

Oct. 28, 1952

B. P. BAKER ET AL

2,616,008

COMPRESSED GAS CIRCUIT INTERRUPTER

Filed March 17, 1950

3 Sheets-Sheet 1

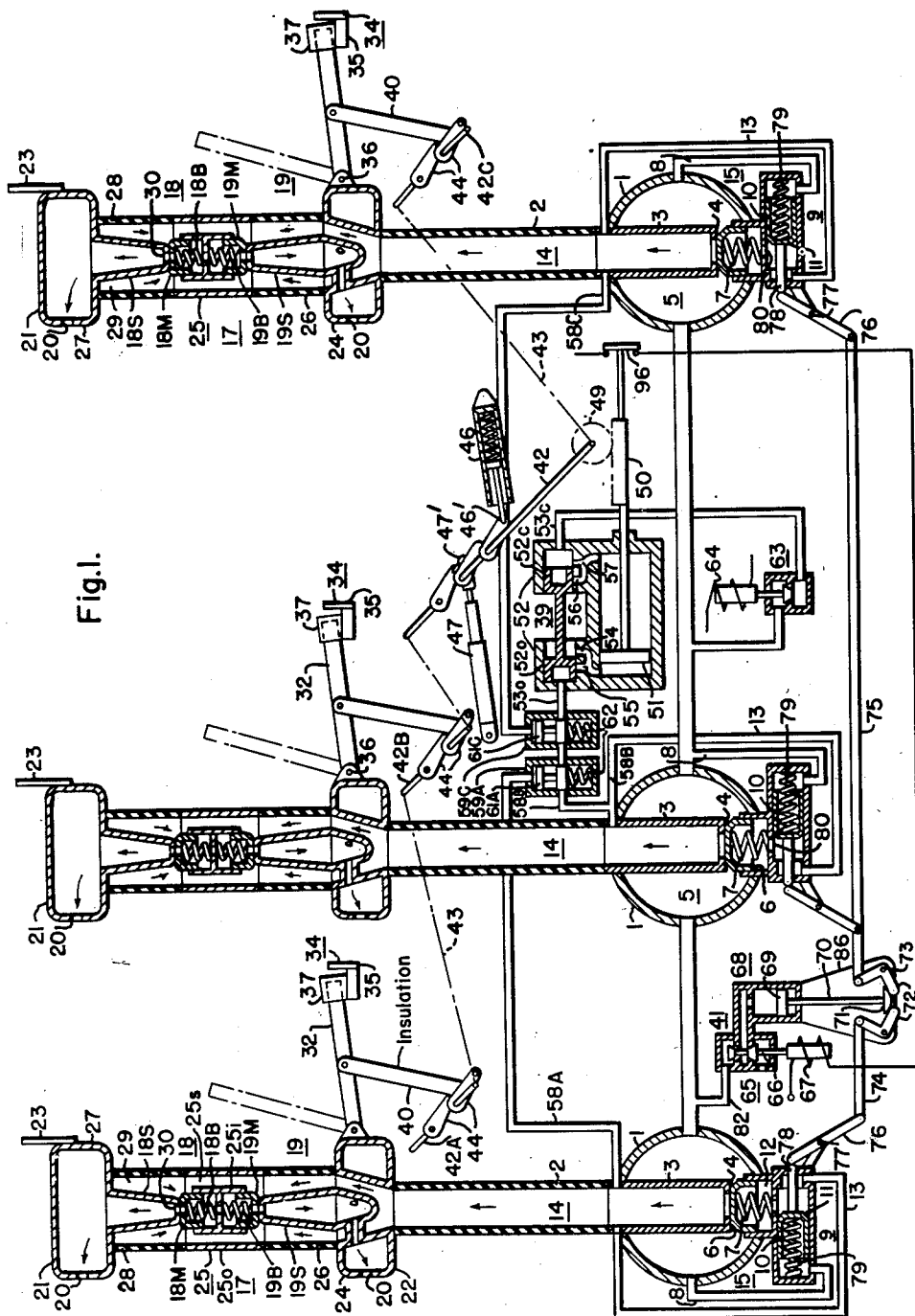


Fig. 1.

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3 Sheets-Sheet 2

Fig.2.

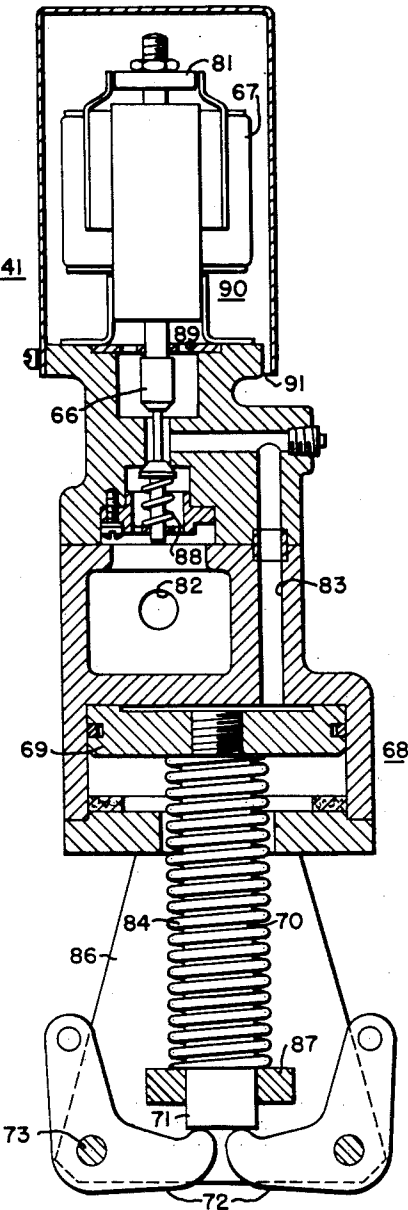
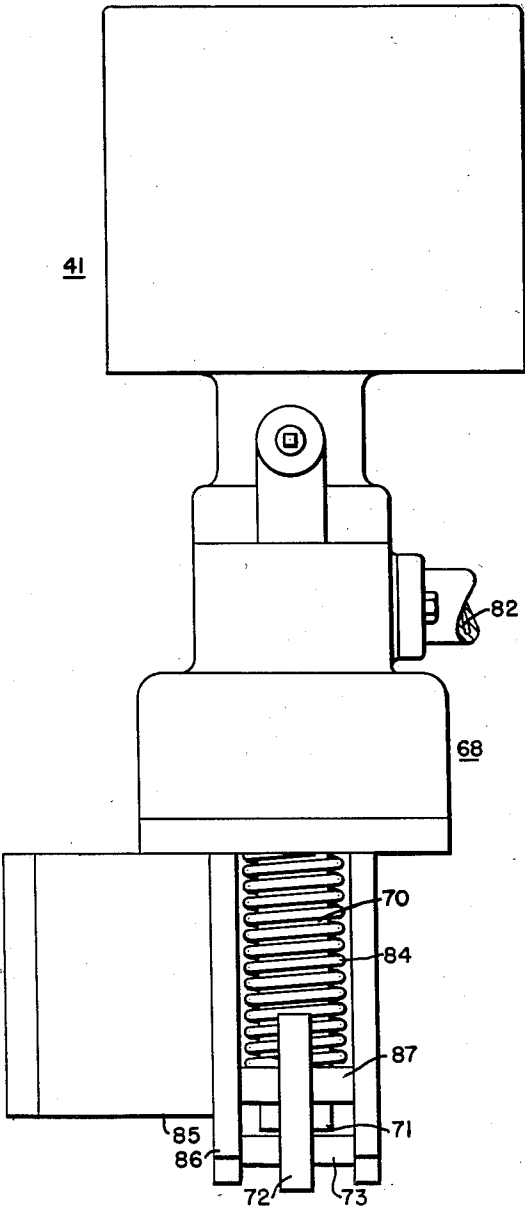


