Other objects will be apparent to those skilled in the art to which my invention appertains.

My invention is fully disclosed in the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a view, somewhat diagrammatic, illustrating an electric power apparatus for operating a gun rammer, and certain control limit switches associated therewith, the electric circuits of the system being omitted from this figure;

Fig. 2 is an electric circuit diagram illustrating the electric power circuits and the electric control circuits, omitted from Fig. 1, the limit switches of Fig. 1 being re-produced in this figure in association with the electric circuits which they control;

Figs. 3, 4, 5, and 6 illustrate diagrammatically a gun rammer operated by the apparatus and system of Figs. 1 and 2, and illustrating different positions and lengths of stroke of the rammer as it successively propels the projectile and two charges of powder into the breech of the gun;

Fig. 7 is a view illustrating a modification of the control system of Fig. 2.

Fig. 8 is a view illustrating a means for adjusting cam devices of Figs. 1 and 2.

Referring first to Figs. 3, 4, 5, and 6 of the drawings, I have illustrated diagrammatically at 1 the breech of the gun to be loaded. At 2 is a pan or shelf upon which first the projectile and then the powder is deposited preparatory to being charged into the gun. At 3 is a horizontally reciprocable rammer having a rammer head 4.

In each of the Figures 3 to 6, the rammer head 4 is illustrated in solid line in its retracted position. In Figs. 3, 4, and 5, the rammer head is shown at 4A, 4B and 4C in its forward reciprocated position to which it is moved by successively shorter forward strokes. On the first forward stroke, the rammer head 4 moves a projectile 5, which has been laid upon the pan 2, from its solid line or starting position to its final position indicated in dotted line in the gun; and in Fig. 4 a first charge of powder 6, which has been laid on the pan 2, is reciprocated forwardly to the dotted line position rearwardly of the projectile in the gun; and in Fig. 5 a second charge of powder 7, which has been laid on the pan 2, is reciprocated forwardly to the dotted line position in the gun rearwardly of the first charge 6; and in Fig. 6, which illustrates the projectile and both charges of powder in the gun, the rammer head 4 has been retracted, and the gun breech may now be closed and the gun fired in the usual manner by means not shown.

It is therefore seen to be convenient to always to retract the rammer head 4 to the same position, but to project it forwardly over successively decreasing distances.

The rammer proper, 3, which reciprocates the rammer head 4, may be variously constructed. In one acceptable and practicable form, the rammer proper is in the form of a chain, and, upon retraction thereof, the chain winds or bends into a housing whereby the overall length of the rammer may be kept down to the minimum; but inasmuch as the construction of the rammer proper constitutes no essential part of the present in-

vention, and in order to simplify the drawings and description, the rammer has been illustrated as in the form of a rack, reciprocated by forward and reverse rotation of a pinion 8 meshed therewith, and driven by a shaft 9. If the chain-form rammer were employed, the pinion 8, or a sprocket connected to the shaft 9, would reciprocate the chain.

The apparatus for thus rotating the shaft 9 in the forward and reverse directions and for carrying out the other features of movement of the rammer head 4 above referred to, will now be described in connection with Figs. 1 and 2, wherein the pinion 8 and shaft 9 have been reproduced.

At 10 is illustrated an electric motor, and as shown, it is an alternating current squirrel cage induction motor. As shown in Fig. 1, the motor drives a pinion 11, the teeth of which are meshed as at 12 with teeth on the outer periphery of a circular differential gearing spider element 13 which rotatively supports pinions 14—14 meshed with differential gear elements 15 and 16.

The differential gear 16 drives the shaft 9 preferably through a friction clutch 17 which clutch as is well known will slip if the torque necessary to rotate the shaft 9 and pinion 8 should exceed a predetermined amount.

The differential gear 15 is connected by a shaft 18 to the rotor of a squirrel cage induction motor 19, having as indicated conventionally, three sets of stator field windings, or a stator field winding that can be connected to supply mains to provide in effect three sets of windings, whereby its rotor may have three synchronous speeds at which it tends to run. The above mentioned motor 10 has a single speed at which it tends to run.

