Feb. 20, 1968 B. J. DOUGLASS ET AL 3,370,220

HAND OPERATED BLASTING GENERATOR

Original Filed March 30, 1964 2 Sheets-Sheet 1

FIG. 1.

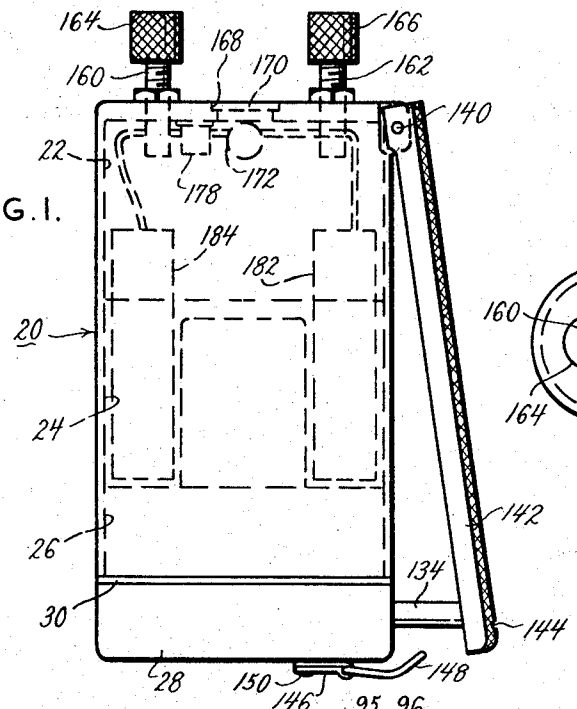

FIG. 2.

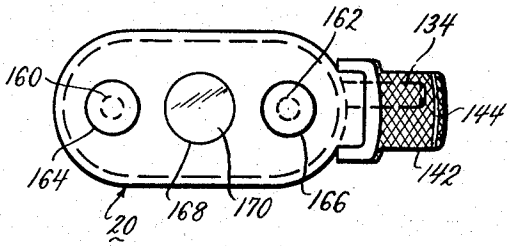

FIG. 3.

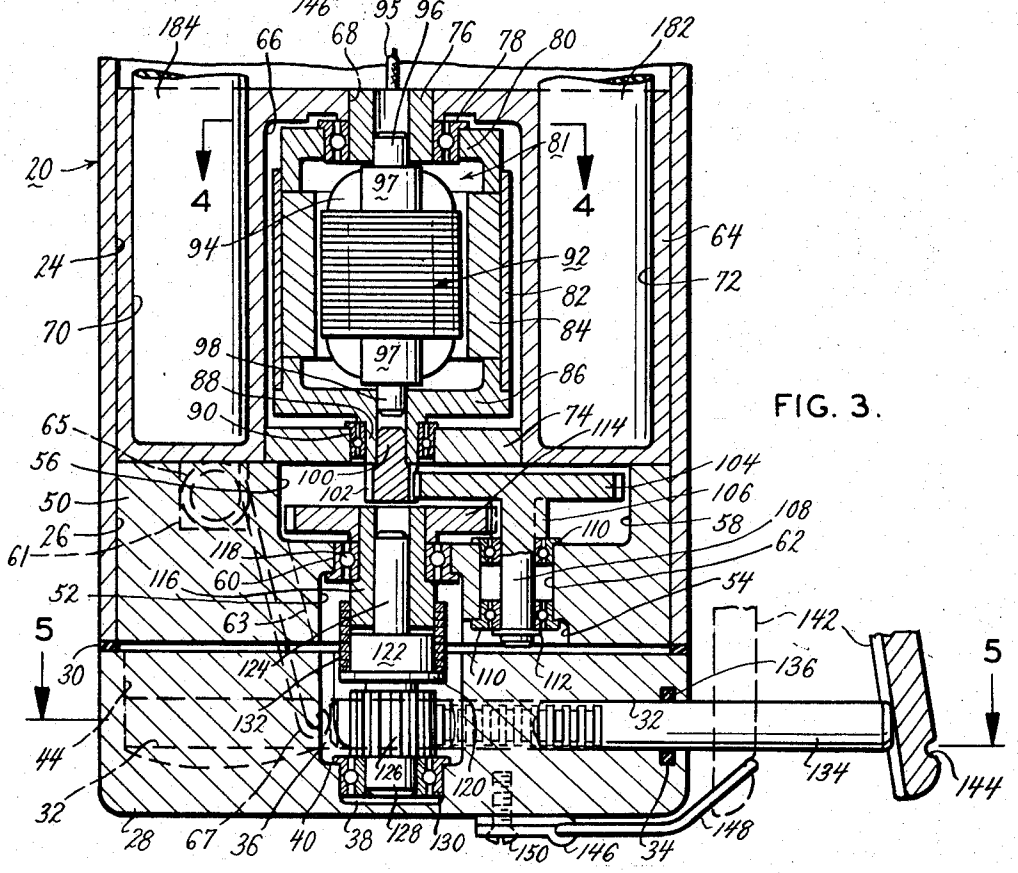

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FIG. 4.

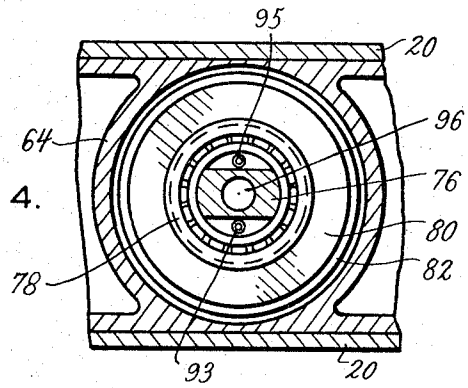


FIG. 5.

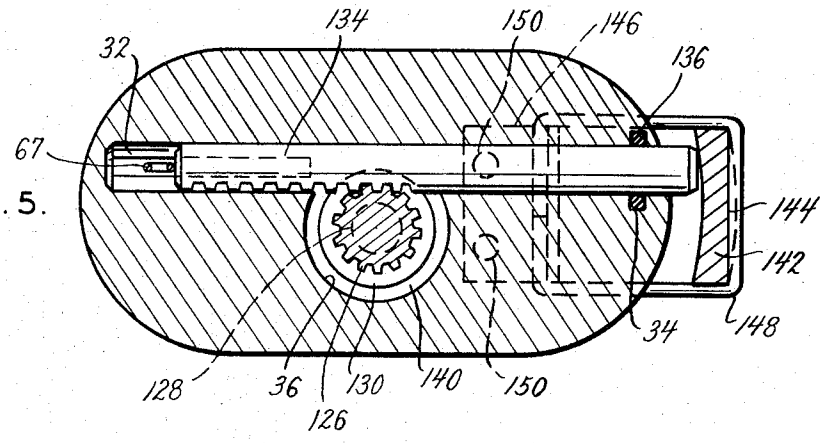


FIG. 6.

