SERVICE INSTRUCTIONS
MODEL 65
SQUARE ROOT EXTRACTOR

SD65
Issue: 7
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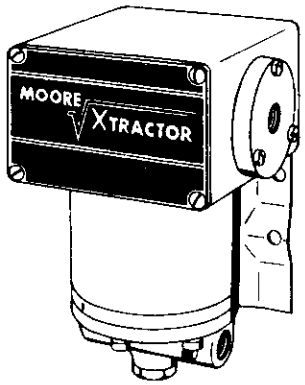


GENERAL INFORMATION

The Square-Root Extractor's most common use is linearizing signals from differential type flow transmitters, i.e.:

1. When two or more rate-of-flow signals are to be added, subtracted, or averaged; or,
2. When linear signals are required to provide proper characterization in open-loop and multiple-loop control systems; or,
3. When required in various analog computing systems.

PRINCIPLE OF OPERATION

The Moore Square-Root Extractor uses the cosine function of a small angle to give square-root conversion. The angle is developed in a continuous balance between the motion of the input pressure capsule and the motion of the transmitter bellows.

Supply air flows through a restriction, into the inner bellows, through the center stem and to atmosphere through the nozzle at the top of the center stem. The restricted pilot air also acts upon the top of the booster diaphragm, controlling the pilot valve, either to admit supply air or to exhaust air to atmosphere through the exhaust port. The pilot air pressure variation is 1/6 of the transmitted air pressure variation.

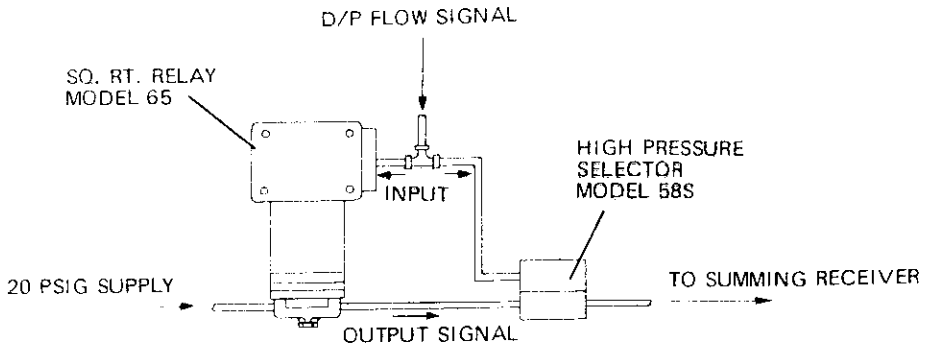
With an increase in input pressure to the input capsule, the floating pilot link is moved closer to the center stem, further closing the nozzle and decreasing the flow of pilot air to atmosphere. The pressure above the booster diaphragm is increased, closing the pilot valve exhaust and opening the supply port, which increases the transmitted pressure. This increase in transmitted pressure acts on the bottom of the exhaust diaphragm, opening the exhaust port and throttling the supply port, thus balancing the booster pilot system to a higher transmitted pressure. The increased transmitted pressure is also fed back to the chamber between the inner and outer output bellows. The bellows expands against the force exerted by the output zero spring, bringing the center stem and nozzle to a higher position, thus establishing equilibrium.

The Square-Root Extractor may be used for input ranges between 3.0 to 13.8 PSIG and 3.0 to 17.2 PSIG.

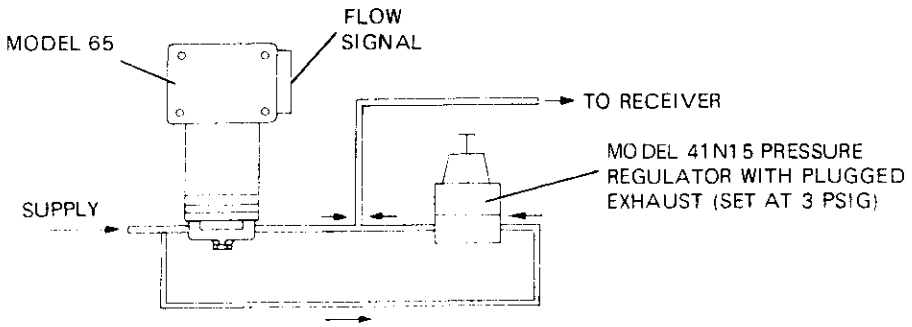
INSTALLATION

Mounting

Refer to Installation Dwg. # 10895-1 for mounting dimensions, connections and configurations. The Square-Root Extractor has been calibrated for vertical mounting. Mounting the unit in any other position may require recalibration.



