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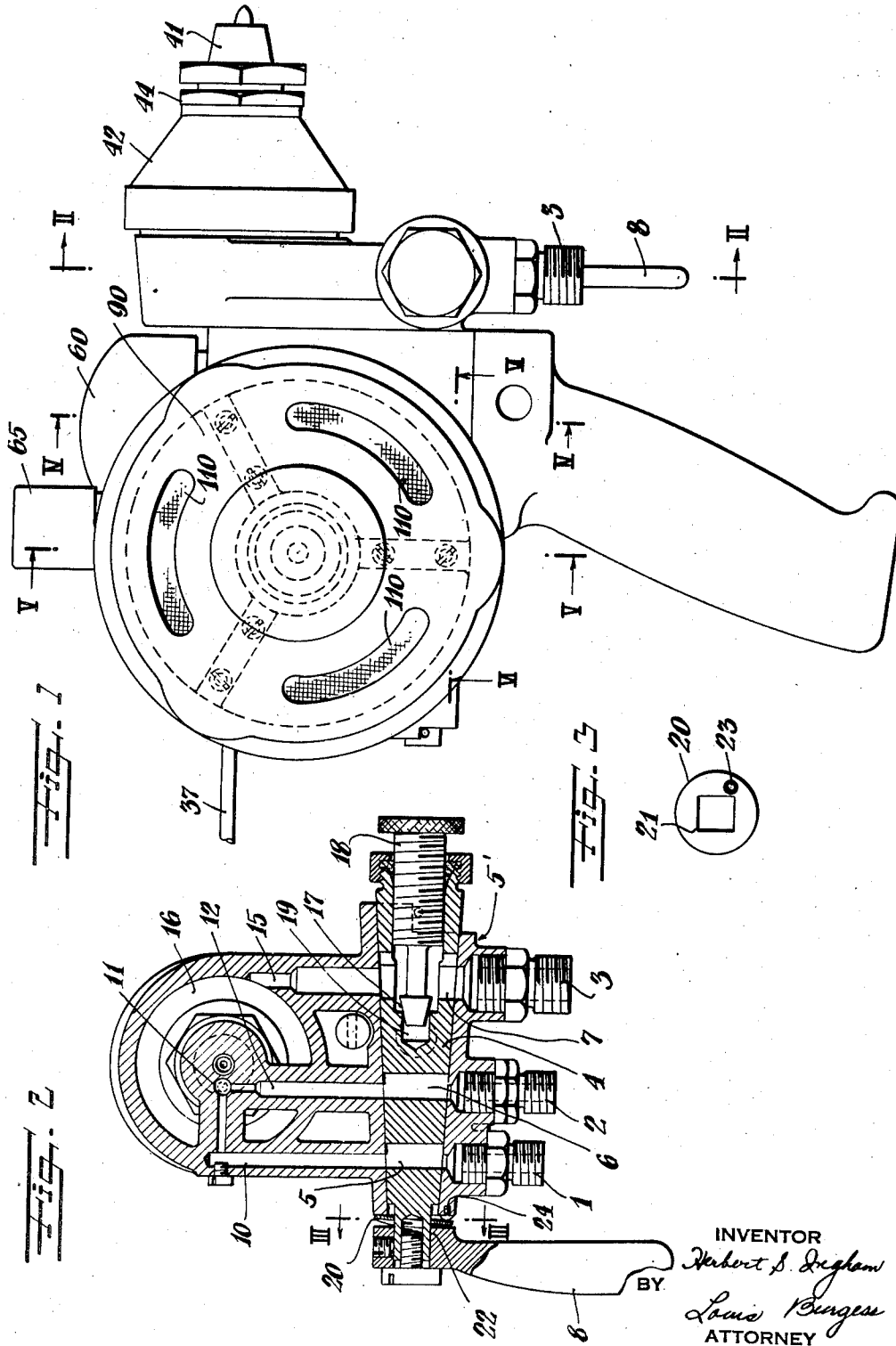
H. S. INGHAM