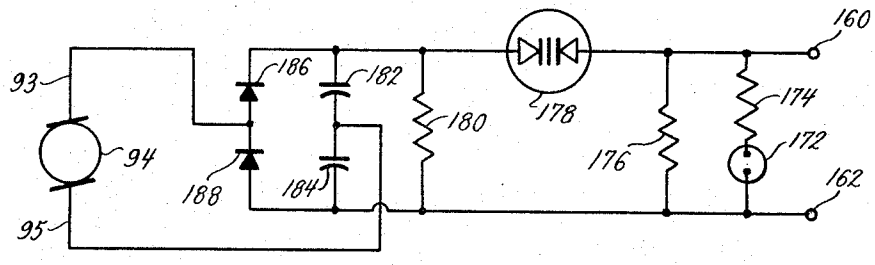
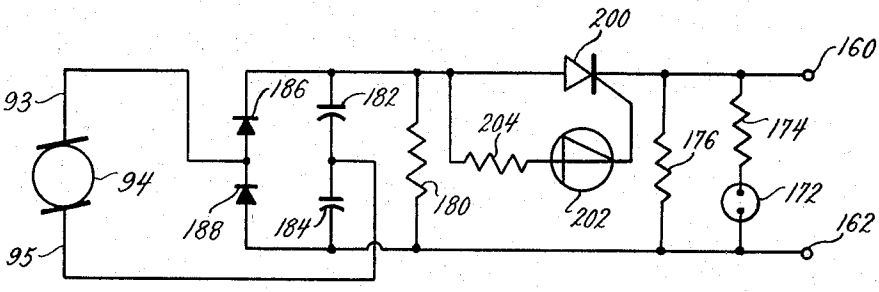


FIG. 7.



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3,370,220

HAND OPERATED BLASTING GENERATOR

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Continuation of application Ser. No. 355,827, Mar. 30, 1964. This application June 9, 1967, Ser. No. 645,063
15 Claims. (Cl. 322—40)

This application is a continuation of application Serial No. 355,827, filed March. 30, 1964, and now abandoned.

This invention relates to improvements in Control Systems. More particularly, this invention relates to improvements in blasting machines for electric blasting caps.

It is, therefore, an object of the present invention to provide an improved blasting machine for electric blasting caps.

In blasting and demolition operations, it is customary to set the explosives in place, to affix electric blasting caps to those explosives, to connect those electric blasting caps in series relation, and then to actuate a blasting machine to "fire" those electric blasting caps. The blasting machine is usually located at a point remote from the series-connected electric caps but it is connected to those caps by elongated leads; and, when that blasting machine is actuated, it causes current to flow through those leads to fire those caps. While blasting machines can differ from each other, a typical blasting machine includes output terminals which are connectable to the elongated leads, a generator which can be actuated to supply direct current to those output terminals, and a push-in handle which can actuate that generator. If the operator pushes the handle of the blasting machine inwardly at a sufficiently rapid rate, and if the generator operates in its intended manner, the current supplied to the output terminals of the blasting machine will fire all of the electric blasting caps. However, if the operator fails to push the handle of the blasting machine inwardly at a sufficiently rapid rate, the current supplied to the output terminals may be just large enough to fire some of the electric blasting caps and not large enough to fire all of those caps. Also, if the generator does not operate in its intended manner, the current supplied to the output terminals of the blasting machine may be just large enough to fire some of the electric blasting caps and not large enough to fire all of those caps. The firing of less than all of the electric blasting caps is objectionable because the unfired electric blasting caps, and the explosives to which they are affixed, can constitute severe hazards to persons who enter the blasted or demolished area. It would be desirable to provide a blasting machine which could regularly fire all of the electric blasting caps connected to the output terminals thereof, and which would not fire just a few of those electric blasting caps while leaving the rest of those electric blasting caps unfired. The present invention provides such a blasting machine; and it is, therefore, an object of the present invention to provide a blasting machine which can regularly fire all of the electric blasting caps connected to the output terminals thereof, and which will not fire just a few of those electric blasting caps while leaving the rest of those electric blasting caps unfired.

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The blasting machine provided by the present invention can regularly fire all of the electric blasting caps connected to the output terminals thereof, because that blasting machine will apply substantially no voltage to those output terminals until it is ready to apply a voltage to those output terminals which is much larger than the minimum voltage needed to fire any one of those electric blasting caps. This means that the electric blasting caps will have substantially no voltage applied to them until the instant when all of them suddenly receive a voltage which is much larger than the minimum voltage needed to fire any one of them; and, at that instant, all of those electric blasting caps will respond to that large voltage to fire. As a result, the blasting machine provided by the present invention can obviate the hazards which unfired electric blasting caps, and the explosives to which those caps are affixed, can constitute. It is, therefore, an object of the present invention to provide a blasting machine for electric blasting caps which applies substantially no voltage to the output terminals thereof until it is ready to apply a voltage to those output terminals which is much larger than the minimum voltage needed to fire any one of those electric blasting caps.

The blasting machine provided by the present invention has an electric circuit which includes a voltage-sensitive device; and that device remains substantially non-conductive until that blasting machine is ready to apply a voltage to the output terminals thereof which is much larger than the minimum voltage needed to fire any one of those electric blasting caps. However, as soon as the blasting machine is ready to apply such a voltage to the output terminals thereof, the voltage-sensitive device will become conductive; and the blasting machine will then apply the said voltage to the output terminals, and thus to the electric blasting caps. It is, therefore, an object of the present invention to provide a blasting machine with an electrical circuit which includes a voltage-sensitive device that remains substantially non-conductive until that blasting machine is ready to apply a voltage to the output terminals thereof which is much larger than the minimum voltage needed to fire any one of those electric blasting caps.

The blasting machine provided by the present invention utilizes a brushless generator; and such a generator is desirable because it is free from the electrical "noise" which develops at the brushes of generators. Such noise is particularly objectionable in a generator which is used in a blasting machine, because that noise can modulate the output voltage of that generator and thereby provide transient voltage peaks which could fire less than all of the electric blasting caps connected to the output terminals of that blasting machine. By using a brushless generator, the present invention avoids all modulation of the output voltage of that generator and thereby prevents firing of less than all of the electric blasting caps connected to the output terminals of that blasting machine. It is, therefore, an object of the present invention to provide a blasting machine for electric blasting caps which uses a brushless generator.

The electrical circuit of the blasting machine provided by the present invention includes capacitance; and that capacitance will respond to the current which the generator supplies to it to develop a voltage across it. That

capacitance will apply that voltage to the voltage-sensitive device of the electrical circuit; and, when that voltage rises to a predetermined level, that voltage-sensitive device will become conductive. If one actuation of the generator causes the voltage across that capacitance to rise to that predetermined level, the voltage-sensitive device will immediately become conductive and fire the electric blasting caps connected to the output terminals of the blasting machine. However, if one actuation of the generator does not cause the voltage across that capacitance to rise to that predetermined level, that capacitance will retain enough of the charge thereon to enable a subsequent actuation of the generator to cause the voltage across that capacitance to rise to that predetermined level. As a result, firing of the electric blasting caps can be attained even if one actuation of the generator does not develop sufficient energy to render the voltage-sensitive device conductive. It is, therefore, an object of the present invention to provide a blasting machine with an electrical circuit that has capacitance which can respond to successive actuations of the generator of that blasting machine to develop a predetermined voltage thereacross.

The capacitance of the electrical circuit of the blasting machine preferably takes the form of series-connected capacitors and the generator is preferably an A.C. generator. In addition, diodes interconnect those capacitors with the A.C. generator in such a way that the A.C. generator applies a voltage to the capacitance during each half-revolution of the rotor of that generator and a voltage-doubling action is attained. As a result, the blasting machine provided by the present invention can develop and apply a substantial voltage. It is, therefore, an object of the present invention to provide a blasting machine with capacitance in the form of series-connected capacitors, with an A.C. generator, and with diodes which interconnect those capacitors with the A.C. generator in such a way that the A.C. generator applies a voltage to the capacitance during each half-revolution of the rotor of that generator and a voltage-doubling action is attained.

