(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 857 515 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.08.1998 Bulletin 1998/33

(51) Int. Cl.[6]: **B05B 5/04**

(21) Application number: **97122068.6**

(22) Date of filing: **15.12.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **05.02.1997 US 795077**

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(54) Exhausting turbine air from powder coating apparatus

(57) A coating dispensing head includes a rotary dispensing device and a rotator for rotating the rotary dispensing device. The head includes a first connection for supplying the coating to the dispensing device and a second connection for supplying motive power to the rotator. The coating is a pulverulent material entrained in a stream of fluidizing gas and the rotator is a compressed gas driven turbine rotator having an output shaft extending from a first side of the turbine rotator. The dispensing device is mounted on the output shaft. The turbine rotator has a second side facing in a direction generally opposite the first side. The turbine rotator includes at least one exhaust passageway having an exhaust port provided on the second side of the turbine rotator.

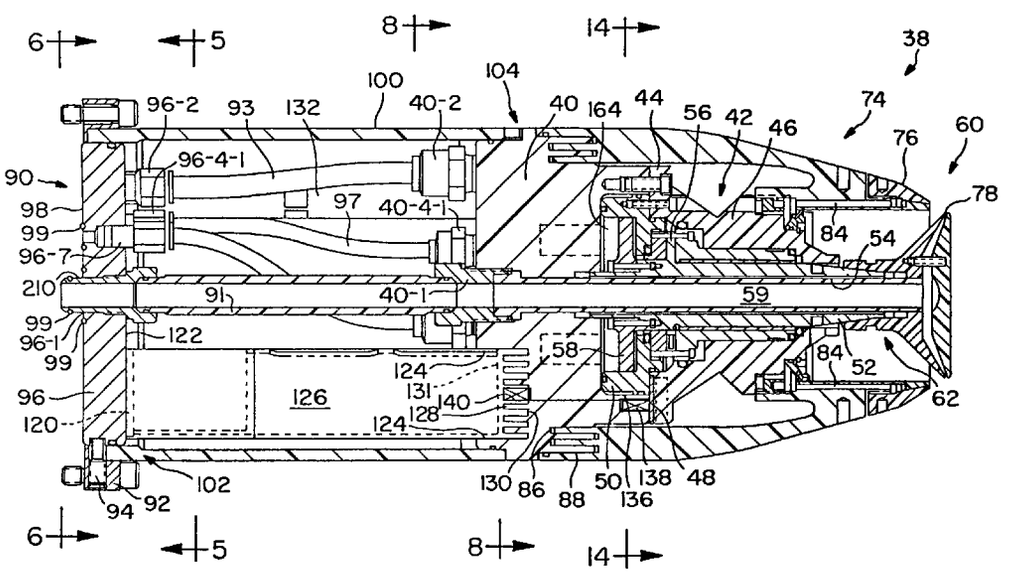

FIG. 1

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Description

Background of the Invention

This invention relates to improvements in the uniformity of powder coatings on articles coated by coating powders.

A number of rotary coating dispensing systems are known. There are, for example, the systems illustrated and described in U.S. Patents: 3,536,514; 4,037,561; 4,114,564; 4,381,079; 4,447,008; 5,353,995; and, 5,433,387; "Aerobell™-Powder Applicator ITW Automotive Division"; and, "Aerobell™ & Aerobell Plus™ Rotary Atomizers, DeVilbiss Ransburg Industrial Liquid Systems." Certain of these rotary coating dispensing systems are designed to dispense powder coatings. See, for example, U.S. Patents: 3,536,514; 4,037,561; 4,114,564; and, 5,353,995; and Aerobell™-Powder Applicator.

A number of other powder coating dispensing systems are known. There are, for example, the systems illustrated and described in U.S. Patents: 3,263,127; 3,870,232; 4,024,815; 4,116,384; 4,232,832; 4,235,381; 4,788,933; 4,993,645; 5,022,590; 5,240,185; 5,323,547; and, 5,335,828; German Offenlegungsschrift (OLS) 28 37 428; OLS 24 46 022; French Published Patent Application 2 605 533; and, "Aerobell™ and Aerobell Plus™ Rotary Atomizers, DeVilbiss Ransburg Industrial Liquid Systems."

No representation is intended that a complete search has been made of the prior art, or that no better art references than those here noted are available.

Among the above identified prior art, U.S. Patent 5,353,995 appears to teach venting of rotary atomiser turbine rotator exhaust forward of the turbine rotator, that is, toward the powder cloud formed around the rotary atomiser. U.S. Patent 4,447,008 contains such a teaching in the context of a rotary liquid atomizer. Indeed, U.S. Patent 4,447,008, for example, teaches that exhausting the turbine forward into the center of the atomized liquid coating material cloud can provide better control of the liquid coating material pattern.

Summary of the Invention

According to the invention, a coating dispensing head includes a rotary dispensing device and a rotator for rotating the rotary dispensing device. The head includes a first connection for supplying the coating to the dispensing device and a second connection for supplying motive power to the rotator. The coating is a pulverulent material entrained in a stream of fluidizing gas and the rotator is a compressed gas driven turbine rotator having an output shaft extending from a first side of the turbine rotator. The dispensing device is mounted on the output shaft. The turbine rotator has a second side facing in a direction generally opposite the first side. The turbine rotator includes at least one exhaust passageway having an exhaust port which exhausts on the second side of the turbine rotator.

Illustratively, the apparatus further comprises a housing having first and second housing portions. The first housing portion generally encloses the first side of the turbine rotator and output shaft, and the second housing portion generally encloses the second side of the turbine rotator. The exhaust port communicates with the inside of the second housing portion.

Further illustratively, the exhaust port is provided on the second side of the turbine rotator.

Additionally illustratively, a muffler is mounted to receive turbine exhaust from the exhaust port.

Brief Description of the Drawings

The invention may best be understood by referring to the following detailed description and accompanying drawings which illustrate the invention. In the drawings:

Fig. 1 illustrates a longitudinal sectional view through a powder dispenser embodying the present invention;

Fig. 2 illustrates another longitudinal sectional view through a detail of the powder dispenser illustrated in Fig. 1;

Fig. 3 illustrates an exploded longitudinal sectional view through a detail of the powder dispenser illustrated in Fig. 1;

Fig. 4 illustrates an exploded longitudinal sectional view through a detail of the powder dispenser illustrated in Fig. 1;

Fig. 4a illustrates an enlarged fragmentary view of a detail of Fig. 4;

Fig. 5 illustrates a sectional view through the powder dispenser illustrated in Fig. 1, taken generally along section lines 5-5 of Fig. 1;

Fig. 6 illustrates a view of the powder dispenser illustrated in Fig. 1, taken generally along section lines 6-6 of Fig. 1;

Fig. 7 illustrates a sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section lines 7-7 of Figs. 5-6;

Fig. 8 illustrates a sectional view through the powder dispenser illustrated in Fig. 1, taken generally along section lines 8-8 of Fig. 1;

Fig. 9 illustrates a side elevational view of certain details of the powder dispenser illustrated in Fig. 1;

Fig. 10 illustrates a view of the details of the powder dispenser illustrated in Fig. 9, taken generally along section lines 10-10 of Fig. 9;

Fig. 11 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 11 and the axis of Fig. 8;

Fig. 12 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 12 and

the axis of Fig. 8;

Fig. 13 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 13 and the axis of Fig. 8;

Fig. 14 illustrates a sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section lines 14-14 of Fig. 1;

Fig. 15 illustrates a fragmentary, exploded, partial longitudinal sectional view of a detail of the powder dispenser illustrated in Fig. 1;

Fig. 16 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 16 and the axis of Fig. 8;

Fig. 17 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 17 and the axis of Fig. 8;

Fig. 18 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section lines 18-18 of Fig. 8;

Fig. 19 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 19 and the axis of Fig. 8;

Fig. 20 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 20 and the axis of Fig. 8;

Fig. 21 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 21 and the axis of Fig. 8;

Fig. 22 illustrates a fragmentary sectional view through a detail of the powder dispenser illustrated in Fig. 1, taken generally along section line 22 and the axis of Fig. 8;

Fig. 23 illustrates an elevational view of a mounting plate for mounting the powder dispenser illustrated in Fig. 1;

Fig. 24 illustrates a sectional view through the mounting plate illustrated in Fig. 23, taken generally along section lines 24-24 of Fig. 23;

Fig. 25 illustrates a powder coating material thickness profile achieved with a forward exhausting dispensing head; and,

Fig. 26 illustrates a powder coating material thickness profile achieved with a dispensing head exhausted rearwardly according to the invention.