2,227,753

METAL SPRAY GUN

Filed Oct. 14, 1938

6 Sheets-Sheet 1



INVENTOR

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**Jan. 7, 1941.**

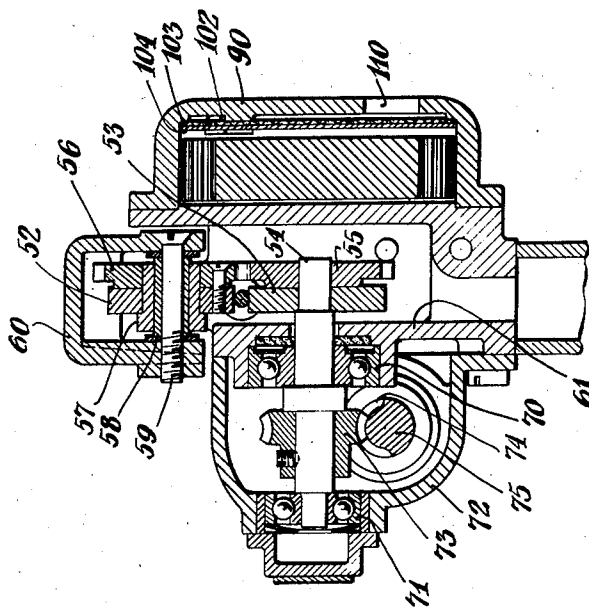
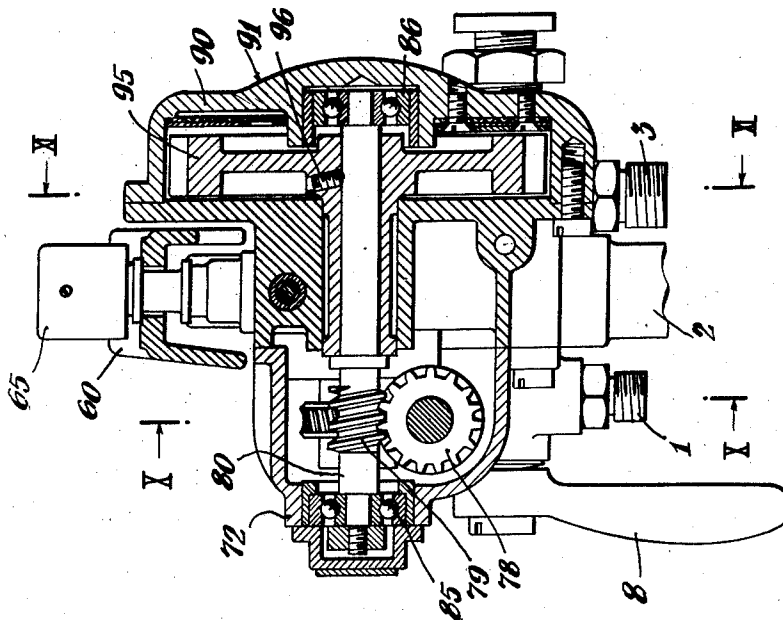
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**METAL SPRAY GUN**

