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Early Thermal Spray Application—*JTST* Historical Patent #12*

United States Patent Office
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METAL SPRAY GUN
2,227,752. Patented 7 Jan 1941. Application 30 June 1938, Serial No. 216,654.

My invention relates to metal spray guns and will be fully understood from the following description read in conjunction with the drawings in which:

Fig. 1 is a side view of a metal spray gun constructed in accordance with my invention.

Fig. 2 is a vertical section through the construction shown in Fig. 1 on the plane indicated by II-II.

Fig. 3 is a vertical section through the construction shown in Fig. 2 on the plane indicated by III-III.

Fig. 4 is a vertical section through the construction shown in Fig. 1 on the plane indicated by IV-IV.

Fig. 5 is a vertical section through the construction shown in Fig. 1 on the plane indicated by V-V.

Fig. 6 is an exploded section through the construction shown in Fig. 1 on the plane indicated by VI-VI.

Fig. 6*a* is a plan view of the interior of the construction shown in exploded form in Fig. 6.

Fig. 7 is a side view of one element of the gun constructed in accordance with my invention.

Fig. 8 is a view of the construction shown in Fig. 7 at a right angle to the showing in Fig. 7.

Fig. 9 is a central vertical section parallel to the construction shown in Fig. 1.

Fig. 10 is a vertical section through the construction shown in Fig. 5 on the plane indicated by X-X.

Fig. 11 is a section on the plane indicated by XI-XI in Fig. 5.

Fig. 12 is an exploded section through the construction shown in Fig. 11 on the plane indicated by XII-XII.

Fig. 12*a* is a perspective view of the plug of the nozzle shown in Fig. 12.

Fig. 13 is a fragmentary view of the face of the turbine casing at the point at which the nozzle discharges, taken on the line indicated by XIII-XIII in Fig. 12.

Fig. 14 is a section through the showing in Fig. 12 (with the parts in operating position, i.e., unexploded) on the plane indicated by XIV-XIV.

Fig. 15 is a section on the plane indicated by XI-XI in Fig. 5 showing an alternative embodiment of my invention.

Fig. 16 is a corresponding section showing a further alternative embodiment of my invention.

Fig. 17 is a corresponding section showing a further alternative embodiment of my invention.

Fig. 18 is a corresponding section showing a still further alternative embodiment of my invention.

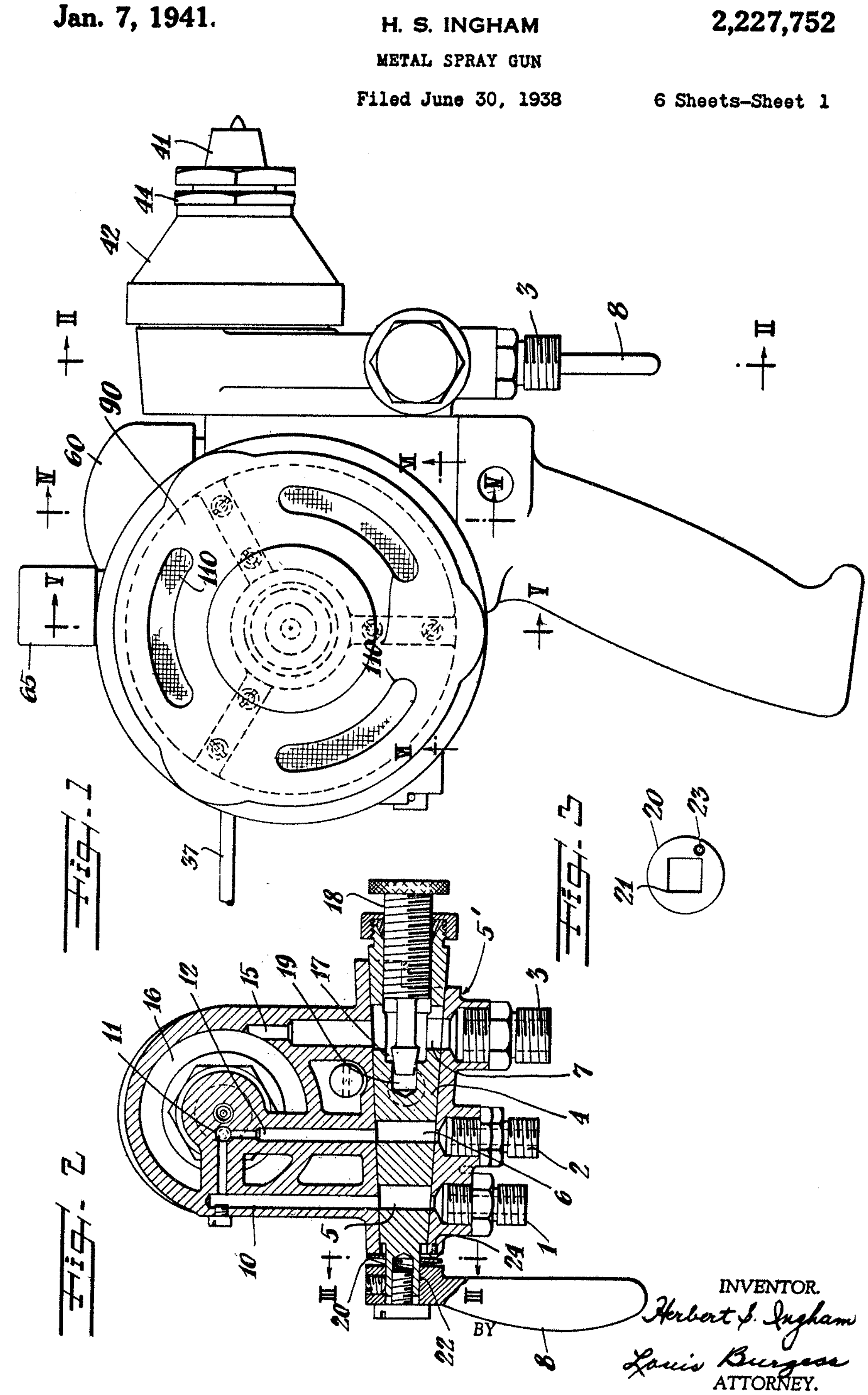
*This series of historical patents concerned with thermal spray technology has been compiled by C.C. Berndt (SUNY at Stony Brook, NY) and K.A. Kowalsky (Flame-Spray Industries, Inc., NY).

