SERVICE INSTRUCTIONS
MODEL 688
IMPULSE RELAY

SD688
Issue: 3
Date: 3/84

GENERAL DESCRIPTION

The Model 688 Impulse Relay adds a transient impulse response to a pneumatic signal. It most often is used for feedforward action in a control loop. The relay includes proportional band and timing adjustments to adjust the magnitude and duration of the impulse response. Relay action is reversible for changing the impulse direction.

The Impulse Relay requires two input signals: normal and impulsing. Its output will equal the normal input if the impulsing input is constant (steady-state conditions). With a step change of the impulsing input, the output will change an amount determined by the proportional band setting; it will then return, at a rate determined by the timing setting, equal to the normal input.

The Impulse Relay timing can be adjusted for a leading or lagging output response, with respect to the impulsing input, when used with a proportional plus reset controller that has an external feedback connection. Refer to Application Engineering Release AD688-1 for details on the use of the Impulse Relay.

GENERAL SPECIFICATIONS

Supply Pressure:..... 20 psig - normal
18 psig - minimum
50 psig - maximum

Air Consumption:..... 0.15 scfm at 20 psig supply

Input/Output Range:..... 3 to 15 psig - normal
0 to 50 psig - maximum

Tracking Accuracy:..... Alignment of output (B) to normal input (A) - within 0.5% of span.

Proportional Band Adjustment:..... 15 to 500%

Timing Adjustment:..... 0.1 to 50 minutes - standard
0.01 to 5 minutes - optional

Ambient Temperature Limits:..... −40°F to +180°F

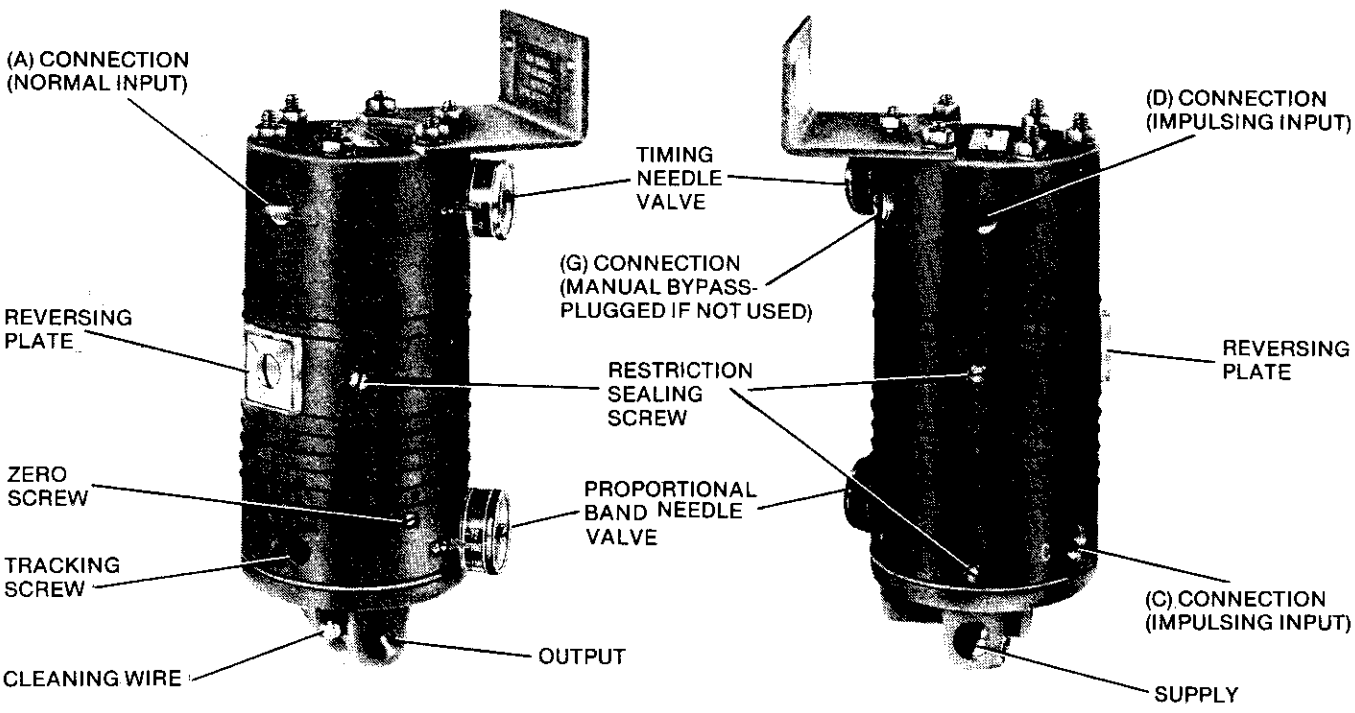
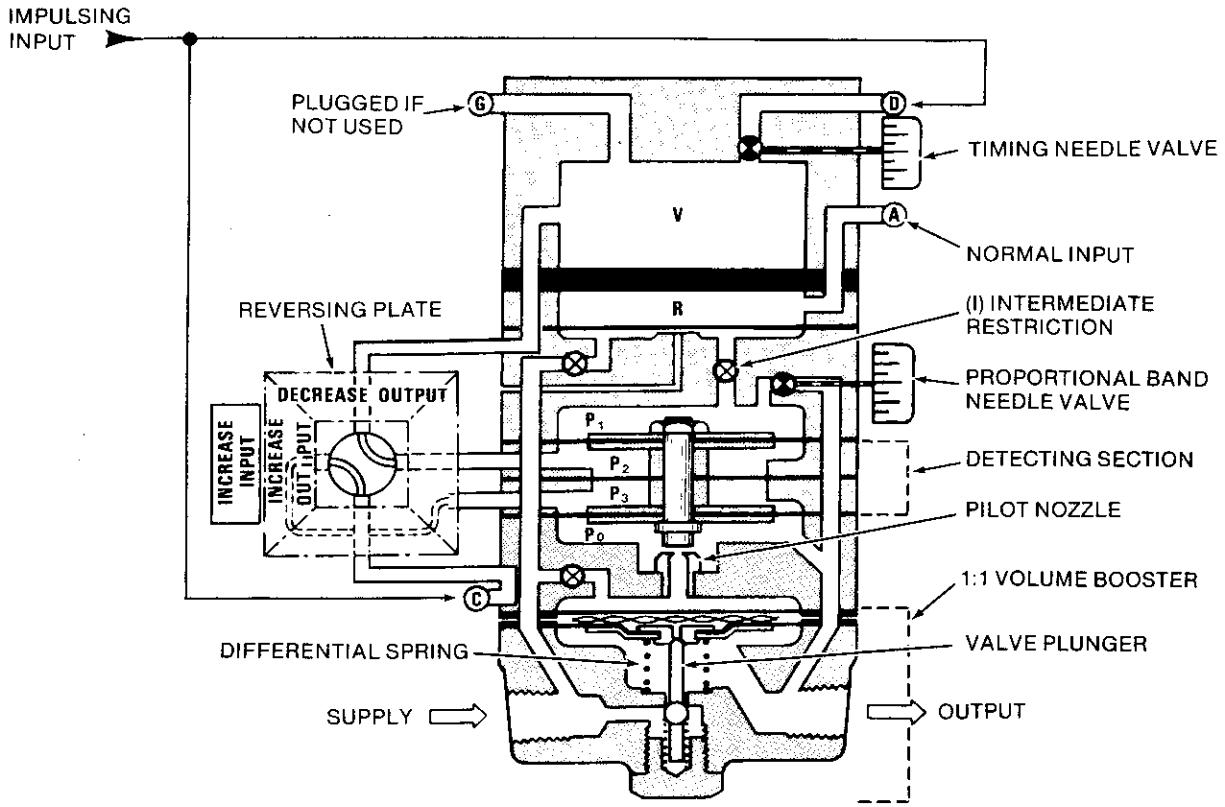