PRESSURE SELECTOR METHOD



NON-BLEED REGULATOR METHOD

Fig. 1

Installation
Minimum Flow Signal

Piping

All connections are 1/4" N.P.T. The direction of flow is indicated by an arrow on the bottom casting. The input signal is connected to the connection block at the top of the housing.

Copper tubing, 1/4" O.D., is recommended for all connections, but any scale-free piping may be used. Always blow out all lines thoroughly before connecting them. Use pipe compound sparingly and then only on the male threads of the connections. All connections must be leak tight. They should be checked using a soapless lather with air pressure on the lines.

Supply Air

Clean air, oil and moisture free, should be used for air supply to the unit. A Moore Air Filter will minimize difficulties which might result from a dirty air supply.

The supply air pressure should be set at 20 PSIG. The input pressure and the supply pressure should not exceed 30 PSIG as damage to the instrument may be incurred. It is recommended a Nullmatic Regulator be used to maintain a constant air supply to the unit.

Summing of Flows

In applications involving summing of flows where one or more flows may be shut down from time to time, there must be a 3 PSIG signal transmitted to the summing receiver when the differential-pressure meter indicates zero flow (3 PSIG). To insure this 3 PSIG minimum signal, a Model 58S High Pressure Selector Relay or a Model 41N15 Regulator is incorporated into the system, as illustrated in Figure 1.

CALIBRATION

General

There are three basic calibration adjustments in the Model 65 Square-Root Extractor. They are zero, deviation, and span. It is recommended they be calibrated in this same order. A stop screw alignment adjustment is also incorporated but should not be used unless the screw was turned. For a complete calibration, the Square-Root Extractor must be removed from service and connected in a test circuit as shown in Fig. 2.