Metal spray guns of the type to which my invention relates are devices which operate by continuously feeding a metal rod or wire into a zone in which it is melted and from which this melted metal is sub-divided and propelled by a blast of air or other gas. The rod or wire is fed into the melting zone by knurled burs which press against opposite sides of the wire and are driven by a gas turbine operating through reduction gears. The load on the turbine varies from time to time due to changes in the position of the operator, kinks in the wire, etc., and since it is essential that the rate of feed of the wire be uniformly maintained, it is likewise essential that the turbine have a comparatively stable speed of operation, i.e., that its speed be affected as little as possible by variations in the load. This may be accomplished by appropriate turbine construction.

In the operation of metal spray guns, it is, however, necessary to maintain different rates of feed when spraying different metals; for example, metals, the heats of fusion of which are low, may be fed and sprayed more rapidly than metals with a high heat of fusion and wires of larger diameter are fed and sprayed more slowly than wires of the same material of smaller diameter. In usual practice an effort is made to approximate proper conditions for the particular metal being sprayed by the provision of replaceable gearing designed to permit the gun to be operated at the desired rate of wire feed while permitting the turbine to operate within a range of stable operation. Changing the gearing involves a loss of time and the possibility that metal particles will be picked up by the gears in handling and interfere with the operation of the gun. If an effort is made to reduce the turbine speed by throttling the gas the turbine becomes unstable and a uniform wire feed is no longer maintained.

I have devised a new metal spray gun in which no change of gearing is necessary and by means of which it is nevertheless feasible to maintain two or, in fact, any number of rates of wire feed within limits practically desirable, shifting from one speed to another by simple adjustment and notwithstanding such changes in the rates of feed, maintaining the turbine at all times in a range of stable operation.

Broadly speaking, I accomplish this purpose by varying the total throat area of the turbine nozzle or nozzles and this may be done within the scope of my invention, either by means for continuously varying the throat area over a predetermined range or by means for varying the total throat area in steps. Starting with the jet adjustment of minimum area, a reduced stable operating speed of the turbine is obtained by increasing the total throat area of the turbine nozzle or nozzles. As the throat area is increased the pressure in the manifold which supplies gas to the nozzle or nozzles decreases so that the turbine speed actually decreases without becoming unstable. This reduction in manifold pressure may be the result of a restriction intermediate the air supply and the jets, but in the preferred construction the rate at which the manifold pressure decreases as the nozzle area is increased is determined by control means incorporated in the gun which may, for example, take the form either of a fixed orifice or a variable valve between the manifold and the air line. In the preferred practice this is controlled by the needle valve which governs the air flowing into the manifold. The operator selects that adjustment of the area of the nozzle or nozzles in use which will maintain the turbine in stable operation at approximately the desired speed, and then adjusts the needle valve to give the precise rate of wire feed required.



