March 8, 1966 J. A. I. ÖHLUND 3,238,642

WEAPON FIRE SIMULATOR

Filed Sept. 4, 1963 5 Sheets-Sheet 1

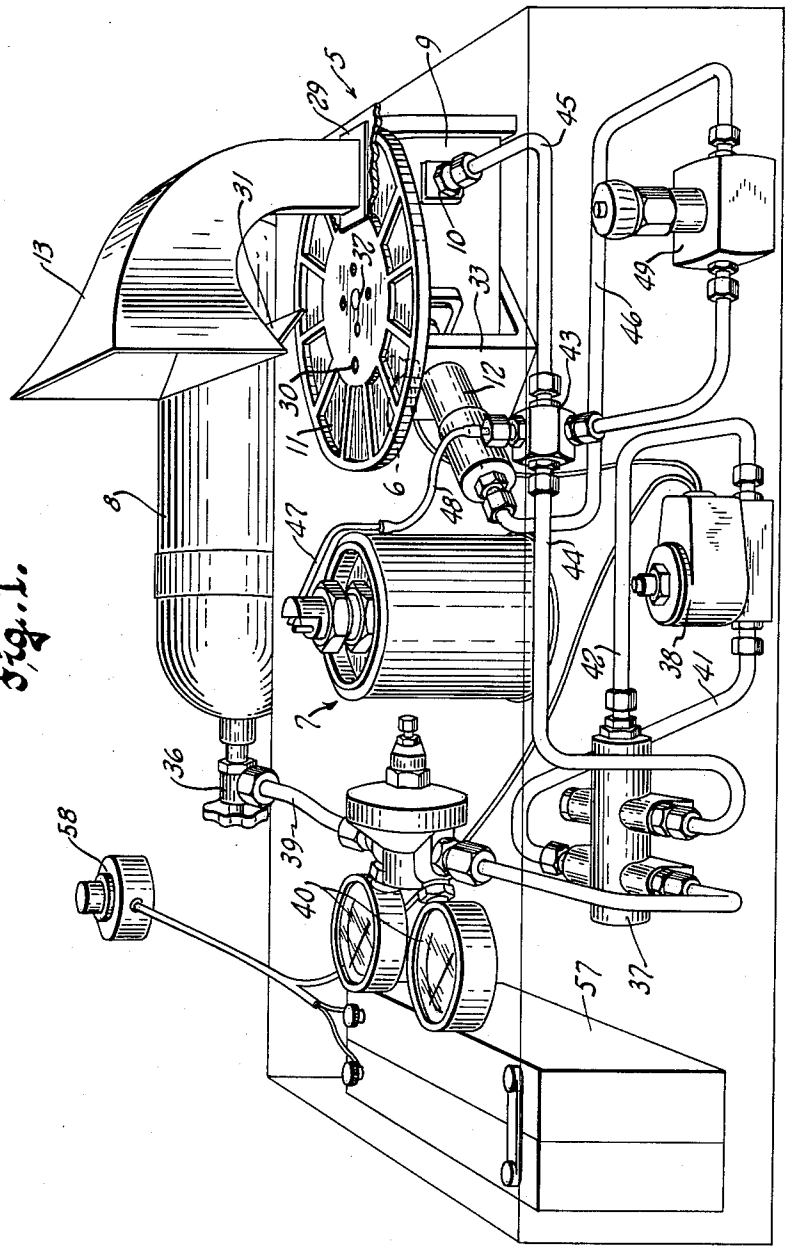

Fig. 1.

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WEAPON FIRE SIMULATOR

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Fig. 2.