The preferred form of generator which is used in the blasting machine of the present invention has a stationary winding and a rotatable field; and that rotatable field encircles that stationary winding. As a result, that rotatable field has a larger radius than it would have if it was disposed within the stationary winding. Further, the greatest proportion of the mass of that rotatable field is concentrated adjacent the periphery of that rotatable field. Consequently, that rotatable field tends to act as a flywheel; and this is desirable, because it enables that rotatable field to momentarily rotate with substantially undiminished speed after each actuation of the generator. That momentary, substantially undiminished speed is helpful in facilitating the firing of electric blasting caps where more than one actuation of the generator is required. Further, that momentary, substantially undiminished speed is helpful in facilitating the firing of electric blasting caps where the voltage developed within the blasting machine during the movement of the handle thereof closely approaches, but does not reach, the required level; because that momentary, substantially undiminished speed can cause the generator to raise the voltage to the required level. It is, therefore, an object of the present invention to provide a generator with a rotatable field which encircles a stationary winding and which has the greatest proportion of the mass thereof concentrated adjacent the periphery thereof.

The blasting machine provided by the present invention can be made so small and so light in weight that it can be carried in the hand or pocket of the operator. This is desirable because it enables that operator to carry that blasting machine with him at all times—thereby making certain that no one can actuate that blasting machine while he is working with, or close to, an electric blasting cap.

It is, therefore, an object of the present invention to provide a blasting machine for electric blasting caps which is small enough and which is sufficiently light in weight to be carried in the hand or pocket of the operator.

The blasting machine provided by the present invention is enclosed within a water-tight casing. That casing makes it possible to use that blasting machine in muddy, sandy, and dirty areas. In fact, that casing makes it possible to use that blasting machine under water. It is, therefore, an object of the present invention to provide a blasting machine which is enclosed within a water-tight casing.

Other and further objects and advantages of the present invention should become apparent from an examination of the drawing and accompanying description.

In the drawing and accompanying description a preferred embodiment of the present invention is shown and described but it is to be understood that the drawing and accompanying description are for the purpose of illustration only and do not limit the invention and that the invention will be defined by the appended claims.

In the drawing, FIG. 1 is a front elevational view of one preferred form of blasting machine that is made in accordance with the principles and teachings of the present invention,

FIG. 2 is a plan view of the blasting machine shown in FIG. 1,

FIG. 3 is a vertical section, on a larger scale, through the middle and lower portions of the blasting machine shown in FIG. 1,

FIG. 4 is a sectional view, on the scale of FIG. 3, through the blasting machine of FIG. 1, and it is taken along the plane indicated by the line **4—4** in FIG. 3,

FIG. 5 is another sectional view, on the scale of FIG. 3, through the blasting machine of FIG. 1, and it is taken along the plane indicated by the line **5—5** in FIG. 3,

FIG. 6 is a schematic diagram of one preferred form of electrical circuit for the blasting machine of FIG. 1, and

FIG. 7 is a schematic diagram of a modified form of the electrical circuit of FIG. 6.

Referring to the drawing in detail, the numeral **20** generally denotes the casing of one preferred embodiment of blasting machine that is made in accordance with the principles and teachings of the present invention. That casing is rectangular in elevation, and it is generally rectangular in plan. In the said preferred embodiment of blasting machine provided by the present invention, the height of the casing **20** is four and one-eighth inches, the width of that casing is two and three-sixteenth inches, and the thickness of that casing is one and one-eighth inches. As a result, that blasting machine can easily be held within the hand of the operator, and can also be easily carried in the pocket of the operator. The casing **20** has an upper compartment **22**, a central compartment **24**, a lower compartment **26**, and a closure **28**. A gasket **30** of resilient material is interposed between the closure **28** and the bottom of the lower compartment **26** of the casing **20**. Elongated machine screws, not shown, extend upwardly through openings, not shown, in the closure **28** and have the threaded shanks thereof seated within threaded openings, not shown, within the upper part of the casing **20**. Those machine screws can be tightened to compress the gasket **30** and thereby provide a water-tight seal between the closure **28** and the lower compartment of the casing **20**. The gasket **30** has the form of a generally rectangular loop; and it largely conforms to the configuration of the bottom face of the lower compartment **26** of the casing **20**.

A vertically-directed, cylindrical recess **36** is provided in the upper face of the closure **28**; and a smaller-diameter, vertically-directed, cylindrical recess **38** extends downwardly from the bottom of the recess **36**. An annular shoulder **40** is provided in the closure **28** intermediate the recesses **36** and **38**. A horizontally-directed, cylindrical passage **32** is provided in the closure **28**; and the right-hand end of that passage opens to the right-hand face of the closure **28**, while the left-hand end of that passage

stops short of the left-hand face of that closure. That passage communicates with, and is generally tangential relative to, the recess **36**. A slot **44** is formed in the closure **28** adjacent the left-hand portion of the passage **32**; and that slot communicates with that passage and also extends to the upper face of the closure **28**. A small annular recess **34** is provided in the closure **28** adjacent the right-hand end of the cylindrical passage **32**; and that recess opens to that passage.

The numeral **50** denotes a supporting block which is dimensioned to fit snugly within the lower compartment **26** of the casing **20**. A vertically-directed, cylindrical recess **52** is provided in the lower face of the block **50**, and that recess is concentric with the recess **36** in the closure **28**. A further, vertically-directed, cylindrical recess **54** is provided in the lower face of the block **50**; and that recess merges into the recess **52**. As shown particularly by FIG. 3, the recess **54** is not as deep as the recess **52**. A vertically-directed, cylindrical recess **56** is provided in the upper face of the block **50**, and that recess is concentric with the recess **52**. A vertically-directed, cylindrical recess **58** is provided in the upper face of the block **50**, and that recess is concentric with the recess **54**; and that recess merges into the recess **56**. A vertically-directed passage **60** extends between, and communicates with, the recesses **52** and **56**. A vertically-directed passage **62** extends between, and communicates with, the recesses **54** and **58**. A slot **63** is formed in the left-hand portion of the block **50**, and that slot communicates with the upper face, the lower face, and the left-hand face of that block. That slot communicates with the recess **56**, and it also communicates with a notch **61** in the upper face of the block **50**. A helical spring **65** is disposed within the notch **61**; and one end of that spring is suitably secured to the block **50**, while the end **67** of that spring extends downwardly through the slots **63** and **44** into the passage **32**.

The numeral **64** denotes a supporting frame which is dimensioned to fit snugly within the central compartment **24** of the casing **20**. That frame has a vertically-directed, cylindrical recess **66** therein; and that recess is concentric with the recess **56** in the block **50**. A cylindrical opening **68** is provided in the closed upper end of the recess **66**; and vertically-directed hollow spaces **70** and **72** are provided in the frame **64**. The casing **20** is preferably made from a sturdy plastic material; and the closure **28**, the block **50**, and the frame **64** are preferably made from a light-weight metal such as aluminum.