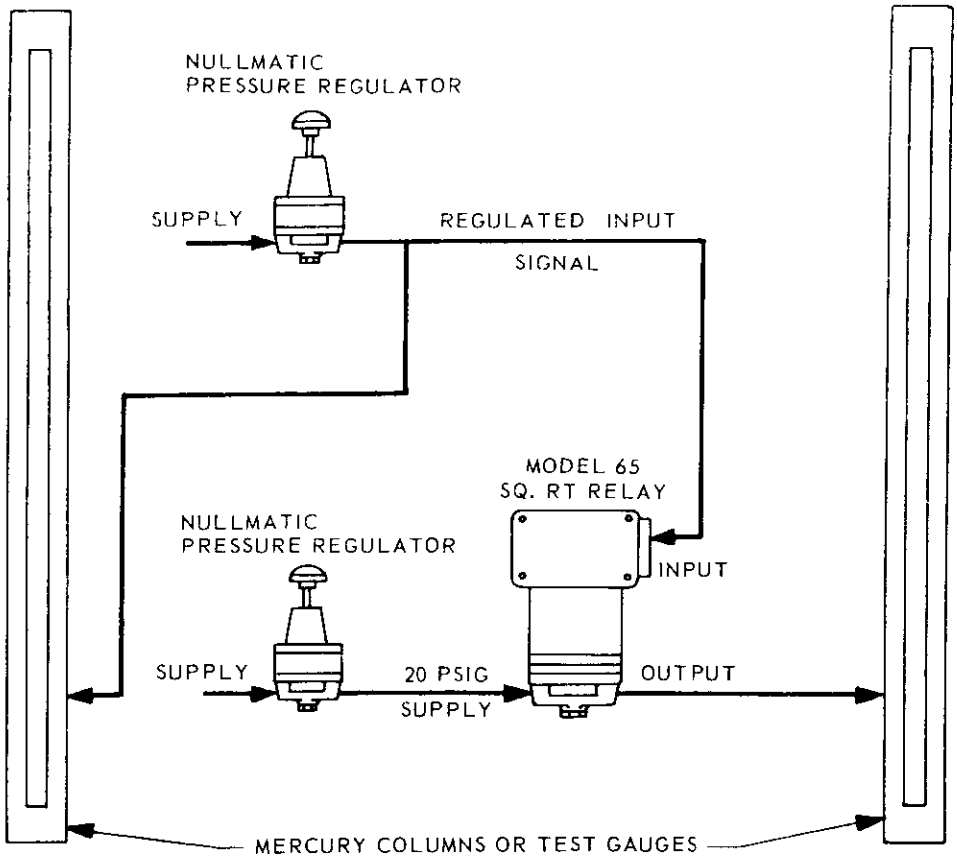


Fig. 2
Calibration Arrangement

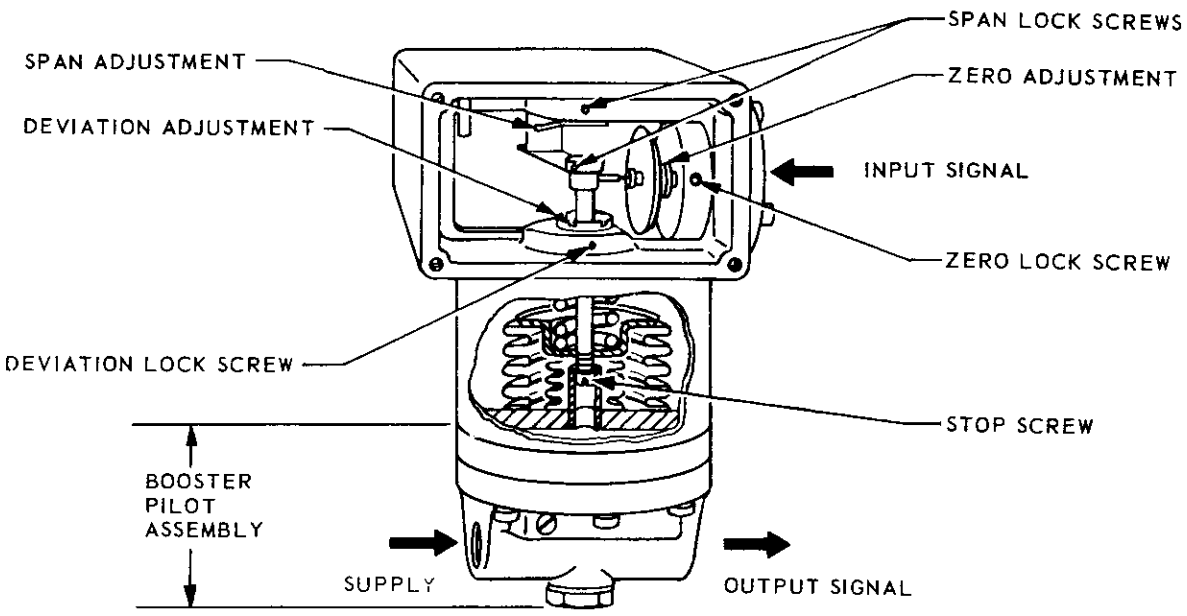


Fig. 3
Calibration Points

Zero (Refer to Fig. 3)

For a standard input range and output range of 3-15 PSIG:

1. Adjust the Extractor input pressure to 3.12 PSIG. The output pressure should be 4.20 PSIG.
2. If the output pressure is not 4.20 PSIG, loosen the zero lock screw and turn the zero adjustment out to raise the output pressure, or turn it in to lower the output pressure.
3. Tighten zero lock screw after setting zero.