Fig.3.



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3 Sheets-Sheet 3

Fig.4.

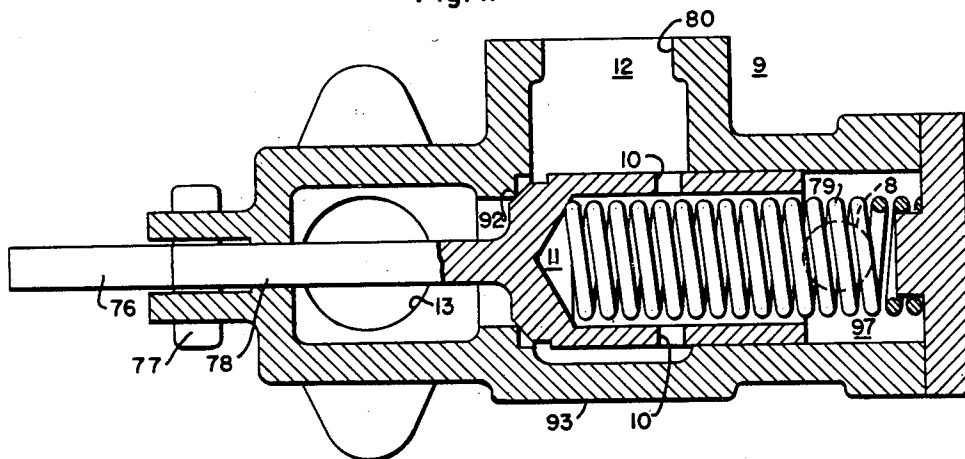
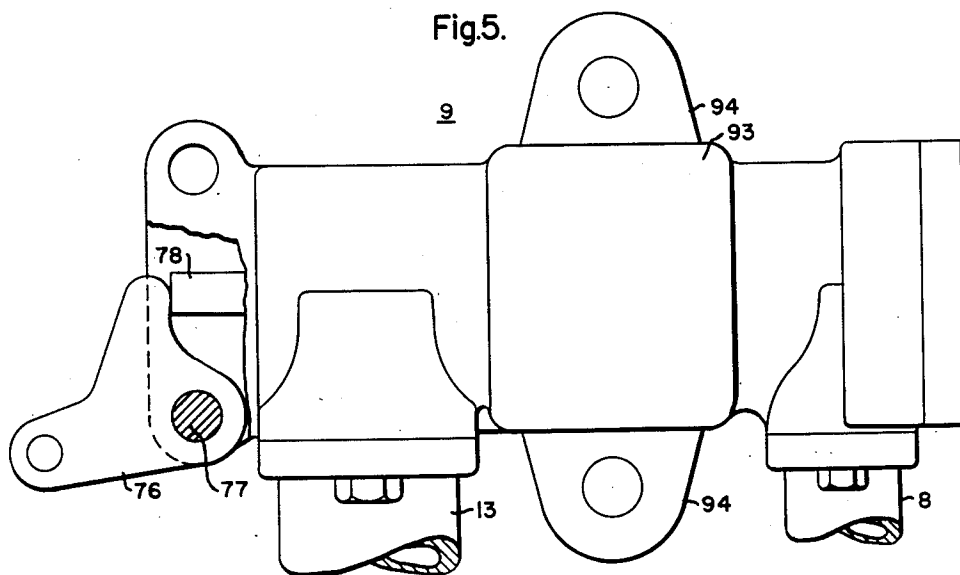


Fig.5.



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2,616,008

COMPRESSED GAS CIRCUIT INTERRUPTER

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Application March 17, 1950, Serial No. 150,262

9 Claims. (Cl. 200-148)

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This invention relates to circuit interrupters in general, particularly circuit interrupters of the compressed gas type, and more particularly to blast valve operating mechanisms therefor.

The general object of our invention is to provide an improved compressed gas circuit interrupter utilizing one or more blast valves in which improved means are employed to control the opening and closing operations of the one or more blast valves.

Another object is to provide an improved differential-type blast valve in which the noise or concussion is reduced to a minimum by an improved dump valve arrangement which exhausts compressed gas directly into the blast tube to avoid noise, and also to utilize the exhaust gas in the subsequent opening operation of the interrupter.

Still a further object is to provide improved blast valve constructions for a three-pole circuit interrupter controlling the three phases of a system in which the blast valves may be synchronized and operated in unison by an improved blast valve operating mechanism.

A further object is to provide an improved dump valve arrangement for a blast valve in which the closing of the dump valve and consequently the closing of the blast valve is expedited by novel pneumatic means.

A further object is to provide an improved multipolar compressed gas circuit interrupter utilizing a plurality of blast valves in which adjustment for the mechanism operating the blast valves in unison may be easily and readily obtained.