FIGURE 1 Impulse Relay

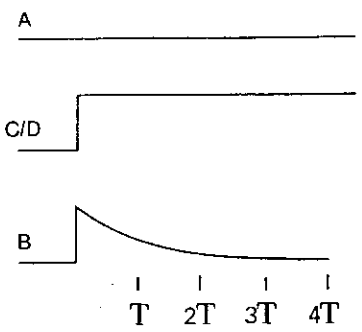


BASIC EQUATION & TRANSFER FUNCTION

$$B = A \pm \frac{100}{PB}(P_3 - P_2)$$

$$B(s) = A(s) \pm \frac{100}{PB}\left(\frac{TFs}{TPs + 1}\right)C(s)$$

STEP RESPONSE



LEGEND

R	1:1 REPRODUCING RELAY
I	INTERMEDIATE RESTRICTION
PB	PROPORTIONAL BAND NEEDLE VALVE
T	TIMING NEEDLE VALVE
V	VOLUME CHAMBER
PV	1:1 BOOSTER RELAY
T	TIMING NEEDLE VALVE TIME CONSTANT
s	LAPLACE OPERATOR

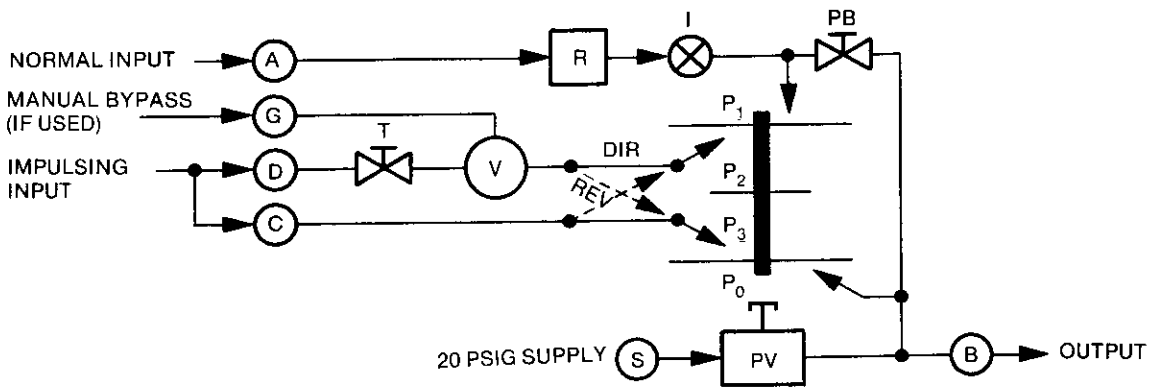


FIGURE 2 Schematic

PRINCIPLE OF OPERATION

The Impulse Relay function is described by the pressure equations in Figure 2.

Refer to Figure 2 and to the following for a basic description of how the Impulse Relay operates.

The normal input (A) is dead-ended in the 1:1 reproducing relay (R). This isolates the normal input from the output of the Impulse Relay to prevent flow into or out of the normal input. The output of the 1:1 reproducing relay appears in P_1 chamber of the detecting section when P_2 and P_3 are equal. When they are not equal, the output of the 1:1 reproducing relay provides a reference pressure for the intermediate restriction (I). This affects the proportional action and will be explained later.

With the impulsing input (C) and (D) constant, the pressures in chambers P_2 and P_3 are equal. The timing needle valve (T) and the volume chamber (V) introduce a first order lag between P_2 and P_3 when the impulsing input changes. Figure 2 shows (C) and (D) connected to P_3 and P_2 respectively to give a direct-acting pulse (i.e. with an increase of the impulsing input, the output of the Impulse Relay will increase). A reverse-acting pulse is achieved by changing the position of the reversing plate. This connects (C) to P_2 and (D) to P_3

The detecting section accomplishes the following:

1. Acts as a comparator to detect any error between P_2 and P_3.

$$(P_3 - P_2)$$

2. Acts as a totalizer to add P_1 to the error.

$$(P_3 - P_2) + P_1$$

3. Provides one part of the proportional action (i.e. the maximum proportional band of 500%).

$$P_0 = 0.2(P_3 - P_2) + P_1$$

As shown schematically, the detecting section has three diaphragms separating P_1, P_2, P_3 and P_0. All three diaphragms are attached to a common center shaft, the bottom of which serves as a nozzle seat for the pilot nozzle. The top and bottom diaphragms of the detecting section have equal areas; the center diaphragm has an area equal to 80% of either the top or bottom diaphragms. Therefore, due to the area differences, only 20% of the error between P_2 and P_3 will be realized, and the detecting section will initially require a 20% output change from the booster section. The remainder of the proportional output change is brought about by the proportional band pressure-divided circuit which will be discussed later.