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6 Sheets-Sheet 2



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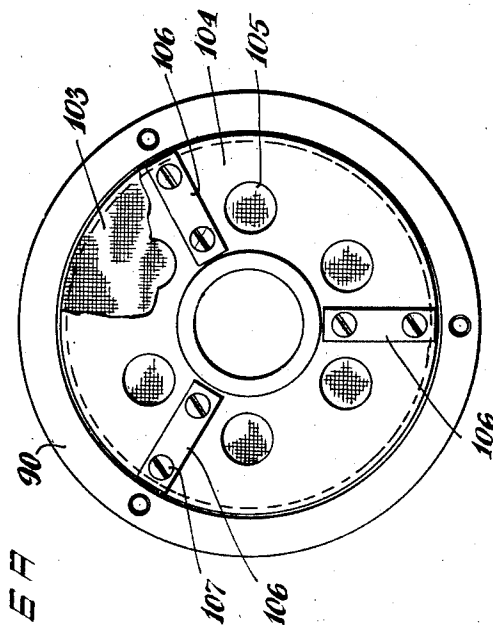
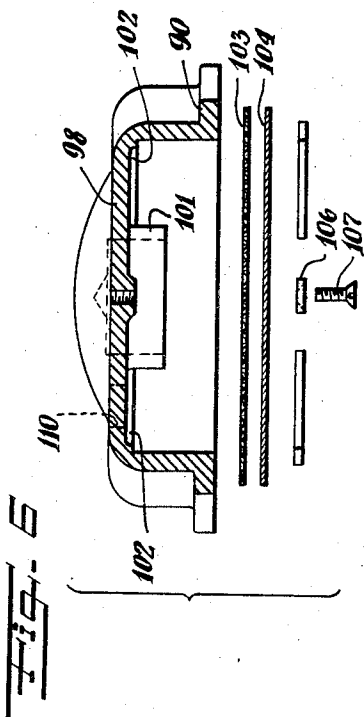
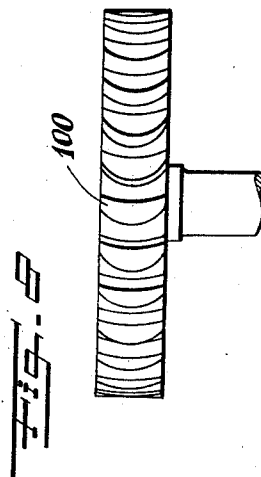
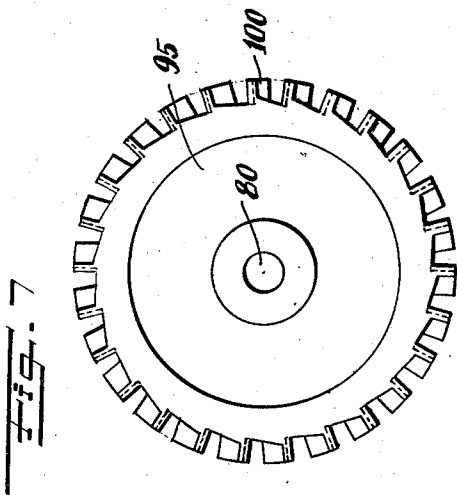
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METAL SPRAY GUN