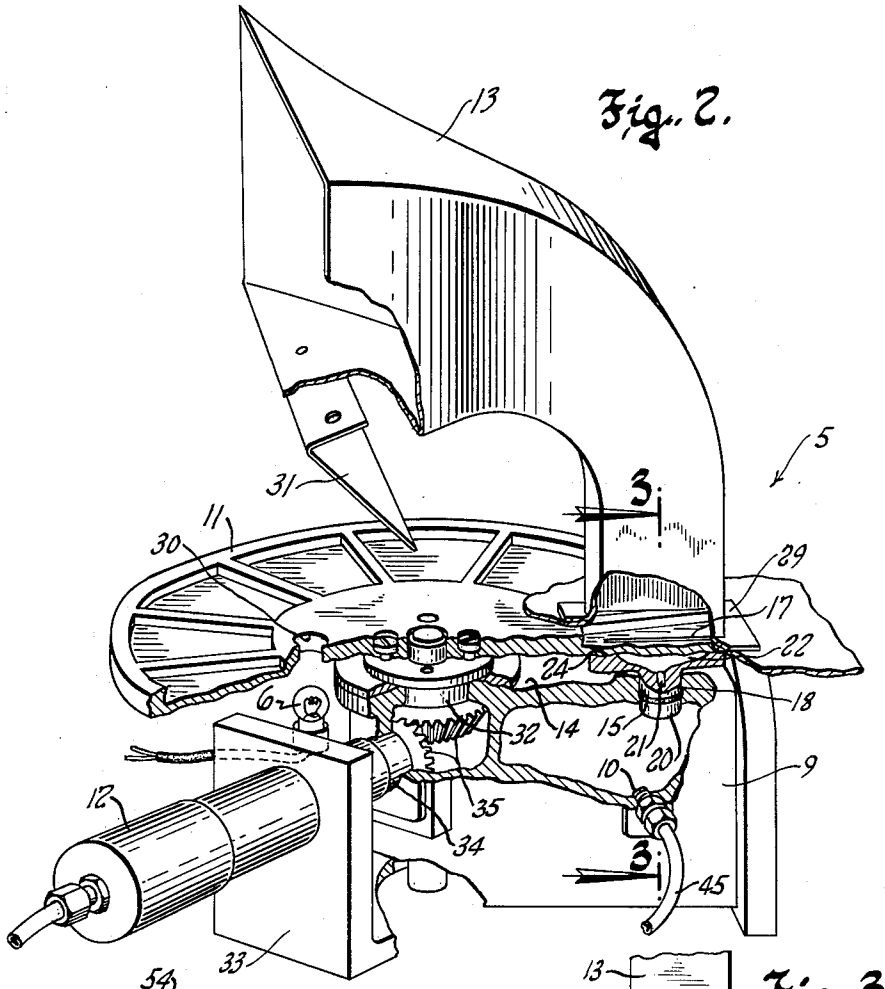


Fig. 4.

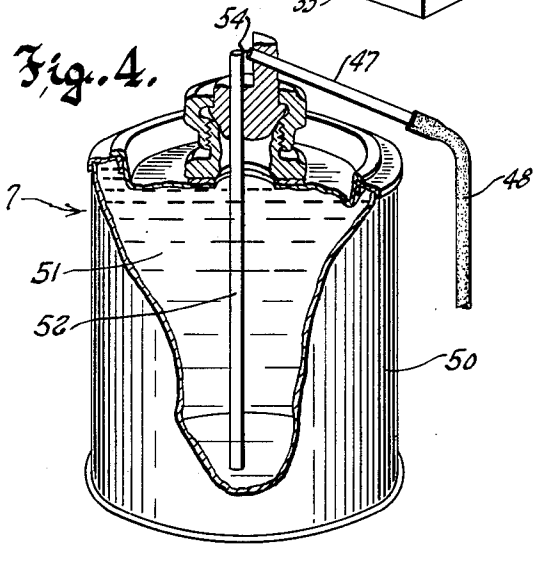
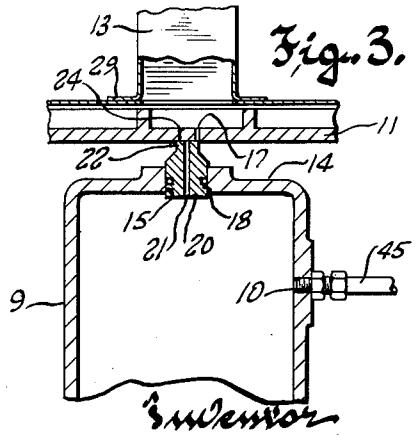


Fig. 3.



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WEAPON FIRE SIMULATOR

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Fig. 5.

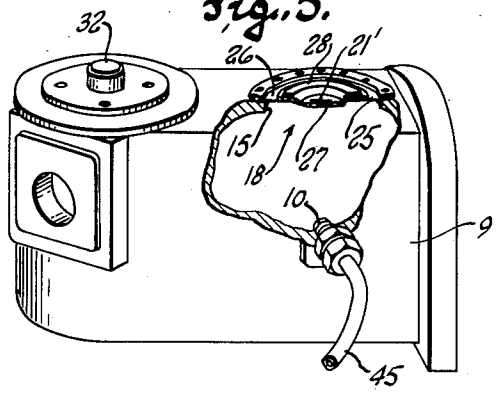


Fig. 6.

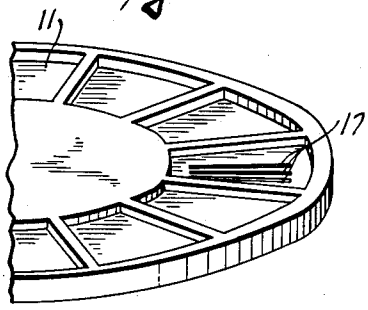
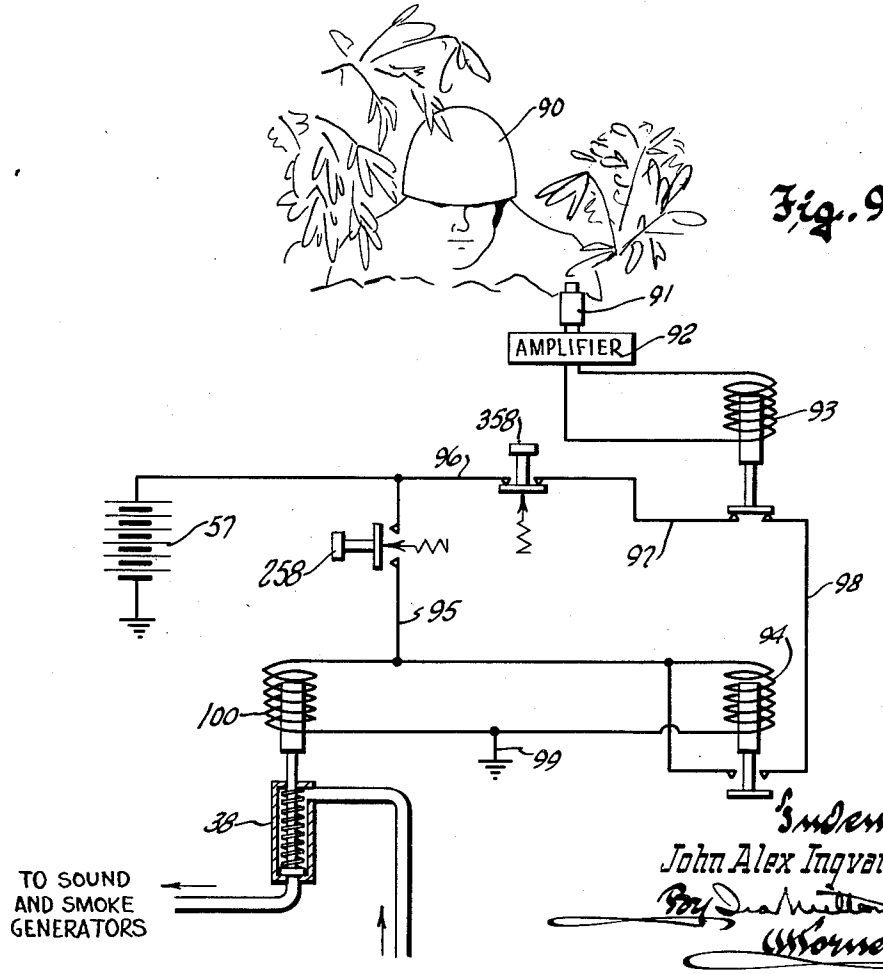