The booster section (PV) produces the output called for by the detecting section. This 1:1 volume booster increases the output capacity of the Impulse Relay. The booster output feeds back to the bottom of the detecting section (P_0) to rebalance the sum of the forces created by P_1, P_2 and P_3. It also feeds back to the proportional band needle valve (PB) to cause a proportional output change when P_2 and P_3 are not equal. Varying either of the inputs to the Impulse Relay will upset the force balance on the detecting section. This upset changes the clearance between the pilot nozzle and the nozzle seat which, in turn, changes the nozzle back-pressure. The nozzle back-pressure acts on the booster to change the output. The booster output will continue to change until the output feedback (P_0) rebalances the sum of the forces created by P_1, P_2 and P_3. The booster section includes a differential spring to maintain a constant pressure drop across the pilot nozzle. This constant drop minimizes movement of the detecting section. (i.e. extremely small clearance changes between the nozzle seat and pilot nozzle) to provide a high degree of accuracy. The differential spring exerts a force equivalent to 3 psi. Therefore, the nozzle back-pressure will always be 3 psi higher than the output (i.e. back-pressure = output + differential spring).

As mentioned earlier, the detecting section provides the initial proportional action. The final amount of proportional output change is determined by a pressure-divided circuit made up of the proportional band needle valve (PB) and the intermediate restriction (I). Changing the setting of the proportional band needle valve with respect to the fixed, intermediate restriction alters the ratio of the pressure drops across them. This achieves the same result as moving the fulcrum point in a force-beam controller. The output of the 1/1 reproducing relay (R) references the pressure-divided circuit to the point about which the proportional action is to occur.

By design, the pressure drop across the proportional band needle valve (PB) will always equal the proportional output change provided by the detecting section.

$$\Delta PB = 0.2(P_3 - P_2)$$

The pressure in chamber P_1 is determined by the pressure-divided circuit and is expressed as follows:

$$P_1 = A + \frac{100\%}{PB\%}(P_3 - P_2) - \Delta PB$$

INSTALLATION

GENERAL

Relays are shipped for reverse action (Inc./Dec.); i.e., an increasing input to connection (C) causes a decreasing relay output. The relay can be changed to direct action (Inc./Inc.) by rotating the reversing plate. The correct position of this plate for a given installation depends on the required output response (leading or lagging) to the input at connection (C).

Refer to Figure 3 for typical installation piping diagrams.

MOUNTING

Dimensions

Refer to Figure 4 for overall dimensions and connections.

Location

The relay should be mounted in a reasonably vibration-free location. It can be mounted indoors or outdoors provided the ambient temperature limits are not exceeded.

Position

The relay may be mounted in any position. It should, however, be calibrated in the same position it is to be mounted.

Piping

Any scale-free piping may be used for connecting the relay; 1/4" O.D. tubing is recommended.

Before connecting the lines, blow them out to prevent foreign material from entering the relay. The connecting lines must be leak-tight. Leak-test the lines with soapless lather.

SUPPLY AIR

The recommended supply pressure for the conventional 3-15 psig instrument signals is as follows:

Recommended — 20 PSIG
Minimum — 18 PSIG
Maximum — 50 PSIG

Although the relay is intended to operate in the 3-15 psig range, the inputs, supply and output can be as high as 50 psig.

Connect the relay to a source of clean, dry, oil-free instrument air. Refer to the Instrument Society of America's "Quality Standard for Instrument Air" (ISA-S7.3).