For an input range of other than 3-15 PSIG:

1. Obtain the input span by subtracting the transmitter output for 0% flow from the transmitter output for 100% flow.

   EXAMPLE:

   Transmitter Output 3-16 PSIG

   16 PSIG
   − 3 PSIG
   13 PSIG – Input Span

2. Multiply the input pressure span by .01 and add the result to the 0% input pressure to obtain the input pressure for checking the zero of the Square-Root Extractor.

   EXAMPLE:

   13 PSIG input span

   13 PSIG
   X .01
   .13 PSIG
   +3.00 PSIG
   3.13 PSIG – Input pressure for checking zero

3. Refer to the standard (3-15 PSIG) range zero adjustment using the preceding input pressure to check zero.

For an output range of other than 3-15 PSIG:

1. Obtain the output span by subtracting the receiver pressure for 0% flow from the receiver pressure for 100% flow.

   EXAMPLE:

   Receiver Range 3-17 PSIG

   17 PSIG
   − 3 PSIG
   14 PSIG – Output span

2. Multiply the output pressure span by 0.1 and add the result to the pressure for 0% flow of the receiver.

   EXAMPLE:

   14 PSIG output span

   14 PSIG
   X 0.1
   1.4 PSIG
   + 3.0 PSIG
   4.4 PSIG – Output pressure for checking zero

3. Refer to the standard (3-15 PSIG) range zero adjustment using the preceding output pressure to check zero.

Deviation (Refer to Fig. 3)

The calibration figures used in the deviation calibration are to be used only in case of 3-15 PSIG input and output ranges. If either the input or output range is other than 3-15 PSIG, see the instructions following the Span Calibration for the method of calculating the correct calibration figures.

1. After setting the zero, adjust the input pressure to 6 PSIG and make a note of the output pressure. The output pressure should be 9 PSIG.
2. Adjust the input pressure to 15 PSIG and make a note of the output pressure. The output pressure should be 15 PSIG.
3. If the pressure outputs do not agree with the standard calibration figures within .06 PSIG, it may be necessary to make a deviation adjustment to correct the shape of the calibration curve. The following formula is used for this determination.

$$\begin{pmatrix}\text{Deviation}\\ \text{Error}\end{pmatrix} = \begin{pmatrix}\text{Error at}\\ \text{half-scale}\end{pmatrix} - \begin{pmatrix}\text{Error at}\\ \frac{\text{full-scale}}{2}\end{pmatrix}$$

EXAMPLE:

Model 65 Input PSIG	Standard Output PSIG	Model 65 Output PSIG	Error PSIG
3.12	4.20	4.20	0
6.00	9.00	10.50	↑ 1.5
15.00	15.00	15.50	↑ 0.5

$$\text{D. E.} = +1.5 - \frac{(+0.5)}{2}$$
$$= +1.5 - (+0.25)$$
$$= +1.5 + (-0.25)$$
$$= +1.25$$

4. If the error is between + .06 PSIG and - .06 PSIG, no deviation adjustment is necessary.
5. If the calibration is not within the above limits, proceed as follows:
   a. Loosen the deviation lock screw located below the slotted deviation adjustment bushing.
   b. If the result of the calculation is a positive quantity, turn out on the slotted adjustment bushing. If it is a negative quantity, turn in on the slotted adjustment bushing.
   c. Tighten the deviation lock screw after making this adjustment.
6. Readjust the zero and again check the shape of the calibration curve. Calculate the error. Continue until the deviation error is within the calibration limits.

Span (Refer to Fig. 3)

The calibration figures used in the span calibration are to be used only in case of 3-15 PSIG input and output ranges. If either the input or output range is other than 3-15 PSIG, see the instructions following the Span Calibration for the method of calculating the correct calibration figures.

1. After adjusting the deviation to within the calibration limits, set the input pressure to 6 PSIG and note the output pressure. The output pressure should be 9 PSIG.
2. Increase the input pressure to 15 PSIG and note the output pressure. The output pressure should be 15 PSIG.
3. If the output pressures do not agree with the standard calibration within .06 PSIG, a span adjustment is required.
   a. Loosen the span lock screws.
   b. The output span is increased by moving the adjustment lever to the left; decreased by moving the adjustment lever to the right.
   c. Tighten both span lock screws after making this adjustment.
   d. Zero the instrument and recheck the span. Continue this procedure until instrument is within the calibration limits described.