Filed Oct. 14, 1938

6 Sheets-Sheet 3



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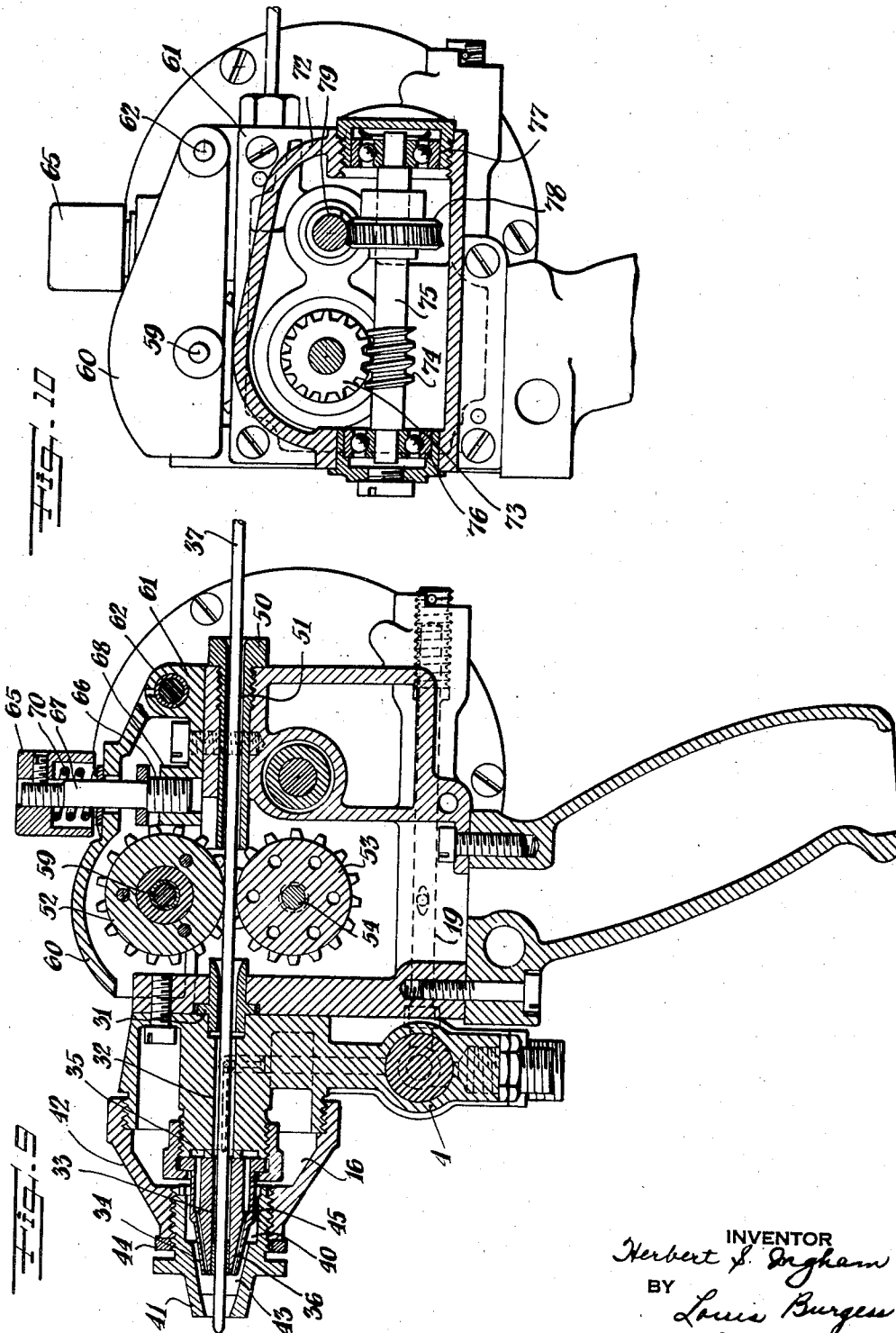
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Fig. 11