Detailed Description of an Illustrative Embodiment

A rotary powder dispenser 38 according to the invention includes a manifold 40. Manifold 40 illustratively is constructed from, for example, Acetron® GP general purpose acetal available from DSM Engineering Plastic Products, Incorporated, Reading, Pennsylvania 19612-4235. An air turbine motor assembly 42 is mounted from a front side 44 of manifold 40 and extends forward therefrom. Motor assembly 42 includes a turbine motor housing 46 constructed from, for example 150SA or 550SA Delrin® material, a high voltage contact plate 48 constructed from, for example, aluminum, a turbine air nozzle plate 50 constructed from, for example, aluminum, an air turbine shaft 52 having a central axial passageway 54 therethrough, a thrust bearing spacer 56 and a turbine rotor 58. The turbine motor assembly 42 can be, for example a part D1245-07 available from Westwind Air Bearings, Inc., 745 Phoenix Drive, Ann Arbor, Michigan 48108. A, for example, glass reinforced Delrin® feed tube 59 extends down the center of passageway 54.

A powder bell cup assembly 60 is threaded onto front end 62 of shaft 52. Powder bell cup assembly 60 includes a bell cup 64 constructed from, for example, filled or unfilled polyetheretherketone (PEEK), a bell cup insert or liner 66 constructed from, for example, Teflon® or Delrin® material, and a diffuser 68 also constructed from, for example, Teflon® or Delrin® material, all held together by three equally circumferentially spaced slotted flat head screws 70. Diffuser 68 illustratively is configured as illustrated and described in U.S.S.N. 08/377,816 filed January 25, 1995. The outer surfaces 74 of bell cup 64 are treated as described in U.S.S.N. 08/451,570 filed May 26, 1995, U.S.S.N. 08/437,218 filed May 8, 1995, and U.S.S.N. 08/451,541 filed May 26, 1995. These four applications are incorporated herein by reference. The material from which bell cup 64 is constructed accepts the above-identified treatment of its outside surfaces 74 well. The material from which the liner 66 is constructed has somewhat less susceptibility to impact fusion of many coating powders of the type being dispensed by dispenser 38.

A somewhat projectile-shaped front shroud 74 having a shaping air ring cap 76 houses the forward part of manifold 40, turbine motor assembly 42, and most of powder bell cup assembly 60 except the forwardmost portions thereof, including the powder discharge slot 78 defined between liner 66 and diffuser 68. Radially outwardly and axially extending ribs 80 provided on shroud 74 help define between shroud 74 and shaping air-ring cap 76 an annular shaping air slot which is provided with shaping air through passageways 81, 82, 84 provided in manifold 40, turbine housing 46, and front shroud 74, respectively. The complementary, mating surfaces 86, 88 of shroud 74 and manifold 40 are labyrinthine in configuration to provide longer pathways across the surfaces of these two components. This reduces the likelihood of tracking of the high magnitude electrical potential which is impressed upon, for example, high voltage contact plate 48 during operation of dispenser 38 back to, for example, grounded dispenser 38 support.

A rear manifold plate assembly 90 includes a rear

manifold mounting flange 92 attached by three equally circumferentially spaced screws 94 to a rear manifold mounting plate 96. The rearward surface 98 of plate 96 is finished flat and smooth. A generally right circular cylindrical rear shroud 100 is captured at its rearward extent in an annular groove 102 provided by adjacent surfaces of plate 96 and flange 92 and at its forward extent in an annular groove 104 provided on the rearwardly facing side of manifold 40. Appropriate fittings and lines connect the respective fluidized PowDeR (fittings 96-1 and 40-1 and line 91), powder cloud SHaPing air (fittings 96-3 and 40-3 and line 95), turbine DRiVing air (fittings 96-2 and 40-2 and line 93), turbine BeaRinG air 1 and 2 (fittings 96-4-1, 96-4-2, 40-4-1 and 40-4-2 and lines 97 and 103) and turbine BRaKing air ports (fittings 96-5 and 40-5 and line 101) on plate 96 and manifold 40. Turbine air EXHaust ports 1 and 2 (ports 96-6) in plate 96 vent turbine exhaust air from within rear shroud 100 This air is exhausted from turbine 42 through mufflers 106 fitted to the two EXHaust ports (40-6) on manifold 40.

FiberOptic speed control fittings (40-7 and 96-7) are provided on both manifold 40 and plate 96. The FiberOptic speed control fitting 96-7 on plate 96 is intersected by a threaded bore 108 which extends into plate 96 from its edge 110. A cap screw is threaded into bore 108 to provide for the precise location of an optical fiber terminal 114 at the flat surface 98 of plate 96. This facilitates matching of the optical fiber terminal 114 to a lens mounted in a flat plate onto which plate 96 is mounted by bolts 116 for quick and easy replacement. This mechanism avoids the time consuming necessity of aligning terminal 114 with the lens if dispenser 38 should have to be removed for any reason including replacement by a similarly designed dispenser. The fluidized PowDeR (96-1), powder cloud SHaPing air (96-3), turbine DRiVing (air 96-2), turbine BeaRinG air (96-4-1 and 96-4-2) and turbine BRaKing air (96-5) ports on surface 98 are provided with surrounding O-ring seals 99.

A generally right rectangular cylindrical boss 120 is provided on the forward or inside surface 122 of plate 96. A generally right circular cylindrical relief 124 is provided on the rearward surface of manifold 40 directly opposite boss 120. An ITW Ransburg MICRO-PAK™ high voltage transformer and cascade-type voltage multiplier 126 is captured between boss 120 and relief 124. The floor 128 of relief 124 is labyrinthine to complement the configuration of high magnitude potential output end 130 of high voltage multiplier 126. Again, this configuration provides longer pathways across the surfaces of multiplier 126 and manifold 40 from the high magnitude potential terminal 131 of multiplier 126 to ground. Manifold 40, turbine motor assembly 42 and front shroud 74 are supported from rear manifold plate 96 by four equally circumferentially spaced support rods 132 which have threaded ends for threading into complementarily threaded holes 133 provides therefor in manifold 40. Support rods 132 are attached to plate 96 by cap screws 135.

Bearing air is supplied to the-turbine 42 air bearing through the 1 BRG port. The 2 BRG port couples the air bearing to a pressure sensing switch, not shown. If the switch senses the loss of pressure in the air bearing, the flows of fluidized powder coating material and driving air are halted and the turbine 42 is permitted to coast to a stop in an effort to save the turbine 42.

Low alternating current voltage, for example 12VAC-30VAC, is supplied through the LowVoltage connector 96-8 on plate 96 to the low voltage terminals of multiplier 126. LowVoltage connector 96-8 is also held in place by a cap screw (not shown) threaded into a bore 137 in the edge 110 of plate 96. Bore 137 intersects the bore into which connector 96-8 is fitted. A, for example, phosphor bronze, wire 136 has several coils of compression spring 138 formed at one end thereof. The end 140 of wire 136 opposite spring 138 fits into the cavity in multiplier 126 in which terminal 131 is provided. The spring 138 is compressed in contact with high voltage contact plate 48 during assembly of turbine 42 to manifold 40.

BeaRinG air for turbine 42 is supplied from fitting 40-4-1 through passageways 144 to the air bearing 145 of turbine 42. This bearing air is sensed through passageways 146 by the above mentioned air BeaRinG pressure sensing switch connected to fitting 40-4-2. If BeaRinG air pressure is present at fitting 40-4-2, DRiVing air for turbine 42 flows forward through fitting 40-2 and passageways 150 from which it flows through the turbine 42 nozzles 152 and against the blades of the turbine rotor 58 to rotate rotor 58 and the powder bell cup assembly 60 mounted on the end 62 of shaft 52.

Turbine 42 rotation rate signals are coupled back through, for example, a DeVilbiss Ransburg model LSMC 5003 inductive-to-fiber optic signal transmitter 156 which generates a pulse of light each time it senses the passage of a small magnetic disk (not shown) mounted in the rearwardly facing surface of rotor 58 facing transmitter 156. This signal is transmitted through fiber optic coupler 114 to surface 98 of plate 96 for further transmission through, for example, another similar fiber optic coupler (not shown) to turbine 42 speed control equipment (not shown) which controls the supply of DRiVing air to fitting 96-2, thereby controlling the turbine 42 rotation rate.

BRaKing air to slow the turbine 42 rotation rate is supplied from fitting 40-5 through passageways 160 to a braking air nozzle 162 which directs braking air, when it is supplied to fitting 40-5 at braking air buckets formed in the rearwardly facing surface of rotor 58.