A supporting disc **74**, which has a cylindrical opening at the center thereof, is dimensioned to fit within the lower end of the cylindrical recess **66**. Preferably, that disc will be dimensioned so it must be pressed into the lower end of that recess. A bushing **76**, which has oppositely-disposed flat faces at the exterior thereof, is pressed within the opening **68** in the closed end of the recess **66**; and the flat faces of that bushing are indicated particularly by FIG. 4. The inner race of an anti-friction bearing **78** is pressed onto the outer surface of the bushing **76**; and that inner race will abut the closed end of the recess **66**.

The outer race of the bearing **78** is disposed within a cylindrical opening in the cup-shaped end **80** of a rotor which is generally denoted by the numeral **81**. The large-diameter portion of the cup-shaped end **80** is pressed within a sleeve **82**; and a cylindrical permanent magnet **84** is pressed within that sleeve and abuts the bottom portion of the cup-shaped end **80**. That cylindrical permanent magnet can be made from alnico, from barium ferrite, or from any other suitable material. A cup-shaped end **86** for the rotor **81** is pressed up into the lower end of the sleeve **82**; and that cup-shaped end has a sleeve-like portion **88** which extends downwardly into the cylindrical opening in the disc **74**. An antifriction bearing **90** has the outer race thereof mounted within the opening in the disc **74**, and has the inner race thereof telescoped over the sleeve-like portion **88** on the cup-shaped end **86**. The cup-shaped ends **80** and **86** will be made from a light-weight, non-magnetic material such as aluminum, but the sleeve **82** will be made from a magnetic material such as iron or steel. The bearings **78** and **90** permit the rotor **81** to rotate relative to the frame **64**, and thus relative to the casing **20**, with a minimum of friction. Because the cup-shaped ends **80** and **86** are made of light-weight material, the greatest proportion of the mass of the rotor **81** is concentrated adjacent the periphery of that rotor. This is desirable, because it enables that rotor to provide a flywheel effect.

The numeral **92** denotes a laminated core which is generally I-shaped in cross section; and the laminations of that core are parallel to the magnetic flux lines developed by the permanent magnet **84**. That core is mounted on a support which has a stud-like upper end **96** that is pressed into the bushing **76**; and it has a stud-like end **98** which extends into the sleeve-like portion **88** on the cup-shaped end **86** of the rotor **81**. The engagement between the stud-like end **98** of the support for the core **92** and the sleeve-like portion **88** of the cup-shaped end **86** of the rotor **81** will be sufficiently loose to permit ready rotation of the rotor **81** relative to the core **92**. A two-pole winding **94** is wound on the core **92**; and leads **93** and **95** extend upwardly from that winding through passages defined by the inner race of bearing **78** and the flat faces of bushing **76**—as shown particularly by FIG. 4. The turns of the winding **94** will be neatly held in assembled relation with the core **92** by insulating tape **97** or the like. The winding **94**, the core **92**, and the rotor **81** constitute a brushless A.C. generator.

The numeral **102** denotes a pinion which has a cylindrical extension **100** projecting upwardly therefrom. That extension is dimensioned so it can be pressed into the sleeve-like portion of the cup-shaped member **86** of the rotor **81**. The engagement between the extension **100** and the sleeve-like portion **88** will be sufficiently tight to enable the pinion **102** to effectively serve as part of the rotor **81**. Consequently, rotation of the pinion **102** will cause rotation of that rotor.

The numeral **104** denotes a spur gear which has a pinion **106** integrally formed therewith and which has a shaft-like portion **108**. That shaft-like portion is held by the inner races of anti-friction bearings **110**; and the outer races of those bearings are set within the passage **62** in the block **50**. A retainer **112**, such as a snap ring, engages the lower end of the shaft-like portion **108** of the spur gear **104** and prevents accidental separation of the spur gear from the bearings **110**. The spur gear **104** is held in register with the pinion **102**, and the teeth of that spur gear mesh with the teeth of that pinion.

A spur gear **114** is pressed onto the upper end of a sleeve **116** which is supported by the inner race of an anti-friction bearing **118**; and the outer race of that bearing is set within the passage **60** in the block **50**. The spur gear **114** is disposed above the level of the bearing **118** and is in register with the pinion **106**; and the teeth of that spur gear mesh with the teeth of the pinion **106**. The sleeve **116** extends downwardly below the lower face of the bearing **118**; and the lower portion of that sleeve has a cylindrical clutching surface thereon. A driving member **120** has a cylindrical clutching surface **122** thereon; and the diameter of that clutching surface is substantially the same as the diameter of the clutching surface on the sleeve **116**. The driving member **120** has a reduced-diameter, upper portion **124** which extends into the sleeve **116**; and the engagement between the sleeve **116** and the portion **124** is loose enough to permit ready rotation of that driving member relative to that sleeve but is intimate enough to maintain that driving member and that sleeve in alinement. The driving member **120** also has a cylindrical portion **128** at the bottom thereof; and it has a pinion **126** intermediate that cylindrical portion and the clutching surface **122**. The portion **128** of the driving member **120** is held by the inner race of an anti-friction bearing **130**; and the outer race of that bearing is set with-

in the recess 38 in the closure 28. A helical clutching spring 132 is telescoped over the clutching surface 122 of the driving member 120 and is also telescoped over the clutching surface on the sleeve 116. The unstressed diameter of the spring 132 is less than either of the diameters of the clutching surfaces of driving member 120 and sleeve 116; and hence that spring normally presses against those clutching surfaces.

The numeral 134 denotes a plunger which is circular in cross section; and that plunger has a rack on the left-hand portion thereof, as shown by FIG. 5. That plunger is dimensioned to fit within, and to reciprocate relative to, the cylindrical recess 32 in the closure 28. The end 67 of the spring 65 abuts the left-hand end of the plunger 134, and biases that plunger for movement toward the extended position shown by FIG. 1. However, that spring can yield to permit that plunger to be moved to, and held in, the retracted position shown by FIG. 5. The teeth of the rack on the plunger 134 mesh with the teeth on the pinion 126 of the driving member 120; and, as that plunger moves within the cylindrical passage 32, the teeth on that rack will force the pinion 126, and hence the driving member 120 to rotate. When the plunger 134 is moved from the extended position shown in FIG. 1 to the retracted position shown by FIG. 5, the rack thereon will cause the driving member 120 to rotate in the counter clockwise direction in FIG. 5. However, when the spring 65 moves that plunger from the retracted position shown by FIG. 5 to the extended position shown by FIG. 1, the rack will rotate the driving member 120 in the clockwise direction in FIG. 5. An O-ring 136 is disposed within the annular recess 34 in the closure 28; and that O-ring engages the plunger 134. The engagement between that O-ring and that plunger is sufficiently intimate to provide a water-tight seal, but is loose enough to permit reciprocation of that plunger relative to the casing 20.

The numeral 140 denotes a pivot which is secured to the upper portion of the casing 20; and a handle 142 is secured to the casing 20 by that pivot. That handle has a concave inner face; and that face engages the right-hand end of the plunger 134. That concave face is desirable because it enables any forces, which are applied to that handle and which tend to rotate that handle in the clockwise direction in FIG. 1, to keep that handle from shifting laterally away from the plunger 134. A shallow groove 144 is provided in the outer face of the handle 142 adjacent the lower end of that handle; and that groove is parallel to the pivot 140. The outer face of the handle 142 is knurled to facilitate firm gripping of that handle.