Calculations

Deviation and span Calibration Calculations for other than 3-15 PSIG Ranges.

INPUT

For an input pressure range other than 3-15 PSIG, the calibration input pressures for the deviation and span calibrations must be calculated as follows:

1. Obtain the input span by subtracting the transmitter output for 0% flow from the transmitter output for 100% flow.

   EXAMPLE:

   Transmitter output 3-16 PSIG

   16 PSIG
   − 3 PSIG
   13 PSIG – Input span

2. Multiply the input pressure span by .25 and add the result to the 0% input pressure to obtain the input pressure for half-scale.

   EXAMPLE:

   13 PSIG input span

   13 PSIG
   X .25
   65
   26
   3.25
   +3.00
   6.25 PSIG – Input pressure for half-scale

3. The 100% input pressure will be the flow transmitter's pressure output for 100% flow.

   EXAMPLE:

   Transmitter output 3-16 PSIG
   Input pressure for full scale – 16 PSIG

   These two pressures are used for the Deviation and Span Calibrations in lieu of the two input pressures (6 PSIG and 15 PSIG) shown in the above calibration.

OUTPUT

For an output pressure range other than 3-15 PSIG, the calibration output pressures for the Deviation and Span Calibrations must be calculated as follows:

1. Obtain the output span by subtracting the receiver pressure for 0% flow from the receiver pressure for 100% flow.

   EXAMPLE:

   Receiver range 3-17 PSIG

   17 PSIG
   − 3 PSIG
   14 PSIG output span

2. Multiply the output pressure span by .5 and add the result to the pressure for 0% flow of the receiver.

   EXAMPLE:

   14 PSIG output span

   14 PSIG
   X .5
   7.0 PSIG
   + 3.0 PSIG
   10.0 PSIG – Output pressure for half-scale

3. The 100% output pressure will be the 100% pressure for the receiver.

   EXAMPLE:

   Receiver range 3-17 PSIG
   The 100% output pressure is 17 PSIG

   These two pressures are used for the Deviation and Span Calibrations in lieu of the two output pressures (9 PSIG and 15 PSIG) shown in the above calibration.

Stop Screw Adjustment (Refer to Fig. 3)

The stop screw, located in the center of the bellows, should not have to be adjusted. If the screw is turned for any reason, it must be adjusted so that the nozzle end of the pilot link assembly is approximately .007" below horizontal.

The stop screw position can be more accurately adjusted as follows:

1. With the unit fully assembled, slowly reduce the input pressure below 3.12 PSIG. The output pressure should start to drop rapidly when it is at approximately 3.5 PSIG. If the output starts to drop rapidly at a value greater than 4.0 PSIG, the stop screw is set too high. For every 1 PSI above 3.5 PSIG that the pressure starts to drop off rapidly, remove the booster pilot assembly and turn the stop screw out slightly less than 1/2 turn.
2. Slowly increase the input pressure from 2.5 PSIG. The output pressure should rapidly increase from 0 PSIG to approximately 3.5 PSIG. If the output pressure increases to above 4.0 PSIG, the stop is set too low. For every 1 PSIG above 3.5 PSIG that this action occurs, turn the stop screw in slightly more than 1/2 turn.

Calibration Table
Model 65 – Moore Square-Root Extractor

This table is based on a 3-15 input signal and a 3-15 PSIG output signal.

SQUARE-ROOT INPUT		LINEAR OUTPUT	
% Full Scale	PSIG	% Full Scale	PSIG
0	3.00	0	*3.00
1	3.12	10	4.20
4	3.48	20	5.40
9	4.08	30	6.60
16	4.92	40	7.80
25	6.00	50	9.00
36	7.32	60	10.20
49	8.88	70	11.40
64	10.68	80	12.60
81	12.72	90	13.80
100	15.00	100	15.00

*Theoretically possible, but due to the infinite slope of the square-root curve at zero, this may not be obtained.

