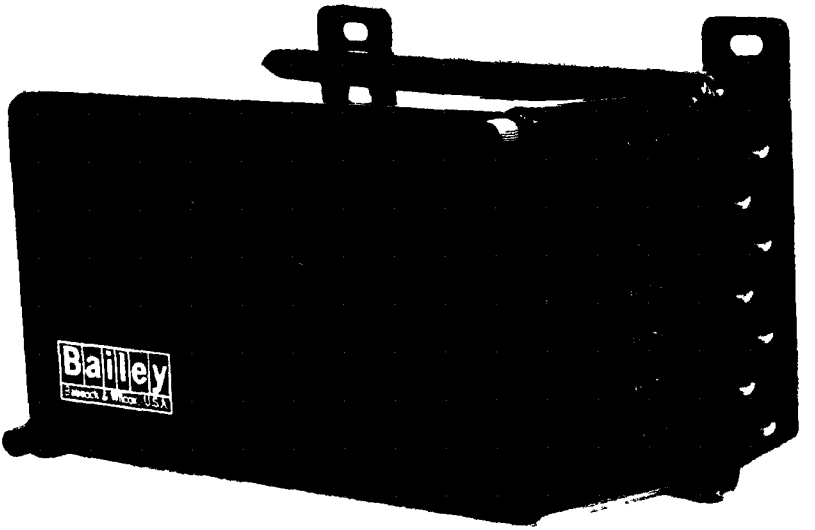
MINI-LINE 520*
Square Root Extractor
Type FS



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Bailey Controls Company
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WARNING	AVERTISSEMENT
NSTRUCT ON MANUALS	MANUELS D OPERAT ON
DO NOT NSTALL MAINTA N OR OPERATE TH S EQUIPMENT WITHOUT READ NG UNDERSTANDING AND FOLLOW NG PROPER **Babcock & Wilcox Bailey Controls Co. U.S.A** NSTRUCT ONS AND MANUALS, OTHERWISE INJURY OR DAMAGE MAY RESULT	NE PAS METTRE EN PLACE REPARER OU FA RE FONCT ONNER CE MATERIEL SANS AVOIR LU COM PR S ET SU V LES NSTRUCTIONS REGLEMENTA RES DE **Babcock & Wilcox Ba ley Controls Company, U.S.A** TOUTE NEGL GENCE A CET EGARD POURRA T ETRE UNE CAUSE D'ACCIDENT OU DE DEFA LLANCE DU MATER EL

INDEX

INSTALLATION

WARNING THIS UNIT SHOULD NOT BE INSTALLED IN AN ENVIRONMENT CONTAIN ING CHLORINATED OR AROMATIC HYDROCARBONS THESE ELEMENTS WILL DAM AGE THE POLYCARBONATE COVER THE COVER WILL ALSO BE DAMAGED BY AMINOS, ALKALIES AND AMMONIA

AVERTISSEMENT CET ENSEMBLE NE DOIT PAS ETRE INSTALLE DANS UN ENVIRONNE MENT CONTENANT DES HYDROCARBURES AROMATIQUES OU CHLORES CES ELE MENTS ENDOMMAGERAIENT LE COUVERCLE EN POLYCARBONATE L'AMMONIAQUE, L'ALCALI ET LES AMINES ENDOMMAGENT EGALEMENT LE COUVERCLE

Unpackng and Storage

1 Check for any obvious damage to shipping carton or contents Report any damage to carrier

2 Make certain that unit is correct range for intended service (refer to identification label)

3 If unit is to be stored, repack in original container and store in an area free of corrosive vapors and extremes in temperature and humidity

Storage temperature should fall within limits of 20°F and +160°F (29°C and +72°C)

Mountng and External Connections

The Square Root Extractor is designed for wall or surface mountng and should be mounted as follows

1 Attach unit to wall, panel or relay rack as shown in Figure 1 and secure with three 1/4 inch cap screws, nuts and lockwashers

NOTE Unit must be mounted as indicated in order to function properly

2 Make external connections to mountng base (Figures 1 and 2) Connections are 1/8" 27 NPT female (E4, S and 0 connections)

3 Adjust air supply to mountng base to 18 to 20 psig (124 to 138 kPa) for 3 to 15 psig service and 30 to 35 psig (206 7 to 241 2 kPa) for 3 to 27 psig service See "Quality Stand ard for Instrument Air", 1975, ISA S7 3 at the end of this section

NOTE If tubing elbows are desired, the following fittings are recommended

E4 and output 1/8 NPT male to tubing elbow

S 1/8 NPT x "1" nipples and 1/8 NPT female to tubing elbows

Quality Standard for Instrument Air 1975 SA S7 3

4 1 1 Outdoor Installations (where any part of the instrument air system is exposed to the outdoor atmosphere)

The dew point at the pressure shall be at least 10°C (18°F) below the minimum ocal recorded ambient temperature at the plant site

4 1 2 Indoor Installations (Where the entire instrument air system is installed indoors)

The dew point at the pressure shall be at least 10°C (18°F) below the minimum temperature to which any part of the instrument air system is exposed at any season of the year In no case should the dew point at the pressure exceed 2°C (approximately 35°F)

4 2 Particle Size

The maximum particle size in the air stream at the instrument shall be three (3) micrometres

4 3 Oil Content

The maximum total oil or hydrocarbon content exclusive of non condensables shall be as close to zero (0) w/w or v/v as possible and under no circumstances shall exceed one 1) ppm w/w or v/v under normal operating conditions

4 4 Contaminants

The instrument air shall be free of all corrosive contaminants and hazardous gases, flammable or toxic which may be drawn into the instrument air stream If contamination exists in the compressor intake area the air should be taken from an elevation or remote ocation free from contamination or processed to remove such contamination Any cross connections or process connections to the instrument air piping shall be isolated to preclude contamination of the air system A regular periodic check should *be made to assure high quality instrument air*

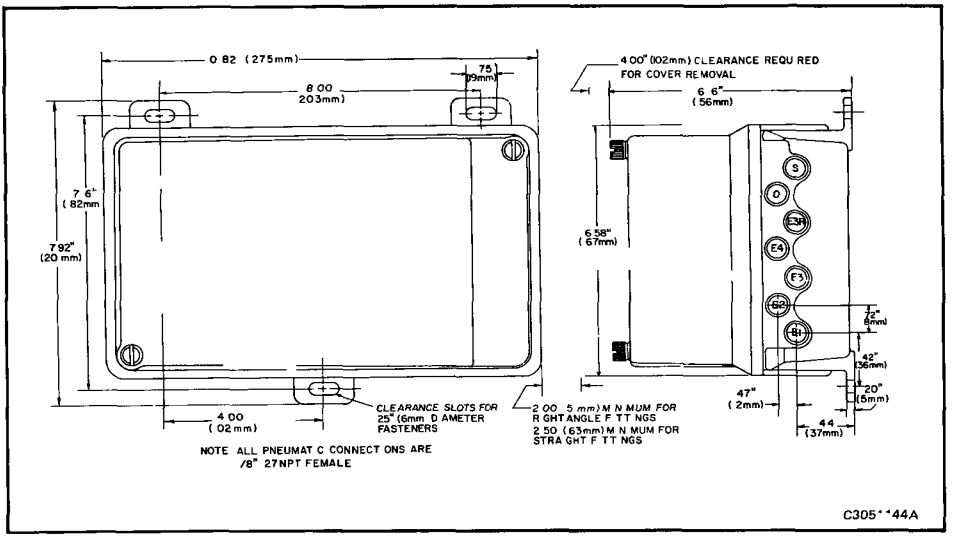


FIGURE 1 External and Mounting Dimensions, Type FS Square Root Extractor

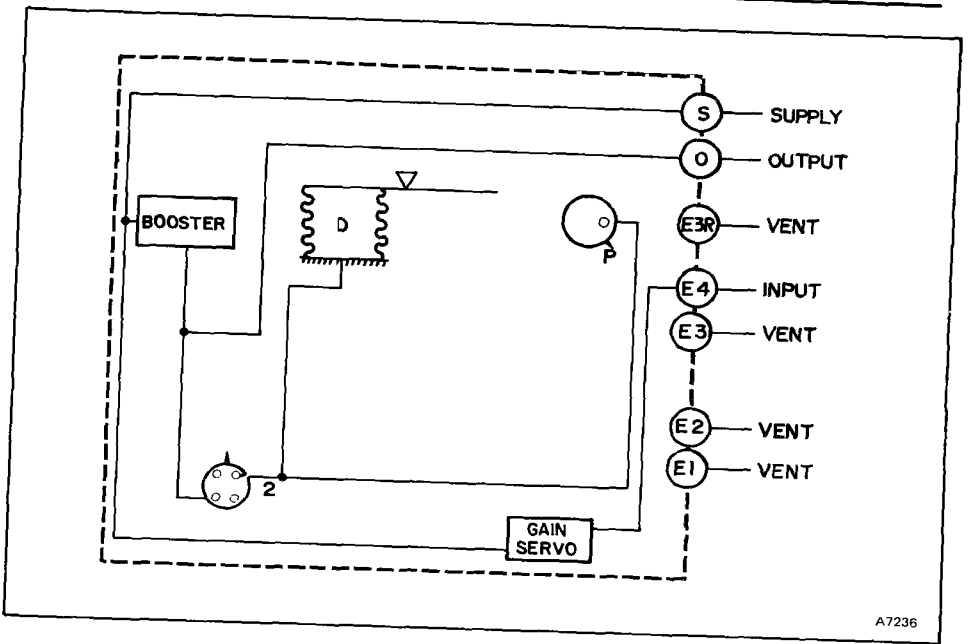


FIGURE 2 Tub ng Connect ons and Sw tch Sett ngs for Type FS Square Root Extractor

PLACING IN SERVICE

The controller is factory calibrated for use as a Square Root Extractor It may be placed directly in service after making the connections listed under "Installation", "Mounting and External Connections", and checking the calibration according to the following procedure

Checking Calibration

1 Apply 18 0 to 20 0 psig (124 to 137 9 kPa) for 3 to 15 psig service or 30 to 35 psig (206 7 to 241 2 kPa) for 3 to 27 psig service to "S" connection

2 Apply 0 to 20 psig (0 to 137.9 kPa) for 3 to 15 psig service or 0 to 30 psig (0 to 206 7 kPa) for 3 to 27 psig service, variable regulated input to "E4" connection