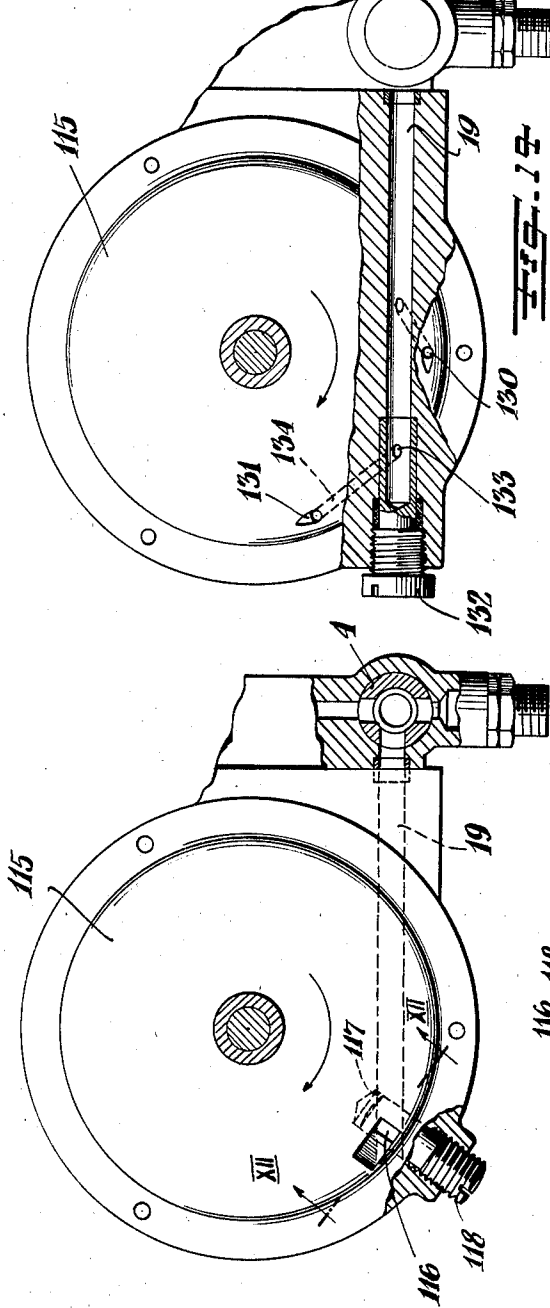


Fig. 12

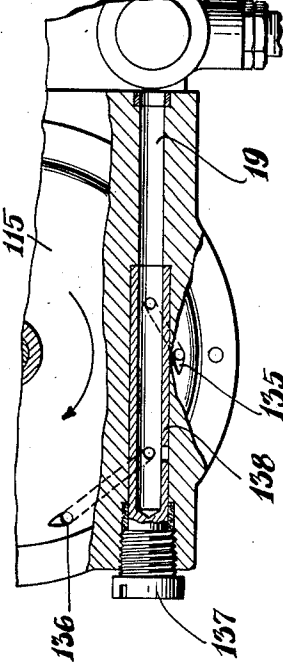
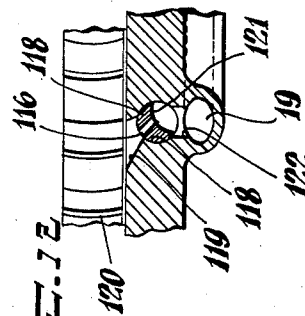


Fig. 13



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Fig. 15

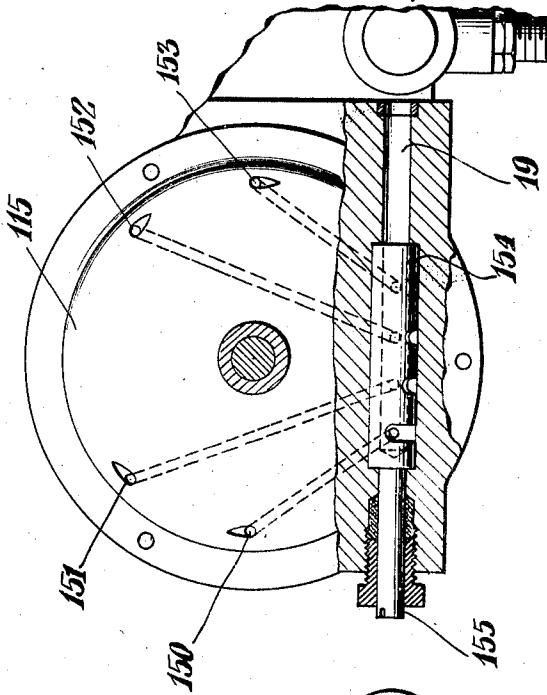
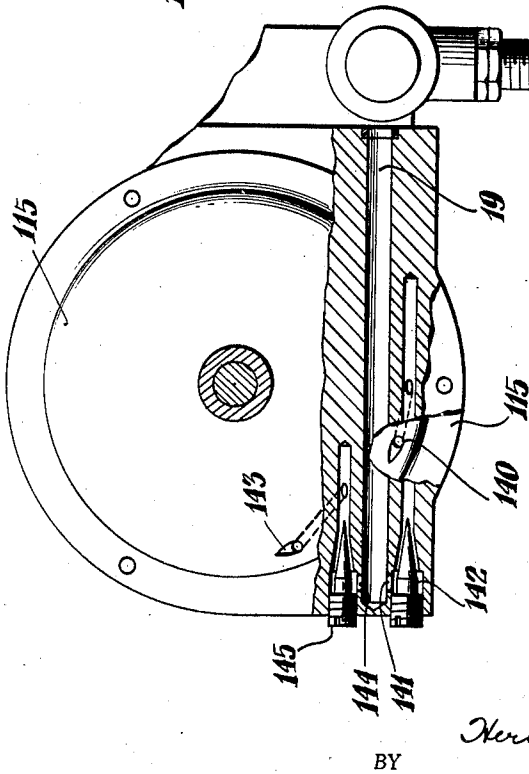