Still a further object is to provide an improved dump valve pneumatic arrangement for the blast valve of a compressed gas circuit interrupter in which the exhaust gas is led into the blast tube, so that near the end of the opening operation some equalization of gas pressure on the two sides of the differential blast valve will be obtained, to thereby cause the differential blast valve to more quickly close and consequently conserve the supply of compressed gas.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which,

Figure 1 is a side elevational view, partly in section, and largely diagrammatic, not to scale, indicating the general principles of our invention as applied to a three-pole compressed-air breaker-assembly controlling a three-phase power system, the interrupter being shown in the closed circuit position at just the time in which

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a tripping impulse has been initiated to cause opening of the three dump valves;

Fig. 2 is a side elevational view, partly in vertical section, of our improved electrically operated pneumatic tripping mechanism, with the mechanism shown in its normally non-operative position;

Fig. 3 is an end elevational view of the common electrically operated pneumatic tripping mechanism of Fig. 2 with the parts shown in a similar position;

Fig. 4 is a plan view in section through our improved dump valve, one of which is associated with each blast valve of the breaker, and the dump valve being shown in its closed position, and;

Fig. 5 is a side elevational view of the dump valve set forth in Fig. 4.

Referring to the drawings, and more particularly to Fig. 1 thereof, it will be observed that we disclose a three-pole compressed-air circuit interrupter, adapted for high voltage application, such as 69 kilovolts or higher, and a high circuit interrupting capacity, such as 3.5 million kilovolt-amperes. Such an interrupter is disclosed and claimed in United States patent application, Serial No. 74,406, filed February 3, 1949, by Benjamin P. Baker, Erling Frisch, Wayne S. Aspey and John B. MacNeill, entitled "The Interrupter Part of a Compressed-Air Breaker." Our invention concerns various improvements concerning the blast valve arrangement for such a type of circuit interrupter.

Each pole of the breaker preferably has its own compressed-air tank or reservoir 1, which is made of steel, and which serves also as a supporting structure for the rest of the assembly. We provide a vertically disposed, insulating blast tube 2 which extends upwardly above the top of the tank and is supported by the tank. Inside of the tank, there is a vertically disposed tube means 3, which is in alignment, and air-flow communication, with the bottom of the blast tube 2 so that said internal tube means 3 serves, in effect, as a blast tube extension which extends downwardly, within the tank, to a point near, but spaced from, the bottom of the tank, as indicated at 4. Physically, this blast tube extension, inside of the tank, could be a part of the insulating blast tube 2, which could be made long enough to extend down to the point 4 near the bottom of the tank, but actually, it is more convenient to make the internal tube means 3 out of iron or steel which is welded or otherwise properly secured within the tank 1.

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Disposed within the tank 1, under the bottom 4 of the tube means 3 is a blast valve 5, which is accessible and operable from the bottom of the tank. The blast valve 5 is preferably a differential-pressure valve, having a vertically movable inverted cup valve member 6 which is pressed up, by a compression spring 7, into tight seating engagement with the bottom end 4 of the tube means 3. The compression spring 7 acts as a weak closing spring, which does not exert enough pressure to close the valve against the air pressure in the tank 1, which may be at something of the order of 250 pounds per square inch. Normally the blast valve 5 is held closed by being supplied, from underneath, with air at the same pressure as the air in the tank 1, as by means of a conduit 8, which is in communication with a dump valve means or assembly 9, associated with each pole of the breaker, and including a dump valve piston 11 having a port 10 extending through a side wall thereof, as clearly shown in Fig. 1.

Thus, in the closed circuit position of the interrupter, as shown in Fig. 1, but with the dump valves in their closed position, as indicated in Figs. 4 and 5, but which is not so indicated in Fig. 1, there is normally pneumatic communication from the reservoir 1, through the conduit 8, through the back side of the dump valve piston 11 and through the port 10 to the region 12 below the blast valve.

It will be observed that associated with each dump valve assembly 9 is a conduit means 15 for exhausting high pressure gas below the blast valve 5 to the blast tube 2. The conduit means 15 includes a dump valve exhaust pipe 13 which leads directly into the region 14 interiorly of the blast tube 2, the purpose for which will be more clearly described hereinafter. The blast valve 5 is maintained closed upon an equilization of gas pressure on the top and bottom sides thereof, as permitted when the dump valve assemblies 9 are closed, as shown in Figs. 4 and 5. The blast valves 5 are opened by releasing the air pressure from the region 12 below the inverted cup member 6 by opening movement of the dump valve assemblies 9, thereby permitting the air pressure within the tank 1 to push down the inverted cup 6, thus permitting air to rush in large quantities, upwardly through the internal tube means 3 and through the insulating blast tube 2.

On top of the insulating blast tube 2, we mount a single column interrupter-assembly or interrupting means 17, which is preferably supported in a vertical position, in alignment with the blast tube 2, and which is physically supported solely, or substantially entirely, by the blast tube, so as to be electrically insulated from ground by said blast tube. The single column interrupter-assembly 17 comprises a plurality of vertically aligned, self-opening, longitudinal blast interrupter gap devices 18 and 19, two such gap devices being used on a 69 kilovolt breaker as illustrated. These gap devices 18 and 19 are electrically connected in series, so that the current flow, in the normal closed position of the breaker, as shown in Fig. 1, is from the top 21 of the interrupter-assembly 17 to the bottom 22 thereof, a suitable line terminal 23 being provided at the top 21. Each interrupter gap device 18 and 19 comprises a stationary contact member 18S or 19S, as the case may be, and a vertically movable contact member 18M or 19M, as the case may be. The two movable contact members 18M and 19M are normally biased toward closed position by

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means of biasing springs 18B and 19B, respectively.

In the construction which is very much preferred, the first stationary contact member 18S is at the bottom 22 of the interrupter-assembly 17, and integrally or electrically united with a lower exhaust chamber 24, which is made of metal. The stationary contact member 18S is hollow and extends down into the lower exhaust chamber 24, as shown.

In the preferred construction, the two movable contact members 18M, 19M are mounted within a metallic moving contact assembly or housing 25 which is in the form of two concentric cylinders, namely an inner cylinder 25i and an outer cylinder 25o so as to provide an annular space 25s between these cylinders, through which the air blast may pass.