Exhaust air from the low pressure side 164 of turbine 42 is exhausted through passageways 40-6 and mufflers 106 into rear shroud 100. From shroud 100, the exhaust air is vented through the 1 EXHaust and 2 EXHaust ports in plate 96. In this way, the turbine 42 exhaust is conducted in a direction away from the area

radially directly outwardly from slot 78 where the dispensed powder cloud is formed and sustained, rather than being exhausted in a direction generally toward the powder cloud.

As best illustrated by comparing Figs. 25 and 26, an appreciable increase in the uniformity of the thickness of powder coating material on an article to be coated can be achieved by exhausting the turbine 42 rearwardly rather than forwardly as taught by, for example, U.S. Patent 4,447,008. It should be noted that the coating material delivery rates to the prior art powder coating dispenser, operation of which yielded Fig. 25, and the powder coating dispenser 38 of the present invention, operation of which yielded Fig. 26 were different. This is reflected in the different scales on the abscissas of Figs. 25 and 26. Specifically, the prior art powder coating dispenser was supplied 300 grams of powder per minute to generate the curve of Fig. 25. The powder coating dispenser 38 was supplied 200 grams of powder per minute to generate the curve of Fig. 26. It is not believed that providing the same delivery rates to both the prior art dispenser and dispenser 38 would negate the results illustrated by comparison of the overall profiles of Figs. 25 and 26.

The powder cloud is shaped by SHaPing air supplied through fitting 96-3, line 95, fitting 40-3 and passageways 81, 82 and 84.

Referring now to Figs. 23-24, a mating plate 200 has a flat forward surface 202 facing the rearward surface 98 of plate 96. Threaded openings 204 are circumferentially equally spaced around surface 202 for receiving cap screws 206 in flange 92. Tightening of cap screws 206 in openings 204 compresses the O-rings 99 between surfaces 98 and 202 around mating fluidized PowDeR, DRiVing air, SHaPing air, BeaRinG air 1 and 2, BRaKing air, FiberOptic and EXHaust air 1 and 2 openings in both of plates 96 and 200. This constructions effectively seals each of these passageways anytime the two plate 96, 200 are so secured to each other, and permits the quick and easy disconnection, reconnection and, if necessary or desirable, replacement of dispenser 38 with another dispenser of like or similar configuration.

Because the fluidized powder supplied to fitting 96-1 is somewhat penetrating, the configuration of the PowDeR fitting 96-1 of the quick disconnect 96, 200 is somewhat different. Specifically, fitting 96-1 includes a nipple 210 provided with an additional O-ring seal 99. The nipple 210 of fitting 96-1 slides into, and is sealed by this additional O-ring 99 within, a relief 212 provided for the nipple 210 in surface 202 of plate 200. Plate 200 is mounted on any desired type of mounting, such as a stand, reciprocator, or the like, which presents powder bell cup assembly 60 at a suitable position adjacent articles to be coated by powder coating material to be dispensed therefrom.

Claims

1. A coating dispensing head including a rotary dispensing device, a rotator for rotating the rotary dispensing device, the head including a first connection for supplying the coating to the dispensing device and a second connection for supplying motive power to the rotator, the coating being a pulverulent material entrained in a stream of fluidizing gas, the rotator being a compressed gas driven turbine rotator having an output shaft extending from a first side of the turbine rotator, the dispensing device mounted on the output shaft, the turbine rotator having a second side facing in a direction generally opposite the first side, the turbine rotator including at least one exhaust passageway having an exhaust port, the exhaust port exhausting on the second side of the turbine rotator.

2. The apparatus of claim 1 further comprising a housing having first and second housing portions, the first housing portion generally enclosing the first side of the turbine rotator and output shaft and the second housing portion generally enclosing the second side of the turbine rotator, the exhaust port communicating with the inside of the second housing portion.

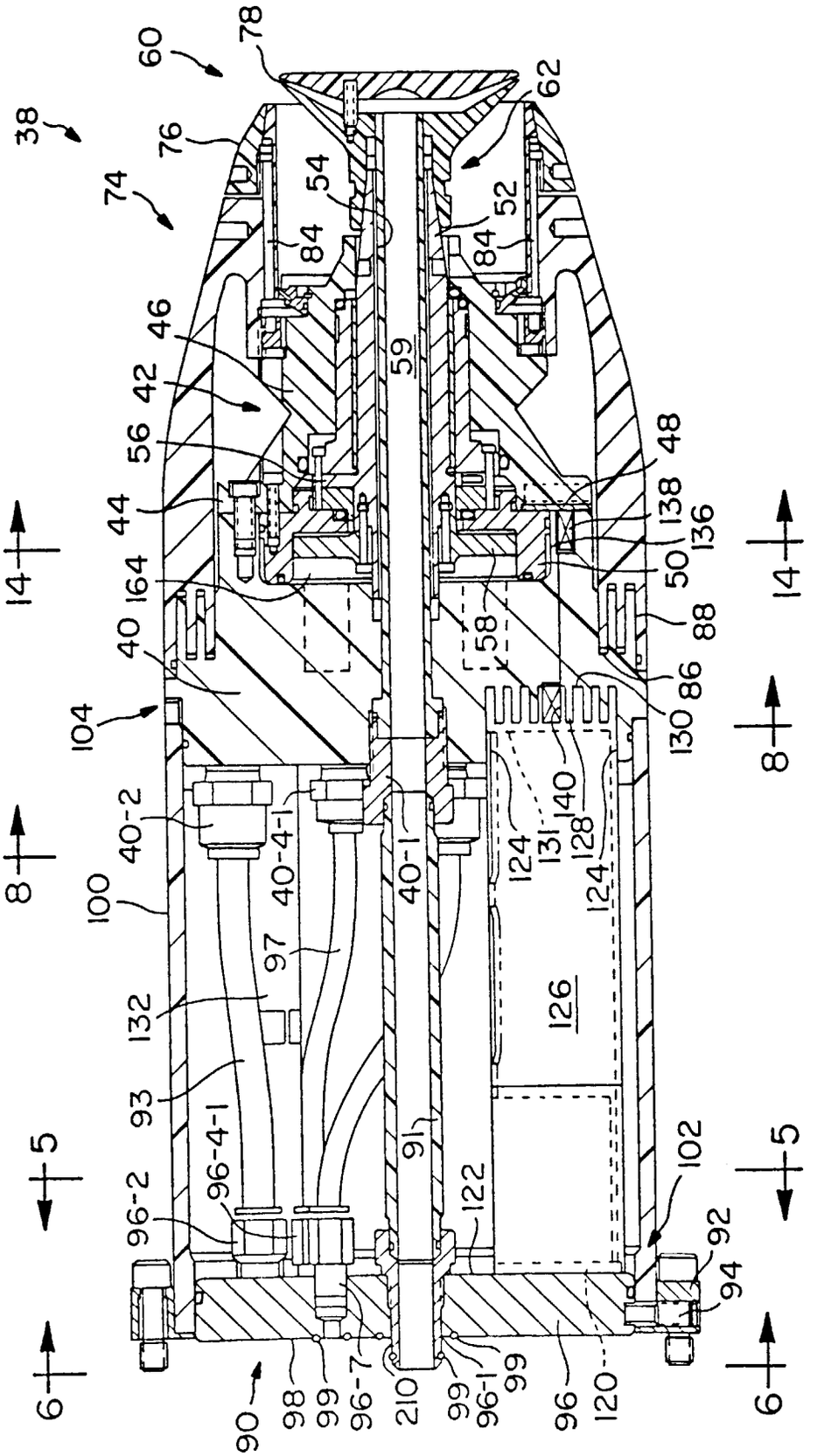
3. The apparatus of claim 2 wherein the exhaust port is provided on the second side of the turbine rotator.