Jan. 7, 1941. H. S. INGHAM 2,227,752

METAL SPRAY GUN

Filed June 30, 1938 6 Sheets-Sheet 2

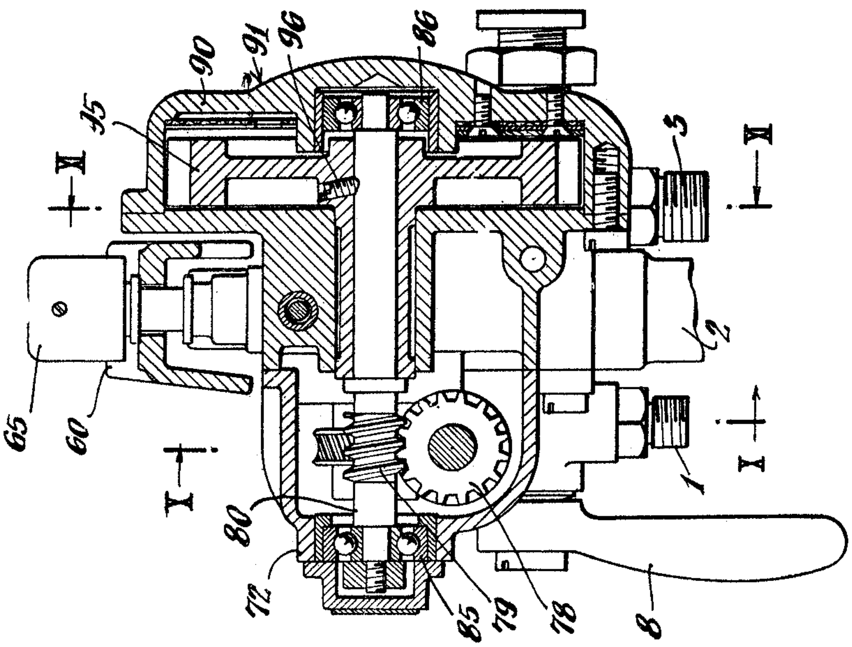


Fig. 5

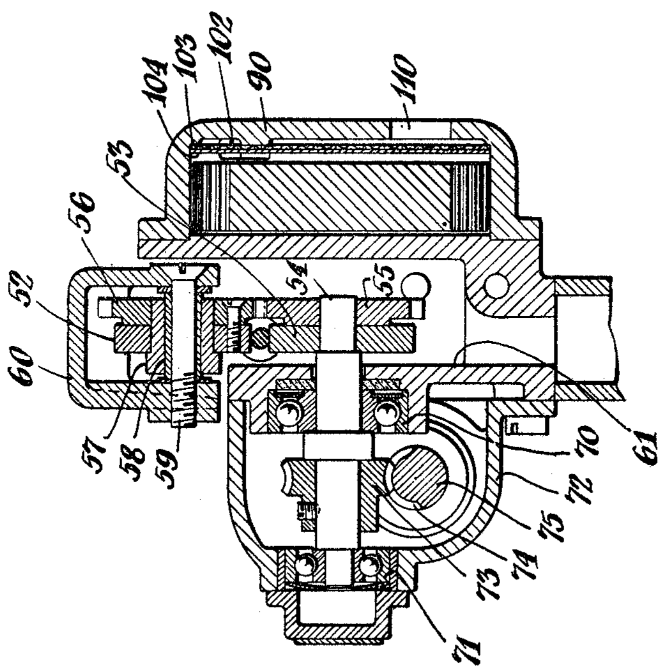


Fig. 4

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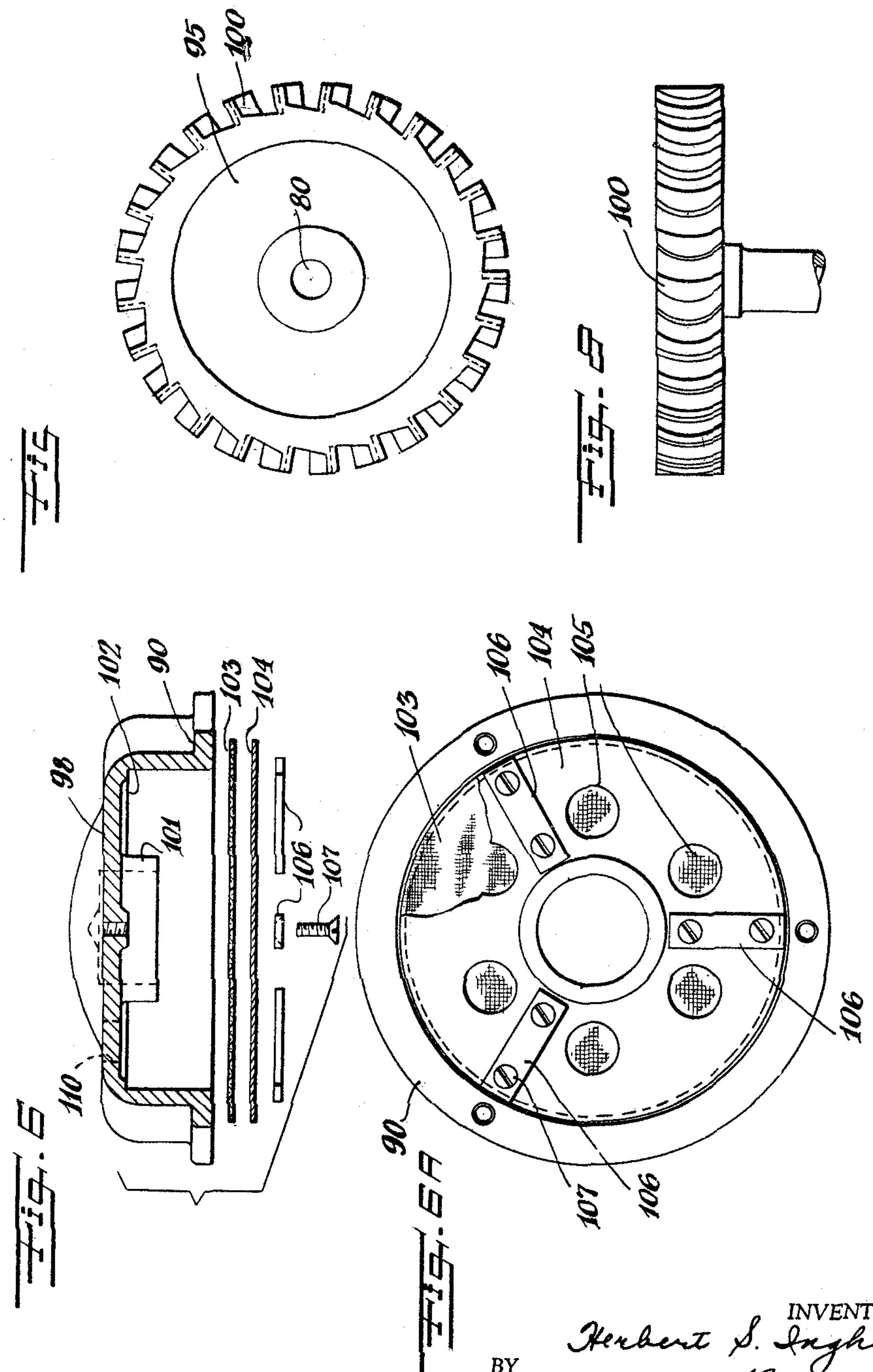
METAL SPRAY GUN