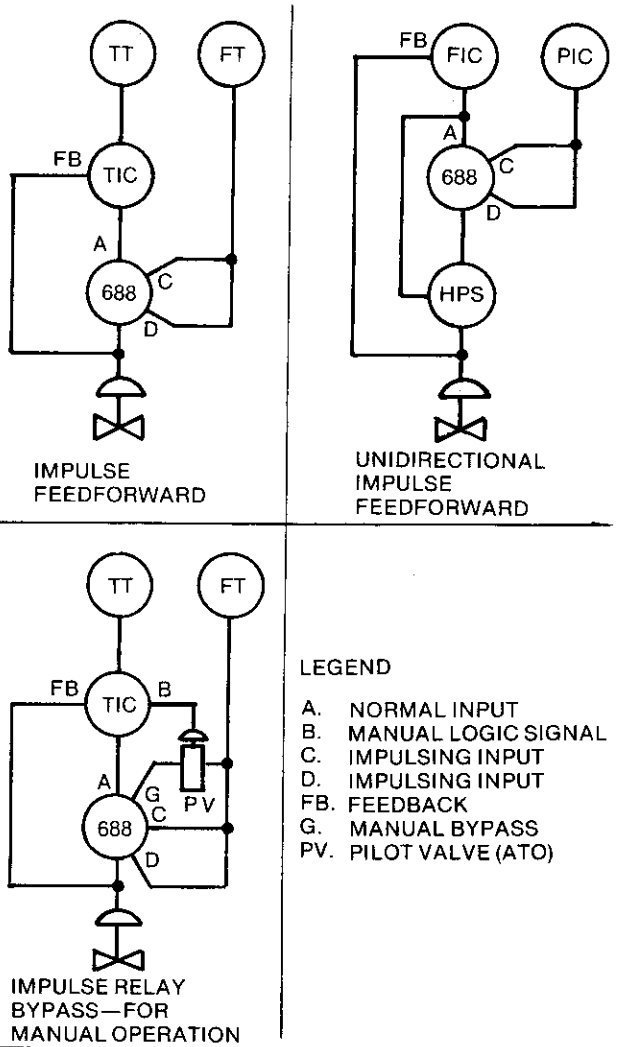


FIGURE 3 Installation Piping Diagrams

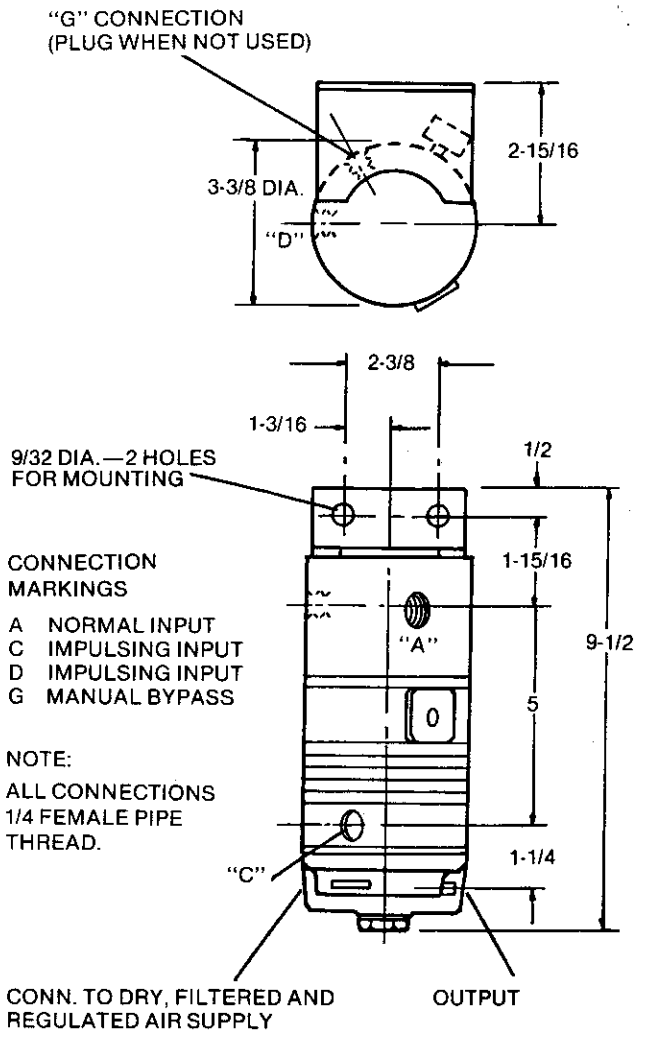


FIGURE 4 Installation

CALIBRATION

When calibrating the Model 688 Impulse Relay, it should be mounted in the same position as it will be used.

1. Set up the relay per Figure 5.
2. Open the timing needle valve (0.1 - standard; 0.01 - optional).
3. Open the proportional band needle valve to 75%.
4. Set reversing plate for Inc/Inc.
5. Adjust the regulator to 10% of span.
6. Adjust the zero screw until the pointers on the duplex gauge match.
7. Adjust the regulator to 90% of span.
8. If the pointers do not match, adjust the tracking screw, making a three-fold over-correction. For example, if the peripheral pointer is at 91%, adjust the tracking screw to move the center pointer to 87%. The amount of over-correction is approximate and may vary a little between relays.
9. Adjust the zero screw until the pointers match.
10. Repeat steps 4 through 8 until the pointers match when the regulator is changed from 10% to 90% of span.

RELAY TUNING

The proportional band of the Impulse Relay is adjusted to give the appropriate change in valve position for a given change in process flow. The timing needle valve can be adjusted to give a leading or lagging valve change, with respect to the process flow.

When used with a proportional plus reset controller and an external reset feedback connection, the Impulse Relay timing can be adjusted for leading or lagging response. The lead or lag is determined by the difference between the relay time constant and the controller reset time.

For tuning the Impulse Relay, it is recommended that the impulse time be adjusted first (as a function of the controller reset time) for the required lead or lag. The proportional band then can be adjusted for the required steady-state gain (the required change in relay output with respect to change in the impulsing input).

MAINTENANCE

GENERAL

Most problems associated with pneumatic instruments can be prevented by using a clean, dry and oil-free supply. Refer to the Instrument Society of America's "Quality Standard for Instrument Air" (ISA-S7.3).

SERVICING

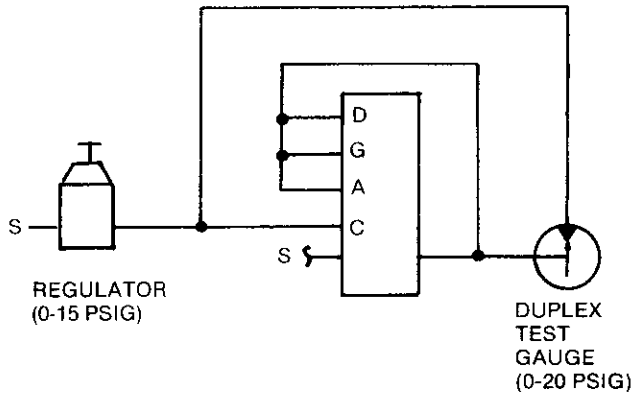
Refer to Figures 6, 7 and 8.

Cleaning

The items to be cleaned are the removable restrictions, needle valves and the valve plunger.

VALVE PLUNGER

Figure 7 shows removal of the valve plunger. The large spherical surface is the supply face; the tip is the exhaust face. Use non-abrasives for cleaning. The supply and exhaust seats in the relay should also be cleaned.



NOTES:

OPEN TIMING NEEDLE VALVE TO 0.1 STANDARD; 0.01, FAST

OPEN PROPORTIONAL BAND NEEDLE VALVE TO 75%.

SET REVERSING PLATE FOR INC/INC.

FIGURE 5 Calibration Setup

The supply seat is readily accessible; the exhaust seat can be reached with a tobacco pipe cleaner.

RESTRICTIONS

Figure 7 shows removal of a restriction screw. There are three removable restrictions in the relay. all are identical and are interchangeable. The Allen wrench stored in the base of the relay is used to remove the restriction screws. They are cleaned with the cleaning wire which is also stored in the base of the relay. When reinstalling, be sure both the restrictions and sealing screws are screwed in tightly.

NEEDLE VALVES

Figure 8 shows removal of a needle valve. There are two needle valves in the relay and they are not interchangeable. The needle valves and valve bodies have matching identification letters stamped on them. Use non-abrasives for cleaning. Lubricate the "O" ring on the needle valve before reinstalling it. If the valve body is removed, inspect the "O" rings on it, especially the small one on the tip. Lubricate the large "O" ring before re-installing the valve body.

Lubrication

Figure 8 shows the "O" ring that may require lubrication. There is one of these on each of the needle valves. If a needle valve knob moves away from a setting immediately after making the setting, the "O" ring lubricant is recommended.

Other "O" rings in the relay can only be reached by disassembly. Normally, they require attention only at a major overhaul.

DISASSEMBLY (Refer to Figure 9)

The relay uses a "stack" construction that allows complete disassembly for inspection, cleaning or replacement of parts. Remove the nuts, separate the diaphragms and rings, and lift the parts off the studs. Use a dull table knife to separate the diaphragms and rings.