3 Check factory calibration (Table 1)

IMPORTANT If factory calibration has been changed the controller must be recalibrated as outlined under "Complete Calibration"

Per Cent of Flow Range	3 15 psig Input Range	3-27 psig Input Range	3-15 psig Output Range	3 27 psig Output Range
0	3 00	3 00	3 00	3 00
10	3 12	3 24	4 20	5 40
20	3 48	3 96	5 40	7.80
30	4 08	5 16	6 60	10 20
40	4 92	6 84	7 80	12 60
50	6 00	9 00	9 00	15 00
60	7 32	11 64	10 20	17 40
70	8 88	14 76	11 40	19 80
80	10 68	18 36	12 60	22 20
90	12 72	22 44	13 80	24 60
100	15 00	27 00	15 00	27 00

TABLE 1
INPUT/OUTPUT RANGES

ROUTINE MAINTENANCE

1 Air supply to unit must be kept free of dirt, oil and moisture for satisfactory operation Inspect felt filters in mounting base and replace them if they are dirty Frequency of filter replacement will depend on the quality of supply air See "Quality Standard for Instrument Air", ISA S7 3, 1975 under "Installation"

NOTE These filters are included as added protection only and are not intended to take place of required clean air supply

2 When necessary, replace felt pad air filters in S connection (Figure 4) as follows

a Turn off supply air and disconnect supply air lines

b Remove fittings

c Remove wire mesh discs and felt pads with pick or similar instrument

d Replace felt pads and wire mesh discs

e Replace fittings

f Reconnect supply air to mounting base

3 All pressure connections must be kept air tight Check all air pressure connections for leakage with suitable leak detector solution

4 Inspect nozzle tip (Figure 9) and vane for deposits of oil, dirt, etc Clean with a suitable solvent

5 Clean booster using orifice cleanout plunger, WHEN EQUIPMENT IS NOT OPERATING

WARNING· USE OF THE BOOSTER CLEANOUT DEVICES WHEN EQUIPMENT IS OPERATING ON-LINE CAUSES PNEUMATIC SIGNAL 'BUMP" WHICH COULD CAUSE SERIOUS SYSTEM UPSET.

AVERTISSEMENT L'EMPLOI DU DISPOSITIF DE NETTOYAGE DU SURPRESSEUR PENDANT QUE L'EQUIPEMENT EST EN FONCTIONNEMENT DIRECT PROVOQUE UN "CONGNEMENT" DU SIGNAL PNEUMATIQUE ET RISQUE DE CAUSER UN DEREGLAGE SERIEUX DU SYSTEM

a To clean booster orifice push cleanout plunger (Figure 3)

b Check output bleed orifice located just below orifice cleanout plunger for normal small air bleed

c If necessary, clean out any obstructions by manipulating cleanout wire

COMPLETE CALIBRATION

If the unit has been disassembled for any reason, or factory calibration has been disturbed, or the unit cannot be correctly adjusted as outlined under "Placing In Service", it must be completely recalibrated as outlined under "Basic Alignment"

No calibration of the booster is required

NOTE For maximum accuracy, the unit should be calibrated in the same position as that of final installation

Also, it is suggested that an extra controller mounting assembly (part no 5327136 1) be used when calibrating in order to eliminate disruption of piping

If it has been necessary to repair or replace any parts, the basic alignment of the unit can be re established by following the applicable procedure outlined below After alignment it will be necessary to repeat the steps outlined under "Placing In Service"

Calibration of the Type FS Pneumatic Square Root Extractor requires variable 0 to 30 psig (0 to 206 9 kPa) or 0 to 20 psig (0 to 138 kPa) regulated pressure sources for supply and input signal Two test gauges of + 1% accuracy are required for input and output signal measurement

Nulling Procedure

1 Remove pressure from "E4" input

2 Apply 18 0 to 20 0 psig (124 to 137 9 kPa) for 3 to 15 psig service or 30 to 35 psig (206 7 to 241 2 kPa) for 3 to 27 psig service to "S" connection

3 With gain arm at a setting of "1", adjust C/D bias screw until output is equal to 3 0

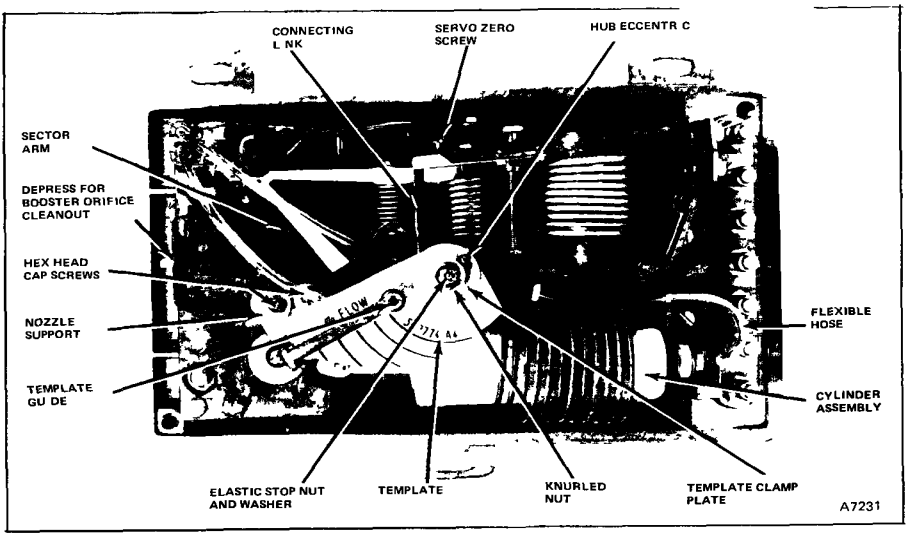
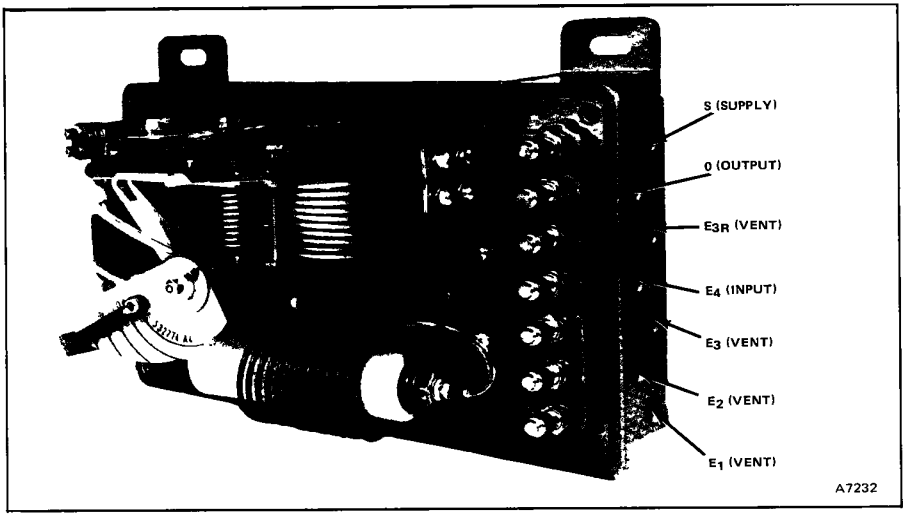


FIGURE 3 Square Root Extractor Adjustments.



F GURE 4 External Connection Ports

+ 12 psig (20 7 + 83 kPa) for 3 to 15 psig and 3 0 + 24 psig (20 7 +1 65 kPa) for 3 to 27 psig

4 Move gain arm to "5" position on gain decal

5 Adjust eccentric in slide bracket assembly (Item 34, Parts Drawing P92 13 2), until the out put is equal to 3 0 + 12 psig

6 Repeat steps 3 thru 5 until difference between output at a gain setting of "5" and out put at a gain setting of " 1" is less than 0 24 psig (1 74 kPa) or 0 48 psig (3 3 1 kPa)

7a Move gain from 1 to 5 and note any change in output between these settings At point of greatest deviation, adjust error using null adjustment screw on gain arm

7b Set gain to 1 and readjust C/D bias screw to required pressure

7c Set gain to 5 and adjust eccentric in slide bracket assembly to obtain output

8. Repeat steps 3 thru 7 until gain arm can be moved from " 1" position to "5" position while output remains constant at 3 0 + 12 psig (20 7 + 83 kPa) for 3 15 and 3 0 + 24 psig (20 7 +1 65 kPa) for 3 27

Basic Alignment

1 Remove plastic cover from unit

2 Remove plastic plugs from ports in con troller mount

3 Check that C/D beam is parallel to edge of controller base and that hinge (Item 33, Parts Drawing P92-13 2) is straight

4 Loosen clamp screw in slide bracket assembly (Item 34) Adjust eccentric until slide (Item 5) is at mid range of travel Snug down clamp screw

5 Check alignment of linkage pivot pin (Item 26, Parts Drawing P92-13-2) End of pivolt pin should be in line with dimple on shaft of range adjustment (Item 14)

6 Check that nozzle on C/D beam is in center of vane (Item 2) and vane body (Item 4) is contacting pivot pin (Item 26)

7 Check that C/D bias adjustment spring (Item 20) is parallel to edge of controller base and that C/D bias spring assembly locknuts (Item 47) are tight

8 Place P/P + I/P + D/P + I + D switch, located next to valve chamber on controller base, in "P" position

9 Place derivative switch, located next to booster assembly, in "I" position

10 If cam is installed on unit, remove by holding cam hub assembly (Item 7, Parts Drawing P92 13 3) and loosening knurled nut (Item 8)

11 Carefully remove hook end of spring (Item 19) from hole in end of connecting rod (Item 16)

12 Remove connecting rod from cylinder and rotate 180° (Rod pointing away from cyl inder)

13 Loosen two hex head cap screws used to retain nozzle support (Item 5) on gain arm and slide nozzle support toward gear side of gain arm, exposing "null" screw on gain arm Lightly tighten two cap screws to retain nozzle support in this position

14 Mount unit on vertical surface

15 Connect a 0 to 30 psig (0 to 206 9 kPa) or 0 to 20 psig (0 to 138 kPa) variable regulated input to "E4" port of controller mount