4. The apparatus of claim 3 further comprising a muffler mounted to receive turbine exhaust from the exhaust port.

5. The apparatus of claim 2 further comprising a muffler mounted to receive turbine exhaust from the exhaust port.

6. The apparatus of claim 1 wherein the exhaust port is provided on the second side of the turbine rotator.

7. The apparatus of claim 6 further comprising a muffler mounted to receive turbine exhaust from the exhaust port.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42
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40-4-1
40-1
124
131
140
128
124
100
97
126
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96-4-1
91
122
102
96-2
92
94
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96-7
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96-1
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14
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5
6
6

FIG. 1

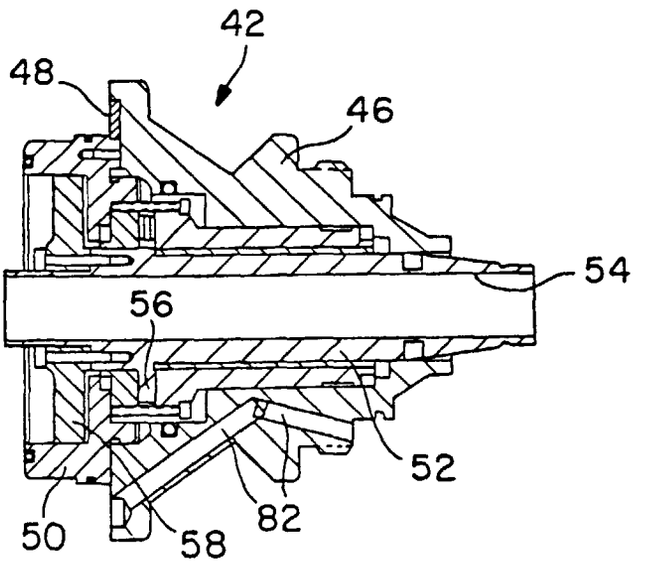


FIG. 2

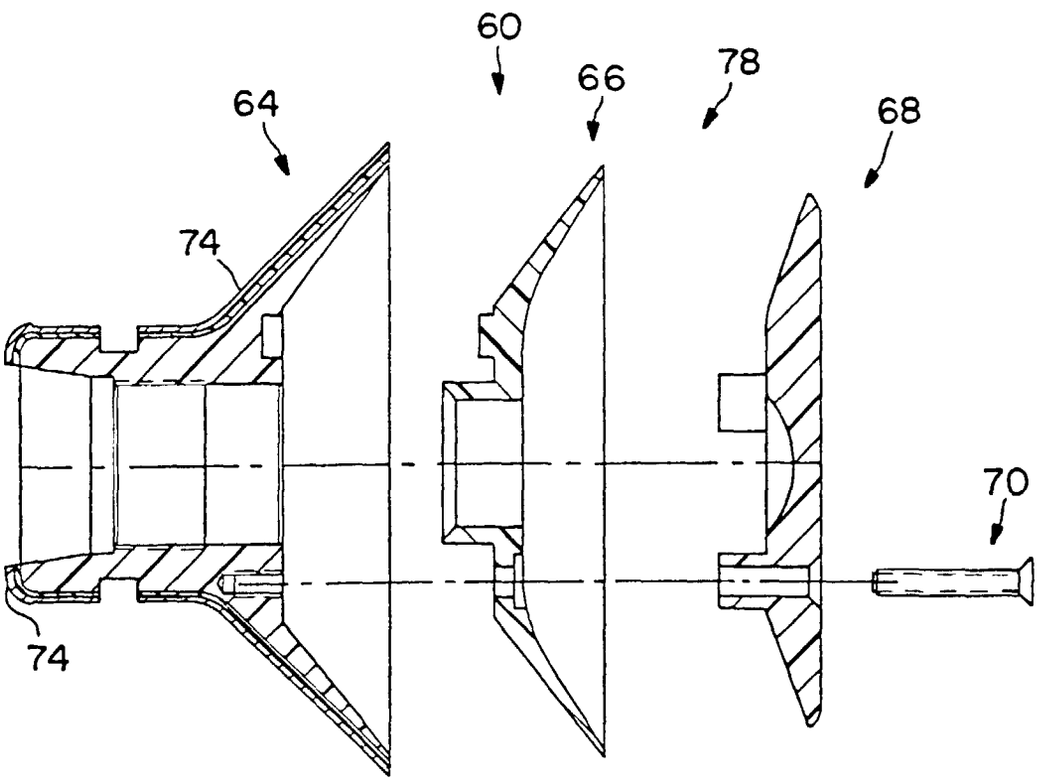


FIG. 3

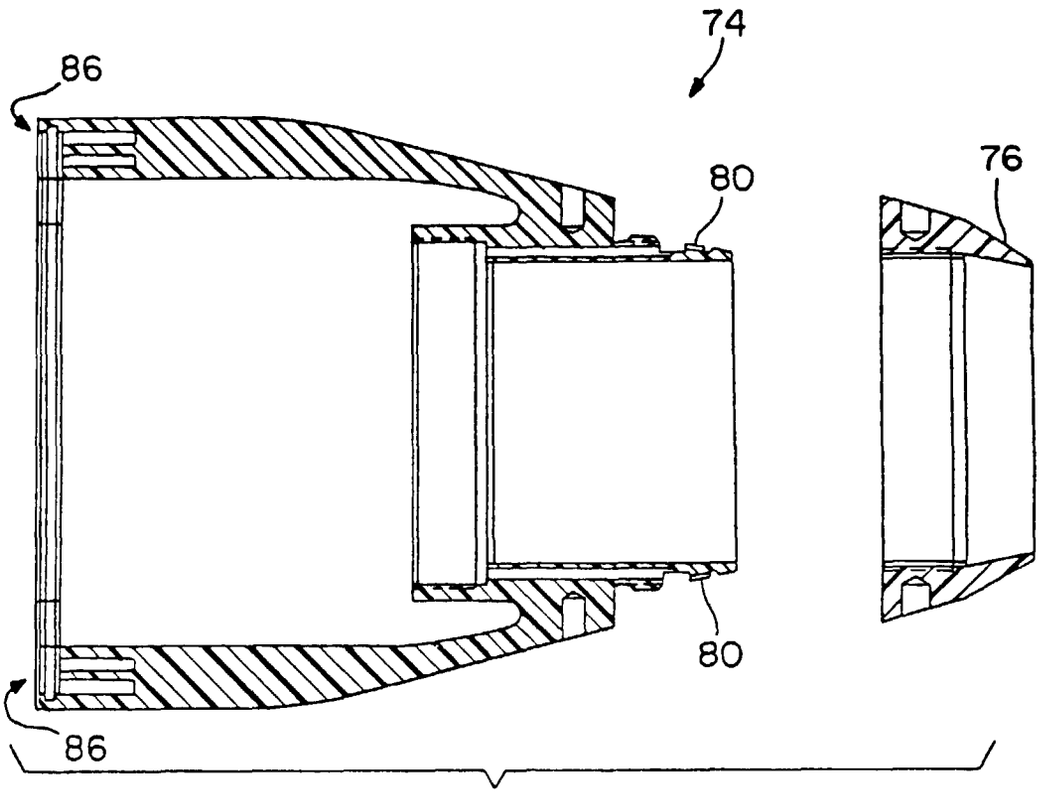


FIG. 4

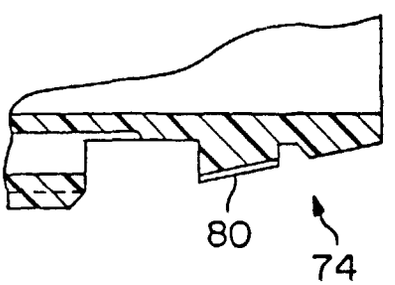
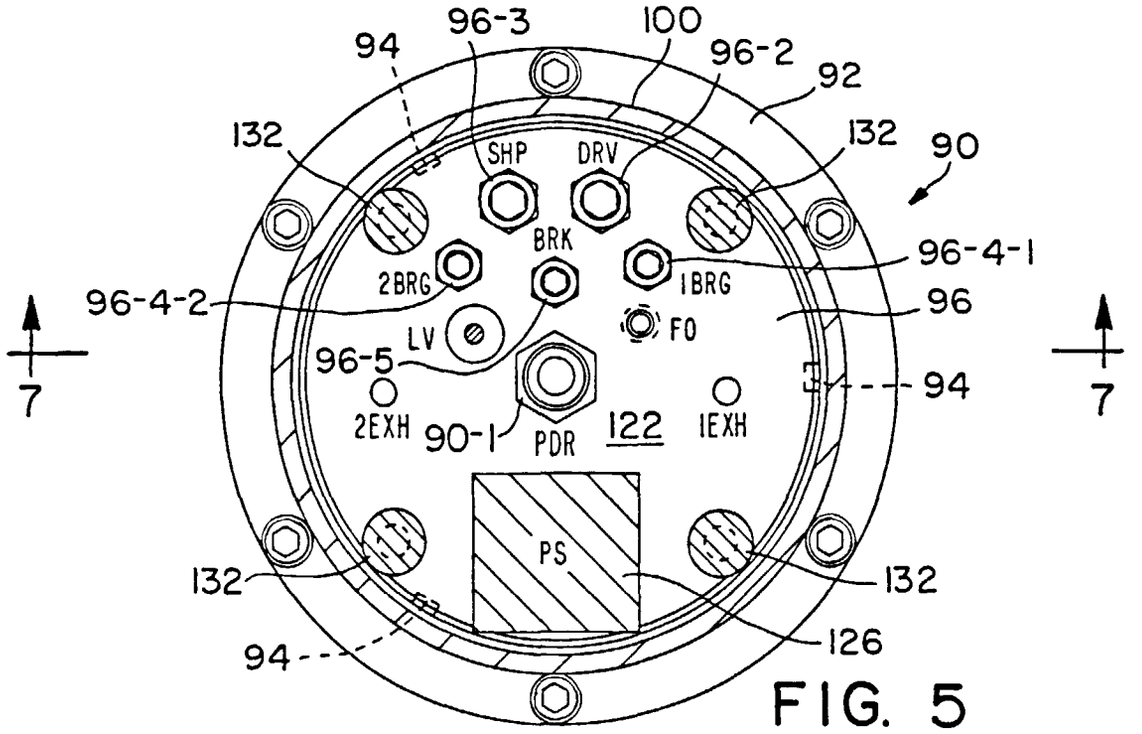