A folded plate is denoted by the numeral 146, and that plate is folded to define a groove adjacent the closed end thereof. Screws 150 extend through the folded plate 146 and extend into threaded sockets in the closure 28 to hold that folded plate in assembled relation with that closure. The groove adjacent the closed end of the folded plate 146 accommodates one side of a loop-like latch 148 and prevents separation of that latch from the closure 28, while permitting rotation of that latch relative to that closure. The ouer side of that loop-like latch is dimensioned to fit within the groove 144 in the outer face of the handle 142. As indicated by FIGS. 3 and 5, the latch 148 can hold the handle 142 in retracted position adjacent the right-hand side of the casing 20; and, as indicated by FIG. 1, that latch can be moved downwardly out of the path of the handle 142 to permit that handle to be moved to extended position. The groove 144 prevents accidental separation of that latch from that handle.

The numeral 160 denotes a threaded output terminal which projects upwardly from the upper surface of the casing 20, and the numeral 162 denotes a similar output terminal. Knurled, cup-shaped nuts 164 and 166 are, respectively, threaded onto the output terminals 160 and 162. An opening 168 is provided in the upper surface of the casing 20 intermediate the terminals 160 and 162; and a transparent window 170 is fixed within that opening.

The numeral 172 denotes a lamp which is disposed in the upper compartment 22 of casing 20 in register with window 170. While a neon lamp is preferred, other lamps could be used. A resistor 174 is connected in series with lamp 172; and that resistor and lamp are connected across output terminals 160 and 162, as shown by FIG. 6. A resistor 176 is connected across output terminals 160 and 162, and hence in parallel with series-connected lamp 172 and resistor 174. A biswitch 178, which is a bilateral switching diode, has one terminal thereof connected to output terminal 160, and has the other terminal thereof connected to the upper terminals of a resistor 180 and a capacitor 182. The lower terminal of resistor 180 is connected to output terminal 162; and the lower terminal of capacitor 182 is connected to the upper terminal of a capacitor 184. The lower terminal of capacitor 184 is connected to output terminal 162; and this means that capacitors 182 and 184 are connected in series with each other and are connected in parallel with resistor 180. A diode 186 has the anode thereof connected to the lead 93 from winding 94 of the A.C. generator, and the cathode of that diode is connected to the upper terminal of capacitor 182. A diode 188 has the cathode thereof connected to lead 93 and has the anode thereof connected to the lower terminal of capacitor 184. The lead 95 of the A.C. generator is connected to the junction between capacitors 182 and 184. Capacitors 182 and 184, lamp 172, biswitch 178, resistors 174, 176 and 180, and diodes 186 and 188 will preferably be secured to a support which has conductors "printed" thereon. The said support, capacitors, biswitch, resistors and diodes will be in upper compartment 22 of casing 20, but the lower ends of the capacitors will extend into the hollow spaces 70 and 72.

The right-hand side of the latch 148 will normally be lodged within the groove 144 in the outer face of the handle 142; and hence that handle will normally be held close to the casing 20 and will normally hold the plunger 134 in the retracted position shown by FIG. 5. At such time, the end 67 of the spring 65 will strongly urge that plunger toward the extended position shown in FIG. 1; and, in doing so, that spring will help prevent accidental freeing of the right-hand side of the latch 148 from the groove 144. As a result, the blasting machine can be carried in the operator's hand or pocket without any likelihood of the handle 142 being released for movement to extended position.

In using the blasting machine provided by the present invention, the operator can keep that blasting machine in his pocket while he is engaged in setting the explosives, in affixing the electric blasting caps to those explosives, in connecting elongated leads to those electric blasting caps, and in paying out those elongated leads as he walks from the site of the intended explosion to the site where he will initiate that explosion. By keeping the blasting machine in his pocket, the operator can have full and complete assurance that a premature firing of the electric blasting caps will not be initiated. After the operator reaches the site where he plans to initiate the explosion, he can loosen the knurled nuts 164 and 166, connect the ends of the elongated leads to the output terminals 160 and 162, and then tighten the knurled nuts 164 and 166.

To free the handle 142 for movement to its extended position, the operator will initially move that handle closer to the casing 20 to release the right-hand side of the latch 148 from the groove 144; and thereafter that operator will release the handle 142. Thereupon, the spring 65 will force that plunger to move to the extended position shown by FIG. 1.

As that plunger so moves, the rack thereon will coact with the pinion 126 on the driving member 120 to rotate that driving member in the clockwise direction in FIG. 5. That rotation will tend to unwind the clutching spring 132 which normally presses against the clutching surfaces of driving member 120 and of sleeve 116; and that spring will unwind sufficiently to permit that driving member to

rotate without rotating that sleeve. This means that the plunger **134** will be able to move from its retracted position to its extended position without causing rotation of the rotor **81** of the A.C. generator.

To fire the electric blasting caps, the operator will place the left-hand side of the casing **20** adjacent the palm of his hand, will wrap his fingers around the handle **142**, and will then firmly and rapidly move that handle to the retracted position shown by FIG. 5. The plunger **134** will simultaneously move to retracted position; and, as that plunger so moves, the rack thereon will rotate the pinion **126** of driving member **120** in the counter clockwise direction in FIG. 5. That rotation will cause the clutching surface **122** of that driving member to rotate in that direction which enables that clutching surface to tend to wind up the clutching spring **132**; and, thereupon, that spring will rotate with the driving member **120** and force the clutching surface on the sleeve **116** to rotate. As the sleeve **116** rotates, it will rotate the spur gear **114**; and that spur gear will rotate the pinion **106** and the spur gear **104**. The rotation of spur gear **104** will rotate the pinion **102**, and thus rotate the rotor **81**.

The resulting rotation of the magnetic field, provided by the cylindrical magnet **84**, relative to the winding **94** on the stationary core **92** will generate an alternating voltage in that winding; and the leads **93** and **95** and the diodes **186** and **188** will apply that voltage to the capacitors **182** and **184**. As a result, whenever the lead **93** in FIG. 6 is positive relative to the lead **95**, current will tend to flow from the winding **94** through lead **93**, diode **186**, capacitor **182**, and lead **95** to that winding; and any such flow of current will tend to charge the capacitor **182** with the upper terminal thereof positive. Also, whenever the lead **95** is positive relative to the lead **93**, current will tend to flow from the winding **94** through lead **95**, capacitor **184**, diode **188**, and lead **93** to that winding; and any such flow of current will tend to charge the capacitor **184** with the upper terminal thereof positive. This means that during each revolution of the rotor **81**, a voltage will be applied to the capacitor **182** and a voltage will be applied to the capacitor **184** by the A.C. generator. Because those capacitors are connected in series relation, the voltages across those capacitors will be additive.

The rotor **81** can be rotated quite rapidly—in one preferred embodiment of the present invention that rotor has been rotated at rates up to ten thousand revolutions per minute—and the voltages which are applied to the capacitors **182** and **184** can quickly cause the voltage across those series-connected capacitors to increase. That voltage will be applied across resistor **180**, and also will be applied across series-connected biswitch **178** and resistor **176**; and, when that voltage reaches the threshold level of the biswitch **178**, that biswitch will become conductive. Until such time as that biswitch becomes conductive, substantially no voltage will be developed across the resistor **176**; and hence substantially no voltage will be developed across the output terminals **160** and **162**. However as that biswitch becomes conductive a resulting rush of current through the resistor **176** will develop a substantial voltage across that resistor **176**, and hence across the output terminals **160** and **162**. In the said preferred embodiment of blasting machine which is made in accordance with the principles and teachings of the present invention, the root mean square of that voltage is about one hundred and twenty-five volts. Such a voltage is much greater than the minimum voltage needed to cause firing of one of the electric blasting caps; and hence the substantially simultaneous firing of all of the electric blasting caps is assured. As the voltage across the resistor **176** causes firing of the blasting caps, that voltage also will cause the neon lamp **172** to become illuminated; and the illumination of that lamp is very desirable, because it will indicate to the operator that an electric charge has been applied to the elongated leads which extend to the electric blasting caps.