MAINTENANCE (Refer to parts list)

A periodic check of the air filter and regularly opening the blow off valve of the dripwell will minimize any difficulty from the supply air.

Should the supply restriction become clogged (located in the bottom casting), it may be removed and cleaned by inserting the cleaning wire through the restriction tube several times. The cleaning wire is located on the small knurled screw in the base of the instrument. No adjustment is provided on the restriction. It is only necessary to screw it in tightly to restore the relay to normal operation.

The exhaust port must be kept open. If it becomes plugged, it will be necessary to disassemble the unit and clean the port.

Disassembly (Refer to parts list)

GENERAL

The unit should be disassembled only if absolutely necessary. Any malfunction of this relay can usually be traced to a dirty air supply. These troubles can be corrected by:

1. Removing the restriction and clearing the tube using the cleaning wire.

2. Removing the pilot plunger and wiping off any dirt or foreign material.
3. Removing the floating pilot link and cleaning the nozzle with a solvent such as carbon tetrachloride. This is a spring-loaded link and can be removed by grasping the link with a pair of tweezers and gently pushing the link to one side.

If necessary, the unit can be disassembled in sections as follows:

DIAPHRAGM AND PILOT VALVE ASSEMBLIES

1. Remove the cleaning wire from the bottom casting.
2. Remove the six screws in the bottom casting.
3. Carefully separate the diaphragms and the exhaust ring.
4. The pilot plunger and spring can be taken out by removing the retaining screw in the bottom casting.

BELLOWS ASSEMBLY

1. After removing the diaphragm and pilot valve assemblies, remove the pilot link assembly.
2. Loosen, but do not remove, the span lock screw in the bottom of the leaf spring assembly.
3. Remove the two flat-head screws in the bottom of the housing. Care should be taken at this point as the bellows assembly is under moderate spring tension.
4. Pull the bellows through the bottom of the housing.

INPUT CAPSULE

1. Remove the floating pilot link.
2. Remove the connecting block from the housing.
3. Loosen the zero lock screw.
4. Using a 1/2" open-end wrench, turn the input capsule assembly out of the connecting block.

Assembly

1. To assemble, reverse the disassembly procedures.
2. When installing the input capsule, turn it in until the outer edge of the input capsule is approximately 7/16" from the face of the connecting block. This is the preliminary zero adjustment.
3. Before installing the floating pilot link, it is recommended Moly-Kote lubricant be applied to the sliding link ball and the input capsule seat, and then wiped off. The penetration of the lubricant at these points provides sufficient lubrication. The detector nozzle and ball require no lubrication (see Fig. 4).
4. Install the floating pilot link so that the ball on the sliding link end is placed into the input capsule seat. The larger end goes into the detector nozzle (proper position shown in Fig. 4).