Fig. 9.



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WEAPON FIRE SIMULATOR

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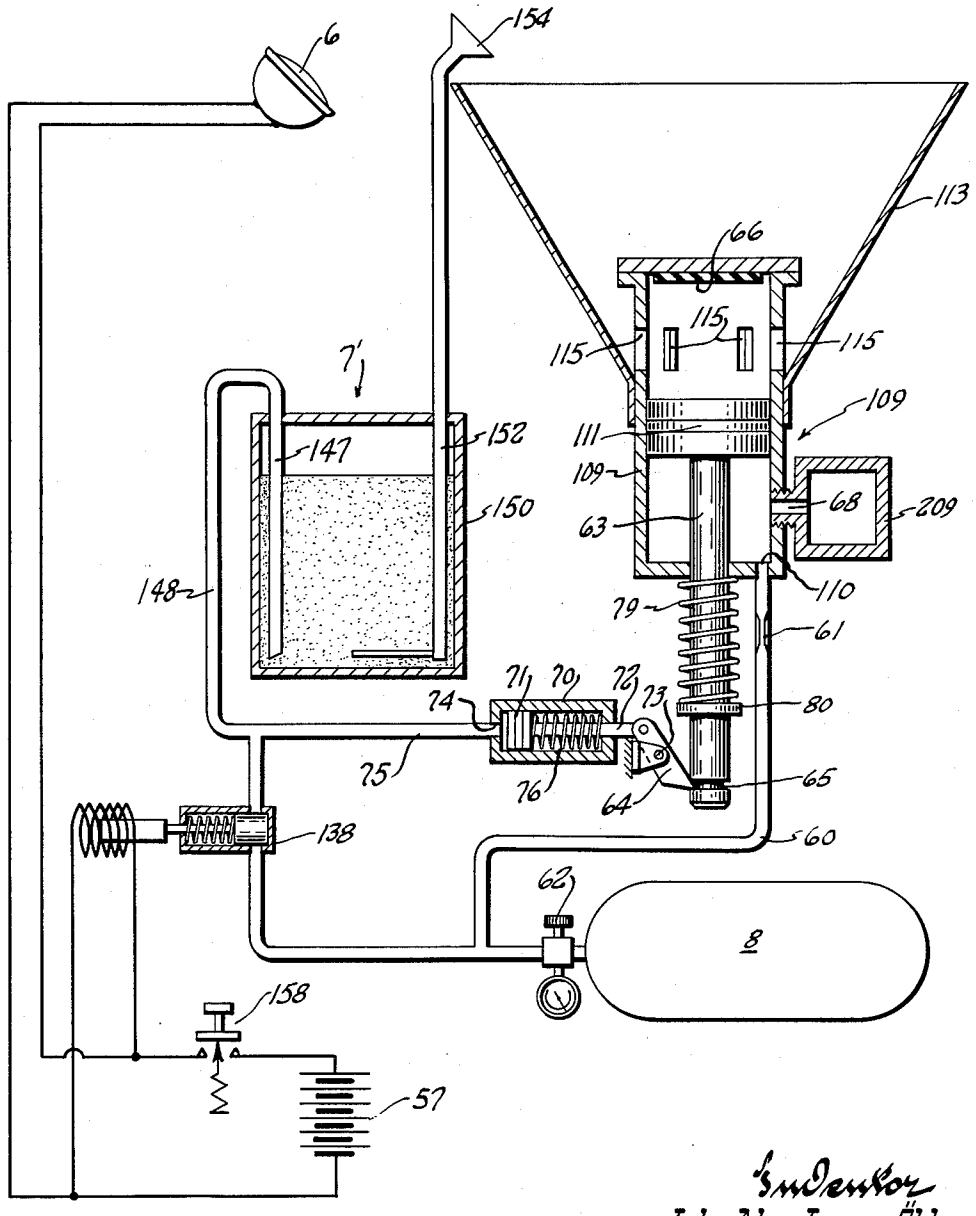
Fig. 7.



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WEAPON FIRE SIMULATOR

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Fig. 10.