16 Apply 9 0 + 01 psig (62 + 07 kPa) or 15 0 + 01 psig (103 4 + 07 kPa) to "E4" input

17 Check that servo beam (Item 24, Parts Drawing P92 13 3) is approximately parallel to servo mounting base (Item 22) If necessary, loosen two nuts retaining servo spring assembly (Item 17) and reposition nuts on spring assembly until servo beam is parallel to mounting base Tighten nuts

18 Apply 15 5 + 01 psig (106 9 + 07 kPa) or 27 5 + 01 psig (189 5 + 07 kPa) to "E4" input

19 Loosen nut retaining stop screw (Item 45) and adjust position of screw until screw head just contacts servo beam Tighten nut to retain stop screw

20 Apply 2 0 + 01 psig (13 8 + 07 kPa) to "E4" input

21 Adjust position of elastic stop nut (Item 25) until nut just contacts underside of servo beam

22 Remove pressure from "E4" input

Square Root Cam Calibration

1 Remove supply pressure from "S" connec tion, insert connecting rod (Item 16, Parts Draw ing P92 13 3) into cylinder and reconnect spring (Item 19) to end of connecting rod

2 Apply 9 0 + 01 psig (62 + 07 kPa) or 15 0 + 01 psig (103 4 + 07 kPa) input to "E4" input

3 Loosen knurled nut (Item 8) on cam hub approximately one turn Grasp cam hub (Item 7) to prevent it from turning and adjust eccentric screw on hub until hub driver arm is approxi mately in mid position of its adjustment range Do not tighten knurled nut

4 Adjust "zero" screw (Item 40) to provide a clearance of approximately 1/16 inch (1 6mm) between zero adjustment arm (Item 15) and servo beam (Item 24)

5 Check that servo beam is approximately parallel to servo mounting base (Item 22) If necessary, loosen two nuts retaining servo spring assembly (Item 17) and reposition nuts on spring assembly until servo beam is parallel to mounting base Retighten nuts

6 Adjust "zero" screw (Item 40) on servo beam until hub driver arm on cam is approxi mately parallel to servo mounting base

NOTE Do not turn "zero" screw more than three turns in either direction If required par allelism between hub driver arm and servo mount ing base cannot be obtained with less than three (3) turns of "zero" screw, reset "zero" screw per step 4 and repeat steps 5 and 6

7 Install square root cam between clamp plate (Item 12) and cam hub Push cam into

hub assembly until cam bottoms against center bushing in hub Install cam in hub assembly so that part number on cam is readable Rotate cam so that cam guide (Item 28) on nozzle support (Item 5) is aligned with approximately 70% flow point on cam (Figure 5) Lightly tighten knurled nut to retain cam

8 Loosen nozzle retaining screw (Item 46) Adjust by placing a 002 005 inch (05 to 13 mm) shim between nozzle and cam (004 inch (10 mm) one sheet of paper) Tighten retaining screw

9 Apply 18 to 20 psig (124 to 138 kPa) or 30 to 35 psig (206 7 to 241 2 kPa) supply to "S" connection

10 Recheck alignment of nozzle for approximately 70% flow

11 Apply 3 0 +01 psig (20 7 +07 kPa) to "E4" input and adjust range eccentric to align minimum travel mark (0% flow radius) on cam with nozzle

12 Apply 9 0 +01 psig (62 +07 kPa) or 15 0 ±01 psig (103 4 +07 kPa) to "E4" input and adjust servo zero screw (Item 40), if necessary to realign 70% mark on cam with nozzle

13 Apply 15 0 +01 psig (103 4 +.07 kPa) or 27 0 +01 psig (186 +07 kPa) to "E4" input Cam's maximum travel mark (100% flow radius) should be aligned with nozzle If not, angularity correction of cam motion will be required

a If nozzle position is less than 100% mark, loosen knurled nut and rotate cam a few degrees counter-clockwise

b If nozzle position is greater than 100% mark, loosen knurled nut and rotate cam a few degrees clockwise

14 Repeat steps 11 thru 13 until radius lines on cam line up with nozzle at 3 0, 9 0 and 15 0 psig (207, 62 and 103 4 kPa) or 3 0, 15 0 and 27 0 psig (20 7, 103 4 and 186 kPa) inputs to "E4"

15 Apply 3 0 +01 psig (20.7 ±07 kPa) to "E4" input Adjust C/D bias screws to obtain 3 0 +01 psig Slightly loosen two #10 32 hex head screws (Item 47) retaining nozzle support to sector arm and rotate sector arm until gain is zero (0.0)

NOTE Zero gain can be checked by loosening clamp screw in slide bracket assembly (Item 34, Parts Drawing P92-13 2) and rotating eccentric causing slide to move from one end of travel to the other IMPORTANT When rotating eccentric in slide bracket assembly, clamp screw should be snugged down tight enough to permit eccentric to be rotated smoothly with minimum amount of slop in slide Adjust gain arm until output will not change more than 3 0 +06 psig (20 7 +4 kPa) when eccentric is rotated Retighten two hex head screws (Item 47, Parts Drawing P92-13 3) and recheck that gain is still zero

NOTE Fine adjustment of nozzle support can be accomplished while two hex head screws are just slightly snug by jiggling nozzle support within clearance afforded by fit between retaining screw thread diameter and slot in nozzle support

16 Apply 3 0 ± 01 psig (20 7 +07 kPa) to "E4" input Input to E_1, E_2, E_3 0 0 psig Output should equal 3 0 +06 psig (20 7 +4 kPa) If not, adjust C/D bias screw until output equals 3 0 +.06 psig

17 Apply 15 0 +01 psig (103 4 ±07 kPa) or 27 0 ±01 psig (186 +07 kPa) to "E4" input Output should equal 15 0 +06 psig (103 4 +4 kPa) or 27 0 +12 psig (186 +8 kPa) Adjust eccentric in slide bracket assembly (Item 34, Parts Drawing P92 13 3) until output is equal to 15 0 +06 psig or 27 0 ± 12 psig (186 + 8 kPa)

18 Apply 6 0 +01 psig (41 +07 kPa) or 9 0 +01 psig (62 +07 kPa) to "E4" input Output should equal 9 0 +06 psig (62 +4 kPa) or 15 0 +12 psig (103 4 +8 kPa) (50% of flow)

a If output is low, loosen knurled nut retaining cam and rotate cam a few degrees clockwise

b If output is high, rotate cam a few degrees counterclockwise Snug down knurled nut

19 Apply 3 48 +01 psig (24 ±07 kPa) or 3 96 +01 psig (27 3 +.07 kPa) to "E4" input Output should equal 5 40 +06 psig (37 +4 kPa)

or 7.80 ± 12 psig (53 7 ±.8 kPa) (20% of flow) If not, adjust servo zero screw until output reads 5 40 +.06 or 7 80 ± 12 psig

20 Repeat steps 16 thru 19 until output is within + 06 psig (±.4 kPa) or + 12 psig (+ 8 kPa) of values specified at each input po nt

21 Apply 3 0 +.01 psig (20.7 +.07 kPa) to "E4" input Output should equal 3.0 + 06 psig (20 7 + 4 kPa) If not, repeat steps 11 thru 20

22 Tighten knurled nut (Item 8, Parts Draw ing P92-13 3) and clamp screw (Item 10) in slide bracket assembly (Item 34)

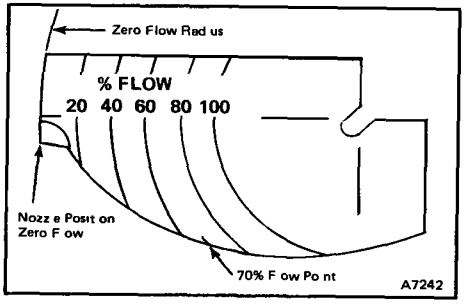


FIGURE 5 Square Root Cam

TROUBLESHOOTING

If the unit is inoperative or if operation is faulty, check the calibration as outlined under "Complete Calibration", and perform operations listed under "Routine Maintenance" If operation is still faulty perform a visual check for loose screws, damaged or broken parts, leaks etc The Fault Correction Chart lists most common problems and corrective actions

Test Gage Kit (Figure 6)

Test gage kits are available as an accessory to aid in troubleshooting the pneumatic control system Kits consist of a gage, tubing and a test probe Slowly attach the test gage probe to a test jack and read pressure. After reading, remove probe and replace jack cap and unit cover

1 Kit part no 5328485-1 (3 to 15 psig/ 20 7 to 103 kPa)

2. Kit part no 5328485 2 (3 to 27 psig/ 20 7 to 186 kPa)

WARNING TEST GAGE SHOULD NORMALLY BE USED ONLY TO TROUBLESHOOT A FAULTY SYSTEM THAT IS NOT IN AN OPERATING MODE PROBE INSERTION CAUSES A PNEUMATIC SIGNAL "BUMP" WHICH COULD CAUSE SERIOUS SYSTEM UPSET

AVERTISSEMENT IL NE FAUT UTILISER LA JAUGE D'ESSAI QUE POUR DETECTER UNE PANNE SUR UN CIRCUIT DEFECTUEUX QUI N'EST PAS EN COURS DE FONCTION NEMENT L'INSERTION DE LA SONDE PRO VOQUE UN "COGNEMENT" DU SIGNAL PNEUMATIQUE QUI RISQUE DE CAUSER UN DEREGLAGE SERIEUX DU SYSTEME

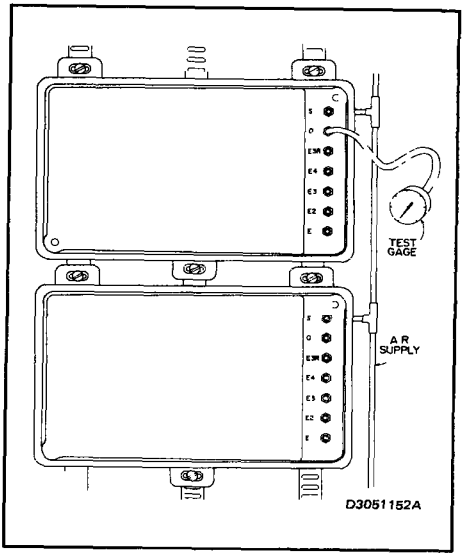
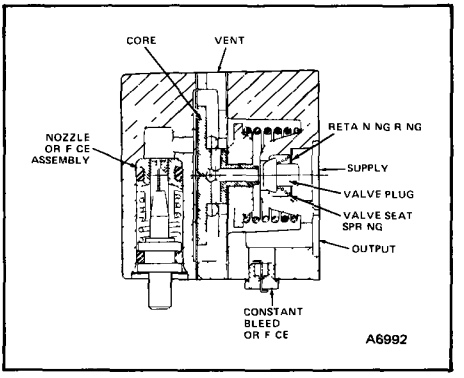