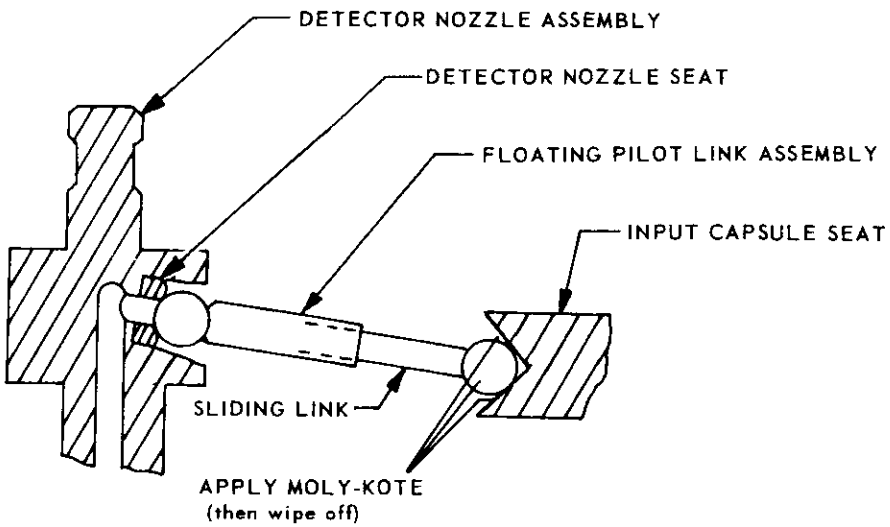
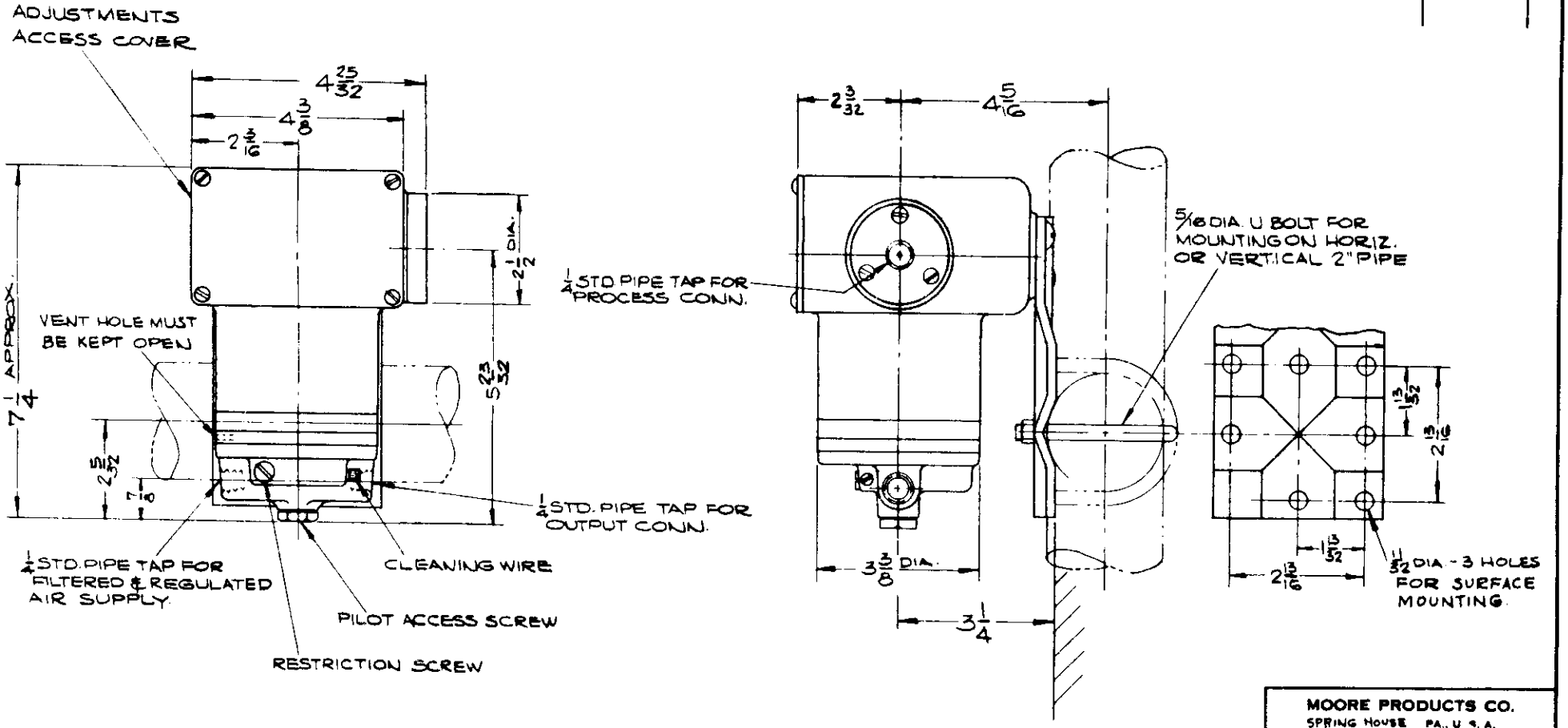