The three different speeds of the motor 19 and the speed of the motor 10 may be variably chosen, and the gear ratio between the pinion 11 and the spider 13 may be variously chosen. As a concrete illustration and for purposes of description herein, the motor 10 has a synchronous speed of 1,800 revolutions per minute; and the gear ratio is one-to-three; whereby the spider 13 is driven at 600 revolutions per minute; and the three speeds of the motor 19 are respectively 600, 1,200, and 1,800 revolutions per minute, as indicated in the drawing. From this it will be apparent to those skilled in the art, that due to the characteristics of the differential gearing illustrated and described, when the motor 19 and the shaft 18 and gear 15 are running at 1,200 revolutions per minute, the differential gear 16 and shaft 9 will remain at rest; and that when the motor 19 is running at 600 revolutions per minute, the shaft 9 will rotate at 600 revolutions per minute in, say, the forward direction; and that when the motor 19 is running at 1,800 revolutions per minute, the shaft 9 will rotate at 600 revolutions per minute in the reverse direction.

The motor 10 runs continuously, and normally the motor 19 runs at 1,200 revolutions per minute to hold the shaft 9 and its rammer driving pinion 8 at rest to hold the rammer at rest. To reciprocate the rammer forwardly, the motor 19 is driven at 600 revolutions per minute, and to retract the rammer the motor 19 is rotated at 1,800 revolutions per minute.

The supply of electric power to the motors 10 and 19 and the control of the power for the purposes just described, is preferably provided by the system of connections shown in Fig. 2.

Three phase alternating current is supplied by mains 20, 21, and 22. In the line of the mains is a threepole electro-magnetic contactor shown generally at 23, the winding of which is energized across the mains 21—22 under the control of a push button or other operator's contactor 24. The motor 10 receives current directly from the supply mains when the contactor 23 is closed. The three sets of windings of the motor 19 are supplied with alternating current from the mains upon the closure of magnetic contactors shown generally at 25, 26, and 27. A manually operable master switch is shown at 28 and comprises an arm 29 which may be rocked clockwise or counterclockwise as viewed in the drawing by a handle 30 which is normally held in an intermediate position by springs 31—31; and in the clockwise direction it engages and bridges contacts 32 and 33, and in the other direction engages and bridges contacts 34 and 35. A selector switch is shown generally at 36 and comprises a contact arm 37 rotatable by a handle 38 to selectively engage one or the other of three contacts 39, 40 or 41. At 42 is shown generally a set of four limit switch devices comprising normally closed switches 43, 44 and 45, and a normally open switch 46, and rotary cams or like devices 47, 48, 49, or 50 for operating the said switches. These switch operating cam devices are shown as rotatable in unison by a shaft 51. As shown in Fig. 1, where these parts are reproduced this shaft is driven by the load shaft 9 through a pinion 52 on the shaft 9 meshed with a gear 53 which transmits its rotary movement through a gear ratio reduction unit 54 to the shaft 51.

At 55 is an electro-magnetic relay having normally closed contacts 56 and normally open contacts 57.

Other parts of Fig. 2 and circuit connections thereof not described above will now be described in connection with a description of the operation as a whole, referring to Figs. 1 and 2.

Upon closing the operator's contactor 24, the main line contactor 23 closes, and current from the supply mains 20, 21 and 22 goes directly by wires 58, 59, and 60 to the motor 10, energizing it and bringing it up to its speed of 1,800 revolutions per minute.

A branch system of three phase wires 61, 62, and 63 connected to the wires 58, 59, and 60 is thereby energized. Current flows from the wire 63 by a control circuit wire 64, through the winding 65 of the magnetic contactor 25 and by a wire 66 through the closed contacts 56 of the relay 55 and by a return wire 67 to the wire 62, energizing the winding 65 and closing the contactor 25; and thereupon three phase current flows through the contacts of this contactor to one of the windings of the motor 19, namely, the winding which operates it at 1,200 revolutions per minute, as indicated by the use at the motor 19 of the reference character 1,200, and this brings the motor 19 up to its speed of 1,200 revolutions per minute; and as will be understood from the foregoing, the load shaft 9 now remains at rest notwithstanding that both motors are running.

To operate the load shaft 9 in the forward direction for the purpose of positioning the projectile in the gun as was heretofore described, it will be assumed that the selector switch 36 has its contact 37 on the contact 39. The master switch 28 is now operated to move the arm 29 clockwise and bridge the contacts 32—33; whereupon current flows by a control wire 68 from the wire 63 to the arm 29, thence to the contact 32, by a wire 69 to the arm 37, to the contact 39, by a wire 70, to and through the limit switch 45 and by a wire 71 through the winding 72 of the relay

56 and thence to the return wire 67, thereby operating the relay 55 to open the contacts 56 and close the contacts 57.