The moving contact housing 25 is vertically spaced from the lower exhaust chamber 24 by means of an insulating tube 26, which supports the outer cylinder 25o and which is larger than the lower stationary contact member 18S so as to provide an annular space therearound, through which the air blast may pass.

The upper stationary contact member 19S is integrally or electrically united with an upper exhaust chamber 27, which is similar to the lower exhaust chamber 24, except that it lacks the funnel or duct for carrying the blast air upwardly on through the upper exhaust chamber 27. The upper stationary contact member 19S is likewise of hollow construction, and its upper end is in communication with the space within the upper exhaust chamber 27. This upper exhaust chamber 27 is supported on the top end of an insulating tube 28, which is similar to the tube 26, except that the lower end of the insulating tube 28 rests on top of the outer cylinder 25o of the moving contact housing 25. This upper insulating tube 28 is also larger than the upper stationary contact member 18S, so as to provide an annular space 29 which forms a closed upper end for the blast air, as this blast initially moves upwardly through the interrupter-assembly 17.

The upper end of the lower stationary contact member 18S, and the lower end of the upper stationary contact member 19S are each provided with a centrally disposed orifice 30, which is normally closed by the cooperating movable contact member 18M or 19M as the case may be. The configuration of these movable contact members 18M, 19M is such that the pressure of the blast air operates on these movable contact members 18M, 19M to press them back away from their respective stationary contact members 18S, 19S, thus making the gap devices 18 and 19 self-opening, that is, making them open automatically, by themselves, as soon as a sufficient gas pressure is built up in the spaces around them, without requiring any other device, not a part of the moving contact assembly 25, for causing a separating movement of the movable contact members 18M or 19M. This opening movement of the movable contact members 18M, 19M draws arcs between said members and their associated stationary contact members 18S, 19S, respectively, thus initiating a circuit interrupting operation of the breaker.

As soon as each movable contact member 18M or 19M moves away from its normally contact making engagement with the end of its associated stationary contact member 18S or 19S, as the case may be, it uncovers the orifice 30 in the hollow stationary contact member 18S or 19S,

thus permitting a blast of air to move longitudinally, or in a vertical direction, through the orifice 30 and thence through the hollow stationary contact member 18S or 19S, and thus acting powerfully to extinguish the arc between the movable and stationary contact members. The upper end of the hollow upper stationary contact member 18S dumps its air directly into the upper exhaust chamber 27, and the lower end of the lower hollow stationary contact member 19S exhausts its blast of air into the lower exhaust chamber 24.

These upper and lower exhaust chambers 27 and 24 thus provide an expansion space in which the longitudinally moving air-blasts within the two stationary contact-members 18S and 19S may accumulate during the brief time which is required for a complete circuit-interruption. It may take the blast something like $\frac{1}{4}$ cycle (assuming a 60-cycle line), before the arcing-contacts begin to separate, and then a time something like $\frac{3}{4}$ cycle for the maximum contact-separation to be achieved. Then the arc may hang on for an additional time which may be a slightly longer than the longest current-flow period or half-cycle which could be expected under asymmetric-wave conditions. It is desirable for the arc to be interrupted at the first important current-zero (or sometimes possibly the second one), after full contact-separation has been achieved, disregarding (as unimportant from an arc-interrupting standpoint), any current-zero which may occur very soon after full contact-separation is obtained. Then it is desirable to prevent a restriking of the arc on the next half-cycle, and to this end it is necessary to have a large quantity of air-movement, a high air-velocity, high turbulence, and cooling, or a combination of these factors. And then, in subsequent half-cycles, it is desirable to continue to have sufficient dielectric strength of the air in the arcing-gap, so as to prevent any subsequent arc-restriking, and for this purpose, the air-pressure of the once-deionized and cooled gap-air is of service in providing dielectric strength to prevent a later breakdown of the gap.

Our upper and lower exhaust-chambers 27 and 24 provide the gas-pressure in the gap-space. The initial blast must be maintained until at least the first (or second) important current-zero after full gap-separation has been reached, but when the back-pressure in these exhaust-chambers reaches as much as something like 50% of the pressure at the high-pressure side of the orifice or arcing-gap, the blast no longer travels at approximately the speed of sound, but begins to slow down. The size of the exhaust-chambers 24 and 27 should be such, therefore, that this 50% air-pressure should not be built up therein until after the above-mentioned important current-zero. To provide a reasonable factor of safety, we prefer to have this 50% pressure occur within about $2\frac{1}{2}$ cycles after the opening of the blast-valve.

However, it is important that these exhaust-chambers 24 and 27 should be present, and that they should develop an important back-pressure after said period of $2\frac{1}{2}$ cycles or the like, and it is important that these exhaust-chambers should be able to hold their back-pressure for a few cycles, or until a serially connected isolating-switch 32 can be opened, as will subsequently be described.

The air which accumulates in the two exhaust-chambers 24 and 27 is cooled, in these chambers,

and is slowly dissipated to the atmosphere, through suitable exhaust-openings 20, which are provided in each of the exhaust-chambers 24 and 27, and which may be provided with any desirable muffling or sound-deadening or flame-extinguishing means (not shown), as is well understood in the compressed-air circuit-breaker art.

Since the movable contact-members 18M and 19M are opened by the air-pressure which is exerted by a large body of fast-moving air, in a blast which moves at a velocity approximating the velocity of sound, it is impractical to sustain such a large movement or blast of air for any considerable length of time. It is necessary, therefore, to close the blast-valve 6 very quickly after it is opened, so as to conserve the high-pressure air or gas which is stored in the tank or reservoir 1. Consequently, after a circuit-interrupting operation, the two movable contact-members 18M and 19M close again into contact with their respective stationary contact-members 18S and 19S, so that these contact-members thereafter remain closed throughout the time when the circuit should remain interrupted. It is necessary, therefore, as in the case of previously known self-opening, longitudinal-blast, orifice-type circuit-breakers, to provide an isolating-switch 32, which is electrically connected in series with the interrupter-assembly 17.