Fig. 4
Floating Pilot Link, Positioning

FINISHING TOLERANCES ON FRACTIONAL DIM. ± 1/64
TOLERANCES ON DECIMAL DIMENSIONS ± .005

ISSUE No.	APP.
1. 9-13-60	[illegible]

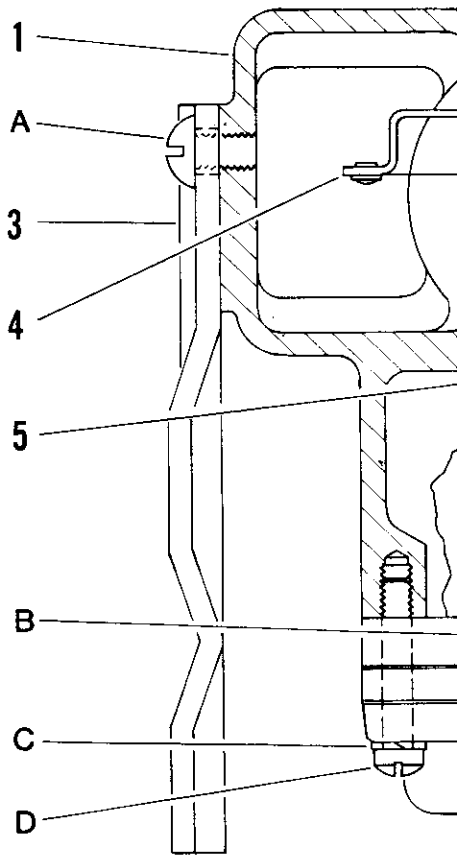


MOORE PRODUCTS CO.
SPRING HOUSE PA., U. S. A.

INSTALLATION DRAWING
MODEL 65
SQUARE ROOT RELAY

DR'N	CH'D	APP.	DWG. NO.
[illegible]	GS		10895-1-N
SCALE HALF	DATE 1-18-60		

Item	Part No.	Description	Req'd
1	10895-58	Housing	1
* 2	1033-22	Cleaning Wire	1
3	8883-7	Mounting Bracket	1
4	10895-136	Leaf Spring	1
5	8179-1	Roll Pin	1
* 6	8880-18	Wrench for #5 Set Screw	1
* 7	3092-36	Wrench for #10 Set Screw	1
8	10895-198	Bottom Forging	1
9	10895-96	Cover	1
10	10895-97	Gasket	1
11	9391-4	Washer	4
*12	4505-40	Diaphragm	1
14	8883-14	Exhaust Ring	1
*15a	10792-10	Restriction Screw (Incl. Items 15b & 30)	1
*15b	2938-1	O-Ring	1
*16	1977-11	Diaphragm	1
17	10895-48	Bushing	1
18	10895-49	Washer	1
19	10895-102	Spring	1
*20	10895-199	Bellows Assembly	1
21	1518-5	Spring	1
22	2155-3	Valve Plunger	1
23	2155-7	Spring	1
24	2155-6	Retaining Nut	1
*25	10895-183	Pilot Link	1
26	10895-140	Connection Block	1
*27	10895-125	Capsule	1
28	10895-143	Friction Plug	3
*29	2938-5	O-Ring	1
*30	111-20	Filter Screen	1
*31	2155-225	Filter Screen	2
A	1-4146	#5/16-18 x 1/2 Rd. Hd.	2
B	1-1950	#8-32 x 9/16 Flat Hd.	2
C	1-7297	#1/4 Med. Lwr.	6
D	1-3520	#1/4-20 x 1.38 Fill. Hd.	6
E	1-1916	#8-32 x 7/16 Truss Hd.	4
G	1-5468	#5-40 x 3/16 Flat Pt. S/S	1
H	1-2470	#10-32 x 5/8 Fill. Hd.	3
J	1-5795	#10-32 x 1/4 Oval Pt. S/S	3



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

MOORE

MODEL 65
SQUARE ROOT EXTRACTOR

Drawing No. 10895PL