If an operator squeezes the blasting machine rapidly and firmly, a single retracting movement of the plunger **134** can regularly fire as many as twenty series-connected electric blasting caps. In fact, an experienced operator can, with just one retraction of that plunger, fire more than fifty series-connected electric blasting caps.

In the event the operator does not squeeze the blasting machine with sufficient rapidity or firmness to effect the firing of the electric blasting caps with just one squeeze, he will release his pressure on the handle **142** and thereby permit the spring **65** to return the plunger **134** to the extended position indicated by FIG. 1. The momentum of the rotor **81**, and of the gear train which includes pinion **102**, spur gear **104**, pinion **106**, and spur gear **114**, will keep the rotor **81** rotating at substantialy undiminished speed for several seconds; and, as a result, the sleeve **116** and the clutching spring **132** will continue to rotate. As the spring **65** moves the plunger **134** from its retracted position to its extended position, the rack on that plunger will rotate the driving member **120** in a direction which is opposite to the direction of rotation of the sleeve **116**. The clutching spring **132** will continue to rotate with the sleeve **116**; and that spring will unwind sufficiently to keep the rotation of the driving member **120** from effecting any appreciable retardation of the speed of that sleeve. Once the handle **142** reaches the extended position shown by FIG. 1, the operator can again squeeze the blasting machine and thereby apply further rotative forces to the rotor **81**. The resulting voltages which will be applied to the capacitors **182** and **184** can, and usually will, increase the voltage across those series-connected capacitors to the threshold value of the biswitch **178**. Thereupon, the electric blasting caps will be fired.

The flywheel effect which is provided for the rotor **81**, by the concentration of the largest proportion of the mass of that rotor adjacent the periphery of that rotor, is important; because it enables that rotor to rotate at almost undiminished speed for several seconds after the plunger **134** reaches its fully retracted position. Such rotation is important because the voltage across the series-connected capacitors **182** and **184** frequently does not reach the threshold value of the biswitch **178** as the plunger **134** moves to its retracted position—that voltage reaching that value immediately after that plunger has reached its fully retracted position. Such rotation also is important where more than one squeeze of the blasting machine is required; because such rotation enables the application of even limited further rotative forces to the rotor **81** to cause the voltage across the series-connected capacitors **182** and **184** to reach the threshold value of the biswitch **178**.

In the event one or the other of the leads extending from the series-connected electric blasting caps to the output terminals **160** and **162** becomes broken, the voltage across the capacitors **182** and **184** will not be applied to those electric blasting caps. That voltage will not, however, be permitted to remain on those capacitors very long; because, in less than one second, the resistors **176** and **180** will reduce that voltage below the threshold value of the biswitch **178**. This is desirable because it will keep the operator from unintentionally firing the electric blasting caps as the broken lead is subsequently repaired.

In the event the operator of the blasting machine provides only a partial retracting movement of the plunger **134**, or provides full retracting movement of that plunger at a low rate of speed, the voltage across the series-connected capacitors **182** and **184** may rise to a value which is close to, but slightly below, the threshold value of the biswitch **178**. It would be undesirable to permit that voltage to remain on those capacitors indefinitely; because if the operator of the blasting machine laid that blasting machine down, subsequently picked that blasting machine up, and then started moving the handle **142** toward retracted position, the residual voltage on those capacitors could coact with a small additional voltage to premature-

ly fire the electric blasting caps. The resistor **180** keeps the voltage on the capacitors **182** and **184** from remaining there indefinitely, because that voltage will be dissipated by that resistor in less than eighteen seconds.

The electric circuit of FIG. 6 is extremely rugged and trouble-free. Specifically, that electric circuit can withstand the high current rush which occurs when a metal bar is applied directly across the output terminals **160** and **162** at the moment the biswitch **178** becomes conductive. The ability to withstand that high current rush is due, in part, to the fact that the internal resistances of the capacitors **182** and **184** are in series with each other and in series with the internal resistance of the biswitch **178**. While the total of those internal resistances is low enough to permit more-than-enough current to flow through the series-connected electric blasting caps, connected to the output terminals **160** and **162**, to fire those electric blasting caps, the total of those resistances is great enough to limit the high rush of current to a value which is not injurious to the capacitors **182** and **184** or to the biswitch **178**.

The circuit shown in FIG. 6 is very desirable; but other electric circuits could be used. One such circuit is shown in FIG. 7; and that circuit differs from the circuit of FIG. 6 in that a controlled rectifier **200** and a firing circuit therefor have been substituted for the biswitch **178**. That firing circuit includes a Shockley 4-layer diode **202** and a series-connected resistor **204**; and it will be voltage-sensitive. The controlled rectifier **200** and the Shockley 4-layer diode **202** will remain substantially non-conductive until the voltage across that Shockley 4-layer diode rises to a predetermined value. Thereupon, that 4-layer diode will become conductive; and the resulting flow of current through the gate-to-cathode circuit of the controlled rectifier **200** will render that controlled rectifier conductive. At such time, the rush of current through resistor **176** will establish the desired firing voltage across the output terminals **160** and **162**.

The biswitch **178** is preferred to the controlled rectifier **200** and a firing circuit therefor; because it reduces the total number of components required. Also the biswitch **178** has a sharper breakover voltage characteristic.

The force which is required to rapidly move the handle **142** from its extended position to its retracted position is well within the gripping capabilities of almost every adult. For example, a force of only thirty pounds is required to rapidly move that handle from its extended position to its retracted position, and such a force is considerably less than one-half of the force which an average adult male can provide.

The blasting machine provided by the present invention is readily portable, because it is not only small in size but it is also light in weight. Thus, the total weight of one preferred embodiment of blasting machine that is made in accordance with the principles and teachings of the present invention is less than eight ounces.

Because the blasting machine of the present invention is waterproof as well as readily portable, that blasting machine can be used in wet, sandy and dirty areas. In fact, that blasting machine can be used under water—as by "frogmen" doing under-water demolition work.

The lamp **172** is not only helpful in indicating when a voltage has been supplied to elongated leads connected to the output terminals **160** and **162**, it is also helpful in showing that the blasting machine is in operative condition. Specifically, when an operator is checking his various items of equipment at the start of a working day, he can easily check his blasting machine by rapidly and firmly squeezing that blasting machine one or more times until the lamp **172** becomes illumined. Thereafter, throughout that day, each illumining of that lamp will show that the blasting machine is in operative condition.

The blasting machine provided by the present invention could, of course, be actuated by using two hands to squeeze it. However, that blasting machine is so compact, so light in weight, and easily actuated that it will, in almost all instances, be actuated by just one hand.

The blasting machine provided by the present invention is particularly useful in the firing of electric blasting caps, electric detonators or electric squibs. However, that blasting machine can be used for other purposes, for example, the firing of flash bulbs. Consequently, wherever the phrase "blasting machine" is used in this description and in the appended claims, it will be understood to comprehend a unit which readily converts mechanical energy into electrical energy.