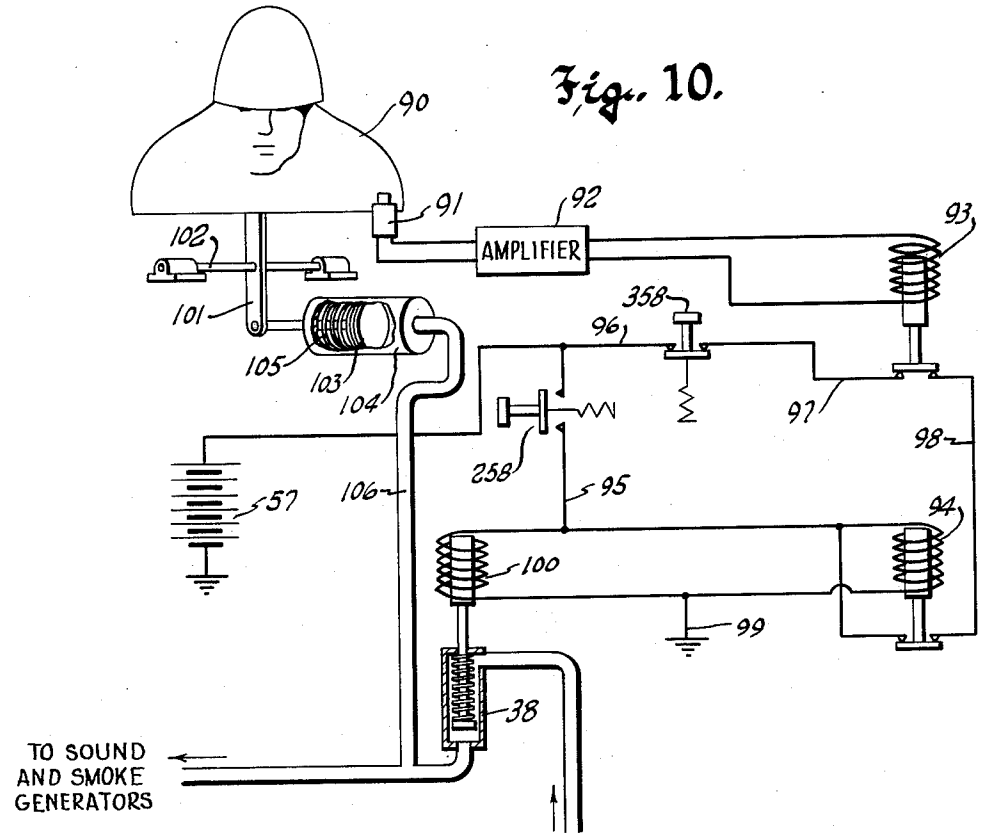
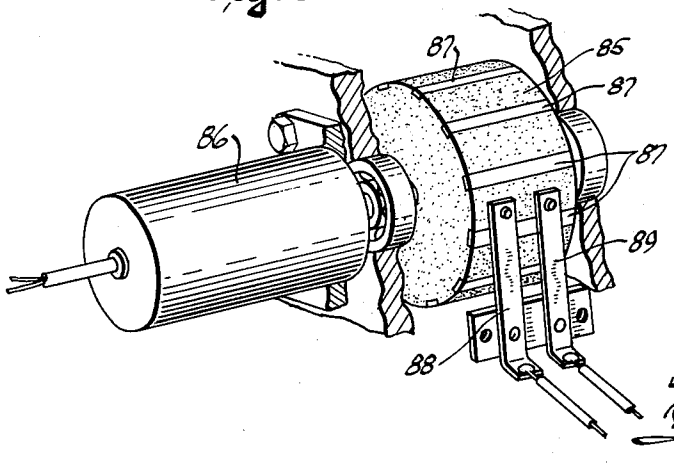


Fig. 8.



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United States Patent Office

3,238,642

Patented Mar. 8, 1966

3,238,642
WEAPON FIRE SIMULATOR

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Filed Sept. 4, 1963, Ser. No. 306,578
5 Claims. (Cl. 35—25)

This invention relates to military training apparatus and refers more particularly to a device for simulating the firing of weapons.

In military gunnery practice and field exercises, it is often desirable to simulate the firing of weapons from a fictitious enemy position so as to increase the realism of the exercise and to accustom troops undergoing training to the sights and sounds of actual combat. The most realistic means heretofore available for simulating fire from an enemy was the firing of blank ammunition from the supposed enemy position or positions; but blank ammunition was costly, especially if it was used to a realistic extent with automatic weapons and large bore guns. The use of blank ammunition had another very important disadvantage in that it required that men be stationed at the weapons from which it was fired, and hence the troops undergoing training could not be permitted to fire live ammunition at the gun emplacements of the fictitious enemy.

With these considerations in mind, it is the principal object of the present invention to provide a simulator of weapons fire which can be suitably emplaced on terrain in which gunnery practice or field exercises are to take place, and which can be remotely controlled so that the simulator of this invention can comprises a target at which those undergoing training can fire with live ammunition without endangering other personnel.

Another object of the present invention is to provide a simulator of the character described which produces not only a sound closely imitative of that of actual firing of a weapon, but which also simultaneously produces a flash and a puff of smoke closely imitative in appearance of actual weapon fire.

Another and more specific object of this invention is to provide a simulator of the character described wherein a sound imitative of weapons fire is produced when pressurized gas from a pressure chamber, delivered thereto from a bottle or tank of compressed gas, is abruptly released through an outlet in the pressure chamber that is controlled by a movable element, and wherein actuation of the movable element can be controlled by an operator who may be stationed remotely from the device.

It is also a specific object of this invention to provide a remotely controllable weapon fire simulator of the character described, which can be started in operation at the will of an operator who is stationed remotely from the device and which can be automatically "put out of action" in a realistic manner when a target associated with the simulator is struck by a missile, to thus provide a realistic means for scoring gunnery or target practice.