Filed June 30, 1938 6 Sheets-Sheet 3



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METAL SPRAY GUN

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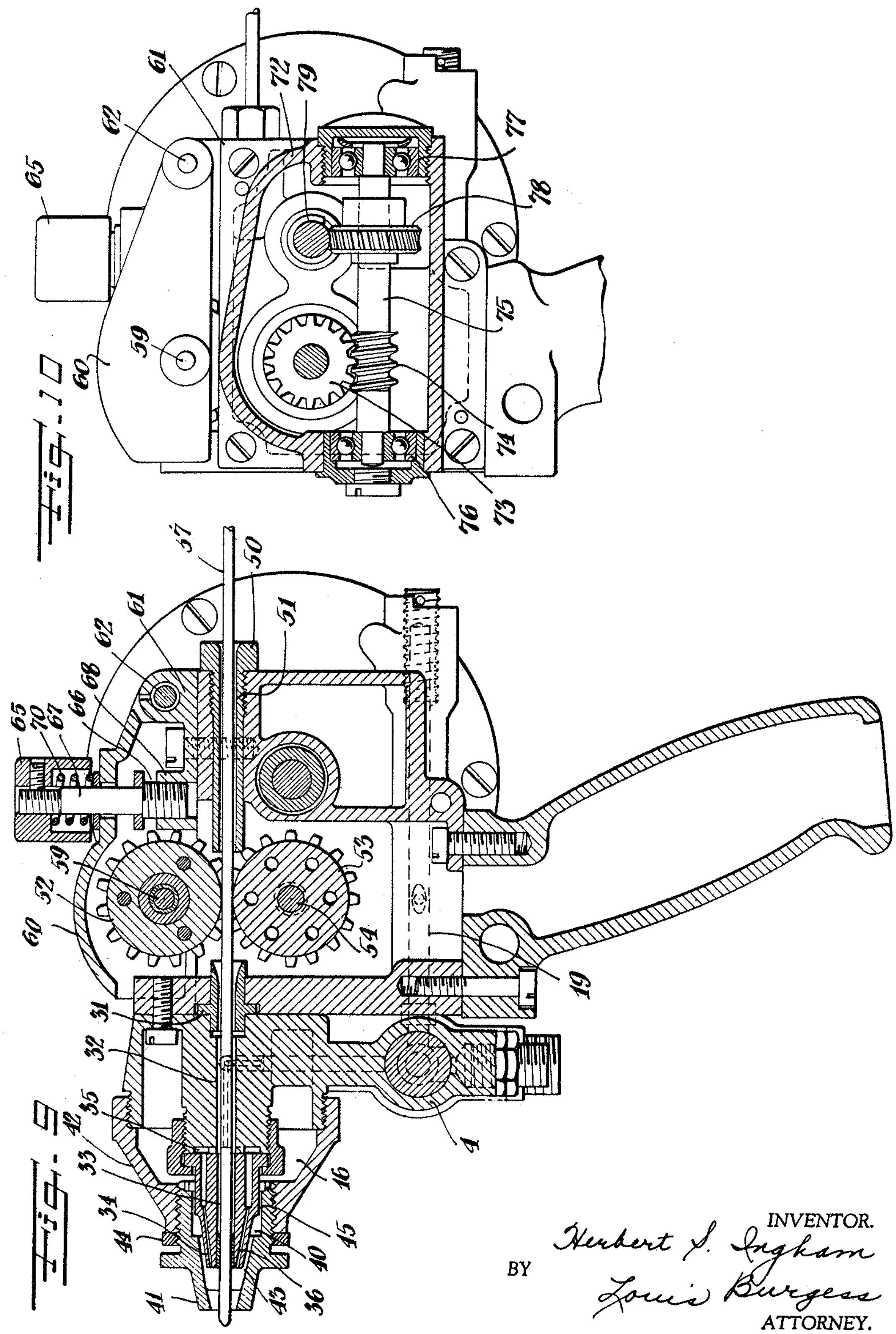

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METAL SPRAY GUN

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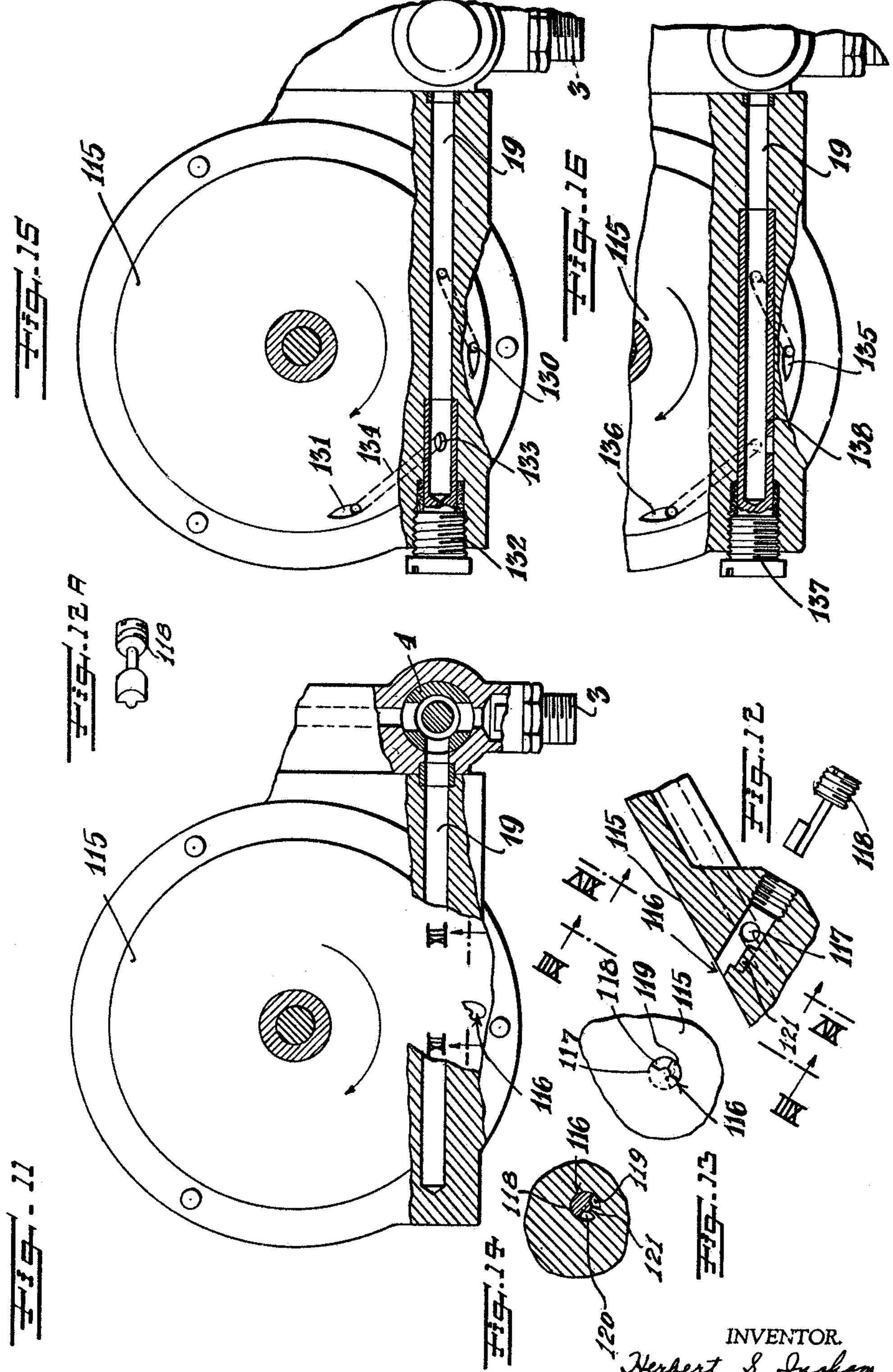