The A.C. generator which is part of the blasting machine of the present invention could be used in other devices. Such a generator is very desirable because it does not require brushes or slip rings. Furthermore, that generator is desirable because the field thereof is rotatable and because the largest proportion of the mass of that field is concentrated adjacent the periphery thereof. That is additionally desirable because the winding **94** is on the core **92** and the field encircles that core; and hence the total amount of iron in the core is small and the total distance which the magnetic lines of flux must traverse in passing through that core is very short. That generator is further desirable because the turns of the winding **94** can be easily and directly wound onto the core **92**.

The blasting machine provided by the present invention can be held in different ways. As indicated previously herein, it can be held with the casing **20** adjacent the operator's palm and with the operator's fingers wrapped around the handle **142**; and that blasting machine can be held in that way with the output terminals **160** and **162** extending upwardly or extending downwardly. If desired, that blasting machine can be held with the handle **142** adjacent the operator's palm and with the operator's fingers wrapped around the casing **20**; and that blasting machine can be held in that way with the output terminals **160** and **162** extending upwardly or extending downwardly. However that blasting machine is held, it can be held comfortably; because the left-hand face of the casing **20** and the outer face of the handle **142** are rounded.

The upper end of the handle **142** projects above the level of the pivot **140**, and that upper end is formed so it can abut the upper end of the casing **20**, or an abutment thereon, to limit the extent to which that handle can rotate away from that casing. Such an arrangement is desirable; because it keeps that handle close enough to that casing to keep the rack on the plunger **134** from moving out of engagement with the pinion **126** on the driving member **120**. Yet, that handle is able to move far enough to provide ample rotation of that driving member.

The latch **148** will normally hold the handle **142**, and hence the plunger **134**, in retracted position, as shown by FIG. 5. That is desirable, because it will keep rough handling or dropping of the blasting machine from effecting "firing" of the biswitch **178**.

The voltage doubler, constituted by the capacitors **182** and **184** and the diodes **186** and **188**, is important because it enables an A.C. generator of small size to effect firing of the biswitch **178**. Specifically, that voltage doubler reduces the number of turns needed in the winding **94**, and thus reduces the overall size of the core **92**—with a consequent reduction in the overall size of the rotor **81**.

That voltage doubler is additionally important because it makes it possible to use a small value of capacitance to provide a large voltage. The resulting small capacitance enables the blasting machine to be made small because the capacitors **182** and **184** can be small. Also, that small capacitance reduces the time constant of the blasting machine, and thereby enables one or two inward movements of the plunger **134** to fire the biswitch **178**.

The biswitch **178**, the controlled rectifier **200**, the Shockley 4-layer diode **202**, and the diodes **186** and **188** are all solid state electrical components. The use of such electrical components is important for several reasons. In the first place, such electrical components do not depend

upon the electrical characteristics of gaseous or liquid components; and hence the operation of those electrical components is not materially affected by heat, pressure, light or radiation. Further, such electrical components permit substantially full voltage to be supplied to the output terminals **160** and **162**. Moreover, such electrical components reduce the total amount of energy dissipated in the blasting machine, because they have low cut-off levels.

In assembling the blasting machine of the present invention, the bushing **76**, bearing **78**, core **92**, rotor **81**, bearing **90**, disc **74**, pinion **102** and its extension **100** will be assembled with the frame **64**. Also, a piece of cardboard, fibre or the like, which has two small openings therein, will have those openings telescoped over the leads **93** and **95**; and then that piece will be pressed against the upper face of the frame **64**.

The capacitors **182** and **184**, the biswitch **178**, the lamp **172**, the diodes **186** and **188**, the resistors **174**, **176** and **180**, and the output terminals **160** and **162** will be suitably secured to a support therefor. The free end of the lead **93** will then be secured to the diodes **186** and **188** and the free end of the lead **95** will be secured to the capacitors **182** and **184**.

The various bearings, shafts, gears and pinions will be assembled with the block **50**, and then the sleeve **116** will be pressed into position. The clutching spring **132** will be telescoped over the clutching surface on the sleeve **116**, and the spring **65** will be set in position within notch **61** and slot **63**. The reduced diameter portion **124** of the driving member **120** will be telescoped within the sleeve **116**, and the clutching surface **122** will be disposed within the lower portion of the clutching spring **132**.

The bearing **130** will be set within recess **38** of closure **28**, and the O-ring **136** will be set in recess **34**. Thereafter, the plunger **134** will be telescoped into the cylindrical passage **32**.

The output terminals **160** and **162**, capacitors **182** and **184**, the biswitch **178**, the diodes **188** and **186**, the lamp **172**, the resistors **174**, **176** and **180**, and the support therefor will be telescoped upwardly through the open bottom of the casing **20** until the threaded upper ends of those output terminals project beyond the top face of the casing **20**. The frame **64** will then be telescoped upwardly through the open bottom of the casing **20**; and the hollow spaces **70** and **72** therein will accommodate the lower ends of capacitors **182** and **184**. Once the frame **64** is set in position, the block **50** will be telescoped upwardly through the open bottom of casing **20** and abutted against the lower face of that frame. The teeth of pinion **102** and the teeth of spur gear **104** will have been set so they will smoothly mesh as the block **50** is moved up into position. The gasket **30** will then be set in engagement with the lower end of the casing **20**, and the closure **28** will be moved toward that gasket. The teeth on the rack of plunger **134** will be set to smoothly mesh with the teeth of pinion **126**, and the inner race of bearing **130** will be alined with the lower end **128** of the driving member **120**. The plunger **123** will be moved far enough to the right to enable the left-hand end thereof to clear the end **67** of spring **65**. Machine screws, not shown, will then be telescoped upwardly through openings in the closure **28** and seated in threaded openings, not shown, in the casing **20**.

At this time the nozzle of a "potting gun" will be set in register with an opening, not shown, in the upper portion of the casing **20**; and a substantially transparent "potting" material will then be introduced into the upper compartment **22** of casing **20** and into the hollow spaces **70** and **72** of frame **64**. Vent holes, not shown, will be provided in the upper surface of the casing **20** adjacent the window **170** and adjacent the output terminals **160** and **162**, and hence the "potting" material will fill all voids in the upper compartment **22** and in the hollow spaces **70** and **72**. That potting material will fully support the various electrical components of the blasting machine and will also keep water, dirt, sand, or the like from entering the upper portion of the casing **20**.

The use of cup-shaped nuts **164** and **166** is particularly desirable where the blasting machine is to be used in the ocean or in other bodies of salt water. Those nuts will be coated with a layer of insulation so only the threads therein will be free of insulation. The portions of the output terminals **160** and **162**, which will not be completely covered by the nuts **164** and **166**, also will be covered with insulation. If only those portions of the ends of the elongated leads, which will be clamped to the output terminals **160** and **162** and overlain by the nuts **164** and **166**, are stripped of insulation, the likelihood of current leaking through the salt water will be materially reduced.

Where desired, the blasting machine provided by the present invention can be used to fire electric blasting caps that are connected in parallel. Also where desired, that blasting machine can be used to fire electric blasting caps that are connected in series-parallel.

The generator provided by the present invention can develop a substantial output voltage although the plunger **134** has only a short stroke. For example, in the preferred embodiment of the present invention, the generator developed a root mean square voltage of seventy volts although the plunger moves only about five-eighths of an inch. The voltage doubler appropriately multiplies that voltage, and thus assures prompt firing of the voltage-sensitive device.