Opening of the contacts 56 as described, de-energizes the contactor 25 and cuts off current from the motor 19; but operation of the relay 55 also immediately closes the contacts 57, and thereupon current flows at the master switch, as described, to the contact 33 and thence by a wire 73 through the winding 74 of the contactor 26 and by a wire 75 through the now closed contacts 57 of the relay 55 and to the wire 67 and so on as before, operating the contactor 26 and connecting the supply wires 61, 62, and 63 through the contactor 26 to the winding of the motor 19 which operates it at 600 revolutions per minute as indicated.

This as described hereinbefore causes the load shaft 9 to rotate in the forward direction to project the rammer forwardly to position the projectile in the gun.

Rotation of the shaft 9 rotates the cam switch shaft 51 as described. When the shaft begins to rotate, the cam device 59, after a small angle of rotation, allows the switch 46 to close, but this at the present moment effects no change.

By the time the shaft 9 has rotated a sufficient number of revolutions to effect the projectile positioning rammer stroke identified with Fig. 3, the cam shaft 51 has been rotated by the reduction gearing described, sufficiently to cause the cam device 49 to open the cam switch 45, the cam shaft 51 and the cam device 49 being considered as rotating in the direction of the solid line arrow associated therewith in Fig. 2.

Opening of the switch 45 de-energizes the relay 55 causing it to restore and open the contacts 57 and close the contacts 56 which, as now will be understood from the foregoing description, causes the contactor 26 to open and the contactor 25 to close again, restoring the motor 19 to its 1,200 revolutions per minute speed and bringing the shaft 9 to rest at the end of the rammer stroke.

As was described in connection with Figs. 3, 4, and 5, the successive forward rammer strokes were respectively long, intermediate and short. The cam device 49 accordingly will be set to operate its switch 45 after a relatively great part of a revolution of the shaft 51, and as will presently appear, the cam devices 48 and 47 are respectively set to operate their switches 44 and 43 after intermediate and short portions respectively of a revolution of the shaft 51.

To retract the rammer the master switch 28 is now operated to move the arm 29 in the counter-clockwise direction to bridge the contacts 34—35, and thereupon current flows as before by the wire 68 to the arm 29 and to the contact 35 and thence by a wire 76 through the now closed limit switch 46 and by the wire 71 to again operate the relay 55 and close the contacts 57 and open the contacts 56; and current also flows from the master switch arm 29 to the contact 34 and thence by a wire 77 through the winding 78 of the contactor 27 and by a wire 79 to the above described wire 75 and thence through the now closed contacts 57 of the relay and thence by the wire 67 and so on as before, thereby closing the contactor 27 and supplying three phase current from the wires 61, 62, and 63 to the motor 19 to operate it at its speed of 1,800 revolutions per minute, as indicated.

This, as described above, causes the load shaft 9 to reverse its direction of rotation and retract the plunger. Rotation of the shaft 9 in the reverse direction reverses the direction of the cam shaft 51 and causes the cam device 50 to rotate in the direction indicated by the dotted line arrow, and to open the limit switch 46 by the time the rammer has been retracted to its original position, whereupon the relay 55 again restores, causing the motor 19, as will now be clear, to operate at its speed of 1,200 revolutions per minute and bring the shaft 9 to rest again. This brings all of the parts back to the condition at which the operation started, the rammer having moved the projectile into the gun and retracted to its starting position.

To perform the ramming operation indicated in Fig. 4, the operator moves the selector switch 36 by the handle 38 to engage the contact 37 with the contact 40; and then moves the master switch arm 29 to bridge the contacts 32—33. Current now flows from the contact 32, as will be apparent, through the limit switches 44 and 45 to operate the relay 55. The operation is now the same as on the first stroke of the rammer, the motor 19 being caused to rotate at 600 revolutions per minute, but in this case, the cam device 48 opens the limit switch 44 earlier in the stroke of the rammer and restores the motor 19 to its 1,200 revolutions per minute earlier and stops the rammer at a shorter stroke. Again, moving the master switch arm 29 counter-clockwise causes the motor 19 to operate at 1,800 revolutions per minute and reverse the rammer, and the limit switch 46 upon being restored, again causes the rammer to come to rest.