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METAL SPRAY GUN

Filed June 30, 1938 6 Sheets-Sheet 6

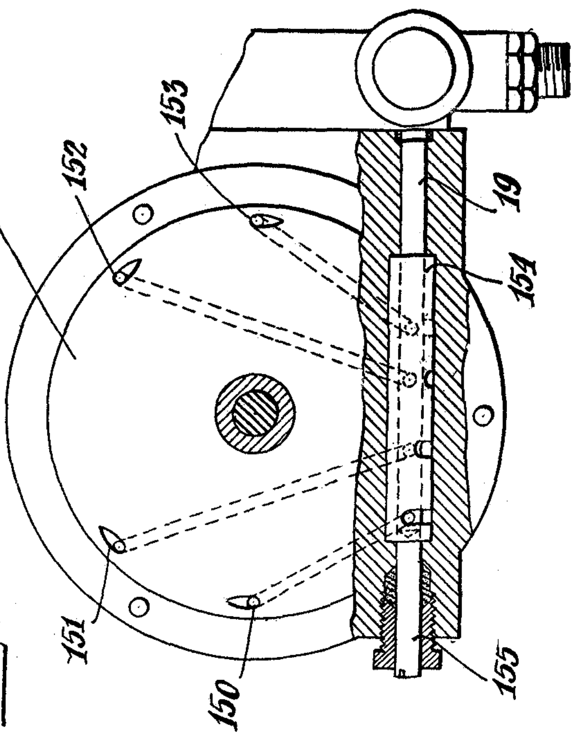

Fig. 18

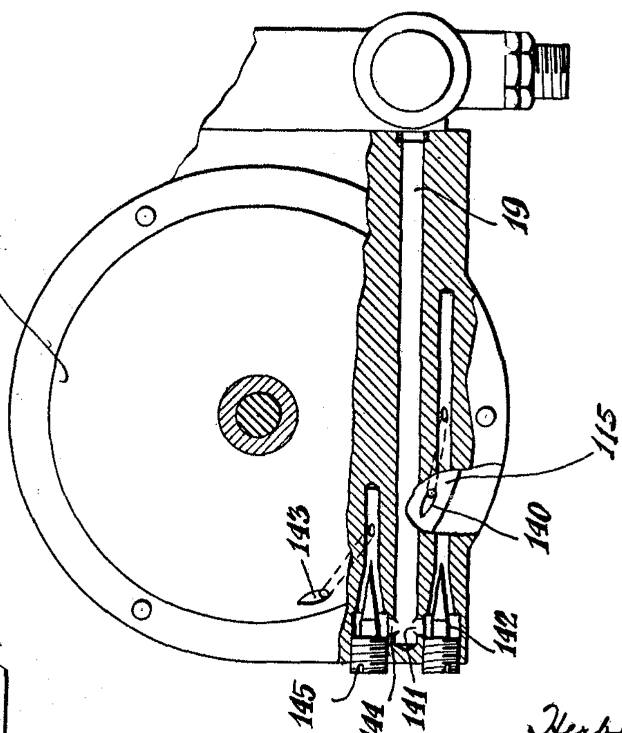

Fig. 17

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In accordance with the principle of my invention, where I provide a turbine nozzle or nozzles, the throat area of which may be continuously varied, any number of stable operating speeds may be obtained by corresponding adjustment of the total throat area in service. Alternatively, I may, in accordance with the principle of my invention, use a number of jets each of fixed throat area, and place in service a jet or combination of jets of progressively greater throat area.

For the purpose of illustrating the scope and character of my invention, I have hereinafter described a spray gun containing certain practical embodiments of the same. Referring to the drawings **1** (Fig. 2) indicates the inlet for oxygen or other combustion supporting gas, **2** the inlet for acetylene or other combustible gas, and **3** the inlet for air or other gas for use to project the metal spray and drive the turbine.