FIGURE 6 Mount ng and Test Gauge Attachment

Pneumatic Booster (Figure 7)

No calibration or adjustment of the booster is required

In normal operation the booster is inaudible However, if the core and the valve plug seat of the output section are not aligned or the valve plug is not seated properly, the booster will produce a hissing sound If this occurs the booster should be removed from the unit and replaced



F GURE 7 Pneumatic Booster

FAULT CORRECTION CHART

Fault	Cause	Correction
Contro er noperab e	a No a r supp y b Booster or f ce c ogged c Vane not touch ng nozz e d D rty a ' supp y e Incorrect sw tch pos t on f Worn base grommet (mount ng base a r va ves c osed)	a Check supp y connect on b Press or f ce c eanout p unger (See Note 1) c Adjust C/D b as d Check operat on of booster e See F gure 2 and correct f Rep ace grommet
Contro er unstab e	a Fasteners oose b nsuff c ent pre oad on nkage p vot p n	a T ghten fasteners b S ght y bend center of vane nk
Contro er output goes to zero	a Booster or f ce c ogged	a Press or f ce c eanout p unger (See Note 1)
Contro er output goes to supp y pressure	a B ocked passages from booster un t to nozz e	a C ean and b ow out passages
Poor accuracy	a Vane pad not centered at nu pressure	a Center vane pad
Poor sens t v ty	a Vane pad not perpend cu ar to nozz e b Booster b eed or f ce c ogged c Vane pad not centered at nu pressures d Leakage n nput nes or test jacks	a Repos t on nkage b Clear by man pu at ng or f ce w re c Center vane pad d Check w th eak detector and repa r
H gh Hysteres s	a Loose fasteners nc ud ng be ows set screws	a T ghten be ows set screw
Ga n changes (h gh v brat on)	a Range (ga n) adjust shaft nsuff c ent y torqued	a Retorque (See Note 2)

FAULT CORRECTION CHART (continued)

Fault	Cause	Correction
Booster output pressure does not mmed ate y ncrease when nozz e back pressure s ncreased	a C ogged or f ce. b Leakage around sect ons of cast ng. c D rty f ters n mount ng base.	a Press or f ce c eanout p unger (See Note 1) b Remove booster and retorque screws c Remove and rep ace f ters
Booster output pressure does not mmed ate y decrease when nozz e back pressure s reduced	a B ocked a r passages from booster un t to nozz e. b Interna eakage of booster	a C ean a r passages b Rep ace booster
Ga n Servo Cyl nder Remains extended	a Supp y pressure too h gh.	a Correct to 18 to 20 ps g (124 to 138 kPa) for 3 15 or 30 to 35 ps g (206 7 to 241 2 kPa) for 3 27
Extends fast, retracts slow Does not retract fu ly	b Leakage past or f ce assemb y. c Nozzle ine plugged. d. Cy nder pre oad spr ng not t ght enough. e Contaminat on n cyl nder.	b Check O r ng and O r ng seat ng surface c Clean or blowout d. Readjust e. Rep ace cy nder/p ston ass'y
Rema ns retracted Retracts fast, extends s ow W not extend fu y	f Low supp y or c ogged f ter n supp y port g Va ve stem n supp y port contro er mount s not actuated fu y h Leakage from nozz e back pressure chamber or passage P ugged or f ce n cy nder base j P ston/cy nder c earance too great k Pre oad spr ng too t ght M sshapec nozz e face m Nozz e not pre oaded aga nst temp ate	f Correct to 18 to 20 ps g or 30 to 35 ps g nsta new f ter pad (supp y) g Check contro e s pushed as far as poss b e nto mount h Check for eaks at or f ces P ug tube f tt ngs, cy nder base C ean or f ce n cyl nder base j Rep ace cy nde:/p ston ass y k Readjust Rep ace nozz e m Pre oad nozz e aga nst temp ate at m n mum rad us check nozz e temp ate gu de c earance
Hysteres s and non repeatab ty (See Note 3)	a Loose be ows ass'y b nterference between be ows beam and temp ate ass'y nkage c nterference between temp ate and nozz e or temp ate gu de d Connect ng rod preloaded too h gh	a T ghten be ows set screw b Stra ghten nkage to e m nate b nd ng c Remove burrs from temp ate and/or adjust temp ate gu de d Adjust rod pivot preload
Instab ty (See Note 3)	a P ston/cy nder nterference b Ga n arm bear ng pre oad too h gh c Nozzle/temp ate guide c earance	a Rep ace cy nder/p ston ass'y b Readjust c Readjust nozz e'temp ate guide clearance

NOTES 1 Press or f ce c eanout p unger on y when equ pment s not operat ng See WARNING under "Rout ne Maintenance"

2 Overtorqu ng w ncrease nu hysteres s

3 Instabil ty, hysteresis anc non repeatab lity are interrelated Cause and correction therefore, w also be nterre ated

OPERATION

Operation of the unit is shown in block form in Figure 8 and schematically in Figure 9

Gain Control Mechanism

A mechanical adjustment, set during calibration, provides an offset of the vane from its null position The magnitude of vane motion towards or away from the nozzle, caused by the mechanical offset is a function of the gain By varying the gain, the amount of vane motion can be varied producing variations in the output The gain is dependent on sector arm position which is controlled by the gain servo air cylinder.

The gain-adjusting servo uses a piston within an air cylinder to provide the power necessary to move the controller sector arm The air cylinder is controlled by the gain servo nozzle which is attached to the sector arm The servo nozzle and air cylinder provide a closed loop motion servo which positions the sector arm so that the nozzle is at the edge of the template The nozzle functions like the roller on a conventional template follower except that it is not limited by steep template rises or abrupt contour changes The nozzle also produces no force against the template permitting it to be made of easily cut polyester film The template is positioned by the E4 gain control signal acting through the gain servo bellows beam and connecting link Template shape determines the sector arm position as a function of the gain control signal

The change in vane nozzle relationship results in an increasing or decreasing nozzle back pressure to the booster which then transmits a corresponding amplified output signal The output is fed back to the D bellows as a 3-15 psig (20 7 to 103 kPa) or 3-27 psig (20 7 to 186 kPa) signal which repositions the D beam, restoring normal vane-nozzle relationship

The template shape provided with the unit produces an output proportional to the square root of the input signal The template shape also provides a hard zero or minimum output of 3 0 psig (20 7 kPa)

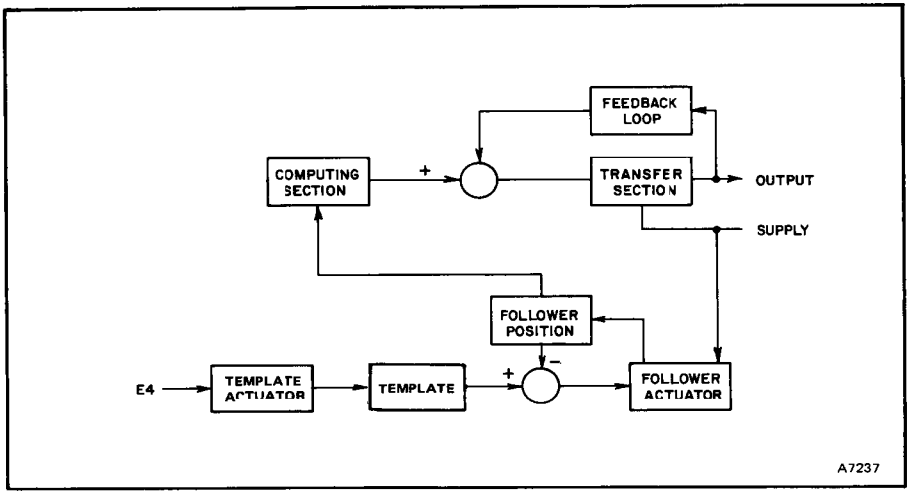


FIGURE 8 Square Root Extractor Block Diagram

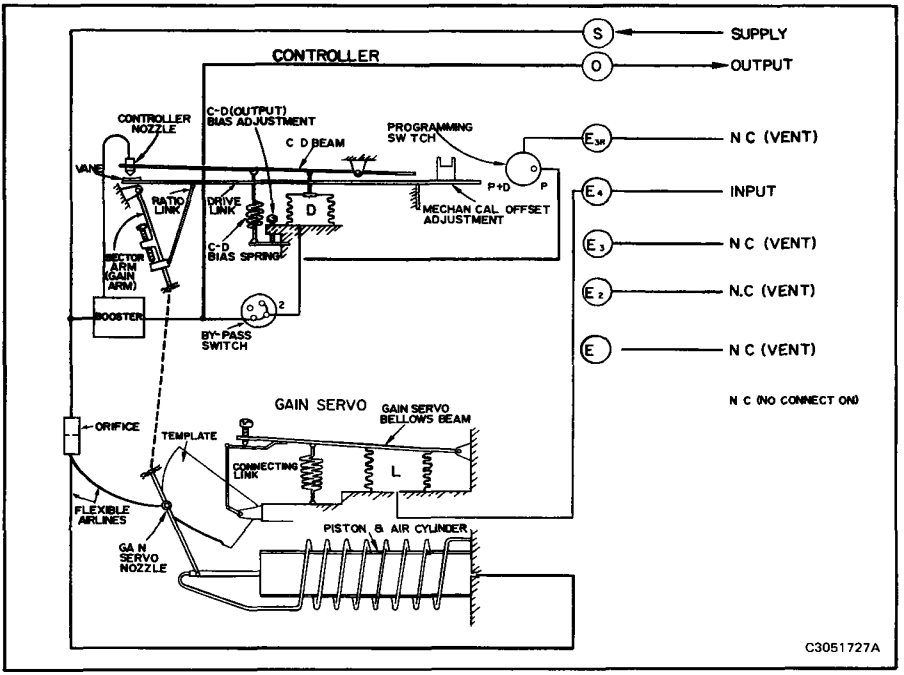


FIGURE 9 Schematic Diagram of Pneumatic Square Root Extractor, Type FS

EXPLANATION OF NOMENCLATURE

Digit 1 2 3	Description
FS 1 * 0	Pneumatic Square Root Extractor
1	3-15 psig (20.7 - 103 kPa) Input/Output Range
2	3-27 psig (20.7 - 186 kPa) Input/Output Range