Whereas the drawing and accompanying description have shown and described a preferred embodiment of the present invention it should be apparent to those skilled in the art that various changes may be made in the form of the invention without affecting the scope thereof.

What we claim is:

1. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor

to supply power to said output terminals, until said capacitor has become substantially fully discharged,
whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,
said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke.

2. A blasting machine which comprises:
a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,
a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and
output terminals for said blasting machine,
said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,
said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,
said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,
said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,
said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,
whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,
said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,
said generator being an A.C. generator,
said capacitor including a plurality of capacitors,
rectifying means connecting said generator to said plurality of capacitors,
said plurality of capacitors and said rectifying means being connected as a voltage multiplier to supply a rectified and multiplied voltage to said solid-state selectively-conductive element.

3. A blasting machine which comprises:
a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
a capacitor that receives power generated by said generator and that responds to said power to develop a change therein and a voltage thereacross,
a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and
output terminals for said blasting machine,
said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,
said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,
said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,
said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,
said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,
whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,
said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,
an impedance path connected between said output terminal,
said impedance path completing a "firing" circuit of predetermined impedance for said solid-state selectively-conductive element which will enable said generator and said capacitor to render said solid-state selectively-conductive element conductive, and thereby cause said solid-state selectively-conductive element and said capacitor to supply power to said output terminals, even where the impedance of the load connected to said output terminals is too great to enable said load to complete a "firing" circuit for said solid-state selectively-conductive element.

4. A blasting machine which comprises:
a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,
manually-operable means to rotate said rotor of said

generator and thereby cause said generator to generate power,
a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,
a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and
output terminals for said blasting machine,
said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,
said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,
said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,
said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,
said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,
whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,
said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,
said manually-operable means including a gear train which has some of the shafts thereof mounted in anti-friction bearings and which has a plurality of gears connected to provide large speed multiplication,
whereby said manually-operable means can effect rotation of said rotor at rates of thousands of revolutions per minute, thereby enabling said generator to quickly supply power to said capacitor and to supply substantial amounts of power to said capacitor.

5. A blasting machine which comprises:
a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,
a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and
output terminals for said blasting machine,
said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,
said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,
said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,
said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,
said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,
whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,
said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,
a bleed-type resistor connected in parallel with said capacitor,
said bleed-type resistor acting, whenever said generator supplies power to said capacitor but the voltage across said capacitor is not large enough to render said solid-state selectively-conductive element conductive, to dissipate energy from said capacitor within a matter of seconds and thereby reduce the voltage across said capacitor to a value well below the threshold level of said solid-state selectively-conductive element.

6. A blasting machine which comprises:
a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,
a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and
output terminals for said blasting machine,
said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,
said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor,

and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

said capacitor being constituted by a plurality of capacitors,

said solid-state selectively-conductive element and said plurality of capacitors being connected in series relation across said output terminals,

said plurality of capacitors and said solid-state selectively-conductive element having sufficient internal resistance to protect said plurality of capacitors and said solid-state selectively-conductive element against injury in the event a "short" is applied across said output terminals.

7. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross.

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a lower level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

said clutch being a uni-directional clutch that permits said rotor of said generator to continue to rotate at substantially undiminished speeds for several seconds after said member has reached the end of said stroke,

said uni-directional clutch permitting said rotor of said generator to continue to rotate in the same direction and at substantially undiminished speed while said member of said manually-operable means is ready for another stroke,

whereby said manually-operable member can be operated through more than one stroke to enable said generator to supply additional power to said capacitor.

8. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to

enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

an indicator connected across said output terminals to indicate whenever said solid-state selectively-conductive element has been rendered conductive.

9. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged.

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including

a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

an impedance path connected between said output terminals,

said impedance path completing a "firing" circuit of predetermined impedance for said solid-state selectively-conductive element which will enable said generator and said capacitor to render said solid-state selectively-conductive element conductive,

said impedance path facilitating testing of said blasting machine prior to the connecting of said output terminals to a load.

10. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time.

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

an impedance path connected between said output terminals,

said impedance path completing a "firing" circuit of predetermined impedance for said solid-state selectively-conductive element which will enable said gen-

erator and said capacitor to render said solid-state selectively-conductive element conductive,

said impedance path facilitating testing of said blasting machine prior to the connecting of said output terminals to a load, and

an indicator connected across said output terminals to indicate whenever said solid-state selectively-conductive element has been rendered conductive.

11. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

said capacitor being part of a voltage multiplier,

said voltage multiplier enabling said capacitor to have a short time constant, thereby minimizing the number of revolutions of said rotor of said generator which are needed to "fire" the load connected to said output terminals.

12. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

a bleed-type resistor connected in parallel with said capacitor,

said bleed-type resistor acting, whenever said generator supplies power to said capacitor but the voltage across said capacitor is not large enough to render said solid-state selectively-conductive element conductive, to substantially completely discharge said capacitor in less than a minute.

13. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor there-

of by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

an indicator connected across said output terminals to indicate whenever said solid-state selectively conductive element has been rendered conductive,

said generator, said capacitor, said solid-state selectively-conductive element, and said indicator being enclosed within a housing, and

said indicator being a lamp and being disposed adjacent a window in said housing.

14. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively-conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

said rotor of said generator having the mass thereof predominately located adjacent the periphery thereof,

the location of the mass of said rotor predominately adjacent the periphery thereof enabling said rotor of said generator to act as a flywheel and thereby continue to rotate at substantially undiminished speed for several seconds after said member has reached the end of said stroke.

15. A blasting machine which comprises:

a generator that has a rotor and a stator and that responds to rotation of said rotor to generate power,

manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,

a capacitor that receives power generated by said generator and that responds to said power to develop a charge therein and a voltage thereacross,

a solid-state selectively conductive element that has a high forward drop whenever it is non-conductive, that has a very low forward drop whenever it has been rendered conductive, and that has a low cut-off level, and

output terminals for said blasting machine,

said solid-state selectively-conductive element being connected between one of the terminals of said capacitor and one of said output terminals,

said generator responding to rotation of said rotor thereof by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor responding to said power to develop a charge therein and a voltage thereacross,

said solid-state selectively-conductive element initially being non-conductive and thereby isolating said one output terminal from said one terminal of said capacitor, and continuing to isolate said one output terminal from said one terminal of said capacitor until the voltage across said capacitor attains a predetermined value,

said solid-state selectively-conductive element thereafter becoming conductive and connecting said one terminal of said capacitor to said one output terminal to enable said capacitor to supply power to said output terminals,

said solid-state selectively-conductive element remaining conductive until the forward drop thereacross falls to a low level, and said solid-state selectively-conductive element thereby continuing to connect said one terminal of said capacitor to said output terminal, and thus continuing to enable said capacitor to supply power to said output terminals, until said capacitor has become substantially fully discharged,

whereby said blasting machine can "fire" loads which can be "fired" only by the application of power to them for appreciable periods of time,

said manually-operable means including a member that can be moved through a stroke of predetermined length to effect rotation of said rotor of said generator, said manually-operable means also including a clutch that permits said rotor of said generator to continue to rotate after said member has reached the end of said stroke, whereby said generator can continue to generate power after said member has reached the end of said stroke,

said generator being a brush-less generator and thereby generating a substantially noise-free output,

whereby said solid-state, selectively-conductive element will not be rendered conductive by brush-generated noise.

No references cited.

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