With the above and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiments of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of physical embodiments of the invention constructed according to the best modes so far devised for

the practical application of the principles thereof, and in which:

FIGURE 1 is a perspective view of a simulator embodying the principles of this invention and which is intended to imitate the firing of small bore automatic weapons;

FIGURE 2 is a fragmentary perspective view of a part of the apparatus shown in FIGURE 1, portions being shown cut away to illustrate details of construction;

FIGURE 3 is a vertical sectional view taken on the plane of line 3—3 in FIGURE 2;

FIGURE 4 is a view partly in perspective and partly in section of the simulated smoke generator of the apparatus of this invention;

FIGURE 5 is a perspective view with portions cut away of a modified embodiment of the sound generator illustrated in FIGURE 2;

FIGURE 6 is a fragmentary perspective view of a modified form of the disc which comprises a part of the sound generator and which is intended for simulating the sound of large caliber automatic weapons;

FIGURE 6 is a more or less diagrammatic view of another embodiment of the weapon fire simulator of this invention particularly intended for simulating the firing of large bore weapons;

FIGURE 8 is a perspective view of a control device intended to effect intermittent simulated firing of a device of this invention;

FIGURE 9 is a more or less diagrammatic view of an embodiment of a control apparatus adapted for cooperation with the simulator of this invention whereby the same is rendered responsive to hits placed upon a target, the apparatus being shown in its inoperative condition; and

FIGURE 10 is a view similar to FIGURE 9 but showing a modified embodiment of the control means embodying a target, the apparatus being shown in its operative condition in which it causes the simulator to produce simulated firing.

Referring now more particularly to the accompanying drawings, the apparatus of this invention generally comprises a sound generator **5**, which simulates the noise of weapon fire, a light bulb **6** which is employed to simulate the appearance of the flash from the muzzle of a weapon, a simulated smoke generator **7** which produces puffs of simulated smoke concurrently with the production of detonations and light flashes, and a pressure bottle or tank **8** containing compressed air, carbon dioxide or other gas under high pressure and which is connected with the sound generator **5** and the simulated smoke generator **7** through certain control elements described hereinafter.

In general the sound generator shown in FIGURES 1 and 2, which is intended to simulate the sound of firing of an automatic weapon, comprises a pressure chamber **9** having an inlet **10** through which pressurized gas from the tank or bottle **8** is introduced, a rotatable disc **11** which controls the release of gas from the pressure chamber, a pneumatic motor **12** which rotates the disc, and a hopper or horn **13** into which pressure gas discharges from the chamber and which functions in the manner of a megaphone to concentrate and direct the sound in a desired direction.

Through one wall of the pressure chamber **9**, preferably its top wall **14**, there is a bore **15** which is spaced from the inlet **10** and which preferably extends parallel to the rotational axis of the disc **11** and is spaced therefrom. The disc has a large enough radius so that it overlies the bore **15**, and it has an opening **17** which is

adapted to align with the bore in one rotational position of the disc. The underside of the disc is spaced a short distance above the top wall **14** of the pressure chamber, but except at times when the opening **17** in the disc is aligned with the bore **15**, a sealing element **18** cooperates with the disc and the top wall of the pressure chamber to prevent the escape of pressurized gas from the chamber.

In the embodiment of the invention illustrated in FIGURE 2 the sealing element **18** comprises a plunger **20** which is slidable in the bore **15** with a close fit and which has an axial passage or hole **21** extending through it. Externally of the bore **15**, in the space between the top wall **14** of the chamber and the disc **11**, the plunger is somewhat enlarged in one lateral direction and reduced in the other lateral direction to provide an outlet nozzle **22** which has the shape of a long narrow rectangle as seen from the upper end of the plunger (compare FIGURES 2 and 3). In the outlet nozzle **22** the passage **21** through the plunger diverges upwardly in the first mentioned lateral direction so that at the upper end of the plunger the mouth of the passage has a shape and size that closely conform to those of the opening **17** in the disc. The rim of the outlet nozzle **22** (i.e., the upper end of the plunger) provides a coplanar sealing surface **24** all around the mouth of the passage **21** through the plunger, which sealing surface can engage the underside of the disc **11**.

The nozzle portion of the plunger is so designed as to have a cross sectional area somewhat smaller than that of the bottom end of the plunger; hence pressurized gas exerts a net upward biasing force upon the plunger to normally maintain its top surface **24** sealingly engaged with the disc. It will be apparent that the value of this biasing force for a given gas pressure in the pressure chamber can be predetermined by selection of the proper relationship of the respective cross sectional areas of the bottom end of the plunger and of its upper nozzle portion, so that the plunger causes minimal friction against the disc to impede rotation thereof but at the same time makes a good seal with the disc.

FIGURE 5 illustrates a modified form of sealing element **18**, comprising a diaphragm **25** which extends across the bore **15** in the top wall of the pressure chamber. The outer marginal edge portion **26** of this diaphragm is resilient, while its central portion **27** is substantially rigid and has a substantially coaxial hole **21'** therethrough which can correspond in shape and size to the opening **17** in the rotatable disc. The sealing surface that engages the underside of the disc is provided by the upper surface of an annular ridge or land **28** on the rigid central portion of the diaphragm, surrounding the hole **21'**. It will be apparent that for any given pressure of gas in the chamber, the sealing ridge **28** will be biased into engagement with the rotatable disc under a force that depends upon the difference between the total cross sectional area of the diaphragm and the area of its upper surface that is enclosed within the ridge **28**.

The horn **13** is mounted, as by means of a suitable bracket **29**, with its inner end substantially aligned with the bore **15**. Hence when the disc **11** is rotated to the position in which the opening **17** therein aligns with the hole or passage **21** in the sealing element, pressurized gas from the pressure chamber can abruptly escape into the horn, producing a loud report which closely simulates the sound of a weapon being fired.