Fig. 15



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## UNITED STATES PATENT OFFICE

2,227,753

## METAL SPRAY GUN

Herbert S. Ingham, Jamaica, N. Y.

Application October 14, 1938, Serial No. 234,869

9 Claims. (Cl. 91-12.2)

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. 6a 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 a section through the construction shown in Fig. 11 on the plane indicated by XII-XII.

Fig. 13 is a section on the plane indicated by XI-XI in Fig. 5 showing an alternative embodiment of my invention.

Fig. 14 is a corresponding section showing a further alternative embodiment of my invention.

Fig. 15 is a corresponding section showing a further alternative embodiment of my invention.

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

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 average angle of the turbine nozzle or nozzles with respect to the turbine blades and this may be done within the scope of my invention, either by means for continuously varying the nozzle angle over a predetermined range, or by varying the same in steps. By use of the nozzle or nozzle setting which projects the gas most nearly in the direction in which the blades are travelling, thus giving the maximum propulsive component of the velocity of the gas, the stable range of greatest speed is obtained. The stable range of lesser operating speed is obtained by use of the nozzle or nozzle setting

which projects the gas less nearly in the direction in which the plates are travelling, thus giving a lesser propulsive component of the velocity of the gas.

5 In accordance with this principle, where I provide a turbine nozzle or nozzles, the average angle of which may be continuously varied, any number of stable operating turbine speeds may be obtained, within the limits for which the turbine was designed. Alternatively, I may apply 10 the principle of my invention by the use of a number of jets in which the average nozzle angle of some units or groups of the total number is different from the average nozzle angle of other 15 units or groups. Each of the units or groups is designed to maintain the turbine within a particular stable range of operating speeds and the change from one range to another is achieved by selecting a particular unit or group.

20 In either case above-referred to, when the particular adjustment for the desired operating speed range has been selected, the line pressure may be throttled to maintain the exact speed desired within this range.

25 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 30 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. 40 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 45 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 50 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 55 the valve passages may be opened but at such rates of flow as to establish favorable lighting conditions which are different from the conditions obtaining when the gun is in operation. This position of the valve is called the lighting 60 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 65 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 70 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 75 a slight pressure against handle 8 forces the de-

pression 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 10 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 gas 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 20 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 25 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 30 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 35 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 40 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 45 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 55 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 60 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 65 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 70 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 75

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. 6a). 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 operation for any given setting of the turbine nozzles by producing turbulent flow of gas within the turbine.

One nozzle falling within the purview of my invention is shown in Figs. 11 and 12. 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 angle. This nozzle is composed of the bore 117 and the plug 118 which is turned within bore 117 to vary the discharge angle of the nozzle. By reference to Fig. 12 it will be seen that by turning the plug 118 nozzle 116 discharging through the recess 119 against the blading 120 of the turbine drum can be made to assume any intermediate position between the mechanical limits. The back of the plug is cut away at 121 so that it will be at all times in communication with the manifold 19 through the side outlet 122.