SPECIFICATIONS

Accuracy†	±1% of output span (20 to 100% of span) ±2% of output span (below 20% of span)
Input Signal Range	3-15 psig (20.7 to 103 kPa) 3-27 psig (20.7 to 186 kPa)
External Connections	1/8 inch 27 NPT female connections
Normal Operating Conditions	Ambient Temperature 40° to 140°F (4.4° to 60°C) Ambient Temperature Effect ±2% maximum of output span over 100°F (55.6°C), temperature span
Repeatability	0.25% of output span (20 to 100% of span) 1.0% of output span (below 20% of span)
Deadband	0.25% of input span
Air Supply	18-20 psig (124 to 138 kPa) supply pressure nominal 30-35 psig (206.7 to 241.2 kPa)
Air Consumption	1.5 scfm (0.004 m^3/min) max. at balance

Supply Pressure Effect	< 1.5% of output span per 1 psig
Supply and Exhaust Capacity	1.0 scfm (0.028 m^3/min) for 1 psig (6.89 kPa) change in output at midrange 9 psig (62 kPa)
Position Sensitivity	±1% of span for 30° rotation in any direction from preferred mounting position
Mounting	Indoor wall or rack-mounted in the indicated position only
Materials	Bronze bellows, aluminum bellows, beams and frame, Buna N O-rings Beryllium Copper linkage, polyester film templates
Weight	Net 9.3 lbs (4.22 kg) Shipping 12 lbs (5.45 kg)
Gain Range	1.0 to 5.0

†As defined by SAMA Standard PMC20.1

NOTE: All data at midrange, reference conditions: Temperature 75°F (24°C) ±5°F (±5.6°C)

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

REPLACEMENT PARTS

Ordering Individual Parts

The following drawings are Parts Drawings for the Type FS Pneumatic Square Root Extractor and its spare parts kits Items with part numbers may be ordered separately Items with kit numbers (without separate part numbers) must be ordered by the kit number in which they are included

Normally, these drawings apply to the unit furnished However, there may be individual differences in specific units because of

a design changes made since the printing of this instruction section, or

b special design of the unit to make it suitable for a special application

Therefore, when ordering individual parts or kits, assure the receipt of correct replacements by specifying on the order

a complete nomenclature and series number of equipment for which parts are desired, and

b the Parts Drawing number and title on which each part is illustrated

Recommended Spare Parts

The following listed spare parts kits should be stocked in the quantities listed.

KIT NO	NAME	QUANTITY
258141 1	BOOSTER	1
258143 1	C D BELLOWS	1
258146 1	FILTER	1
258152 1	COVER	1
258148 1	O RING REPLACEMENT	1
258150 1	CYL NDER	1

Accessories

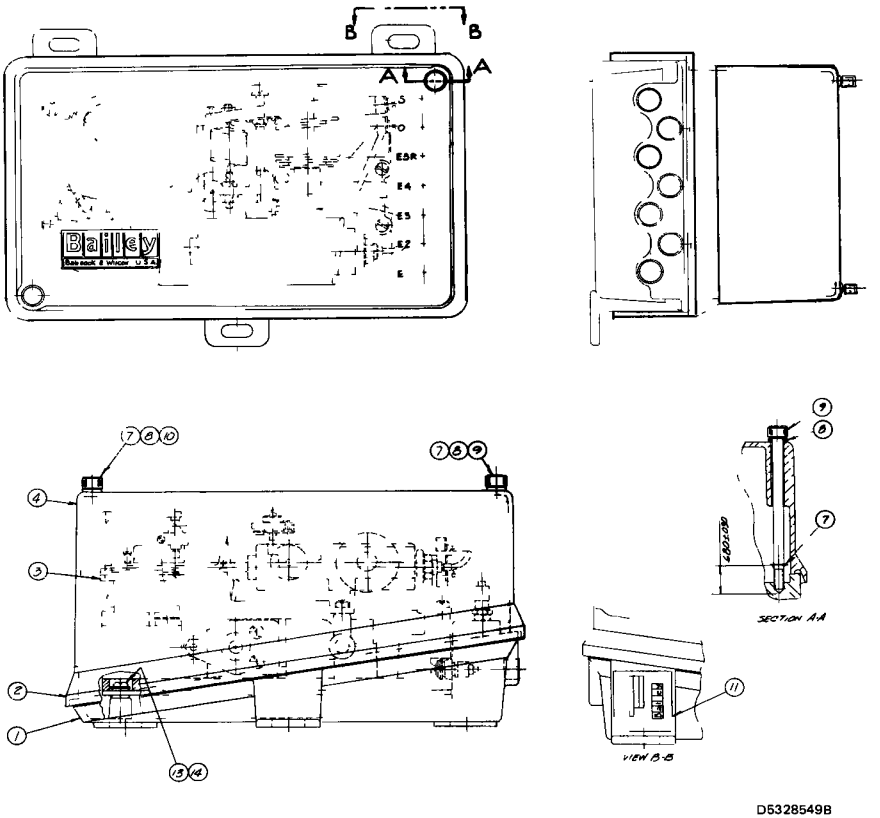
The following accessories are recommended

PART NO	NAME	QUANTITY	COMMENTS
5327136 1	Contro er Mour t	1	P ug n mount to be used for ca brat ng contro er base assem b es
5328485 1 (3 to 15 ps g)	Test Probe K t	1	Assemb y (gage, tub ng, test connector) for con tro s gna mon tor ng, and adjustment, ca bra t on and performance checks
5328485 2 (3 to 27 psig)			
5324066 1	Va ve Core	1	Extra a r trapp ng va ve for output con nect on

Bailey Control Systems

Parts Drawing
P92-13-1

TYPE FS SQUARE ROOT EXTRACTOR
PART NO. 5328549-□



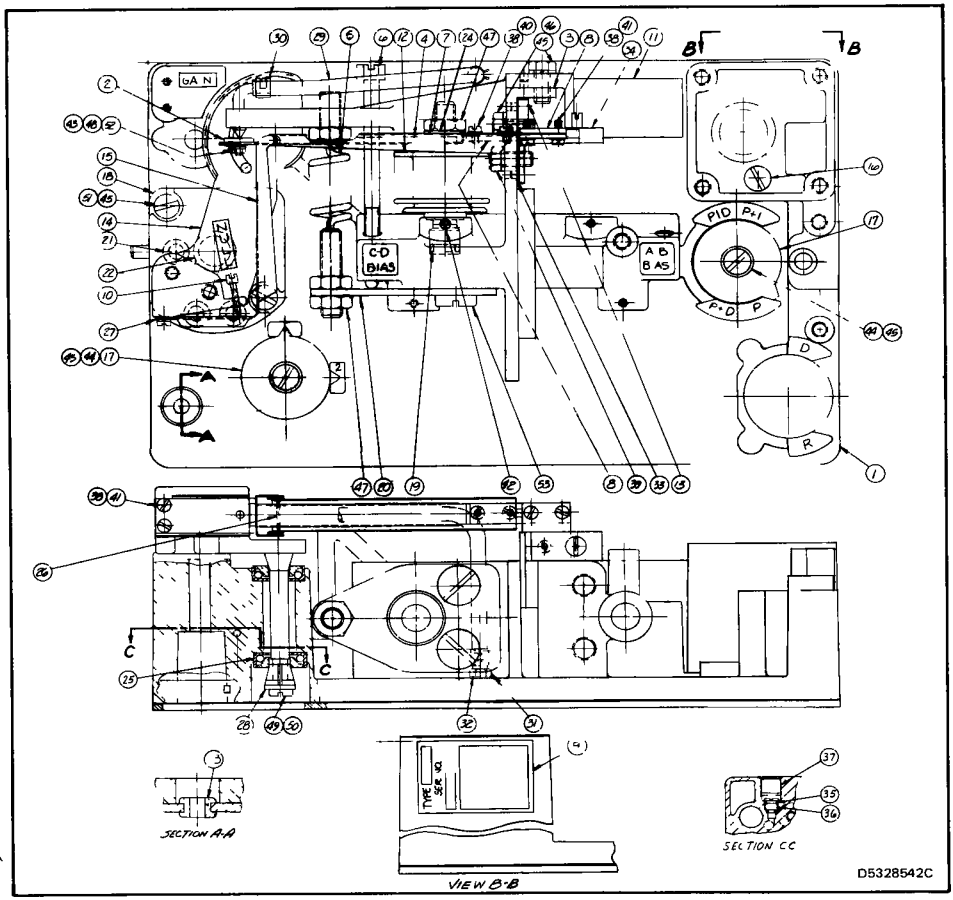
SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

P92-13-1 Square Root Extractor, Type FS

ITEM	PART NO	NAME
1	5327136 1	CONTROLLER MOUNT
2	5312316 1U	SEAL NG CORD
3	SEE TABLE	GA N SERVO ASSY
4	5327134 2	COVER
7	197480 25	RETA N NG R NG, 2 REQD
8	5311428 3	O R NG GASKET, 2 REQD
9	5327782 2	COVER SCREW
10	5327782-3	COVER SCREW
11	1962929 1	NAMEPLATE
13	219x 500x 049	PLA N STNLS STL WASHER
14	190-32x 500L	PAN HD STNLS STL MACH SCR

PART NO	ITEM 3
5328549 1 (3 to 15 PS G/20 6 to 103 kPa)	5328548 1
5328549 2 (3 to 27 PS G/20 6 to 186 kPa)	5328548 2