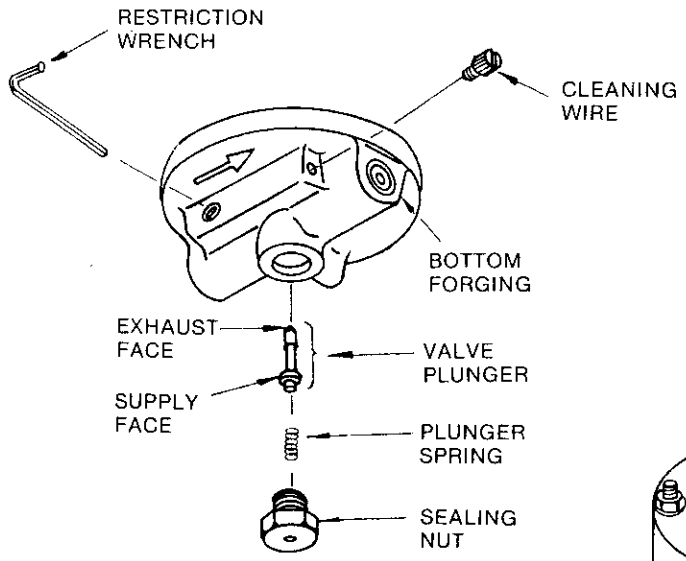
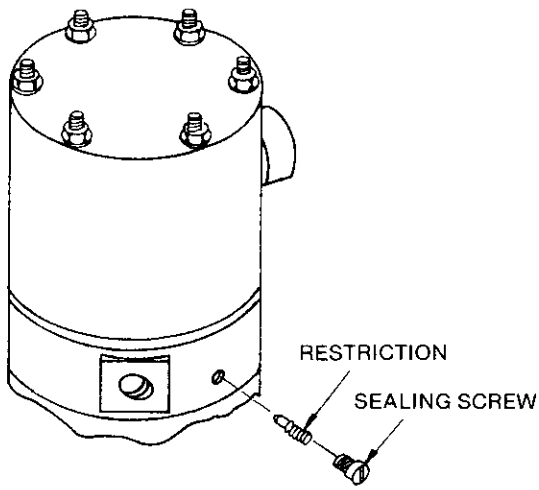


FIGURE 6 Valve Plunger



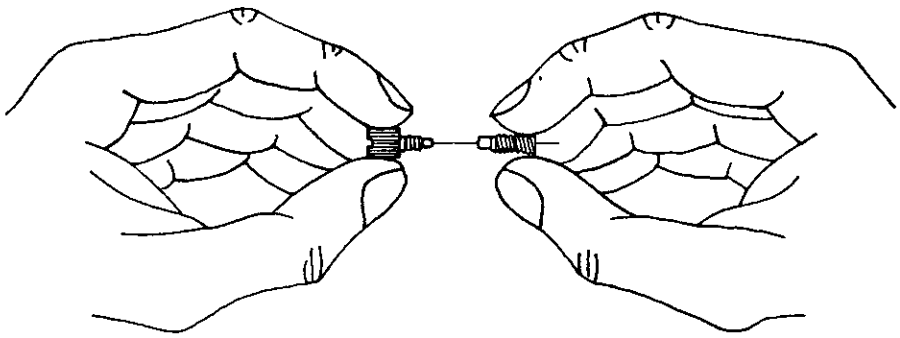


FIGURE 7 Restriction Screw

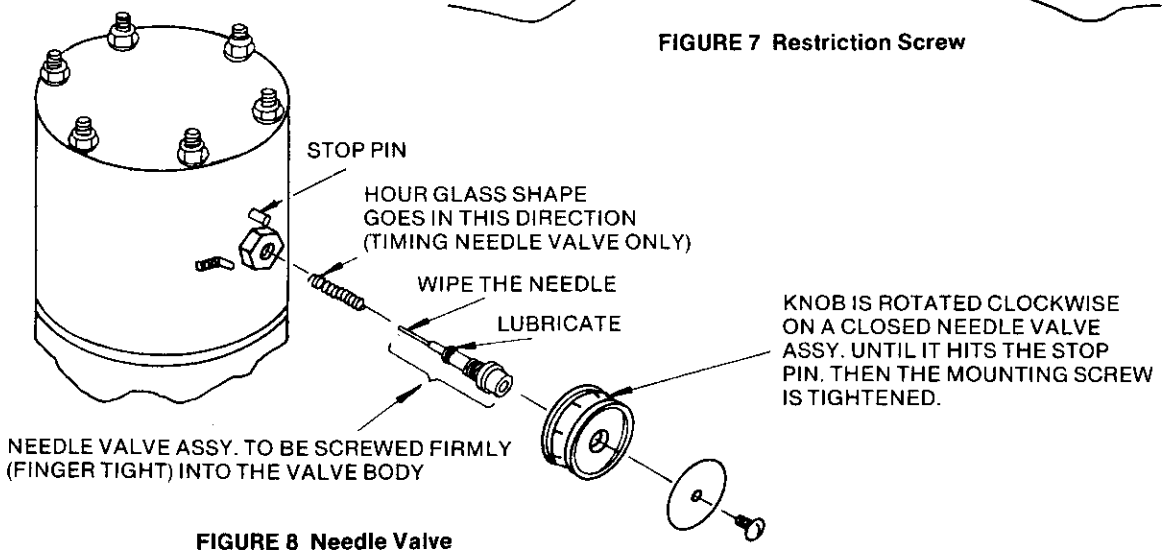


FIGURE 8 Needle Valve

Caution

Because of an internal motion stop arrangement shown in Figure 9, the "control diaphragm assembly" and the pilot ring assembly must be lifted off the studs before they can be separated from each other. These two assemblies must be slid apart in a certain direction. Otherwise, the pilot nozzle will be damaged.

Use the following procedure to disengage the control diaphragm and pilot ring assemblies from each other:

1. Loosen the control diaphragm assembly from the pilot ring assembly. DO NOT PRY. The diaphragm between these two assemblies must not adhere to the pilot ring assembly.
2. Hold the two parts with the zero adjustment screw aligned under the dot on the control diaphragm assembly.
3. Hold the pilot ring assembly and push the control diaphragm assembly away from you.