For the third stroke of the rammer, identified with Fig. 5, the selector switch 36 is moved to engage the contact 37 with the contact 41; and then when the master switch 28 is moved clockwise, current from the contact 32 flows from the contact 41 and through the limit switches 43, 44 and 45, again operating the relay 55 and causing the motor 19 to rotate at 600 revolutions per minute; and the cam device 47 opens the limit switch 43 at a still earlier point in the rammer stroke performing the ramming operation of Fig. 5. And again, when the master switch 28 is moved counter-clockwise, the motor 19 is caused to run at 1,800 revolutions per minute and reverse the load shaft and the cam shaft and retract the rammer, at the end of which movement the limit switch 46 again brings the apparatus to rest.

As will be seen from the foregoing, the amount of retraction of the rammer is always determined by only one limit switch, 46, and the rammer therefore always retracts to the same position.

It will be observed that to cause the rammer to move forward the relay 55 is first raised and then the contactor 26 is closed. In some cases, it may be desirable to give a forward movement to the rammer independently of the limit switches, such for example as a small or inching movement. When this is desired, an operator's switch or push button 80 may be moved to momentarily, or repeatedly, close its contacts 81. Current then will flow from the supply main 63 through the contacts 81 and by a wire 82 to the wire 71 to effect raising of the relay, and current will also flow through the contacts 81 and by a wire 83 to the winding 74 and through it to the wire 75 and so on, effecting momentary or repeated closing of the contactor 26.

In the foregoing description, the selector switch 36 is arranged to be moved from one position to the other by hand.

In the modification shown in Fig. 7, this may

be accomplished automatically. A ratchet wheel 84 is connected to the contact 37. A pawl arm 85 is pivoted at the center of the ratchet wheel 84 and a pawl 86 on the arm 85 engages the teeth of the ratchet. A rod 87 is pivotally connected to the arm 85. A spring 88 connected to one end of the rod 87 tends to rock the arm 85 clockwise to turn the ratchet wheel and move the contacts 37 from one position to another. An electromagnet comprising a winding 89, and a plunger 90 connected to the rod 87 tends to rotate the arm 85 counter-clockwise to tension the spring 88. Limit stops 91 and 92 are adjustable to predetermine the angular stroke of the arm 85.

The limit switch 46 rotated by the cam device 50 has another switch 93 associated therewith which opens and closes concurrently with the switch 46. A circuit from one of the supply mains 62 through the switch 93 and through the winding 89 to another supply main 63 is provided.

In the operation of the apparatus of Fig. 7 above described in connection with Fig. 2, when the rammer starts forward, the limit switch 46 closes. In Fig. 7, this also closes the switch 93 and energizes the winding 89 and raises the plunger 90 and rod 87 and tensions the spring 88. When the rammer has made its forward stroke and has retracted to its original position, the limit switch 46 opens; and in the arrangement of Fig. 7 this also opens the switch 93 deenergizing the winding 89 and allowing the spring 88 to ratchet the contact 37 around to its next successive position.

Thus by the arrangement of Fig. 7, each time that the rammer is retracted, the selector switch is automatically set to a new position for the next forward stroke of the rammer.

The cam devices 47 to 50 may be of any suitable construction or of known commercial construction; and may be adjustable to adjust the times at which they operate their associated switches to determine the extent of the several strokes of the rammer. A diagrammatic showing of adjustment is given in Fig. 8, wherein the set screw 94 may be loosened and the body 95 of the cam device rotated on the shaft 51 to adjustably position it and the set screw then tightened.

There are advantages and improvements in my invention which are not obvious from the foregoing description, as follows.

It will be observed that the motor 19 begins to move the rammer in the forward direction at the instant that its speed begins to decrease from a 1 200 to a 600 revolutions-per-minute motor. In order that the rammer may be moved forwardly without delay and be quick-acting as is known to be desirable, the motor 19 should be slowed down to its 600 revolutions per minute as quickly as possible, and there is means inherent in the invention for producing this action. When the synchronous speed of the motor 19, that is, the speed of its rotating magnetic field, is changed from 1,200 to 600 revolutions per minute, the rotor is at that instant still rotating at 1,200 revolutions per minute, which is twice the new synchronous speed. The motor then as is well known will operate as an induction generator, developing electrical load and delivering it back to supply mains and this electrical generator load quickly slows down the rotor by what may be called dynamic braking. Furthermore, and additive thereto, the kinetic energy of the motor rotor upon slowing down from the higher speed is partly absorbed by the load to start and accelerate it. Thus very quick, if not instantaneous, starting and accelerating of the rammer occurs and without the necessity of correspondingly accelerating the motor itself which has been necessary in prior electrical systems for this purpose.