FIG. 4A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100
94
96-2
92
132
SHP
DRV
132
90
BRK
96-4-1
2BRG
1BRG
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96
LV
FO
96-5
94
2EXH
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PDR
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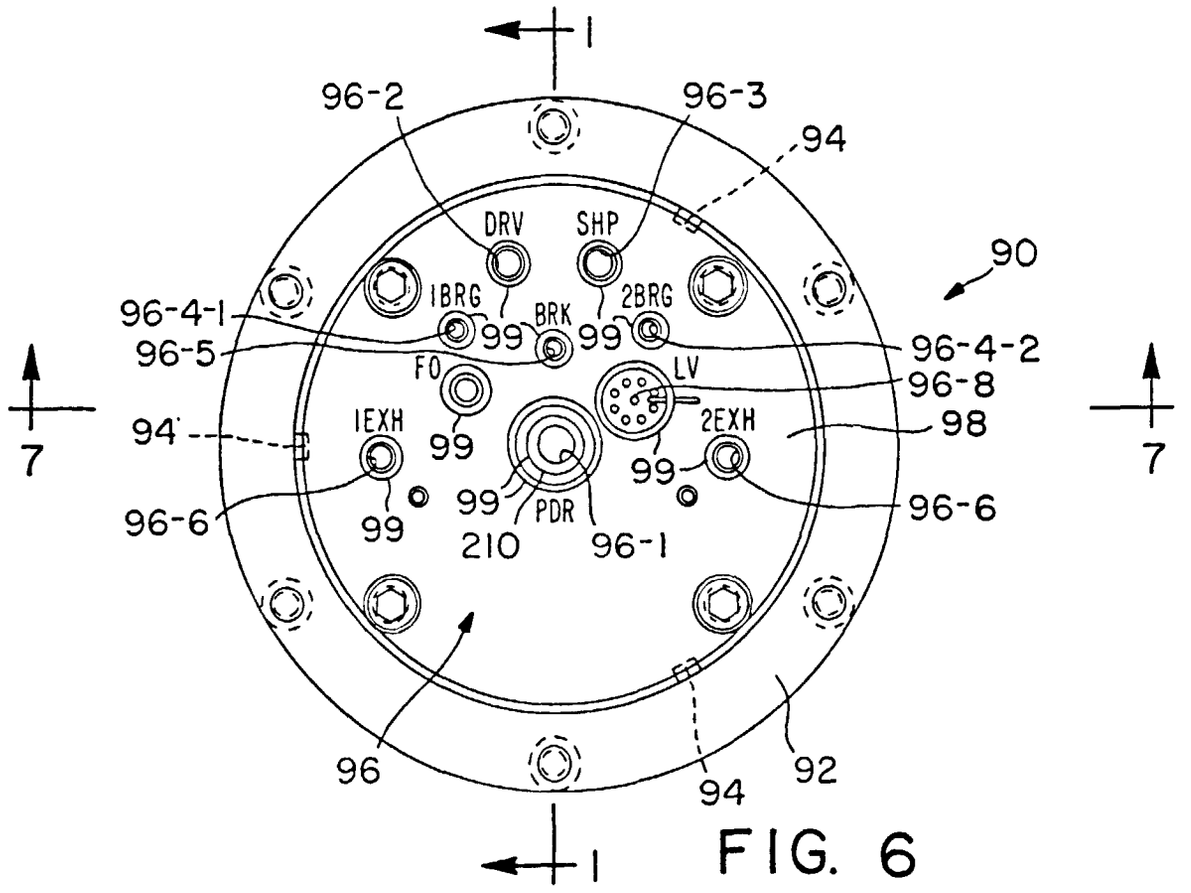
7
7
PS
132
132
126
94

FIG. 5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DRV
SHP
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96-4-1
BRK
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FO
LV
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7
7
94
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96-1
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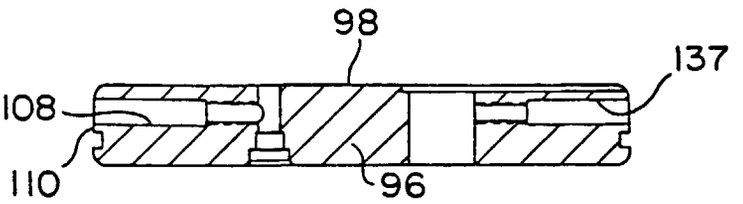
94
92
1

FIG. 6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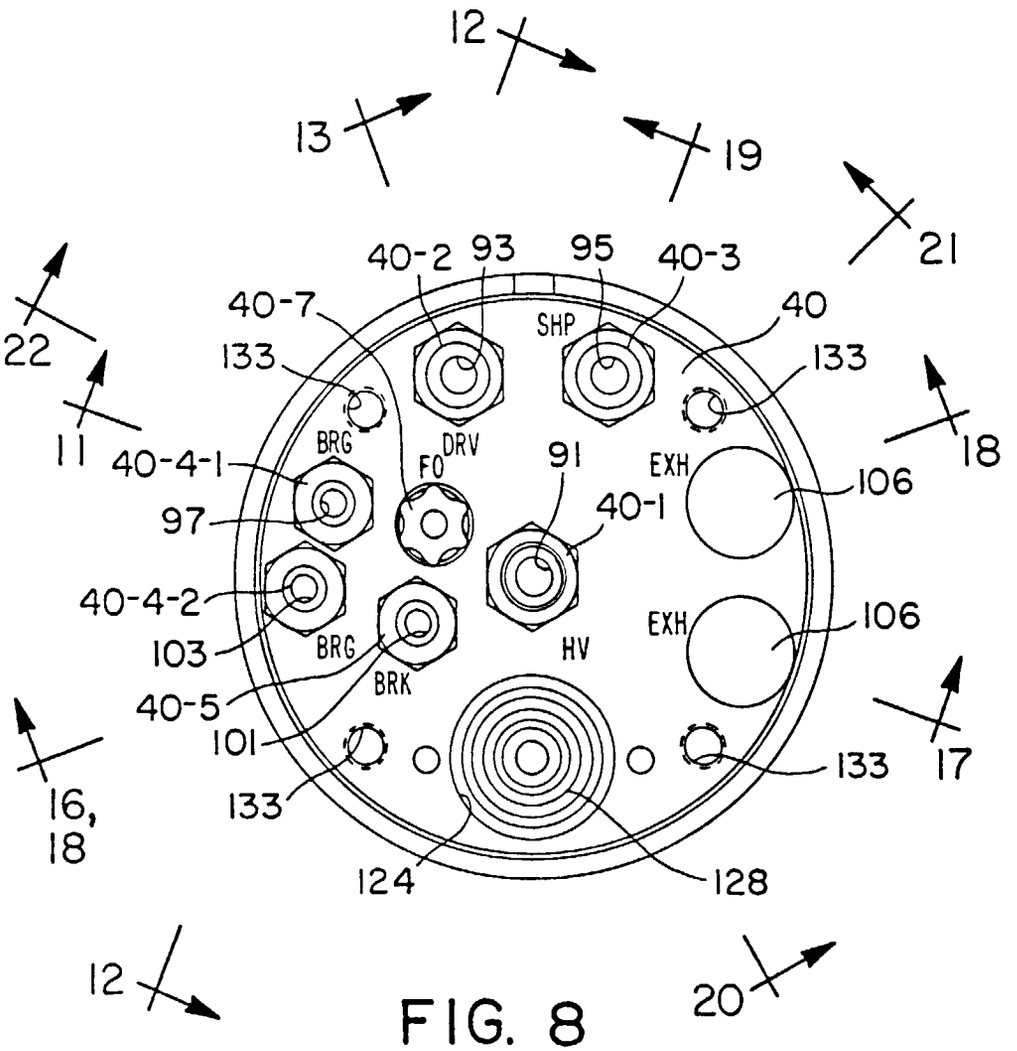
96