We also provide a second vertically disposed insulating column (not shown, referred to in aforementioned patent application, S. N. 74,406), which is spaced from the blast tube 2 and which also extends upwardly above the top of the tank. This second column is surmounted by a metal terminal member 34, which is provided with a line terminal 35, so as to provide the second line terminal of the breaker assembly, the first line-terminal being the terminal 23 at the top of the interrupter-assembly 17. The isolating-switch 32 is movable so as to close or open an electrical circuit between this metal terminal-member 34 at the top of the second insulating column and the bottom 22 of the interrupter-assembly 17 which is mounted at the top of the insulating blast-tube 2. In the illustrated construction, the isolating switch 32 is pivotally connected to the lower exhaust-chamber 24, as indicated at 36, and its free end is movable into and out of contact with suitable contact-fingers 37 carried by the metal terminal-member 34.

An operating-mechanism is provided, as diagrammatically indicated at 39, in a location which is on, or close to, the tank 1, and which is at substantially the same electrical potential as the tank, which would normally be grounded. Thus, this operating-mechanism 39 is physically and electrically at the ground-level, which is of considerable advantage from the standpoint of the amount and size of the equipment which must be insulatively supported, up in the air, as by the two insulating supporting-columns. The operating-mechanism 39 is operatively joined to the switch 32 through an insulating switch-operating rod 40, for opening and closing the isolating-switch 32.

The operating-mechanism 39 may be controlled in any desired manner which will permit or cause it to open the isolating-switch 32, and lock it open, at the completion of the arc-interruption during the opening-operation of the interrupter-assembly 17, and before the two movable contact-members 18M and 19M are spring-closed again after a reclosure of the blast-valve 6.

The three poles are, or may be, identical, ex-

cept for the provision of a common operating-mechanism 39 which operates the isolating-switches 32 of all three poles, and a common electrically operated pneumatic trip-valve 41 which simultaneously opens all of the blast-valves 6, as will be subsequently described more in detail.

Confining our attention, for the moment, to the operating-mechanism 39, it will be seen, from Fig. 1, that this mechanism is associated with a crankshaft 42, which turns through a limited motion of approximately 180°, and which similarly operates a number of other crankshafts, such as 42A, 42B and 42C, through suitable mechanical connecting-means, which have been diagrammatically indicated in the form of linkages or connecting-rods 43. The three auxiliary crankshafts 42A, 42B and 42C are associated with the respective poles of the breaker, and are provided with crank-members 44 which are connected to the respective insulating switch-operating rods 40 of the several poles, this connection being made in such manner that, at each of the extreme limits of motion of each crankshaft, the associated insulated switch-operating rod 40 is in complete toggle, so that the isolating-switches 32 are locked in both their open position and their closed position.

The principal crankshaft 42 of the operating-mechanism 39 is illustrated as being provided with two auxiliary attachments, in the form of a compression-spring linkage 46, which is crank-connected to the crankshaft 42, as indicated at 46', in such manner that the compression-spring of this linkage 46 presses the crankshaft toward either one of its limits of travel, once it has passed its central or 90° point in its travel from one extreme limit of motion to the other extreme limit of motion. This compression-spring linkage 46 thus serves to hold the crankshaft 42 in its extreme limit of motion, at either end of its direction of movement, so as to hold the crankshaft 42 in such position that the toggle-lock is provided for holding the isolating-switches 32 in either one of their open or closed positions, as the case may be.

The second auxiliary attachment which is associated with the main crankshaft 42 of the operating-mechanism 39 is a shock-absorber, which is diagrammatically indicated at 47, and which is crank-connected to the crankshaft 42, as indicated at 47', in such manner as to strongly retard the last half of the rotating-movement of the crankshaft 42, during either direction of movement of the crankshaft. When the crankshaft first begins to move, from either extreme limit of its motion, the shock-absorber 47 is at first extended or lengthened, and it offers practically no opposition to such movement. After the crankshaft passes its mid-point or 90° point, it begins to contract the shock-absorber 47, or to push together its telescoping cylinders, and this contraction is very slow and gradual at first, but becomes extremely rapid as the crankshaft 42 approaches the extreme limit of its motion. The shock-absorber 47 opposes this contraction, with a force which increases very rapidly as the velocity of compression is increased.

The general effect of this shock-absorber is to slow down the speed of rotation of the crankshaft 42, particularly as it approaches the end of its motion, and as a result of this slow-down action, the crankshaft has a more nearly uniform speed of rotation or movement, as distinguished from being constantly accelerated under the influence of the operating-force which is ap-

plied to it from the operating-mechanism 39, as will be subsequently described. In fact, the reaction of the shock-absorber actually decreases the angular velocity of the crankshaft at or near the ends of its travel.

As a result of the controlled speed of rotation of the crankshafts 42, 42A, 42B and 42C, the insulating switch-operating rods 40 impart a sort of a sinusoidal type of motion to the several isolating-switches 32, so that these switches begin to move very slowly, but with a strong break-away force, if necessary to overcome any opposition to the beginning of the switch-movement, and then the switches 32 move very rapidly near the mid-points of their swinging-movement, and finally they approach the end of their swinging-movement with a speed which gradually reduces to zero, so that there is no shock or banging of the isolating-switches 32 when they reach the limit of their travel, in either direction of movement, and at the same time the switches are capable of exerting a rather considerable pressure, for overcoming any obstacle or impediment near the extreme end of their swinging-movement, in either direction of operation.

The principal crankshaft 42 is rotated by means of a pinion 49 which is engaged by a rack 50 which is connected to the operating-piston 51 of the pneumatic operating-mechanism 39. In addition to this operating-piston 51, the operating-mechanism 39 includes also a double-piston air-valve 52, disposed with its two pistons 52a and 52c opposing each other. The left-hand air-valve piston 52a, which controls the opening of the isolating-switches 32, is preferably larger than the right-hand piston 52c, which controls the closing of the isolating-switches 32. Each of the air-valve pistons 52a and 52c is provided with its own air-inlet means 53a and 53c, respectively, for applying air, under pressure, to the respective air-valve pistons.