Each of the said inlets is connected by a suitable fitting and flexible tubing to a source of required gas. When plug **4** of valve **5′** is in the position shown, each of the inlets registers with a corresponding hole in the plug, these holes being indicated by numerals **5, 6,** and **7** respectively. When handle **8** and plug **4** are in the position shown, oxygen flows through duct **10** into duct **11.** The combustible gas flows through duct **12** to mix with the oxygen in duct **11.** The air flows through duct **15** into chamber **16** and also flows through the side connection **17** controlled by needle valve **18** into turbine manifold **19.** Openings **5, 6,** and **7** in plug **4** are so arranged that as handle **8** is turned from the off position which is at a right angle to the showing in Fig. 2 first some combustible gas passes into duct **11** and thence to the burner outlet to enable the burner to be lighted, some air passes simultaneously into manifold **19** to enable the turbine to come up to speed. Alternatively all the valve passages may be opened but at such rates of flow as to establish favorable lighting conditions which are different from the conditions obtained when the gun is in operation. This position of the valve is called the lighting position. Under former practice a certain degree of experience was necessary to enable the operator to turn the handle **8** to the exact position at which the burner may be properly lighted, but with my construction this difficulty is eliminated, the washer **20** (Fig. 3) defines a hole **21** of rectangular cross-section which fits closely the shank **22** (of corresponding section) (Fig. 2) of the plug **4.** The washer **20** is formed with the depression **23** (Fig. 3). This washer is spring pressed, and this depression slips onto the head of pin **24** when handle **8** is in the correct position for lighting the burner. This offers sufficient resistance to indicate to the operator the lighting position. After the burner has been lighted a slight pressure against handle **8** forces the depression **23** out of engagement with the head of the pin **24.** A further movement of handle **8** causes oxygen to flow through duct **10** which establishes a melting flame with the ignited gas and the final movement of handle **8** to the position shown in Fig. 2 permits air to flow into duct **15** and thence into chamber **16** to project the sprayed metal upon the surface to be covered.

The construction of that part of the gun by which the rod or wire is melted and projected will be explained by reference to Fig. 9. The wire **37** moves forward to guide **31** and through duct **32** to the interior **33** of the burner tip **34.** The mixture of air and oxygen move forward through the duct **11,** which is immediately behind duct **32** (the arrangement is shown in Fig. 2) and into the annular space **35.** From this annular space **35** the combustible mixture moves forward through a number of holes to be discharged through convergent orifices **36** against the wire. This forms a zone of gases undergoing combustion, whereby the wire **37** melts as rapidly as it is progressively advanced into the zone, for which reason this zone may be hereinafter referred to as a melting zone. The air from chamber **16** advances through the annular space **40** surrounding burner tip **34** and is projected by air nozzle **41** in such a way as to sub-divide and propel the molten metal. The air tip **41** is threaded to the outer shell **42** of the burner so that the orifice **43** defined by conical interior of air tip **41** and conical exterior of burner tip **34** may be adjusted with corresponding variations in the characteristics of the air blast. When a satisfactory adjustment has been made, the tip **41** is locked in position by the lock nut **44.** It will be noted that the air in passing forward from the chamber **16** goes through the constricted annular space **45** which exerts a definite control over the volume of air passing. As a result of this constriction and the orifice effect thereby created, the adjustment of air tip **41** modifies the characteristics of the air blast without so great a modification of the volume of air passing thereto as would otherwise result, which is decidedly advantageous in the adjustment and operation of the gun.

The wire **37** (Fig. 9) enters the gun through the annular guide **50** of hardened material in which is the duct **51.** The upper and lower surfaces of the wire are engaged respectively by the burs **52** and **53.** Bur **53** is carried by shaft **54,** which shaft is driven by an air turbine through suitable intermediate gearing which will be hereinafter described. Shaft **54** (Fig. 4) also drives the gear **55** in mesh with gear **56,** which in turn drives the upper bur **52.** Both gear **56** and bur **52** are secured to the tubular member **57** which rotates on the spool **58** carried by pin **59** (Fig. 4). The screw **59** is carried by the saddle **60** and this saddle is pivotally secured (Fig. 9) to frame **61** of the gun by the hinge **62.** When cap **65** is turned the threaded end **66** of the screw **67** advances into the threaded member **68** which is a part of frame **61** and the spring **70** exerts pressure on the saddle **60,** thereby forcing the upper bur **52** toward the lower bur **53** and thereby causing the burs to engage and advance the wire **37.** Conversely, when cap **65** is turned in the reverse direction, pressure of spring **70** on saddle **60** is released and the burs move freely without engaging and advancing the wire.

The shaft **54** (Fig. 4) which drives bur **53** is mounted in ball bearings **70** and **71.** Bearing **70** is held in frame **61** and bearing **71** is held in the housing **72** which is attached to frame **61.** The shaft **54** is driven by the worm gear **73,** which in turn is driven by the worm **74,** carried by the shaft **75.** Shaft **75** (Fig. 10) is carried by ball-bearings **76** and **77** mounted in the housing **72.** Shaft **75** is in turn driven through the worm gear **78** by the worm **79.** The worm **79** (Fig. 5) is integral with shaft **80** carried by bearings **85** and **86.** Bearing **85** is mounted in housing **72** and bearing **86** is mounted in the cap or cover **90** of the turbine **91**.

Turbine **91** (Fig. 5) includes the turbine rotor drum **95** secured to shaft **80** by the set screw **96.** Details of the blading **100** are apparent from Figs. 7 and 8. As evident from the exploded view (Fig. 6) of the cover **90,** this cover includes the mounting **101** for the ball-bearing **86** and three ridges **102** radially arranged about mounting **101** on the interior surface of the cover. The washer-shaped member **103** is made of fine wire mesh and rests directly upon ridges **102.** The washer **104** rests directly on the washer **103** and is composed of fiber. The fiber washer **104** defines the perforations **105** (Fig. 6*a*). The washers **103** and **104** are held in contact with each other and with the ridges **102** by the strips **106,** which in turn are secured to the ridges **102** by the screws **107.** One result of this construction is that the exhaust from the turbine flows through perforations **105** in the fiber washer **104,** thence through the openings in the fine screen of which washer **103** is composed, and thence through exhaust ports of the turbine **110,** formed in the cover **90** (Fig. 6 and Fig. 1) thereby resulting in more quiet operation of the turbine. The strips **106** form ridges in the space in which the bladed drum of the turbine revolves. These ridges operate to broaden the range of stable operations for any given setting of the turbine nozzles by producing turbulent flow of gas within the turbine.