FIG. 7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21
22
11
18
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40-7
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BRG
DRV
FO
91
EXH
106
40-4-1
97
40-1
40-4-2
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BRG
BRK
HV
EXH
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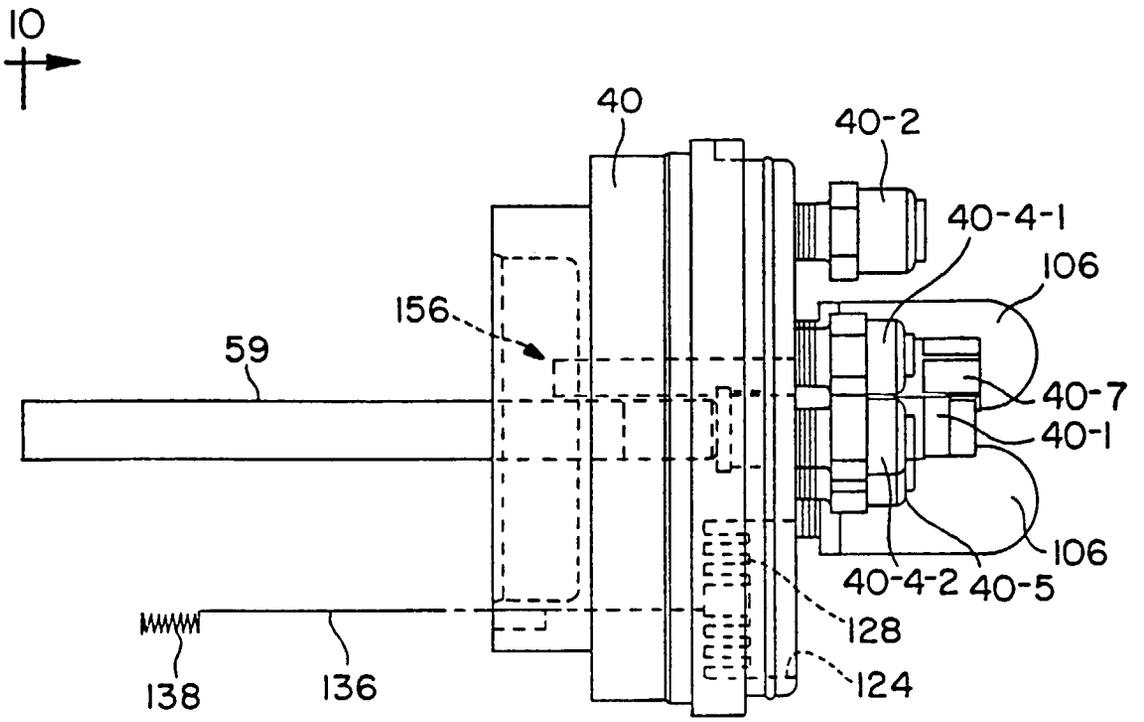
18
124
128
12
20

FIG. 8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40-2
40-4-1
106
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59
40-7
40-1
106
40-4-2
40-5
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138
136
10

FIG. 9

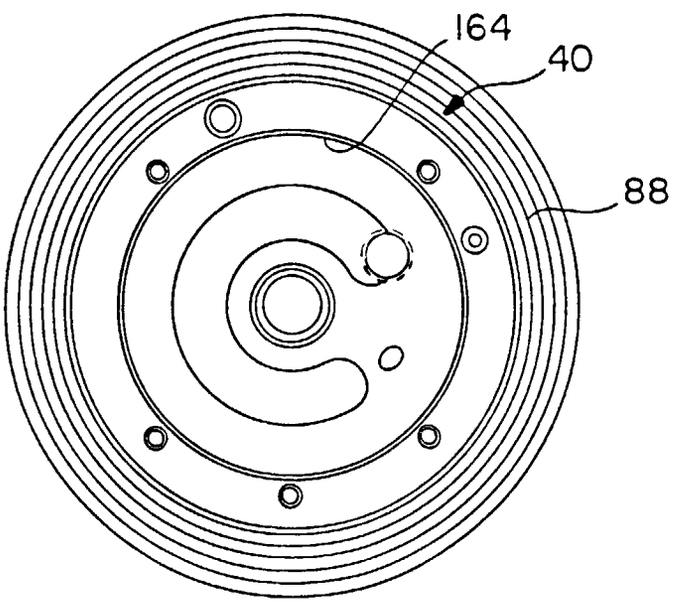
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FIG. 10