Again, at the end of the forward rammer stroke the motor 19 is changed from a 600 to a 1,200 revolutions-per-minute motor to stop the forward movement of the rammer, and it is likewise desirable that this change of speed shall occur as quickly as possible; and again means is inherent in the invention to accomplish this end. The instant that the rotating magnetic field of the rotor is changed to 1,200 revolutions per minute, the rotor is still rotating at 600 revolutions per minute; and the torque developed by the high speed rotating field is very much greater, approximately twice that which was developed when the magnetic field was rotating 600 revolutions per minute, so that, a very great or what may be called excessive torque is applied to the rotor at its 600 revolutions per minute speed, to quickly bring it up to the 1,200 revolutions per minute speed.

When the rammer is started in the reverse direction the motor speed must be changed from 1,200 to 1,800 revolutions per minute and again this is brought about very quickly because of the fact that with the rotor going at 1,200 revolutions per minute and the speed of the rotating magnetic field instantaneously changed to 1,800 revolutions per minute, the very great or excessive torque thereby applied to the rotor very quickly brings it up to the new speed; and this is further facilitated by the fact that at this time there is no load on the motor except the idle returning rammer.

At the end of the returning stroke of the rammer, the motor speed changes from 1,800 revolutions per minute to 1,200 revolutions per minute and here again, when the connections to the stator are changed, the rotor is rotating above the new synchronous speed and again acts as an induction generator developing electrical load which very quickly reduces the speed of the rotor.

Thus the speed of the motor 19 is automatically and inherently quickly changed in the operation of the apparatus as described and this, coupled with the fact that both motors run continuously and do not have to be stopped and started and reversed, enables them to run at very high efficiency; and for a given output horsepower makes possible the use of smaller motors than would otherwise be necessary, and avoids the necessity of auxiliary apparatus to accelerate or decelerate the motors or either of them to effect the changes of speed and direction of the load.

My invention is not limited to the exact details of construction illustrated and described nor to the exact arrangement of the electrical connection thereof. Changes and modifications other than those described above may be made within the scope and spirit of my invention without sacrificing its advantages; and my invention comprehends all such changes and modifications which come within the scope of the appended claims.

I claim:

1. In a power operated gun rammer apparatus, a reciprocatory rammer; a power transmission mechanism; a constant speed electric motor and a variable speed electric motor, connected to the

transmission; a power take-off from the transmission mechanism connected to the rammer; the transmission mechanism comprising means to effect forward and reverse movements of the rammer and to bring it to rest, responsive respectively to different speeds of the variable speed motor; a source of current for the motors; a control system controlling the current to control the speed of the variable speed motor, and comprising means coordinated with the movement of the rammer to effect changes of speed of the variable speed motor after a predetermined extent of movements of the rammer in the forward and reverse directions.

2. In a power operated gun rammer apparatus, a reciprocatory rammer; a power transmission mechanism; a constant speed electric motor and a variable speed electric motor, connected to the transmission; a power take-off from the transmission mechanism connected to the rammer; the transmission mechanism comprising means to effect forward and reverse movements of the rammer and to bring it to rest, responsive respectively to different speeds of the variable speed motor; a source of current for the motors; a control system controlling the current to control the speed of the variable speed motor, and comprising means coordinated with movement of the rammer to effect changes of speed of the variable speed motor after a predetermined extent of movements of the rammer in the forward and reverse directions; and operable means to variably predetermine the extent of forward movements.

3. In a power operated gun rammer apparatus, a reciprocatory rammer element; a differential gearing comprising three elements, namely: a rotary spider element rotatably supporting a pinion and two rotary differential gear elements meshed with the pinion; a constantly running electric motor drivingly connected to one element of the gearing and rotating it at constant speed; a power take-off from a second element of the gearing for reciprocating the rammer element; a variable speed electric motor drivingly connected to the third element of the gearing; a source of current and control means for causing the variable speed motor to run at different respective speeds at which the said power take-off remains at rest, and at which the power take-off reciprocates the rammer element in the forward direction, and at which the power take-off reciprocates the rammer element in the reverse direction, respectively; stop means operable by the power take-off and controlling the control means to limit the movement of the rammer element in the forward and reverse directions of reciprocation; and selector means controlling the stop means to selectively predetermine the extent of successive forward reciprocations.

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