The preferred form of nozzles for practical applications is that shown in Fig. 13 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 the nozzles 130 and 131 have different angles of discharge with respect to the turbine blading and the nozzle 131 discharges the gas with a lower propulsive component than nozzle 130. In this case it is evident that when both jets are in operation the average nozzle angle is such that the average propulsive component of the velocities is less than when nozzle 130 is in operation alone and, therefore, with both nozzles in use, a stable range of slower operating speeds is obtained. The pres-

sure in manifold 19 will be so controlled, either by the provision of a fixed orifice, or by throttling that the air pressure in manifold 19 is such as to drive the turbine within the range of lower operating speed.

A further alternative form of construction is shown in Fig. 14 in which case I have shown two nozzles, 135 and 136, which may be brought alternatively into communication with manifold 19 by turning the plug 137 so that the 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 angle of discharge of one nozzle is different from the angle of discharge of the other nozzle, so that the propulsive component of the gas delivered from one nozzle is different than the propulsive component of the gas delivered from the other nozzle, and the stable range of lower operating speed is obtained by the use of the nozzle which delivers with the lesser propulsive component of the velocity.

A further alternative embodiment of my invention is shown in Fig. 15. This also comprises two nozzles which may be alternatively used. Nozzle 140 is in communication with manifold 19 through side arm 141 controlled by needle valve 142. Nozzle 143 is in communication with manifold 19 through side arm 144 controlled by needle valve 145. The angle of discharge of nozzle 140 is different from the angle of discharge of nozzle 143 with respect to the turbine blading. A lower stable operating speed is obtained by the use of the nozzle which has the lesser propulsive component of the velocity of the gas discharged. Since in this case the amount of gas discharged through either jet may be accurately controlled by the needle valve so that the turbine operates within the range for which the jet was designed, 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. 16 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, so that any one of the nozzles may be brought respectively into communication with manifold 19 by turning the plug 155. The angle of discharge of each nozzle with respect to the turbine blading is different from the angle of discharge of any other nozzle, i. e., the propulsive component of the velocity of the gas discharged is different and any one of four stable ranges of speed may be obtained by the use of the nozzle appropriate to the particular range.

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 means controlling the supply of combustible gas and oxygen, 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 for varying

the angle of discharge of said nozzle means with respect to the direction of travel of said blading, independent of the means controlling the supply of combustible gas and oxygen to said gun.

5 2. The improvement in a metal spray gun according to claim 1 in which said turbine comprises in addition a manifold in communication with said nozzle means and pressure reduction means between the inlet for compressed gas and  
10 said manifold.

3. 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  
15 of gas therein in air frictional engagement with said rotor drum.

4. In a metal spray gun of the molten metal gas blast type having means controlling the supply of combustible gas and oxygen, an inlet for  
20 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  
25 improvement comprising means for varying the angle of discharge of said nozzle with respect to the direction of travel of said blading, independent of the means controlling the supply of combustible gas and oxygen to said gun.

30 5. The improvement in a metal spray gun according to claim 4 in which said turbine comprises in addition a manifold in communication with said nozzle means and pressure reduction means between the inlet for compressed gas and  
35 said manifold.

6. The improvement in a metal spray gun according to claim 4 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  
5 said rotor drum.

7. In a metal spray gun of the molten metal gas blast type having means controlling the supply of combustible gas and oxygen, an inlet for compressed gas, and turbine actuated means for  
10 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 angle of discharge of at least a part  
15 of said nozzles being different from the angle of discharge of the remainder of said nozzles, the improvement comprising means for selectively placing a part of said nozzles in use independent of the means controlling the supply of  
20 combustible gas and oxygen to said gun.

8. The improvement in a metal spray gun according to claim 7 in which said turbine comprises in addition a manifold in communication with said nozzle means and pressure reduction  
25 means between the inlet for compressed gas and said manifold.

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

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