HAND OPERATED BLASTING GENERATOR
Byron J. Douglass, Webster Groves, and Kenneth E. Bleich, University City, Mo., assignors to Universal Match Corporation, St. Louis, Mo., a corporation of Delaware


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 activate 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 activated, 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 activate that generator. If the operator puts 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 un-fired 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 un-fired. 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 un-fired.

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 un-fired 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
3 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 remain immediately 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 charge to fire 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 to cause the 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, this 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 momentarily, 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 momentarily, 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 momentarily, 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.
3,370,220

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 dimensioned so it must be pressed into 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 recess 56 is concentric with 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 cylindrical opening 68 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 the opening is dimensioned so it must be pressed between the recesses 66 and 62. 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 face 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 rotor 81 is pressed into 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 forms the inner end of a sleeve-like portion 88 which extends downwardly into the cylindrical opening in the disc 74. An anti-friction 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 are designed 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 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 mounted in 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 clamping surface thereon. A driving member 120 has a cylindrical clamping surface 122 thereon; and the diameter of that clamping surface is substantially the same as the diameter of the clamping 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 clamping 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 28 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 210 of the sleeve 116. The unthreaded 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 thereof 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 the 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 located in the upper portion of the handle 142 adjacent to 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 outer 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 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 165 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 neat means by which a filament 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 biswicht 178, which is a bi-stable 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 cathde 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 172, biswicht 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, biswicht, 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 closed 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 likehood 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 the upwardly from the casing 20, the rack thereof 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 move 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 located in the upper portion of the handle 142 adjacent to 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 outer 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 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 165 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.
rotate without rotating that sleeve. That 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; whereupon the sleeve 126 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 as 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 168 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, whereas, 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 176, 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 retracting of that plunger, fire more than thirty 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, the operator may squeeze the handle on the plunger 142 and thereby cause the spring 65 to raise 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 substantially 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 affecting 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 electric blasting caps 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 the 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 bistch 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 bistch 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 bistch 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 bistch 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 bistch 178 is preferred to the controlled rectifier 200 and a firing circuit therefor; because it reduces the total number of components required. Also the bistch 178 has a sharper breakover voltage characteristic. The voltage 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 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 underwater 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 illuminated. Thereafter, throughout that day, each illuminating 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, in 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 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 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 bistch 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 bistch 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 operation downward movements of the plunger 134 to fire the bistch 178.

The bistch 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 biswch 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 in the clamping spring 132, the clamping spring 132 will be telescoped over the clamping 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 clamping surface 122 will be disposed within the lower portion of the clamping 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 biswch 178, the diodes 186 and 188, 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 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 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 aligned 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, will also 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 over lain 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 plurality 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, wherein said "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 whereby 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, 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,
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.
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,
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 voltage 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,

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.

asolid-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,

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 un-
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 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 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 length to effect rotation of said rotor of 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.
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-operative 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 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-operative 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 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-operative 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-operative 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-conduc-
tive 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 gen-
erate power,
a capacitor that receives power generated by said gen-
erator and that responds to said power to develop a charge therein and a voltage thereacross,
as said generator and thereby cause said generator to gener-
erate power,
a capacitor that receives power generated by said gener-
erator and that responds to said power to develop a charge therein and a voltage thereacross,
as said generator and thereby cause said generator to gen-
erate power,
a capacitor that receives power generated by said gener-
erator and that responds to said power to develop a charge therein and a voltage thereacross,
as said generator and thereby cause said generator to gen-
erate power,
a capacitor that receives power generated by said gener-
erator and that responds to said power to develop a charge therein and a voltage thereacross,
as said generator and thereby cause said generator to gen-
erate power,
a capacitor that receives power generated by said gener-
erator and that responds to said power to develop a charge therein and a voltage thereacross,
as said generator and thereby cause said generator to gen-
erate power,
a capacitor that receives power generated by said gener-
erator and that responds to said power to develop a charge therein and a voltage thereacross,
as said generator and thereby cause said generator to gen-
erate power,
a capacitor that receives power generated by said gener-
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,
as said generator and thereby cause said generator to generate power, a capacitor that receives power generated by said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
manually-operable means to rotate said rotor of said generator and thereby cause said generator to generate power,
of by said manually-operable means to generate power and to supply power to said capacitor, and said capacitor for supplying to said output terminals for developing 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 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 thereo-
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.

JOHN F. COUCH, Primary Examiner.

H. HUBERFELD, Assistant Examiner.