The light bulb **6** is also mounted in the structure that comprises the pressure chamber, beneath the rotatable disc, spaced from the bore **15**, and at a different radial distance from the disc axis than the opening **17** in the disc. Hence the disc can be provided with another opening **30**, so located as to align with the light bulb at the same time that the opening **17** comes into alignment with the opening **21** in the sealing element, thus briefly uncovering the light to produce a simulated muzzle flash concurrently with production of a detonation. A suitable

reflector **31**, preferably mounted on the horn, projects the flash from the light bulb in an appropriate direction.

The disc **11** is mounted on an upright shaft **32** that is carried in suitable bearings in the structure that defines the pressure chamber, and the pneumatic motor **12** can be mounted, as by means of a bracket **33**, to have its shaft **34** at right angles to the disc shaft **32** and connected thereto by bevel gearing **35**.

Pressurized gas can be conducted from the bottle **8** to the pressure chamber **9** and to the pneumatic motor **12** by way of a manually controllable valve **36** and a distributor valve **37**, the latter being under the control of a solenoid valve **38** (see FIGURE 1). The bottle, which can have the manual valve **36** at its outlet, is connected with the distributor valve **37** by means of a duct **39** in which there can be connections for pressure gages **40**. The solenoid valve **38** is connected with the distributor valve by means of ducts **41** and **42**, and may be of the kind disclosed in Swedish patent application Serial No. 11,518/61.

When the solenoid valve effects opening of the distributor valve, the latter permits flow of pressurized gas from the duct **39** to a manifold or T **43**, by way of a duct **44**; and from the T such gas flows to the inlet **10** of the pressure chamber **9** by way of a duct **45**, and also to the pneumatic motor **12** by way of a duct **46**, and to the inlet **47** of the simulated smoke generator **7** by way of a duct **48**. A manually adjustable throttling valve **49** in the duct **46** provides for regulation of the speed of the motor **12** and thus enables adjustment of the frequency of simulated firing.

The simulated smoke generator **7** comprises, as best seen in FIGURE 4, a container **50** in which there is a store of air dispersable material **51** such as fine powder or suitably colored liquid. A delivery tube **52** extends downward in the container, nearly to its bottom, and projects above the top of the container to cooperate with an eduction nozzle **54** which discharges obliquely across the top of the delivery tube and which has its inlet **47** connected with the pressure gas duct **48**, as mentioned above. Thus material is expelled from the container and atomized so long as the solenoid valve **38** is energized to permit pressure gas to flow to the simulated smoke generator. Preferably the eduction nozzle **54** and the outlet of the delivery tube **52** are so positioned relative to the light beams from the reflector **31** that the simulated smoke is illuminated by the flashes of reflected light.

The solenoid valve **38** is electrically connected in series with a battery **57** and a manually operable switch **58** that can be located remotely from the apparatus, the circuit being such that the solenoid valve, and hence the distributor valve **37**, are open as long as the switch is closed. The light bulb **6** is also energized from the battery, its energizing circuit likewise being under the control of the switch **58**.

The strength and character of the sound shock produced by the simulator can be varied by changing the gas pressure, the rotational speed of the disc, or the shape of the nozzle **22**. It will be apparent that an increased frequency of simulated firing sounds can be obtained by making a number of openings **17** in the disc **11**, spaced at regular circumferential intervals around the same, the spacing of such openings of course being correlated with the speed of the pneumatic motor. The disc would then have a corresponding number of openings **30** for the light to shine through, which openings would be so arranged that the light flashes would always coincide with the detonations produced by the sound generator.

FIGURE 6 suggests another possible modification of the disc, whereby it can be used to provide a realistic reproduction of the sound of a gun having a detonation of comparatively long duration. In this case the disc is provided with a plurality of openings **17** that are spaced apart by only a small distance circumferentially of the disc, so that these openings pass the nozzle **22** in rapid

succession as the disc rotates. As will be appreciated from this, the duration and intensity of the light flashes can be controlled by varying the shape and size of the light emitting opening or openings **30** in the disc.

The embodiment of the invention illustrated in FIGURE 7 is particularly intended to simulate the firing of large bore weapons. In this case the pressure chamber **109** comprises a cylinder **109'** having a pressure gas inlet **110** at one end thereof and outlet ports **115** in its side wall, near its other end. The inlet **110** is communicated with a bottle **8** of compressed gas by means of a duct **60** having a suitable throttling restriction **61**. The outlet of the bottle, to which the duct **60** connects, can be provided with a manually operable valve **62**.

A piston **111**, having a coaxial rod **63** that projects from the inlet end of the cylinder, is slidable in the cylinder **109** to and from a normal position intermediate the ends of the cylinder, in which position the piston blocks communication between the inlet **110** and the outlet ports **115**. The piston is held in this position by means of a releasable latch **64** that is engaged in a groove or notch **65** in the rod, so that pressure can gradually build up behind the piston as gas flows from the bottle **8** to the cylinder through the throttling restriction **61**.

When a simulated firing is to take place, the latch **64** is disengaged from the piston rod **63**, and under the biasing force of pressurized gas in the inlet end of the chamber the piston **111** abruptly slides to the other end of the cylinder, uncovering the outlet ports **115** as it does so and permitting the pressurized gas to escape through them into a more or less conical horn or hopper **113** which surrounds the outlet end of the cylinder. A disc **66** of rubber or the like at the outlet end of the cylinder serves as a bumper or snubber to damp the impact of the piston against the cylinder end wall, and it will be observed that the outlet ports **115** are spaced from the outlet end of the cylinder by a distance at least equal to the axial length of the piston so that the outlets will be cleared by the piston when the latter engages the bumper.