TYPE FS SQUARE ROOT EXTRACTOR CONTROLLER ASSEMBLY PART NO. 5328542-□



SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

3-2 Controller Assembly

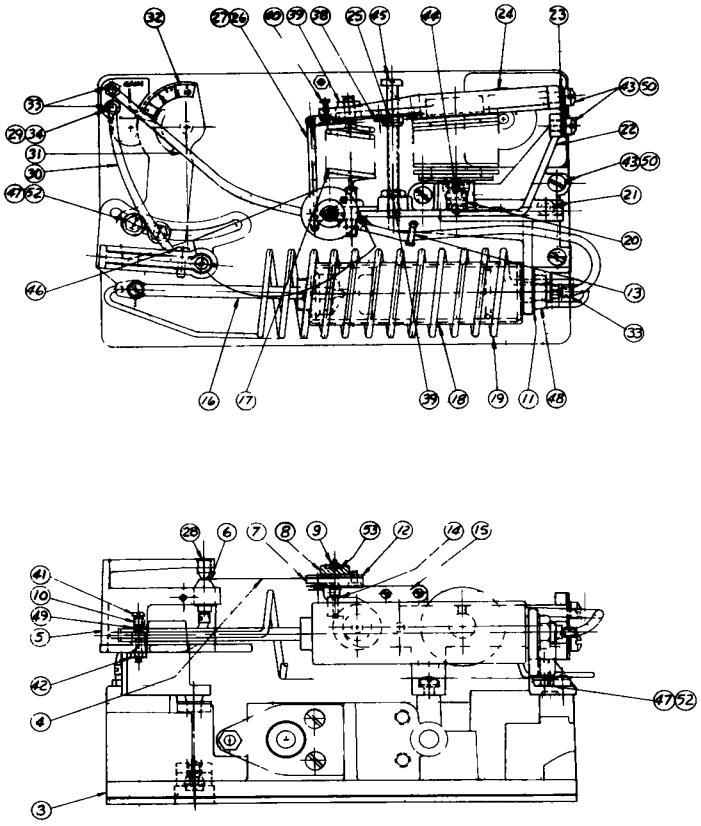
ITEM	PART NO	NAME
1	5326961 1	CONTROLLER BASE ASSY
2	5327778 1	ADJ VANE END
3	5327114 1	CLAMP PLATE
4	5327058 1	VANE BODY
5	SEE TABLE	C/D B AS SPR NG ASSY
6	5326981 1	B AS ADJ SCREW
7	5326980 1	DR VE L NK
8	5327055 1	H NGE CLAMP 2 REQD
9	1962928 1	SERV CE LEGEND
10	5326974 1	NULL ADJ SCREW
11	5326975 1	C D BEAM ASSY
12	5326966 1	BELLOWS ASSY
13	5326970 1	CLAMP PLATE
14	5326992 1	RANGE ADJ
15	5326986 1	RAT O L NK
16	452219-3	SEAL NG SCREW
17	5320657 1	ON-OFF SW TCH ASSY 2 REQD
18	5327120 1	PNEU BOOSTER
19	5311428 3	O R NG GASKET
20	5326956 1	SPRING BIAS ADJ
21	5311428 2	O R NG GASKET 3 REQD
22	5311428 11	O R NG GASKET
23	67125 10	GROMMET
24	197526 1	SPR NG WASHER
25	193205 1	BEAR NG 2 REQD
26	5315891 1	P N
27	5327771 1	RAT O L NK SUPPORT
28	5316156 1	RANGE ADJ SHAI T CLAMP
29	R9025-0426	156 O D x 094 I D CLEAR POLYURETHANE TUB NG
30	1951049-3	COMPRESS ON CL P 2 REQD
31	26002 1	TUBE F TT NG
32	26126 1	S AL WASHER
33	5328547 1	SPR NG H NGE
34	5328543 1	S DE BRKT ASSY
35	5311428 2	O R NG
36	5316464 5	OR F CE
37	1951485 1	P PE PLUG
38	086	STNLS STL REG SPR NG LKWASH 6 REQD
39	190 32x 500L	HEX HD STNLS STL SI MS EXT 2 REQD
40	086 56x 125L	PAN HD STNLS STL MACH SCR, 2 REQD
41	086-56x 250L	PAN HD STNLS STL MACH SCR, 4 REQD
42	112-40x 125L	HEX SOC HDLS CD P CONE PT SET SCR
43	094x 250x 032	P A N BRASS WASHER
44	190 32x 375L	F L HD STNLS STL MACH SCR 2 REQD
45	190	STNLS STL REG SPR NG LKWASH 8 REQD
46	190-32x 375L	HEX HD STNLS STL CAP SCR 4 REQD
47	250 28	STN STL REG HEX JAM NUT 4 REQD
48	1702-00	STNLS STL SHAKEPROOF LKWASH
49	138 32x 312L	PAN HD STNLS STL MACH SCR
50	156X 375x 049	P A N STNLS STL WASHER
51	190 32x1 375L	F L HD STNLS STL MACH SCR 2 REQD
52	086 56	BRASS HEX NUT
53	250 20x 500L	PAN HD STNLS STL MACH SCR 2 REQD

PART NO	ITEM 5
5328542 1 (3 to 15 PS G/20 6 to 103 kPa)	5327781 1
5328542 2 (3 to 27 PS G/20 6 to 186 kPa)	5327115 1

Bailey Control Systems

Parts Drawing
P92-13-3

TYPE FS SQUARE ROOT EXTRACTOR
GAIN SERVO ASSEMBLY
PART NO. 5328548-□



D5328548B

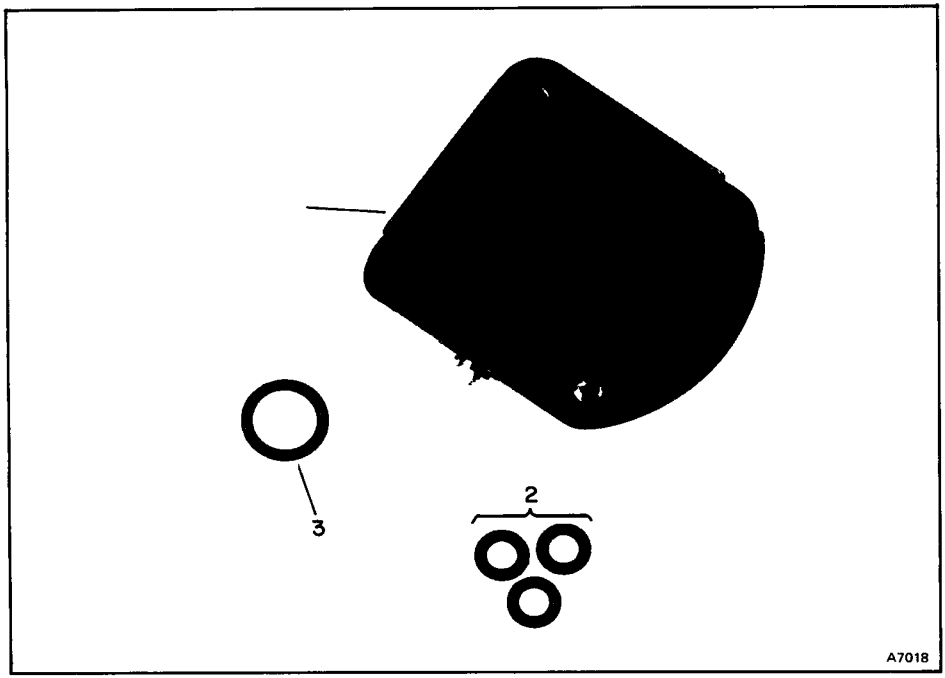
SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

52-13-3 Gain Servo Assembly

ITEM	PART NO	NAME
3	SEE TABLE	CONTROLLER ASSY
4	5327741-4	SQUARE ROOT CAM
5	5327713 1	NOZZLE SUPPORT
6	5327729 1	NOZZLE
7	5327743 1	CAM HUB ASSY
8	5327735 1	KNURLED NUT
9	197120 26	ELAST C STOPNUT
10	5327715 1	PRELOAD SPR NG
11	19734-41	SMALL WASHER
12	5327718 1	CLAMP PLATE
13	1943785 3	CABLE T E
14	451871 2	WASHER
15	5327738 1	ZERO ADJ ARM
16	5327689 1	CONN ROD
17	SEE TAB E	SPR NG ASSY
18	5327720 1	CYL NDER ASSY
19	5327690 1	SPR NG
20	5311428 3	O R NG
21	5311428 2	O R NG
22	5327707 1	MTG BASE
23	5327730 1	H NGE ASSY
24	5327709 1	BEAM & BELLOWS ASSY
25	197120 5	ELAST C STOP NUT
26	5327726 1	L NK
27	5327725 1	FLAT SPR NG
28	5327727 1	CAM GU DE
29	26002 1	TUBE F TT NG 4 REQD
30	R9025-0426	156 O D x 094 I D CLEAR POLYURETHANE TUB NG
31	R9025-0426	156 O D x 094 D CLEAR POLYURETHANE TUB NG
32	5327698A1	GA N DECAL
33	1951049A3	COMPRESS ON CL P, 4 REQD
34	26126A1	SEAL WASHER, 4 REQD
38	086 56x 188	LG PAN HD CD PL STL SEMS NT 2 REQD
39	190-32	CD PL STL HEX NUT 4 REQD
40	086-56x 375	LG PAN HD CD PL STL MACH SCR
41	112-40x 875L	LG PAN HD CD PL STL MACH SCR
42	112-40	CD PL STL HEX NUT
43	190 32x 375	LG F HD STN STL MACH SCR, 7 REQD
44	112-40x 188	LG HEX SOC HDLS STN STL CONE PT SET SCREW
45	190 32x 2 500	LG PAN HD CD PL STL MACH, SCR
46	112-40x 500	LG PAN HD STN STL SEMS EXT
47	190 32x 375	LG HEX HD STN STL CAP SCR 3 REQD
48	375 16	SEM F N STN STL REG HEX JAM NUT
49	125x 281x 025	PLA N BRASS WASHER
50	190	STN STL REG SPR NG LOCKWASHER, 8 REQD
52	203x 406x 040	PLA N CD PL STL WASHER 3 REQD
53	094x 250x 032	PLA N BRASS WASHER

PART NO	ITEM 3	ITEM 17
5328548 1 (3 to 15 PS G/20 6 to 103 kPa)	5328542 1	5327733 1
5328548 2 (3 to 27 PS G/20 6 to 186 kPa)	5328542 2	5327733 2

MINI-LINE 520 PNEUMATIC COMPUTER/CONTROLLER, TYPE FC, FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS BOOSTER SPARE PARTS KIT NO. 258141-1