ASSEMBLY

To re-assemble the controller, use the parts drawing for the sequence of parts, and align the rings by the locating grooves on their periphery.

The control diaphragm and pilot ring assemblies must be asembled to each other before being placed on the studs. Use the following procedure:

1. Hold the pilot ring assembly so the "zero" adjustment screw faces you.
2. Position the control diaphragm assembly above and behind the pilot ring assembly. Line-up the dot on the bottom ring of the control diaphragm assembly with the "zero" adjustment screw on the pilot ring assembly.
3. Slide these assemblies together. While doing so, guide the zero adjustment leaf spring into the opening formed by the motion stop, and make sure the "U" shaped plate engages under the head of the pilot nozzle.
4. Hold the two assemblies together, align their locating grooves and place them on the studs.

If the control diaphragm assembly was disassembled, the "U" plate portion of the motion stop must be put back in the correct position.

Align the open end of the "U" plate with the dot on the periphery of the bottom control diaphragm assembly ring.

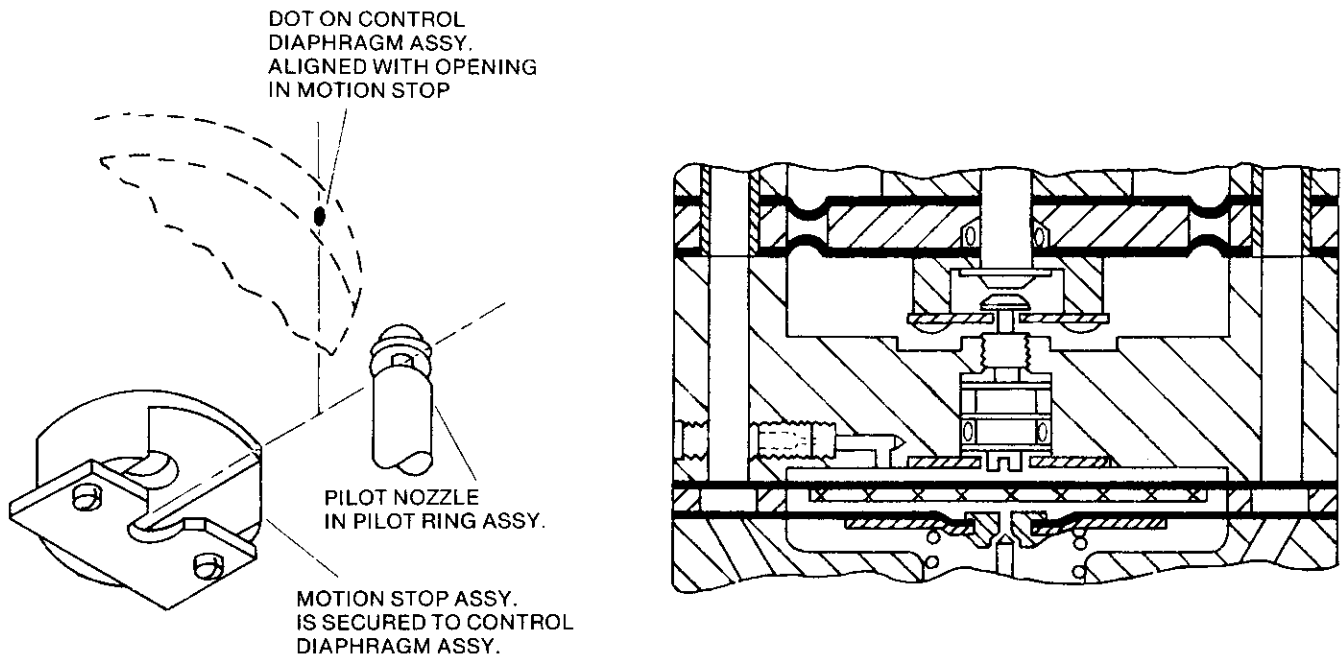


FIGURE 9 Control Diaphragm Assembly Motion Stop

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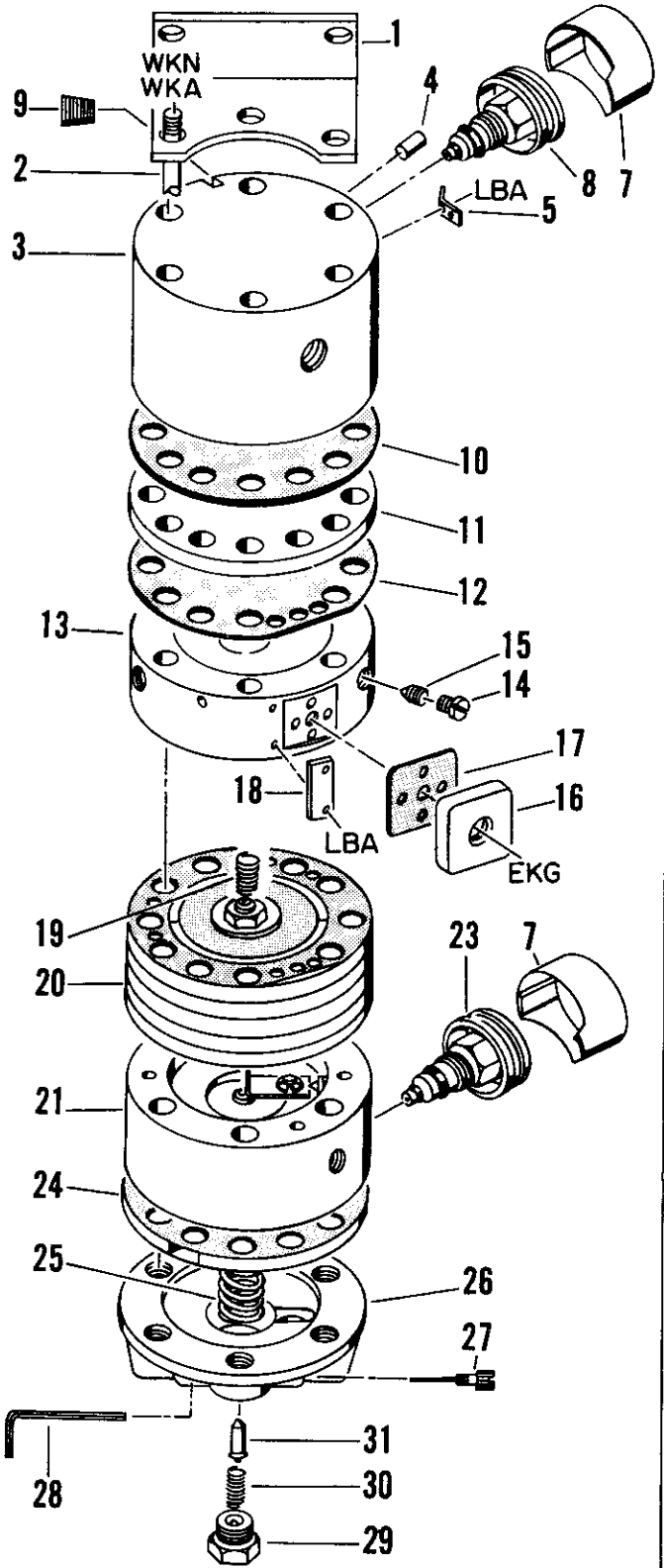
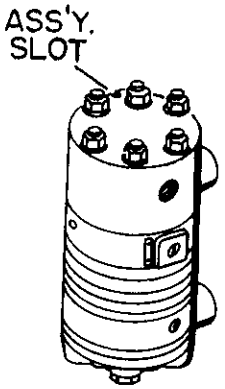
PARTS LIST