One nozzle arrangement falling within the purview of my invention is shown in Figs. 11, 12, 12*a*, 13, and 14. Fig. 11 shows the face **115** which (together with the housing **90**) defines the space in which the turbine drum rotates; the drum is not shown to facilitate inspection of the nozzle structure. In this case one individual nozzle **116** is shown which is of variable area. This nozzle is composed of the bore **117** and the plug **118** which is turned within bore **117** to vary the effective area of the nozzle. The actual form of the delivery opening **119** from which the gas is discharged is shown in Fig. 13, which is a view of the face **115** at the point at which the nozzle discharges. It is evident from this that approximately half of the bore **117** is available for discharge. Fig. 14 is a section through Fig. 12 on the plane indicated by XIV-XIV (with the plug in operative position). By inspection of this figure, it is evident that gas in the space **120** between the plug **118** and the longitudinally extending barrier **121** cannot escape because this space is capped or covered by the extension of face **115,** but that on the contrary, the only opening through which air may escape is that part of the opening **119** which is not occupied by the plug **118** and for this reason the actual nozzle in use at any one time may be enlarged or decreased within the limits shown in Fig. 13 by turning the plug **118.**

The preferred form of nozzle for practical applications is that shown in Fig. 15 in which the nozzle **130** is permanently connected to the manifold **19** while nozzle **131** may at any time desired be additionally connected by turning plug **132** so that hole **133** defined by the plug registers with inlet **134** of nozzle **131.** In this case it is evident that when both jets are in operation, the effective nozzle area is greater than with either jet individually, and in this case two stable ranges of operation may be obtained by using either jet **130** alone or by the combined use of jets **130** and **131.** As hereinbefore pointed out, a slower stable range of operating speeds is obtained by increasing the effective nozzle area.

A further alternative form of construction is that shown in Fig. 16 in which case I have shown two nozzles, **135** and **136,** which may be alternatively brought into communication with the manifold **19** by turning the plug **137** so that holes in the tubular portion **138** of the plug register with either inlet to nozzle **135** or inlet to nozzle **136.** In this case it will, of course, be understood that the nozzles are of different cross-sectional areas and are, therefore, of different effective discharge areas and that the lower stable range of operating speeds is obtained by the use of the jet of greater discharge area. The tubular section **138** may in addition carry another set of holes simultaneously registering with the inlets to nozzles **135** and **136** so that both nozzles may be simultaneously in use whereupon a third and still lower stable range of operating speeds will be obtained.

A further alternative embodiment of my invention is shown in Fig. 17. This also comprises two nozzles which may be alternatively used. Nozzle **140** is in communication with manifold **19** through side-arm **141** and is controlled by needle valve **142.** Nozzle **143** is in communication with manifold **19** through side-arm **144** and is controlled by needle valve **145.** In case the nozzles shown are of the same or substantially the same cross-sectional area, a lower stable range of operating speed of the turbine is obtained by placing both nozzles simultaneously in communication with the manifold. The nozzles may, however, be constructed with different cross-sectional areas, in which case a lower stable operating speed is obtained by the use of the nozzle of greater cross-sectional area and a still lower stable range of operating speeds is obtained by the simultaneous use of both nozzles. Since in this case the amount of gas discharged from each jet may be accurately determined by the needle valve controlling it, the use of a restriction or valve controlling the admission of air into the manifold **19** is not essential although in practical operation it is desirable.

A still further embodiment of my invention is shown in Fig. 18 in which case the turbine is provided with four separate nozzles, numbered respectively **150, 151, 152,** and **153.** Communication of these nozzles with manifold **19** is controlled by tubular section **154** of the plug **155** in manifold **19.** The sleeve is provided with slots so that nozzle **153** may be placed in service alone or nozzle **152** may be additionally placed in service or nozzle **151** may be placed in service in addition to nozzle **152** and **153** or if desired, all four nozzles may be placed in service. In this way any one of four stable ranges of operating speed may be obtained, the speed being inversely related to the number of nozzles in operation and to the total cross-sectional area of the nozzles in operation. It will, of course, be understood that in this embodiment of my invention, the nozzles may be constructed with cross-sectional area different from one another so that a corresponding control would be obtained by their alternative use and if desired additional ports may be provided in the tubular section **154** so that these nozzles may also be combined with one another in various ways to produce additional ranges of operating speed.

The foregoing description is furnished by way of illustration and not of limitation and it is, therefore, my intention that the invention be limited only by the appended claims or their equivalents wherein I have attempted to claim broadly all inherent novelty.

I claim:

1. In a metal spray gun of the molten metal gas blast type having an inlet for compressed gas and turbine actuated means for progressively advancing metal into a melting zone and including in said turbine a rotor drum and nozzle means positioned to direct a blast of gas against the blading of said rotor drum, the improvement comprising a manifold in communication with said nozzle means, means for varying the area of the nozzle means in use and pressure reduction means between said inlet and said manifold.

2. The improvement in a metal spray gun according to claim 1 in which said turbine comprises in addition at least one

gas baffle within the same positioned to produce turbulent flow of gas therein in air frictional engagement with said rotor drum.