If desired, a supplementary gas chamber **209** can be attached to the cylinder **109'**, communicated with its interior through an opening **68** near its inlet end. The supplementary container can be readily replaceably threaded into the cylinder wall to permit different sized supplementary containers to be fitted, for varying the pressure gas volume of the pressure chamber **109** and thus adjusting its sound output.

The latch **64** is swung to and from its piston rod engaging position by means of a pneumatic latch actuator comprising a cylinder **70** in which a piston **71** is slidable. A coaxial rod **72** on the latch actuator piston **71** projects through one end of its cylinder **70** and is pivotally connected at its free end with one end of the latch **64**, which comprises a lever that is medially fulcrumed about a fixed pivot **73**. The inlet **74** to the latch actuator cylinder **70** is near the end thereof that is opposite the piston rod, and is communicated with the pressure bottle **8** by means of a duct **75** controlled by a solenoid valve **138**. A spring **76**, which surrounds the piston rod **72** inside the cylinder **70** and reacts between the piston **71** and the rod end of the cylinder, biases the piston toward the inlet end of the cylinder and hence toward a position in which the latch **64** is engaged in the notch or groove **65**. When the solenoid valve **138** is opened to admit pressurized gas to the latch actuator cylinder **70**, such gas moves the piston **71** against the bias of its spring **76** to release the latch, in turn allowing the pressure chamber piston **111** to move toward the outlet end of its cylinder **109'** in response to the pressure of gas therein, as described above.

After all pressurized gas is released from the pressure chamber **109**, the piston **111** is automatically returned to its normal or latched position by means of a compression spring **79** that surrounds the piston rod **63** and reacts between the adjacent end of the pressure chamber and a flange or washer **80** fixed on the rod. The latch **64**, which acts like a pawl, automatically reengages when the piston **111** returns to its normal position, thus readying the apparatus for another detonation as soon as gas pressure in the chamber **109** reaches a high enough value.

The solenoid valve **138** can be manually controlled by a normally open momentary contact switch **158**, connected in series with the solenoid valve and a battery **57**. Since the switch **158** is intended to be closed only briefly when the simulator is "fired," it can also control the energizing circuit for a light **6**, so that the light flashes concurrently with each energization of the solenoid valve and hence with each detonation.

It is to be noted that the solenoid valve **138** does not control flow of gas to the pressure chamber **109**. Instead, gas flows to said chamber continuously, through the throttling restriction **61**, so long as the manually controllable valve **62** is open. However the solenoid valve does control flow of pressure gas to a simulated smoke generator **7'**, which in this case comprises a container **150** for powdered material, having an inlet tube **147** extending downwardly thereinto and terminating near its bottom and having an outlet tube **152** extending upwardly from near its bottom and terminating in a nozzle **154** spaced above the top of the container. The inlet tube **147** is connected with a pressure gas duct **148** which branches from the duct **75** that connects the solenoid valve **138** with the latch actuator, and hence pressure gas flows into the container whenever the solenoid valve is opened, driving powdered material upwardly in the outlet tube **152** and expelling it through the nozzle **154** as a simulated puff of smoke.

If desired, the simulator shown in FIGURES 1 and 2 can be automatically "fired" in intermittent bursts, and the simulator illustrated in FIGURE 7 can be automatically caused to "fire" repeatedly, at intervals, by means of the apparatus illustrated in FIGURE 8, which comprises a drum **85** of insulating material, driven for rotation about its axis by means of an electric motor **86**. A series of axially extending conductor strips **87** is arranged at circumferentially spaced intervals on the cylindrical surface of the drum, to be engaged by a pair of brushes **88** and **89**. Whenever the drum rotates to a position in which the two brushes are simultaneously engaged with a conductor strip **87**, a circuit is completed through the brushes, and hence the apparatus just described can be connected into the electrical circuit of the simulator of FIGURES 1 and 2 in place of the switch **58**, or into the circuit of the FIGURE 7 simulator in place of switch **158**, the circuit connections in each case being made to the brush terminals instead of to the switch terminals. A suitable switch controlled energizing circuit for the motor **86** will of course be provided, or the drum **87** can be driven by an air motor connected to the bottle **8** and controlled by a suitable valve.

It will be apparent that when the "firing" of the simulator is manually controlled, the control switch **58** or **158** can be located remotely from the simulator, so that an operator of the device is not endangered by bullets fired at it, but under these circumstances it would be difficult for the operator to judge the accuracy of fire aimed at the simulator. The invention therefore contemplates automatic means for interrupting or discontinuing operation of the device when a hit is made on a target associated with it.

FIGURE 9 illustrates such a control device, comprising a target board **90**, which is preferably cut out to an outline of some suitably realistic shape and which is easily camouflaged or partly camouflaged so as to make it difficult to see. The target board is mounted in an upright position, close to the location of the simulator to be controlled, and to it is attached a transducer **91** of known type which generates an electrical impulse signal in response to the impact of a missile upon the target board. (The transducer can be of the type disclosed in Swedish patent application Serial No. 1,734/61.)