The air-valve 52 is provided with ports 54, 55, 56 and 57, which are so arranged that, when the switch-opening piston 52a is subjected to air-pressure from its inlet-means 53a, it moves to the right, thus closing the port 54 which dumps the air from the left-hand side of the operating-piston 51, and at the same time it opens the port 55 which leads the inlet-air into this left-hand side of the operating-piston 51, thus driving said operating-piston to the right, in a switch-opening movement. At the same time, the movement of the left-hand air-valve piston 52a pushes the right-hand piston 52c over to the right, thus causing it to open its dump-port 56 and close its port 57 which, when open, connects the space to the right of the operating-piston 51 with the closing-piston air-inlet means 53c. It will be understood that the air-pressure and dumping-ports 53 and 54 are both connected to the space to the left of the operating-piston 51, while the air-pressure and dumping-ports 56 and 57 are both connected to the space to the right of the operating-piston 51, the two dumping-ports 54 and 56 being for the purpose of exhausting air to the atmosphere, while the respective air-pressure ports 55 and 57 are for the purpose of supplying air-pressure to the operating-piston 51 from one or the other of the air-inlet means 53a and 53c, as the case may be. By this means, we provide what is known as functional dumping, for dumping the air which would otherwise be trapped behind the operating-piston 51 when said piston is being moved in either direction of its travel.

We also provide novel means for both timing the operating-mechanism 39 and providing a switch-opening operating-force therefor, in the form of compressed air which is supplied to the air-inlet means 53o of the switch-opening air-valve piston 52o, and also, at the same time (whenever the breaker-assembly has more than one pole), providing a pneumatic interlocking-means for making sure that the interrupter-assemblies 17 of each of the poles has completed its circuit-interrupting operation before the common operating-mechanism 39 is energized in the switch-opening direction.

As shown in Fig. 1, we provide, near the top of each air-storage tank 1, and near the bottom of each insulating blast-tube 2, of each pole of the breaker-assembly, a small bleeder-tube 58A, 58B and 58C, as the case may be. The central bleeder-tube 58B is connected to the air-inlet means 53o of the switch-opening air-valve piston 52o by means of two interlocking-valves 59A and 59C, while the other two bleeder-tubes 58A and 58C are connected so as to supply air-pressure to operate the pistons 61A and 61C of the respective interlocking-valves 59A and 59C. When no air-pressure is being supplied to these interlocking valves 59A and 59C, said valves are held in their non-operated positions by means of springs 62. When these interlocking-valves 59A and 59C are operated, the movement of their pistons uncovers ports which open a normally closed connection between the central bleeder-tube 58B and the mechanism-opening air-inlet means 53o.

The several bleeder-tubes 58A, 58B and 58C normally have no air-pressure therein, because the several blast-valves 6 are normally closed, and the compressed air which has last actuated the several interrupter-assemblies 17 has all leaked out. When the blast-valves 6 are first opened, to initiate a circuit-interrupter operation, large blasts of air travel upwardly, at substantially the velocity of sound, in the several insulating blast-tubes 2, and because of the high velocity of this air, the bleeder-tubes receive no effective or adequate air-pressure. When the first inrush of the air-blast has been halted, at the top of the interrupter-assembly 17, the air-pressure begins to build up, starting at the top, and travelling back downwardly, in a reflected-wave effect, still at a velocity approximating the velocity of sound, so that, at last, the several bleeder-tubes 58A, 58B and 58C all receive an effective or adequate air-pressure, which is greater than a predetermined minimum pressure to which the apparatus is effectually responsive.

The time required for this air-wave to travel up, and to be reflected down again, is really very small, but so is the time required to effect a circuit-interrupting operation of the several interrupter-assemblies 17. In addition to the time required for a pressure-wave to appear at the inlets of the several bleeder-tubes 58A, 58B and 58C, there is to be added also the time necessary for the interlocking-valves 59A and 59C to open, the time necessary for the air-valve 52o to move from its left-hand position to its right-hand position, and the time necessary for the operating-piston 51 to move to the right, against the inertia of the operating-mechanism itself and of the several isolating-switches 32, together with the mechanical interlinkage between the mechanism and the switches. All of this time adds up to a switch-operating time-delay in getting the several isolating-switches 32 separated from their several contact-fingers 31, and this

switch-operating time-delay is timed to be slightly longer than the three cycles (more or less) which are required for completing a circuit-interrupting operation in all of the interrupter-assemblies 17, under the most adverse operating-conditions.

The operating-mechanism 39 is closed by means of an electrically energized closing-valve 63, which is illustrated as having an operating-coil 64 which, when electrically energized, opens the closing-valve, and admits compressed air from one or all of the tanks or reservoirs 1 to the switch-closing air-inlet means 53c of the air-valve 52c of the operating-mechanism 39. This causes the right-hand air-valve piston 52c to move to the left, pushing the left-hand piston 52o with it, thus admitting compressed air from the air-inlet means 53c to the right-hand side of the operating-piston 51, while dumping air from the left-hand side of this piston. This causes the mechanism to close each of the isolating-switches 32, and to lock them in their closed positions, by reason of the previously-described toggle-action.

The smaller size of the switch-closing air-valve piston 52c, as compared with the switch-opening air-valve piston 52o, in our preferred form of construction, insures that whenever there is a conflict between the switch-opening means and the switch-closing means, that is, when air is being admitted to both pistons 52o and 52c at the same time, the force exerted by the switch-opening piston 52o will prevail, and will cause a switch-opening operation.

In accordance with our invention, as previously stated, we provide a common electrically operated pneumatic tripping mechanism 41, which comprises an electrically energized tripping valve 65, the latter including a pilot valve 66 actuated by an operating coil 67. Associated with the tripping valve 65 is a tripping mechanism 68 including an operating piston 69 having a piston rod 70 affixed thereto, to the lower end of which is an actuator 71. The actuator 71 moves a pair of bell cranks 72, stationarily pivoted at 73 to simultaneously move links 74, 75. The links 74 and 75 simultaneously actuate levers 76 which are stationarily pivoted at 77. The other ends of the levers 76 force the valve stems 78 of the dump valves 11 of the dump valve assemblies 9 open against the opposition afforded by compression springs 79. This dumps the air in the region 12 below the differential blast valve 6 down through a port 80, through the dump valve assembly 9 and out through the dump valve exhaust pipe 13 to the region 14, which at this time is at atmospheric pressure by virtue of the previous leakage of gas out of the interrupter-assembly 17 through the exhaust chambers 27, 24 and out through the exhaust openings 20 to atmosphere.