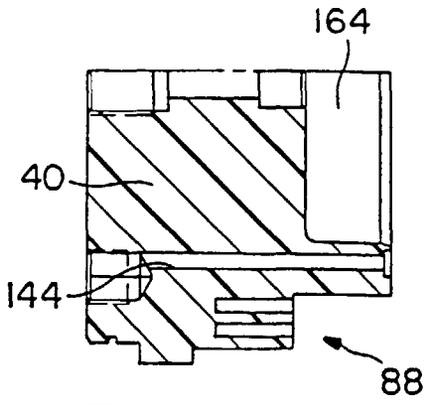


FIG. 11

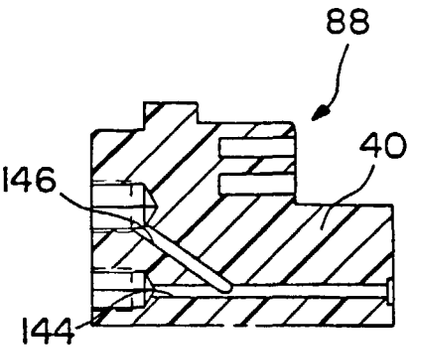


FIG. 12

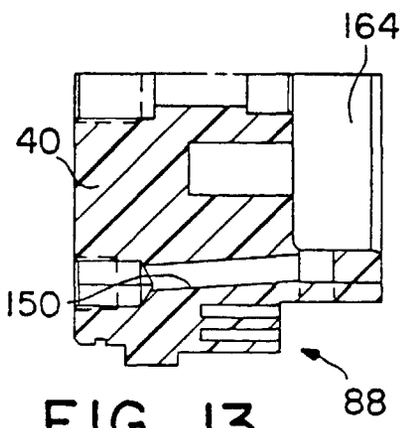


FIG. 13

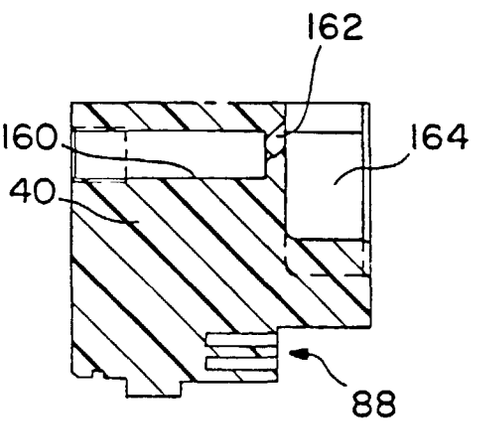


FIG. 16

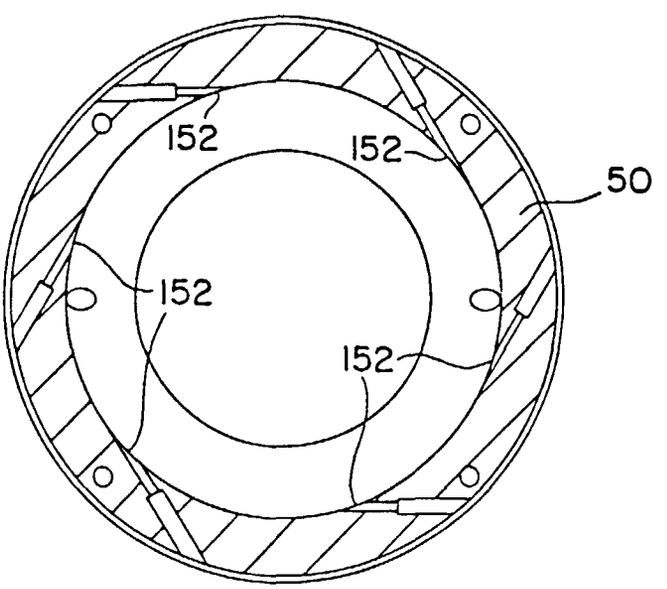


FIG. 14

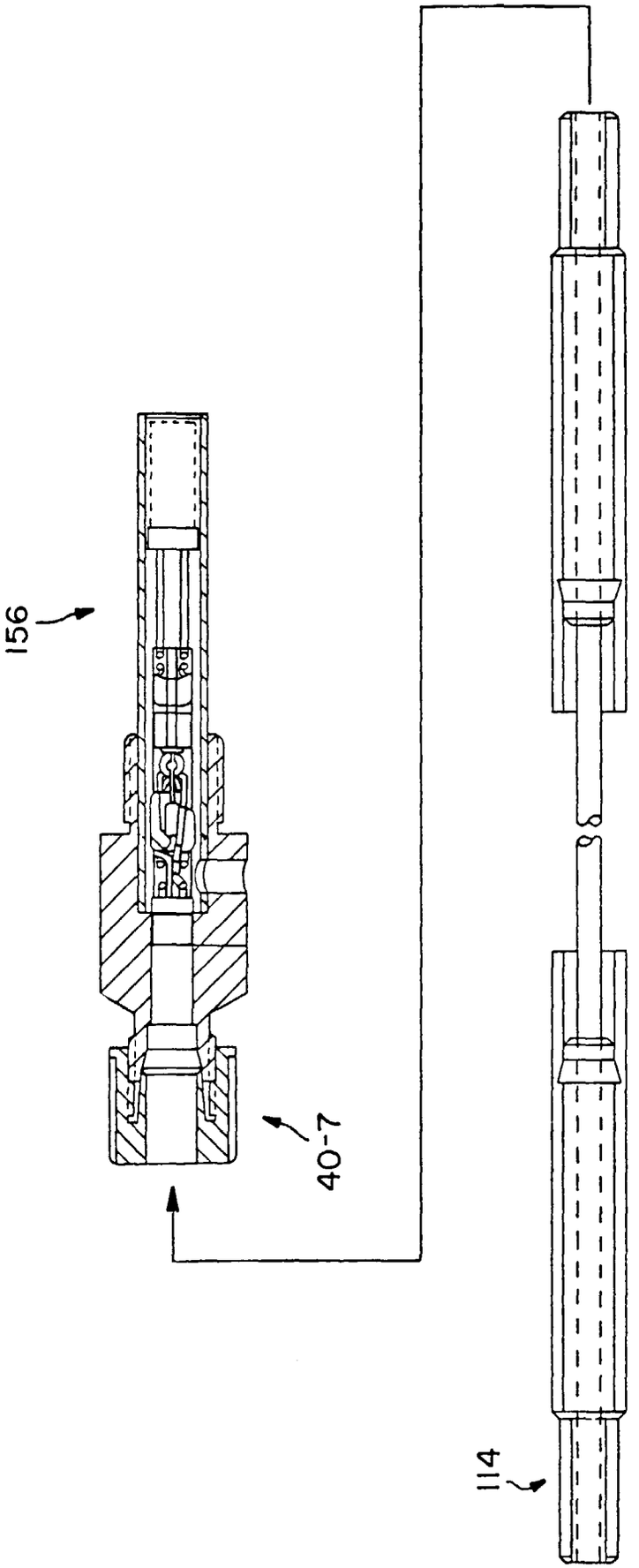


FIG. 15

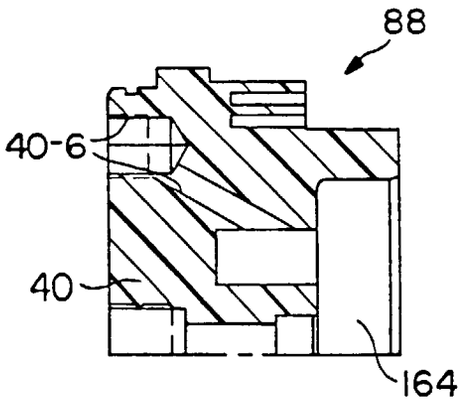


FIG. 17

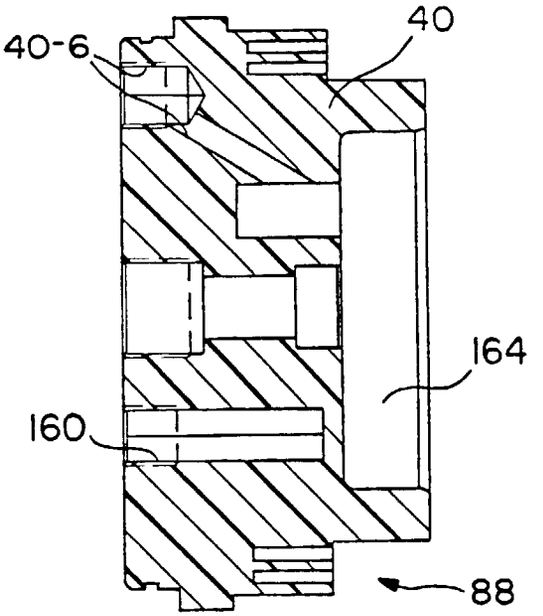


FIG. 18

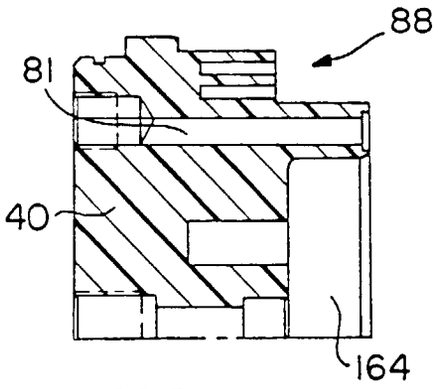


FIG. 19

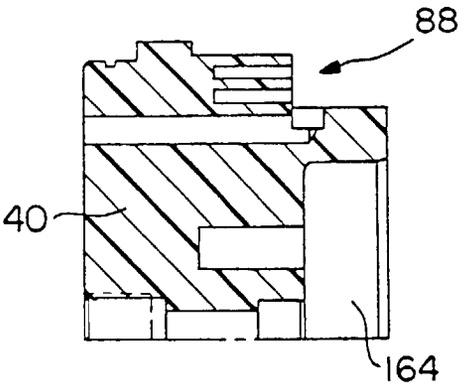