MODEL 688
IMPULSE RELAY

Drawing
No. 14281–181PL





Model	B/M or P/N
688	14281–181S3

Item No.	Part No.	Description	Req'd.
1	3093–3	Mounting Bracket	1
2	7307–7	Studs	6
3	8855–81	Top Housing (Incl. Items 4 and 5 and LBA)	1
4	3035–1	Stop Pin	1
5	3092–31	Pointer	1
7	3092–47	Knob Cover	2
8	10880–60	Reset Needle Valve Assy. (See Parts Dwg. 10880–76A)	1
9	3092–35	Pipe Plug	1
*10	1977–11	Gasket	1
11	8883–20	Diaphragm Ring	1
*12	2900–25	Diaphragm	1
13	8855–79	Center Housing (Incl. Items 14 thru 18, LBA & EKG)	1
*14	2900–23	Sealing Screw	2
*15	2900–22	Restriction	2
16	3850–13	Reversing Plate	1
*17	3092–3	Gasket	1
18	3850–43	Nameplate	1
*19	8106–32	Spring	1
*20	14278–31	Control Diaph. Assy. (See Parts Dwg. 14278–50)	1
21	14281–9	Pilot Ring (See Parts Dwg. 14281–51)	1
23	10880–69P	Throttling Needle Valve (See Parts Dwg. 10880–76A)	1
*24	8003–8	Exhaust Diaph.	1
25	1447–13	Differential Spring	1
26	8855–1	Bottom Housing (Incl. Items 27 thru 31)	1
*27	1518–4	Cleaning Wire	1
*28	3092–33	Restriction Wrench	1
*29	8003–2	Retaining Nut	1
*30	2155–7	Plunger Spring	1
*31	8003–5	Plunger	1

CODE	HARDWARE	Req'd.
EKG	1/4–20 x 1/2 Lg. Oval Hd. Screw	1
LBA	0–1/8 Lg. Type "U" Drive Screw	4
WKA	1/4 Lockwasher	6
WKN	1/4–20 Hex Nut	6

* Recommended On-Hand Spare Parts. Always Specify Range, Serial No., or Other Nameplate Information When Ordering Spare Parts.

Printed in U.S.A. 3/84 Supersedes 2/79

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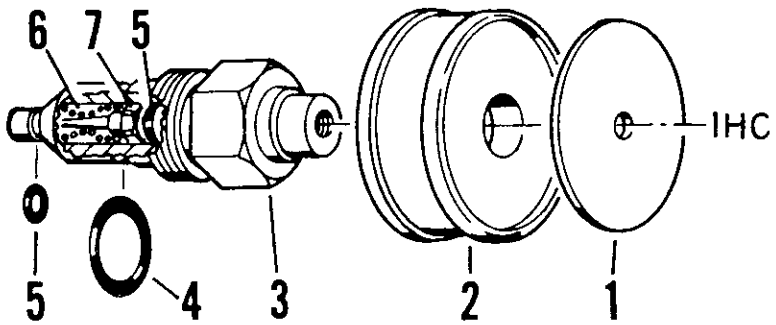
SPRING HOUSE, PA. 19477

PARTS LIST

PROPORTIONAL BAND & RESET
KNOB & NEEDLE VALVE ASSEMBLIES

From Drawing
No. 10880–76A

USED ON:
Model Series 50, 50X2, 501, 502,
503, 507, 508, 509, 55, 55X2, 561, 569, 688



RESET KNOB & NEEDLE VALVE

Item No.	Part No.	Description	Req'd.
P/N 10880–60 (STANDARD .1–50)			
1	3850–8	Knob Disc	1
2	10880–41	Knob	1
3	10880–1	Needle Valve Ass'y. (incl. 4 thru 7)	1
*4	2938–3	"O" Ring	1
*5	2938–15	"O" Ring	2
*6	10852–8	Valve Spring	1
7	10852–59	Friction Washer	1
Code		Hardware	Req'd.
IHC		#6–32 x 1/4 Lg. Truss Hd. Screw	1
P/N 10880–61 (FAST .01–5)			
1	3850–8	Knob Disc	1
2	10880–42	Knob	1
3	10880–2	Needle Valve Assy. (incl. 4 thru 7)	1
*4	2938–3	"O" Ring	1
*5	2938–15	"O" Ring	2
*6	10852–8	Valve Spring	1
7	10852–59	Friction Washer	1
Code		Hardware	Req'd.
IHC		#6–32 x 1/4 Lg. Truss Hd. Screw	1

PROPORTIONAL BAND KNOB & NEEDLE VALVE

Item No.	Part No.	Description	Req'd.
P/N 10880–62 (STANDARD 2–200)			
1	3092–26	Knob Disc	1
2	10880–45	Knob	1
3	10880–3	Needle Valve Assy. (incl. 4 thru 7)	1
*4	2938–3	"O" Ring	1
*5	2938–15	"O" Ring	2
*6	10852–46	Valve Spring	1
7	10852–59	Friction Washer	1
Code		Hardware	Req'd.
IHC		#6–32 x 1/4 Lg. Truss Hd. Screw	1
P/N 10880–69P (WIDE 5–500)			
1	3092–26	Knob Disc	1
2	10880–50	Knob	1
3	10880–3	Needle Valve Assy. (incl. 4 thru 7)	1
*4	2938–3	"O" Ring	1
*5	2938–15	"O" Ring	2
*6	10852–46	Valve Spring	1
7	10852–59	Friction Washer	1
Code		Hardware	Req'd.
IHC		#6–32 x 1/4 Lg. Truss Hd. Screw	1

* Recommended On-Hand Spare Parts. Always Specify Range, Serial No., or Other Nameplate Information When Ordering Spare Parts.

