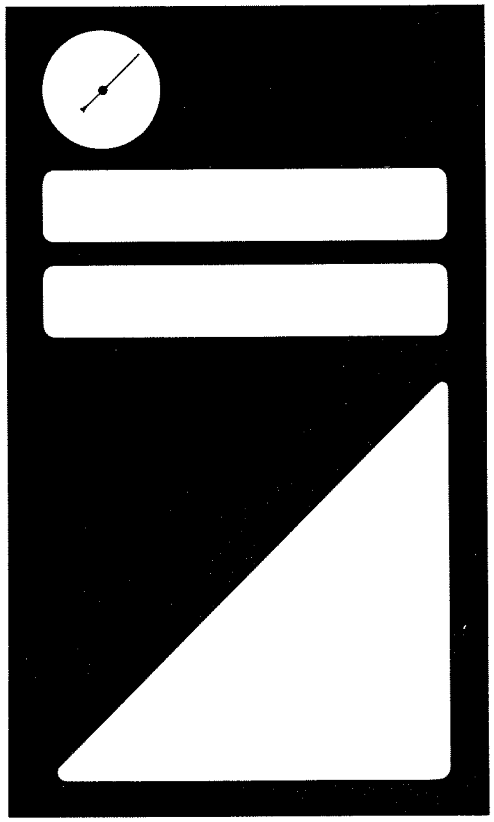


Pneumatic Controls

Operator's Manual

JOHNSON CONTROLS

FOREWORD

For over a century, Johnson Controls has pioneered the development of automatic controls, systems, and services to meet the exacting demands of heating, ventilating, and air conditioning systems. Today, Johnson Controls Facility Management Systems control all facets of building operations, including: heating, ventilating and air conditioning, energy management, fire safety, security, and lighting.

Your Johnson Controls system has been engineered, manufactured, and installed to provide many years of trouble-free operation. Careful and regular maintenance, however, is the key to extending the life of your system and maintaining the highest level of performance.

As new and improved equipment has been developed, other equipment has been discontinued. This Operator's Manual provides general calibration procedures for many of these discontinued items to help you keep your control system operating at peak efficiency.

At the beginning of each section of this manual is a listing of discontinued devices; in most cases, these devices are no longer supported by our Repair Parts program. Please refer to the back of the current Johnson Controls Counterline Catalog for a complete listing of discontinued devices along with their recommended replacements. For calibration of new devices not shown here, consult the literature supplied with each device or contact your local Johnson Controls branch office.

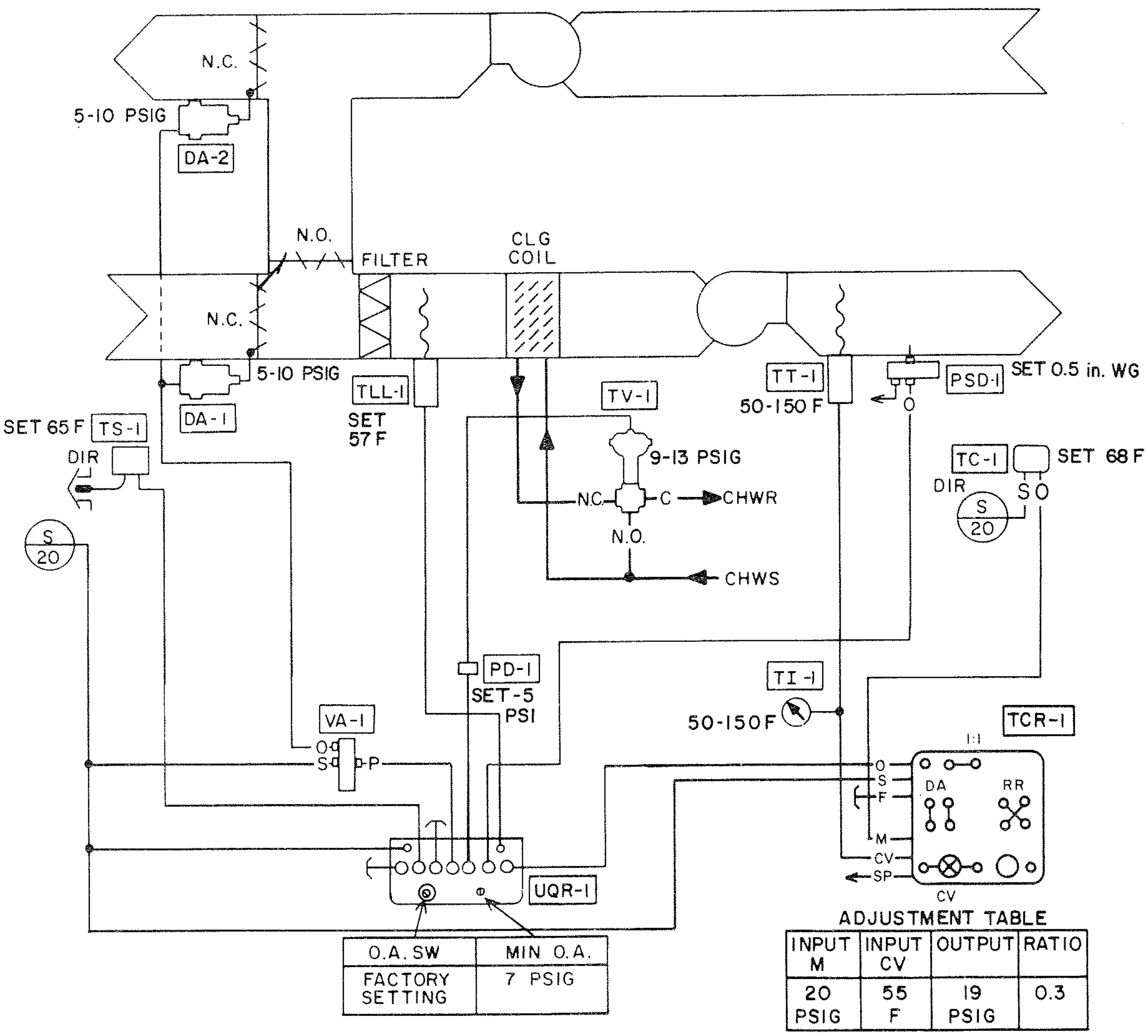
Local Johnson Controls branch offices around the world offer a full line of services to complement your efforts. These offices are fully staffed with experienced personnel, well trained in scheduled service, air and water balancing, repair, retrofit, and application engineering services – the perfect mix of personnel and services to meet any or all of your control and service needs.