The net result is that by energization of the operating coil 67 there is a simultaneous opening movement of all of the dump valves 11 so that all of the differential blast valves 6 are simultaneously opened. This simultaneous opening movement of the several blast valves 6 is desirable so that pressure will arise within the interiors 14 of the several blast tubes 2 so that the interlock valves 59A and 59C will open at the desired time to permit thereby pneumatic operation of the pneumatic operating mechanism 39 to bring about opening of the several disconnect switch blades 32.

Figs. 2 and 3 more clearly show the actual

structure of the electrically operated pneumatic tripping mechanism 41. It will be observed that the operating coil 67 actuates an armature 81 downwardly, when energized, so that the pilot valve 66 will move downwardly thereby opening a passage from the high pressure conduit 82 past the pilot valve 66 and through the passage 83 to the top side of the operating piston 69. Actually, this piston 69 is biased upwardly to its normally inoperative position by a compression spring 84 so that the actuator 71, or lower tip portion of the piston rod 70 is ineffective to move the bell cranks 72. A bracket 85 is provided to mount the tripping mechanism 41 rigidly into place and a pair of support plates 86 provide journals for the pivot shafts 73. Also the support plates 86 provide a guide 87 for the piston rod 70. The pilot valve 66 is spring biased to its upwardly closed position, as shown in Figs. 2 and 3 by a compression spring 88. The pilot valve 66, when in its upward closed position, as shown in Fig. 2, and with the coil 67 deenergized, permits the exhaust of compressed gas from the top side of the operating piston 69 through the passage 83 and through the ports 89 to the region 90 which is freely vented to atmosphere, at the region 91.

Figs. 4 and 5 show the actual construction of the dump valve assembly 9. It will be observed that the dump valve 9 has a plurality of the ports 10 provided therein to provide ready access for the high pressure gas flowing from the valve controlling pipe 8 to the region 12 under the differential blast valve 6. It will be observed that normally in the deenergized condition of the operating coil 67 of the pneumatic tripping mechanism 41, that the compression spring 79 maintains the dump valve 11 against its seat 92 closing the exhaust of gas out through the dump valve exhaust pipe 13. The casting 93 forming the body of the dump valve assembly 9 also forms a pair of lugs 94 which serve to mount the dump valve assembly 9 rigidly in place relative to the circuit breaker assembly.

From the foregoing description, it will be apparent that with the interrupter in the closed circuit position, as shown in Fig. 1, energization of the operating coil 67 may be obtained either manually or in response to overload conditions existing in the controlled circuit. Energization of the operating coil 67 actuates the pilot valve 66 to permit high pressure gas to pass from the tanks 1 through the high pressure conduit 82, past the pilot valve 66 and through the passage 83 (Fig. 2) to the top side of the operating piston 69. The piston 69 moves downwardly in opposition to the force of the springs 84 and 79 to cause simultaneous opening of the dump valves 9. The right-ward movement of the dump valve pistons 11 not only permits the exhaust of high pressure gas from the region 12 out through the exhaust pipe 13 and to the region 14 within the blast tubes 2, which is at atmospheric pressure, but also the right-ward movement of the dump valve pistons 11 close the ports 10 provided in the side walls 95 of the dump valves 9. The dumping of gas from beneath the differential blast valve 6 permits the high pressure gas within the tanks 1 to open the blast valve 6 and pass upwardly through the blast tube 2 to bring about contact separation and arc extinction within the interrupter-assembly 17. Subsequently, the increased pressure within the region 14 passes through the bleeder tubes 58 to open the interlock valves 59A and 59C to permit high pressure gas to pass into

the opening air inlet means 530 to effect opening of the isolating blades 32 in a manner as previously described.

It will also be observed that the right-ward movement of the operating piston 51 will open the interlock switch 96 to break the energizing circuit through the operating coil 67 of the pneumatic tripping mechanism 41. At this same time the pressure within the region 14 of the blast tube 2 has built up sufficiently so that there is a reverse flow of high pressure gas back through the dump valve exhaust pipe 13 to bring about a somewhat equalization of pressure on both sides of the differential blast valve 6. Thus at the time the interlock switch 96 breaks the energizing circuit through the operating coil 67 to deenergize the pneumatic tripping mechanism 41, at this same time the pressure within the region 12 below the blast valve has built up by virtue of the reverse flow through the exhaust pipe 13, so that at the moment when the dump valve piston 11 closes against its seat 92 permitting high pressure gas again to pass out of the ports 10, there is required very little increase of pressure to bring about closing of the blast valves 6.

In fact, it is possible by suitable selection of the dimension of the exhaust pipe 13 and other adjustments to make the reverse flow of high pressure gas through the exhaust pipe 13 so rapid that closure of the blast valve 6 will be obtained even before closure of the dump valve 9. This is distinctly desirable in some instances to conserve the supply of compressed gas within the tanks 1. In any event, whether the reverse flow through the pipe 13 is rapid or not the somewhat equalization of gas pressure on both sides of the differential blast valves 6 is desirable to provide a dump valve 9 which when closed will immediately result in closure of the blast valve 6.

As mentioned when the interrupter is in the fully open circuit position, the opening of the interlock switch 96 prevents energization of the operating coil 67 and therefore renders the tripping mechanism 41 ineffective until after the breaker has been subsequently reclosed by energization of the operating coil 64 of the electrically energized closing valve 63.

The foregoing description shows how, by an application of slight force exerted by the operating piston 69, we have provided novel means for simultaneously opening the several blast valves 6 and have provided an arrangement in which closing of the dump valves 9 is very high speed by virtue of the presence of the compression spring 79 and the admittance of high pressure gas through the conduit 8 and into the region 97 back of the dump valve piston 11, tending to close the same. Since the dump valve pistons 11 are relatively small, the force required to operate them is likewise small. The pneumatic system of all the dump valves is identical and therefore as their operation is synchronized, the blast valves 6 will operate in unison. When in the closed position, full reservoir air pressure is applied to the underside of the blast valves 6 and also to the back sides of the dump valve pistons 11. Moreover, by exhausting the air below the blast valve 6 to the region 14 within the blast tubes 2, noise and concussion is eliminated since such air must pass through the muffling structure usually provided with compressed gas circuit interrupters. Moreover, the passage of such exhaust gas into the region 14 enables such gas to be used in the in-

interrupting operation subsequently to be performed.

Although we have shown and described a specific structure, it is to be clearly understood that the same was merely for the purpose of illustration and that changes and modifications may readily be made therein by those skilled in the art without departing from the scope of the appended claims.