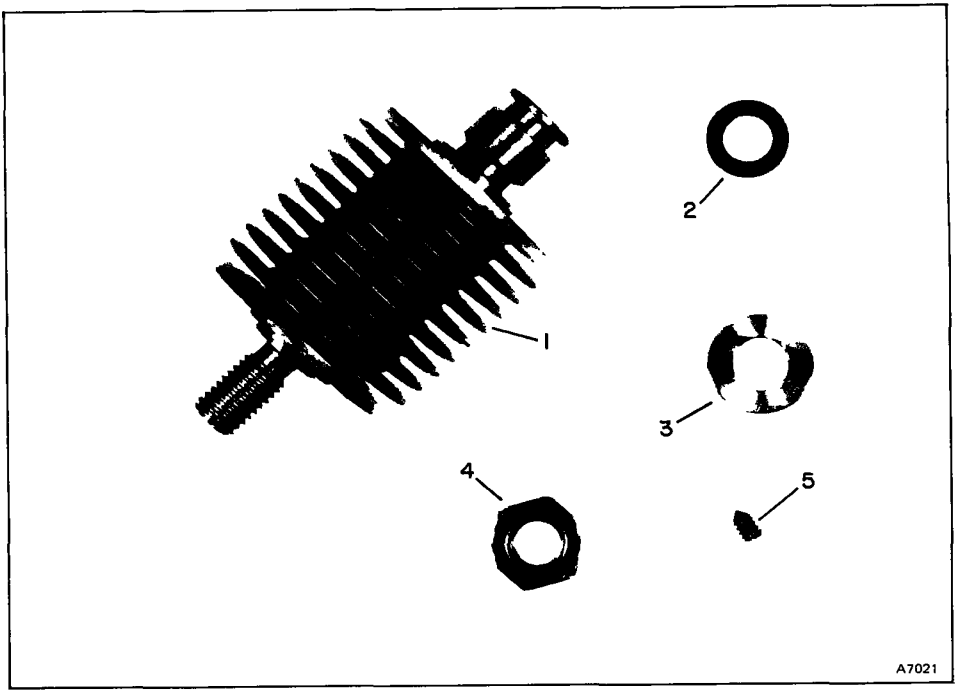
ITEM	NAME	QUANTITY
1	BOOSTER	1
2	O RING	3
3	O RING	1

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

Bailey Control Systems

Parts Drawing
P92-11-5

MINI-LINE 520 PNEUMATIC COMPUTER/CONTROLLER, TYPE FC; FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS C-D BELLOWS SPARE PARTS KIT NO. 258143-1



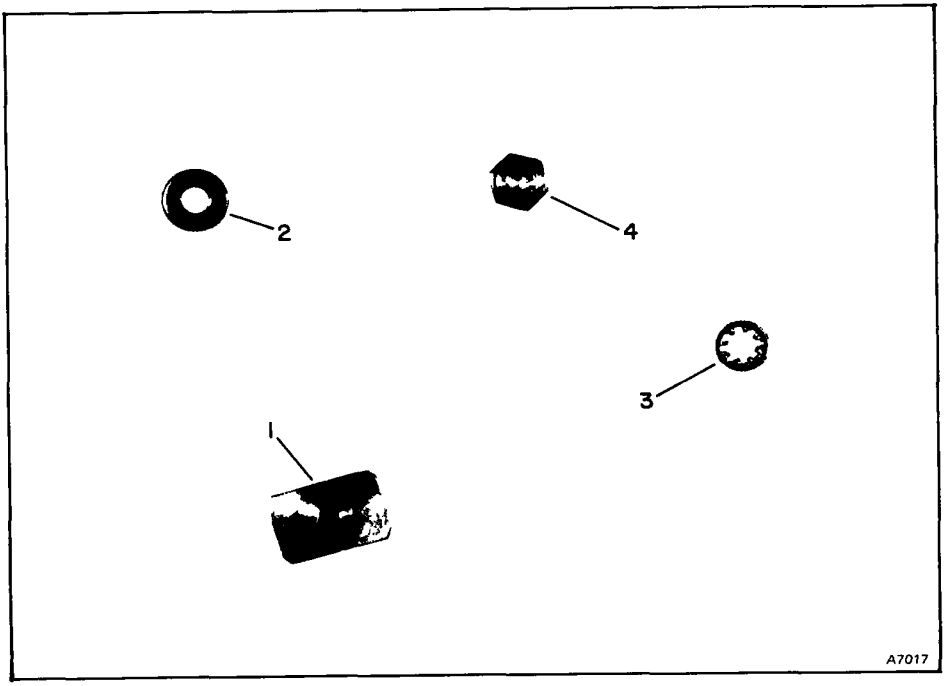
ITEM	NAME	QUANTITY
1	BELLOWS ASSEMBLY	1
2	O RING	1
3	SPRING WASHER	1
4	TH N NUT	1
5	112-40x 188 LG HEX SOC HDLS STN STL CONE PT SET SCR	1

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

Form PD-P92 11-5A L tho n U S A 680

Bailey Controls Company
Babcock & Wilcox a McDermott Company

MINI-LINE 520 PNEUMATIC COMPUTER/CONTROLLER, TYPE FC; FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS VANE PAD SPARE PARTS KIT NO. 258144-1

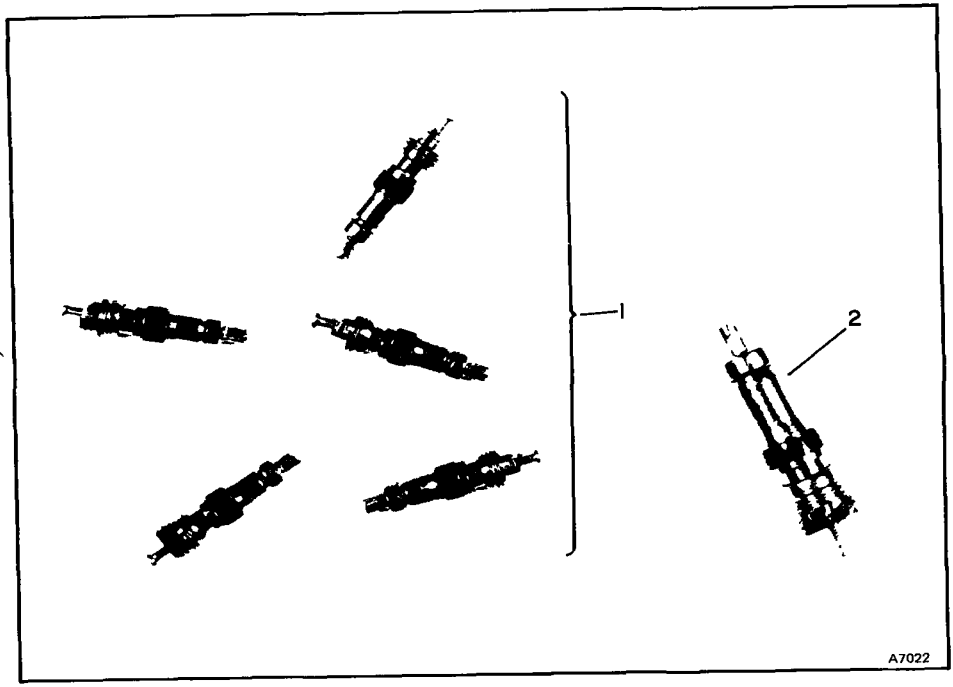


ITEM	NAME	QUANTITY
1	ADJUSTABLE VANE END	1
2	086 BRASS FLAT WASHER	1
3	1202-00 STN ST_S PROOF L'WASHER	1
4	086 56 BRASS HEX NUT	1

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

Bailey Controls Company
Babcock & Wilcox, a McDermott Company

MINI-LINE 520 PNEUMATIC COMPUTER/CONTROLLER, TYPE FC; FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS VALVE CORE SPARE PARTS KIT NO. 258145-1



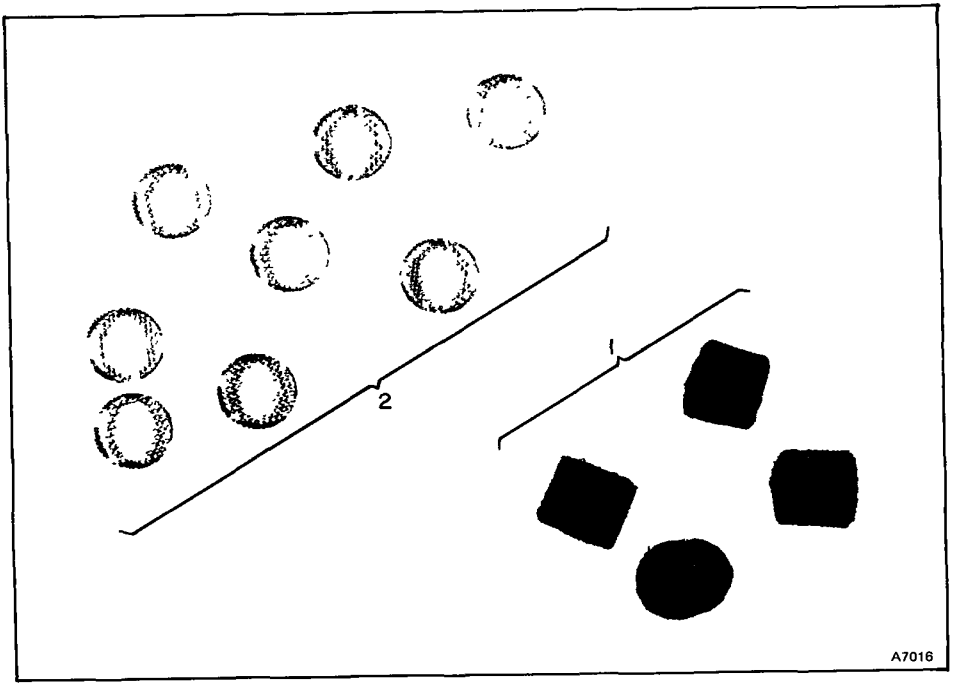
ITEM	NAME	QUANTITY
1	VALVE CORE	5
2	VALVE CORE	1

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

Form PD-P92 11 7A L tho n U S.A 680

Bailey Controls Company
Babcock & Wilcox, a McDermott Company

MINI-LINE 520 PNEUMATIC COMPUTER/CONTROLLER, TYPE FC, FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS FILTER SPARE PARTS KIT NO. 258146-1