3. In a metal spray gun of the molten metal gas blast type having an inlet for compressed gas and turbine actuated means for progressively advancing metal into a melting zone and including in said turbine a rotor drum and a nozzle positioned to direct a blast of gas against the blading of said rotor drum, the improvement comprising a manifold in communication with said nozzle, means for varying the cross-sectional area of said nozzle and pressure reduction means between said inlet and said manifold.

4. The improvement in a metal spray gun according to claim 3 in which said turbine comprises in addition at least one gas baffle within the same positioned to produce turbulent flow of gas therein in air frictional engagement with said rotor drum.

5. In a metal spray gun of the molten metal gas blast type having an inlet for compressed gas and turbine actuated means for progressively advancing metal into a melting zone and including in said turbine a rotor drum and a plurality of nozzles positioned to direct a blast of gas against the blading of said rotor drum, the improvement comprising a manifold in communication with said nozzles, means for varying the average area of the nozzles in use and pressure reduction means between said inlet and said manifold.

6. In a metal spray gun of the molten metal gas blast type having an inlet for compressed gas and turbine actuated means for progressively advancing metal into a melting zone and including in said turbine a rotor drum and nozzle means positioned to direct a blast of gas against the blading of said rotor drum, the improvement comprising a manifold in communication with said nozzles, means for varying the number of nozzles in use and pressure reduction means between said inlet and said manifold.

7. The improvement in a metal spray gun according to claim 6 in which said turbine comprises in addition at least one gas baffle within the same positioned to produce turbulent flow of gas therein in air frictional engagement with said rotor drum.

8. In a metal spray gun of the molten metal gas blast type having an inlet for compressed gas and turbine actuated means for progressively advancing metal into a melting zone and including in said turbine a rotor drum and a number of nozzles of different cross-sectional areas positioned to direct a blast of gas against the blading of said rotor drum, the improvement comprising a manifold in communication with said nozzles, means for selectively placing a part of said nozzles in use, and pressure reduction means between said inlet and said manifold.

9. The improvement in a metal spray gun according to claim 8 in which said turbine comprises in addition at least one gas baffle within the same positioned to produce turbulent flow of gas therein in air frictional engagement with said rotor drum.

10. In a metal spray gun of the molten metal gas blast type having an inlet for compressed gas and turbine actuated means for progressively advancing metal into a melting zone and including in said turbine a rotor drum and nozzle means positioned to direct a blast of gas against the blading of said rotor drum, the improvement comprising means including at least one gas baffle in said turbine positioned to produce turbulent flow of gas therein in air frictional engagement with said rotor drum.

11. In a metal spray gun of the molten metal gas blast type having an inlet for compressed gas and turbine actuated means for progressively advancing metal into a melting zone and including in said turbine a rotor drum and nozzle means positioned to direct a blast of gas against the blading of said rotor drum, the improvement comprising means including at least one station stationary internal projection positioned to produce turbulent flow of gas therein in air frictional engagement with said rotor drum.

12. In a metal spray gun of the type including means for maintaining a melting zone, means for directing a blast of gas against metal which has been melted in said zone adapted to subdivide and convey such melted metal, a control cock for gases required in the operation of said gun, said control cock including a housing defining multiple inlets and corresponding outlets, and including a handle operated plug defining at least three passages, each of said passages controlling flow through one of said inlets and the corresponding outlets, at least one of said passages defining a port for combustible gas, at least one other a port for oxygen and at least one-third a port for a compressed non-combustible gas, the improvement comprising gas bleeding means within said housing positioned to bring into communication said combustible gas inlet and outlet in advance of the registry of said port for combustible gas with its inlet and outlet in substantially lighting position, and a detent positioned to arrest the motion of said plug when said bleeding means are in said lighting position.

13. In a metal spray gun of the type including means for maintaining a melting zone, means for directing a blast of gas against metal which has been melted in said zone adapted to subdivide and convey such melted metal, a control cock for gases required in the operation of said gun, said control cock including a housing defining multiple inlets and corresponding outlets, and including a handle operated plug defining at least three passages, each of said passages controlling flow through one of said inlets and the corresponding outlet, at least one of said passages defining a port for combustible gas, at least one other a port for oxygen and at least one-third a port for a compressed non-combustible gas, the improvement comprising the first gas bleeding means within said housing positioned to bring into communication said combustible gas inlet and outlet in advance of the registry of said port for combustible gas with its inlet and outlet in substantially lighting position, second gas bleeding means within said housing positioned to bring into communication said compressed non-combustible gas inlet and outlet in advance of the registry of said port for compressed non-combustible gas with its inlet and outlet in substantially lighting position and a detent positioned to arrest the motion of said plug when said first and said second bleeding means are in said lighting position.

14. In a metal spray gun of the type including means for maintaining a melting zone, means for directing a blast of gas against metal which has been melted in said zone adapted to subdivide and convey such melted metal, a control cock for gases required in the operation of said gun, said control cock including a housing defining multiple inlets and corresponding outlets, and including a handle operated plug defining at least three passages, each of said passages controlling flow through one of said inlets and the corresponding outlet, at least one of said passages defining a port for combustible gas, at least one other a port for oxygen and at least one-third a port for a compressed non-combustible gas, the improvement comprising first gas bleeding means within said housing positioned to bring into communica-

tion said compressed non-combustible gas inlet and outlet in advance of the registry of said port for compressed non-combustible gas with its inlet and outlet in substantially lighting position, second gas bleeding means within said housing positioned to bring into communication said compressed non-combustible gas inlet and outlet in advance of the registry of said port for compressed non-combustible gas with its inlet and outlet in substantially lighting position, third bleeding means within said housing positioned to bring into communication said oxygen gas inlet and outlet in advance of the registry of said port for oxygen with its inlet and outlet in substantially lighting position and a detent positioned to arrest the motion of said plug when all of said bleeding means are in said lighting position.

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