We claim as our invention:

1. A circuit interrupter of the compressed gas type comprising: a tank for compressed gas; interrupting means; a blast tube pneumatically interconnecting the tank of compressed gas and the interrupting means; a differential type blast valve for controlling the flow of high pressure gas through the blast tube; means biasing the blast valve toward its closed position; a dump valve assembly for controlling the pressure of gas on the rear side of the differential-type blast valve; the dump valve assembly including a dump valve piston; a conduit for feeding high pressure gas to the region on the rear side of the dump valve piston; and means pneumatically interconnecting said region with the rear side of the blast valve only when the dump valve piston is in its closed position.

2. A circuit interrupter of the compressed gas type comprising: a tank for compressed gas; interrupting means; a blast tube pneumatically interconnecting the tank of compressed gas and the interrupting means; a differential type blast valve for controlling the flow of high pressure gas through the blast tube; means biasing the blast valve toward its closed position; conduit means for exhausting the high pressure gas in back of the differential-type blast valve to the blast tube; a dump valve assembly for controlling the exhaust of high pressure gas through said conduit means; the dump valve assembly including a dump valve piston; a conduit for feeding high pressure gas to the region on the rear side of the dump valve piston; and means pneumatically interconnecting said region with the rear side of the blast valve only when the dump valve piston is in its closed position closing said conduit means.

3. A circuit interrupter of the compressed gas type comprising: a tank for compressed gas; interrupting means; a blast tube pneumatically interconnecting the tank of compressed gas and the interrupting means; a differential type blast valve for controlling the flow of high pressure gas through the blast tube; means biasing the blast valve toward its closed position; and dump valve means for dumping the high pressure gas in back of the differential-type blast valve to the region within the blast tube.

4. A compressed-air circuit-breaker assembly comprising: a compressed-air tank; an insulating blast-tube connected to the tank and extending away from a wall of the tank; a tube means, within the tank, in substantial alignment, and in air-flow communication, with said blast-tube, and serving, in effect, as an intact blast-tube extension which extends, within the tank, to a point spaced from the opposite wall of the tank; a differential-type blast valve, accessible and operable from said opposite wall of the tank, for normally closing the end of said blast-tube extension; an air-blast interrupter-assembly disposed at the outer end of the blast tube; and dump valve means for dumping the high pressure gas in back of the differential-type blast valve to the region within the blast tube.

5. A compressed-air circuit-breaker assembly comprising: a compressed-air tank; an insulating blast-tube connected to the tank and extending away from a wall of the tank; a tube means, within the tank, in substantial alignment, and in air-flow communication, with said blast-tube, and serving, in effect, as an intact blast-tube extension which extends, within the tank, to a point spaced from the opposite wall of the tank; a differential-type blast valve, accessible and operable from said opposite wall of the tank, for normally closing the end of said blast-tube extension; an air-blast interrupter-assembly disposed at the outer end of the blast tube; a dump valve assembly for controlling the pressure of gas on the rear side of the differential-type blast valve; the dump valve assembly including a dump valve piston; a conduit for feeding high pressure gas to the region on the rear side of the dump valve piston; and means pneumatically interconnecting said region with the rear side of the blast valve only when the dump valve piston is in its closed position.

6. A compressed-air circuit-breaker assembly comprising: a compressed-air tank; an insulating blast-tube connected to the tank and extending away from a wall of the tank; a tube means, within the tank, in substantial alignment, and in air-flow communication, with said blast-tube, and serving, in effect, as an intact blast-tube extension which extends, within the tank, to a point spaced from the opposite wall of the tank; a differential-type blast valve, accessible and operable from said opposite wall of the tank, for normally closing the end of said blast-tube extension; an air-blast interrupter-assembly disposed at the outer end of the blast tube; conduit means for exhausting the high pressure gas in back of the differential-type blast valve to the blast tube; a dump valve assembly for controlling the exhaust of high pressure gas through said conduit means; the dump valve assembly including a dump valve piston; a conduit for feeding high pressure gas to the region on the rear side of the dump valve piston; and means pneumatically interconnecting said region with the rear side of the blast valve only when the dump valve piston is in its closed position closing said conduit means.

7. A multi-polar compressed gas circuit interrupter comprising: a plurality of blast tubes; a plurality of differential-type blast valves for controlling the flow of high pressure gas through said blast tubes; a source of high pressure gas for sending gas through said blast tubes when the blast valves are opened; a dump valve assembly for controlling the pressure of gas on the rear side of each differential-type blast valve; each dump valve assembly including a dump valve piston; a conduit for feeding high pressure gas to the back side of each dump valve piston; means pneumatically interconnecting the back side of each dump valve piston with the rear side of the blast valve associated therewith only when the dump valve piston is in its closed position; and means responsive to a tripping impulse to open the interrupter for mechanically causing simultaneous opening of the several dump valve pistons.

8. A multi-polar compressed gas circuit interrupter comprising: a plurality of blast tubes; a plurality of differential-type blast valves for controlling the flow of high pressure gas through said blast tubes; a source of high pressure gas for sending gas through said blast tubes when the

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blast valves are opened; a dump valve assembly for controlling the pressure of gas on the rear side of each differential-type blast valve; each dump valve assembly including a dump valve; conduit means controlled by the dump valve for exhausting the high pressure gas in back of each blast valve to the blast tube associated therewith; and means responsive to a tripping impulse to open the interrupter for mechanically causing simultaneous opening of the several dump valve pistons.

9. A multi-polar compressed gas circuit interrupter comprising: a plurality of blast tubes; a plurality of differential-type blast valves for controlling the flow of high pressure gas through said blast tubes; a source of high pressure gas for sending gas through said blast tubes when the blast valves are opened; a dump valve assembly for controlling the pressure of gas on the rear side of each differential-type blast valve; each dump valve assembly including a dump valve piston; a conduit for feeding high pressure gas to the back side of each dump valve piston; means pneumatically interconnecting the back side of

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each dump valve piston with the rear side of the blast valve associated therewith only when the dump valve piston is in its closed position; conduit means controlled by the dump valve piston for exhausting the high pressure gas in back of each blast valve to the blast tube associated therewith; and means responsive to a tripping impulse to open the interrupter for mechanically causing simultaneous opening of the several dump valve pistons.

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