ITEM	NAME	QUANTITY
1	FELT PAD	4
2	W RE MESH D SC	8

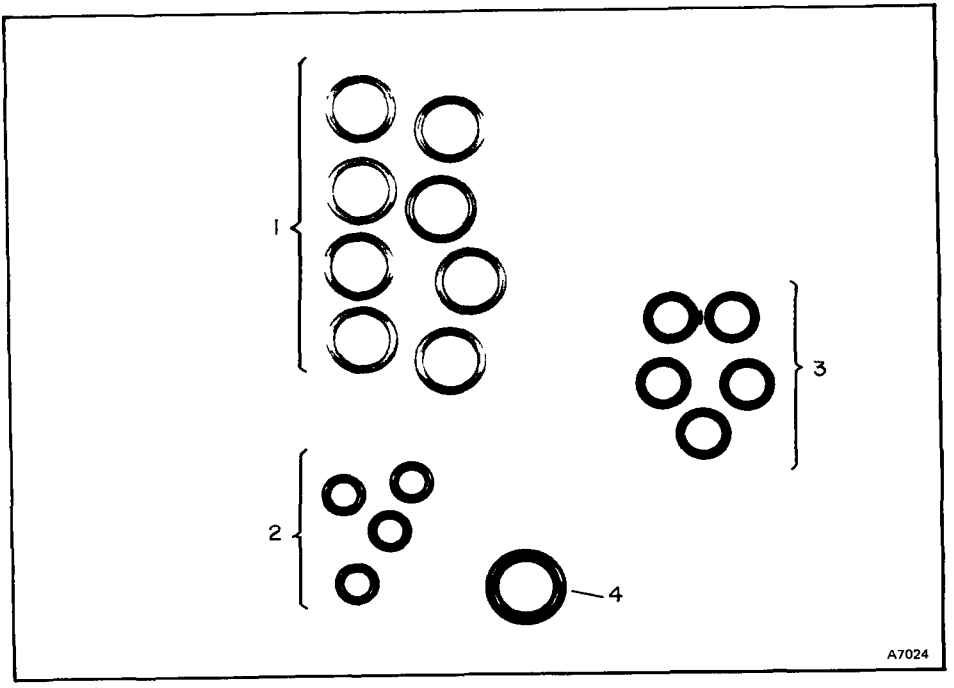
SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

Bailey Controls Company
Babcock & Wilcox, a McDermott Company

Bailey Control Systems

Parts Drawing
P92-11-10

MINI-LINE 520 PNEUMATIC COMPUTER/CONTROLLER, TYPE FC; FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS O-RING SPARE PARTS KIT NO. 258148-1



ITEM	NAME	QUANTITY
1	O R NG	8
2	O R NG	4
3	O R NG	5
4	O R NG	1

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

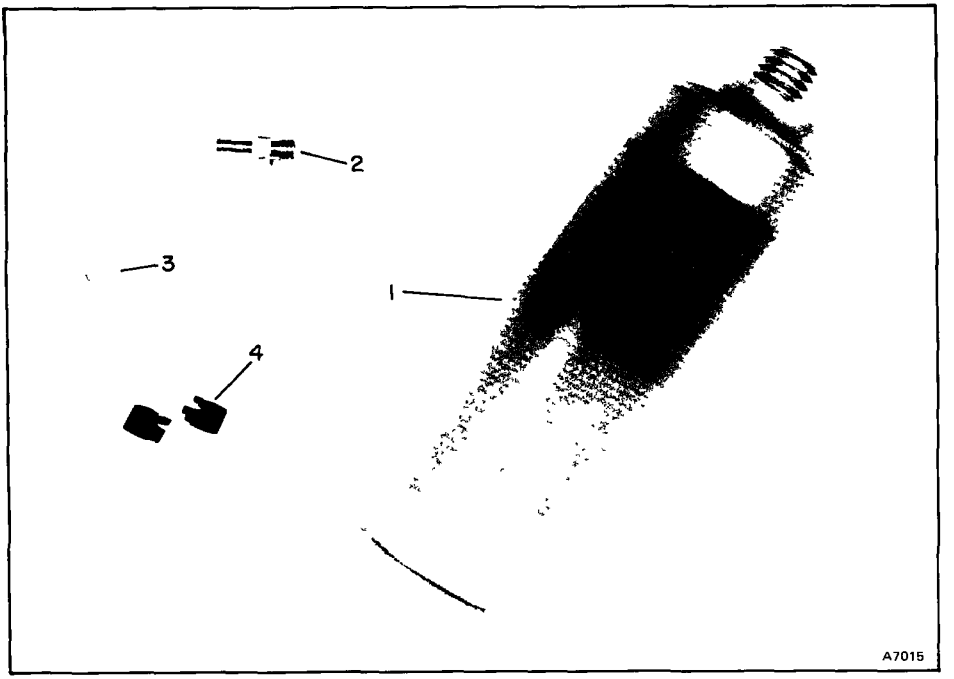
Form PD-P92 11 10A L tho in U.S A 680

Bailey Controls Company
Babcock & Wilcox, a McDermott Company

Bailey Control Systems

Parts Drawing
P92-12-3

MINI-LINE 520 PNEUMATIC FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS CYLINDER SPARE PARTS KIT NO. 258150-1



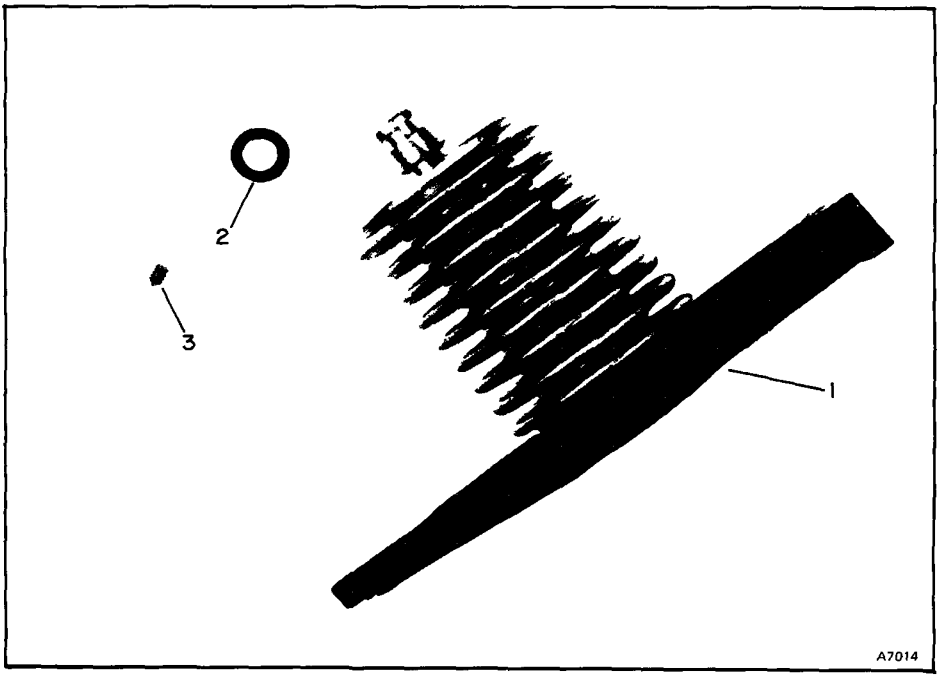
ITEM	NAME	QUANTITY
1	CYL NDER ASSEMBLY	1
2	TUBE F TT NG	1
3	SEAL WASHER	1
4	COMPRESSION CL P	2

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

Bailey Control Systems

Parts Drawing
P92-12-4

MINI-LINE 520 PNEUMATIC FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS BELLOWS SPARE PARTS KIT NO. 258151-1



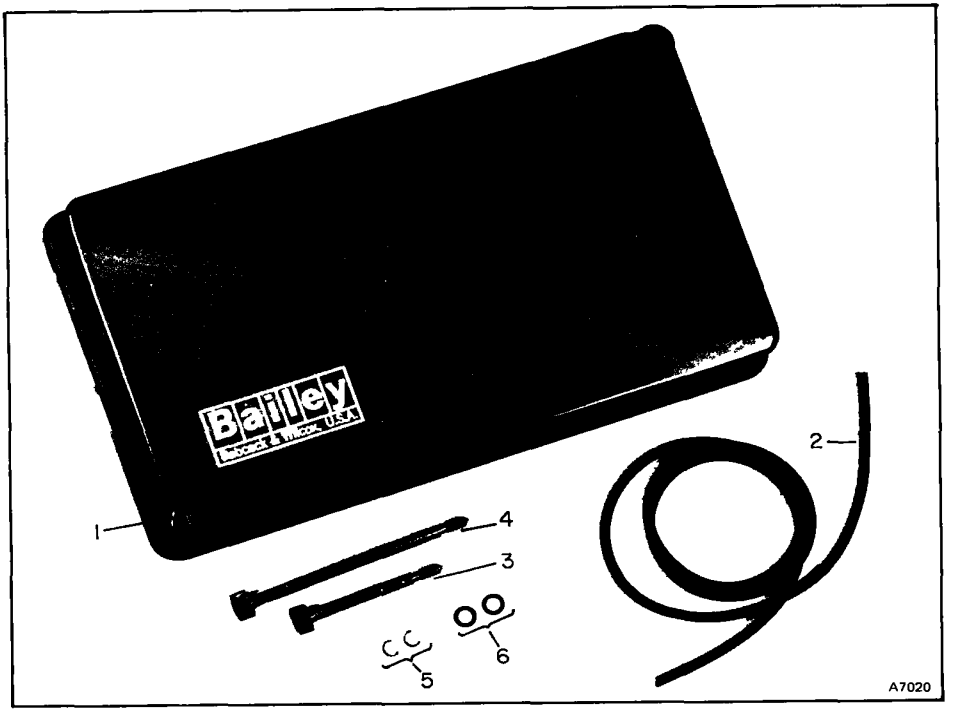
ITEM	NAME	QUANTITY
1	BELLOWS BEAM ASSEMBLY	1
2	O RING	1
3	112-40x 188 LG HEX SOC HDLS STN STL CONE PT SET SCR	1

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING

Bailey Control Systems

Parts Drawing
P92-12-5

MINI-LINE 520 PNEUMATIC FUNCTION GENERATOR, TYPE FG AND SQUARE ROOT EXTRACTOR, TYPE FS COVER SPARE PARTS KIT NO. 258152-1



ITEM	NAME	QUANTITY
1	COVER	1
2	SEALING CORD	1
3	COVER SCREW	1
4	COVER SCREW	1
5	RETAINING RING	2
6	O RING GASKET	2

SPECIFY ALL INFORMATION ON NAMEPLATE WHEN ORDERING