Signals from the transducer **91**, as amplified by an amplifier **92**, are fed to a normally closed relay **93** in an energizing circuit for the solenoid valve **38**. The energizing circuit also includes the battery **57** or some other suitable power source, a holding relay **94**, and a normally closed manually operable switch **358**. When simulated firing is to be produced by the device, the operator briefly closes a manually operable normally open momentary contact switch **258** to energize the holding relay **94** through a shunt circuit comprising a conductor **95** which connects the coil of the holding relay with said switch **258**, and through it with the battery. The switch **258** can be released after a brief closure because the holding relay **94** thereafter maintains itself energized through a circuit that includes, in series, the battery **57**, a conductor **96**, the normally closed switch **358**, another conductor **97**, the contacts of the normally closed relay **93**, a third conductor **98**, the contacts of the holding relay, and a ground connection **99**. The winding **100** of the solenoid valve is connected in parallel with the coil of the holding relay **94** hence the solenoid valve is energized at all times that the holding relay is closed, and simulated firing therefore takes place at such times. If the operator for any reason wishes to discontinue simulated firing, he momentarily opens the normally closed switch **358**, thus breaking the energizing circuit to the holding relay **94** and the solenoid valve, and simulated firing will not recommence until he again closes the normally open switch **258**.

If the target board is struck by a missile while the holding relay **94** and solenoid valve **38** are energized, the amplified signal from the transducer **91** which is produced in consequence of a hit upon the target board **90** energizes the normally closed relay **93**, which has its winding connected across the output of amplifier **92**, and thus interrupts the energizing circuit to the holding relay **94** and the solenoid valve winding **100**, terminating simulated firing immediately. The operator can thereafter cause simulated firing to be resumed by momentarily closing the switch **258**.

The modified embodiment of the control apparatus illustrated in FIGURE 10 again comprises a target board **90** of suitable shape, which in this case, however, is mounted for tilting motion to and from an upright position, and which is adapted to swing down, parallel to the ground, when struck by a missile fired at it, so as to substantially disappear when hit. The target board is carried for such swinging motion on the upper end of a lever **101** that is medially fulcrumed on a fixed horizontal pivot support **102**. At its lower end the lever **101** is pivotally connected to a piston **103** which is slidable in a pneumatic cylinder **104**, and a compression spring **105** in the cylinder acts upon the piston to bias it in the direction to swing the target board to its lowered position. Pressurized gas, brought to the cylinder **104** by way of a duct **106** controlled by the solenoid valve **38**, moves the piston **103** against the bias of its spring **105**, thus causing the target board to be swung to its upright position. Hence the target board remains upright as long as the simulator is in operation.

The control circuit for the FIGURE 10 apparatus is essentially identical with that described above, and includes a transducer **91** secured to the target board and which emits an electrical impulse when the target board is struck. When energization of the solenoid valve **38** ceases, either as a consequence of a hit signal from transducer **91** or as a result of opening of the normally closed switch **358**, the flow of pressurized gas to the simulator and to cylinder **104** is of course cut off, and spring **105** acts to swing the target board down to its horizontal position simultaneously with termination of simulated firing by the simulator.

From the foregoing description taken together with the accompanying drawings it will be apparent that this invention provides a very realistic simulator of weapons fire which is capable of reproducing the sound detonations of

almost any type of recoil weapon and which also provides a realistic imitation of the appearance of a weapon being fired by producing a simulated muzzle flash and puff of smoke concurrently with the sound. It will also be apparent that the simulator of this invention is well adapted to be remotely controlled and has special value for training purposes because it can be automatically "put out of action" by a hit scored on a target board associated with it.

What is claimed as my invention is:

1. In apparatus for simulating the firing of a weapon, the combination of:

(A) means defining a gas pressure chamber having

(1) an inlet connectable with a source of gas under pressure and

(2) a bore through one wall of the chamber, spaced from said inlet;

(B) a disc mounted for rotation about an axis spaced from said bore and substantially parallel thereto, said disc overlying the outer end of the bore and having an opening therein which substantially aligns with the bore in one rotational position of the disc;

(C) an axially movable pressure responsive sealing element in the bore having a hole extending axially therethrough, said sealing element having an annular sealing surface on its exterior, surrounding the hole therein, which can engage the adjacent face of the disic to provide a seal that does not interfere with rotation of the disc but prevents escape of pressurized gas from the chamber when the disc is out of its said rotational position, said sealing element being adapted to be biased into such engagement with the disc by pressurized gas in the chamber; and

(D) means for rotating the disc so as to cyclically bring said opening therein into alignment with the bore and hence into register with the hole in the sealing element so that pressurized gas can thus be abruptly released from the chamber to produce a sound simulating the firing of a weapon.

2. The apparatus of claim **1**, further characterized by:

(A) a container for air dispersable material having an outlet;

(B) means connectable with the source of gas under pressure for entraining material from said container in gas from said container in gas from said source, to effect propulsion of material out of the container into the air through said outlet in the container;

(C) means for controllably connecting said last named means with the source of gas under pressure so that dispersion of gas from the container can be effected substantially simultaneously with production of a sound simulating firing.

3. The apparatus of claim **1**, further characterized by:

(A) a light bulb mounted adjacent to the disc in a location spaced from said bore and from the rotational axis of the disc, to shine through another opening in the disc which registers with said light bulb when the disc is in its said one rotational position, thereby simulating a flash of flame concurrent with the simulated sound of firing; and

(B) means for energizing said light bulb.

4. The apparatus of claim **1**, further characterized by the fact that said sealing element comprises a diaphragm extending across the bore and having its hole substantially at its center, and having a coaxial circumferential land surrounding the hole and spaced radially inwardly if its periphery, which land provides said surface that engages the disc.

5. The apparatus of claim **1**, further characterized by the fact that said sealing element comprises a plunger which is axially slidable in the bore and the hole in which comprises a passage therethrough that diverges toward its outer end, said surface that engages the disc being the outer end of the plunger.

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