FIG. 20

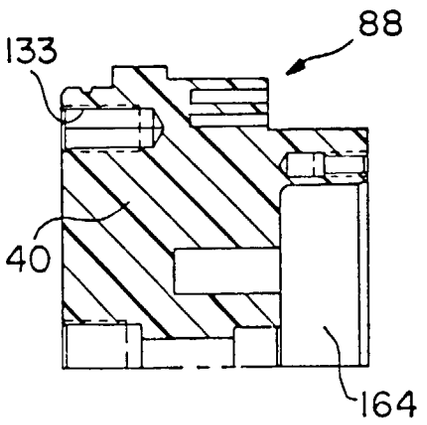


FIG. 21

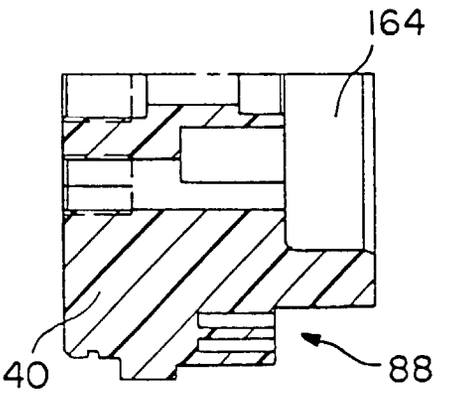
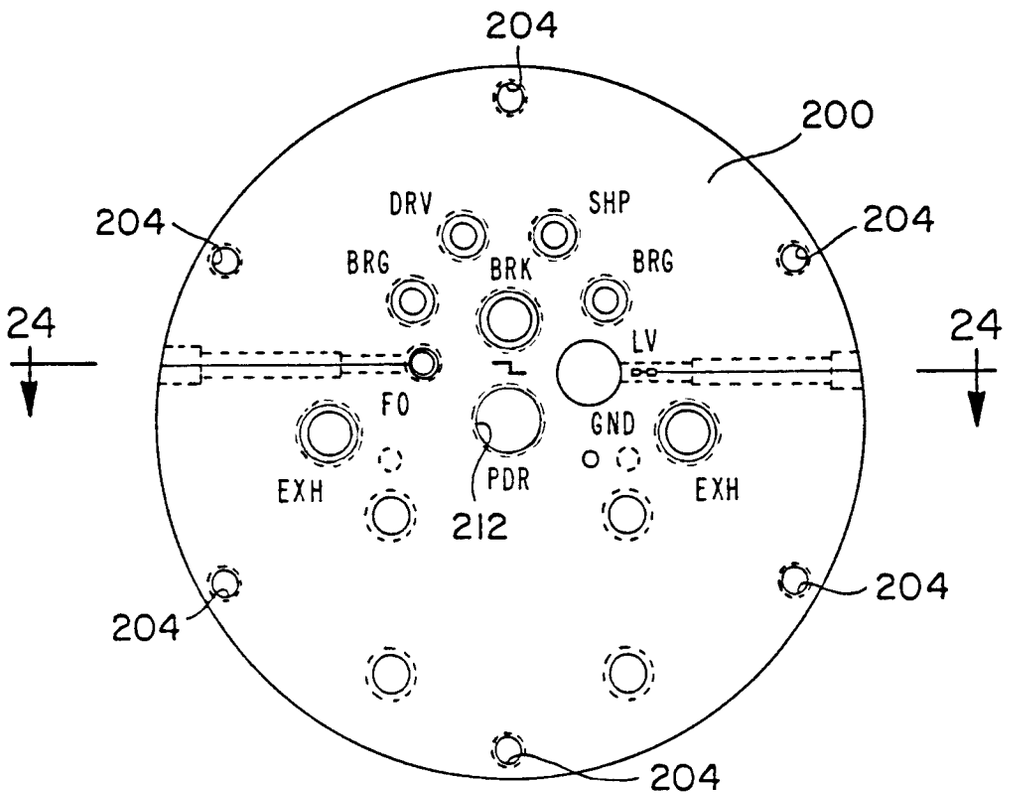


FIG. 22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SHP
BRG
BRK
BRG
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LV
FO
GND
EXH
PDR
EXH
212
204
204
204

FIG. 23

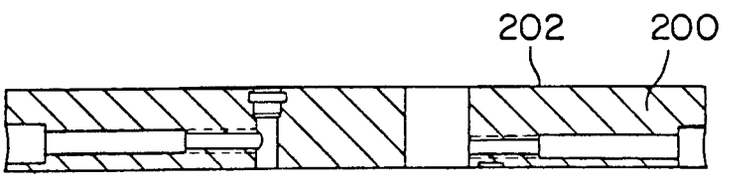
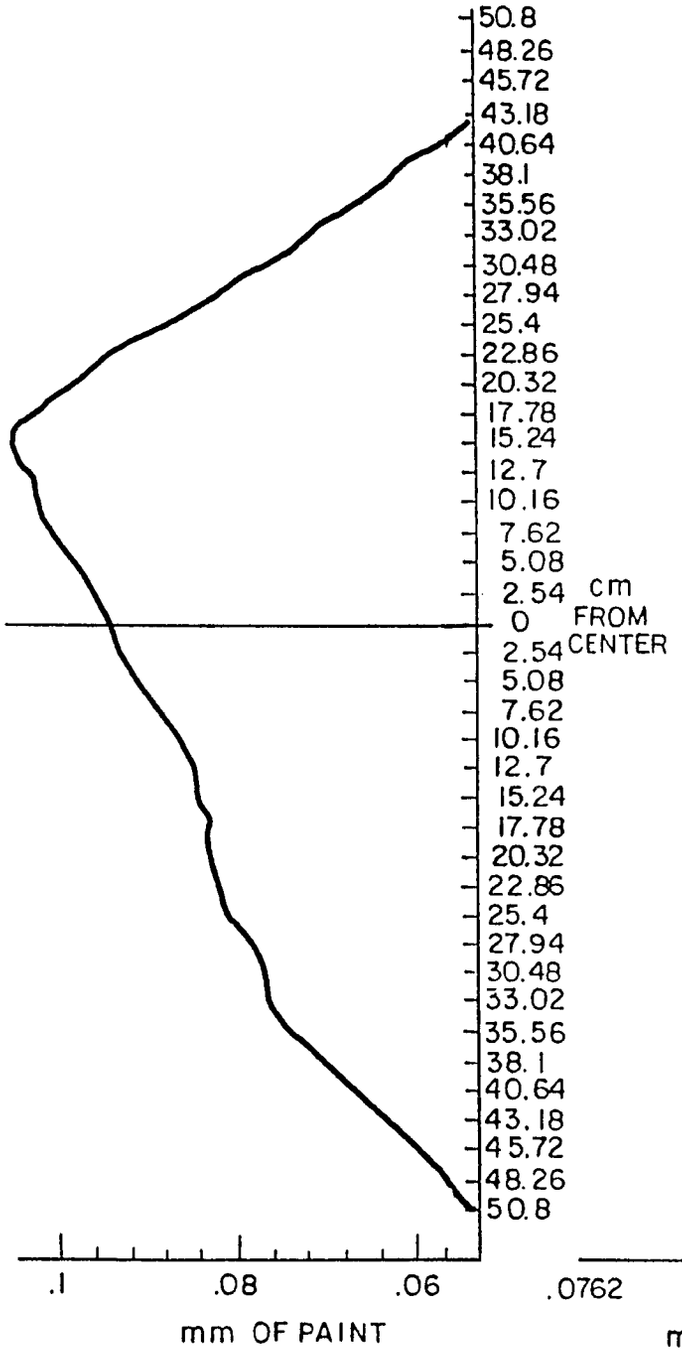

202
200

FIG. 24



PRIOR ART

FIG. 25

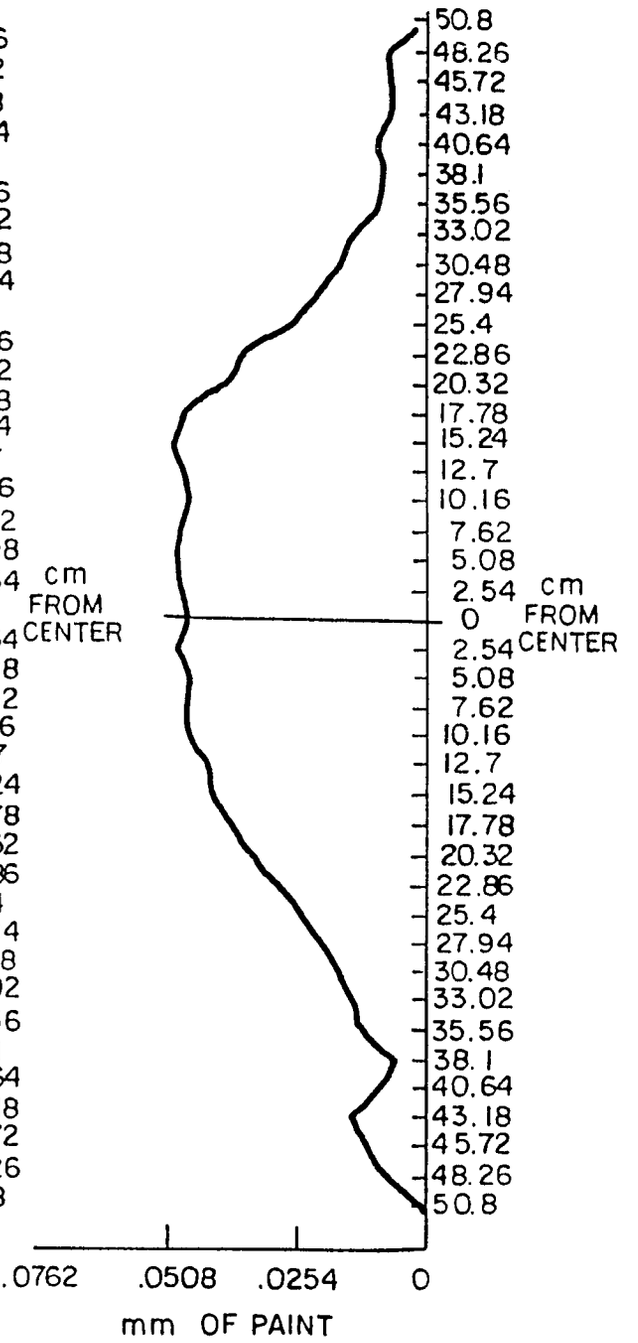


FIG. 26