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SPRING HOUSE, PA. 19477

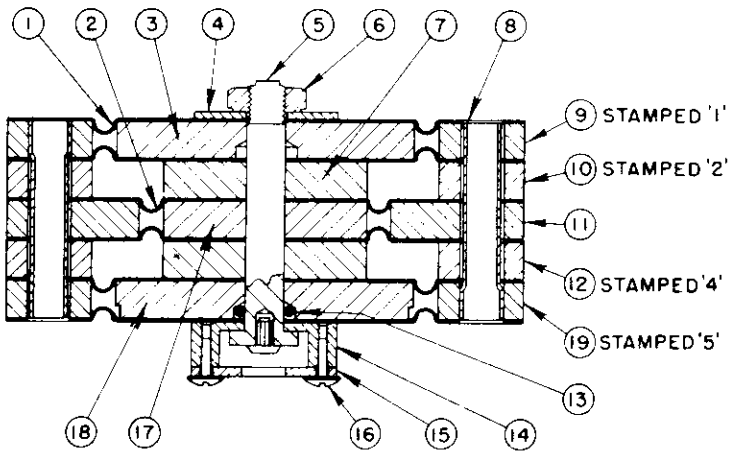
PARTS LIST

CONTROL DIAPHRAGM ASSEMBLIES

Drawing
No. 14278–50PL

COMPLETE ASSEMBLY: P/N 14278–11 (Standard 2–200%)
P/N 14278–31 (Wide 5–500%)

USED ON
Model Series 50, 50X–2, 509,
55, 55X–2, 561, 569 and 688



Item No.	Part No.	Description	Req'd.	
			200%	500%
*1	8648–5	Diaphragm	4	4
*2a	8648–4	Diaphragm	2	–
*2b	8648–13	Diaphragm	–	2
3	4551–5	Upper Spacer - Outer	1	1
4	3092–40	End Plate	1	1
5	4551–22	Rod Assy.	1	1
6	3821–32	Jam Nut	1	1
7	4551–6	Center Spacer	3	2
8	4551–10	Dowel Tube	2	2
9	4551–1	Vent Ring - Upper	1	1
10	4551–90	Spacer Ring - Upper	1	1
11a	4551–3	Vent Ring - Center	1	–
11b	4551–50	Vent Ring - Center	–	1
12	4551–92	Spacer Ring - Lower	1	1
*13	2938–1	"O" Ring	1	1
14	14278–12	Stop Bracket	1	1
15	14278–14	Stop Plate	1	1
16	Screw	#4–40 x 1/4 Lg. Truss Hd.	2	2
17	4551–51	Center Spacer	–	1
18	14956–924	Lower Spacer	1	1
19	4551–81	Vent Ring-Lower	1	1

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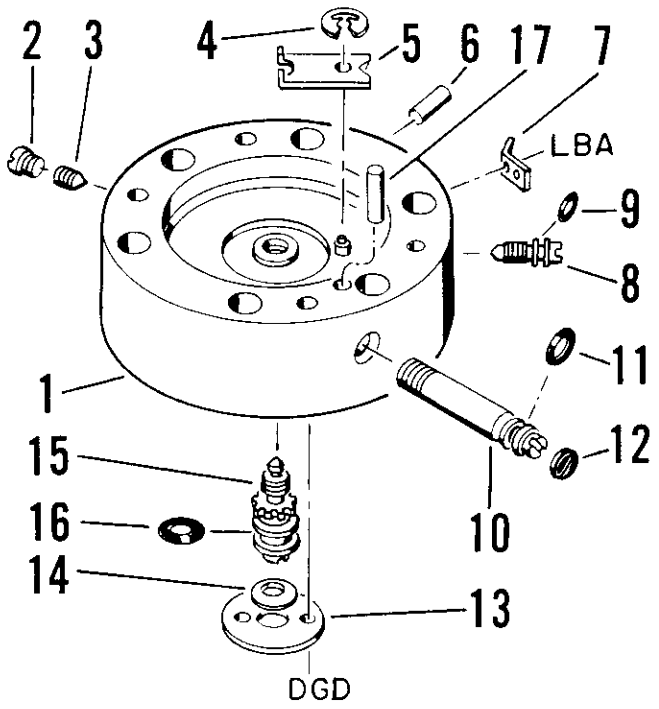
PARTS LIST

PILOT RING ASSEMBLIES

From Drawing
No. 14281–51PL

COMPLETE ASSEMBLY: P/N 14281–9 (with tapped "C" port)
P/N 14281–10

USED ON:
Model Series 50, 50X–2, 55, 55X–2,
561 and 688



Item No.	Part No.	Description	Req'd.
1a	14278–5	Pilot Ring (For Assy. 14281–9)	1
1b	14278–34	Pilot Ring (For Assy. 14281–10)	1
*2	2900–23	Sealing Screw	1
*3	2900–22	Restriction	1
4	7044–1	Retainer Ring	1
5	8051–42	Leaf Spring	1
6	3035–1	Pin	1
7	3092–31	Pointer	1
8	8051–41	Zero Screw	1
9	2938–4	"O" Ring	1
10	14568–4	Tracking Screw	1
11	2938–4	"O" Ring	1
12	8051–56	Plug	1
13	14278–43	Stop	1
14	14278–40	Curved Washer	1
15	14278–13	Nozzle	1
16	2938–2	"O" Ring	1
17	8179–2	Pin	1

CODE	HARDWARE	Req'd.
DGD	#5–40 x 5/16" Lg. Flat Hd. Screw	2
LBA	#0 x 1/8" Lg. Type "U" Drive Screw	2

* Recommended On-Hand Spare Parts. Always Specify Range, Serial No., or Other Nameplate Information When Ordering Spare Parts.

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