Introduction

To understand the essential elements of control system maintenance, a general understanding of control drawings is helpful. A typical control drawing, as shown in Fig. i includes the following information:

1. Symbols representing the instruments.
2. Instrument identifications which correspond to the bill of material.
3. Input/output markings.
4. Instrument action, setting, spring range, and normal position.

The control drawing serves as a handy reference in understanding the system and identifying components for calibration or service.



O.A. SW	MIN O.A.
FACTORY SETTING	7 PSIG

INPUT M	INPUT CV	OUTPUT	RATIO
20 PSIG	55 F	19 PSIG	0.3

Fig. i: Typical Control Drawing

Pneumatic control systems consist of four major types of equipment: air supply system components, controllers, auxiliary devices, and controlled devices (which include terminal units). There are a variety of instruments within each category, but basically devices within each category perform the same kinds of functions and are serviced and calibrated in much the same way. The simple drawing in Fig. ii illustrates how these major components interact.

The sections that follow provide the general information required to keep your control system operating properly. If special problems develop, contact the service department of your local Johnson Controls branch office. Each office is staffed with experienced personnel, well trained to service your control system.

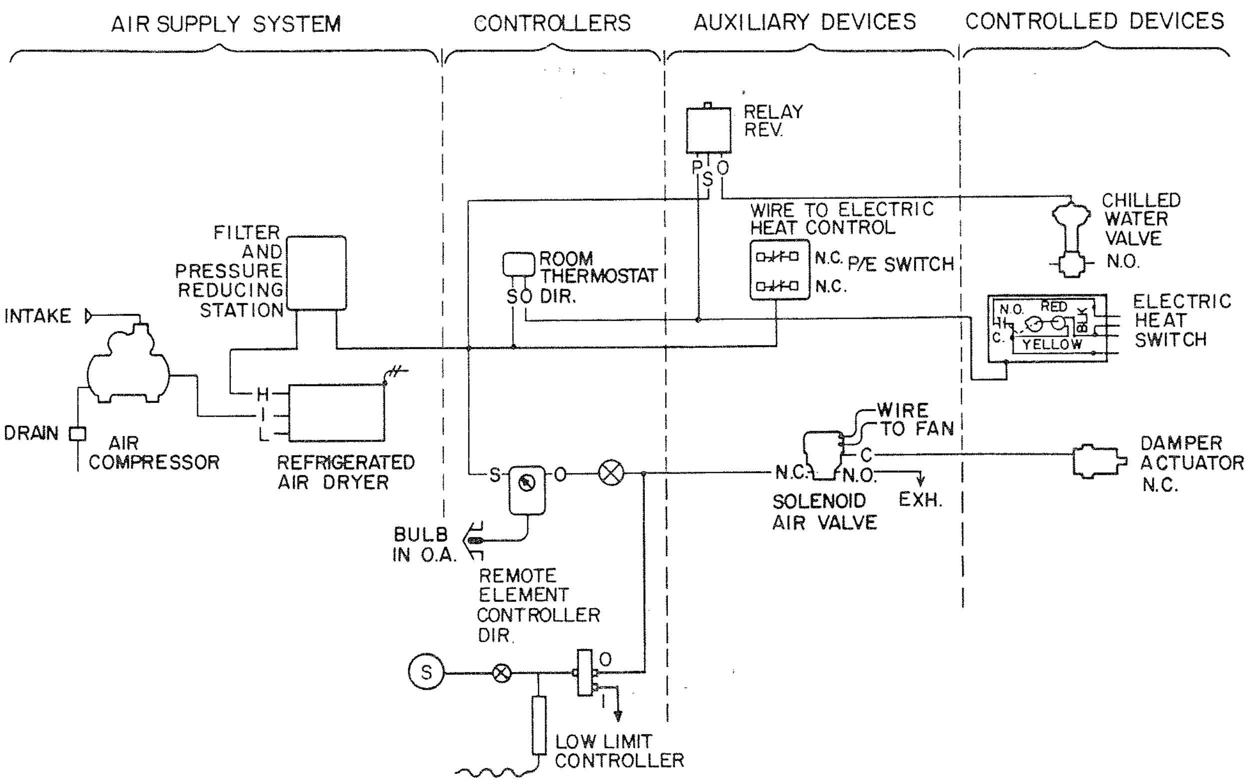


Fig. ii: The Four Categories of Pneumatic Equipment

Section I: Air Supply System

Information in this section pertains to the following Johnson Controls devices, some of which may have been discontinued:

- A-300, A-400, A-1000, A-3000, A-5000, and AS/AD-XXX Series Air Compressors.
- A-400 and A-4000 Series Air Filters.
- A-420 and A-4000 Series Air Dryers.
- R-125 and R-130 Series Pressure Reducing Valves.

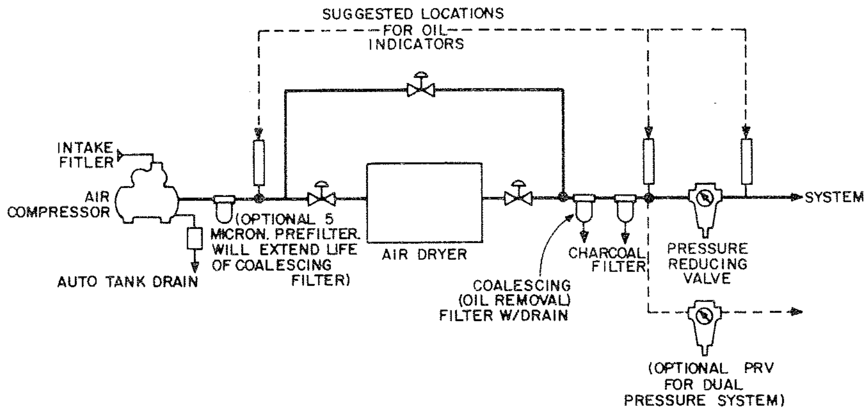


Fig. 1.1: Typical Air Supply System

Clean, dry, oil free air, at the proper pressure, from the supply system is the key to efficient operation of the control system. This section provides routine maintenance schedules and servicing instructions for the major components of the air supply system.

The size of the air compressor, tank, refrigerated air dryer, oil removal filter, and pressure reducing station has been selected to provide the necessary amount of compressed air to power the control system. The air compressor cut-in pressure is normally 70 PSIG (490 kPa) and the cut-out pressure is normally 90 PSIG (630 kPa).

Air Compressor Maintenance

SAFETY NOTE

WHEN PERFORMING MAINTENANCE ON THE COMPRESSOR, THE ELECTRICAL DISCONNECT MUST BE TURNED OFF AND LOCKED OUT.

Moisture in Tank

Water in the tank reduces the effective tank volume and is harmful in two ways:

1. It decreases the time that air spends in the tank, thus reducing the oil removal effect of the tank.
2. It decreases the tank volume which, in turn, increases the number of motor starts.

If the tank is not equipped with an automatic drain, the moisture must be drained from the tank once a week. When the air intake is located in outside air and it is cold and dry outside, there will be very little moisture in the tank. Warm, humid weather will cause water to collect more quickly. Don't try to outguess the weather – drain the tank regularly.

Intake Air Filter

Johnson Controls air compressors are furnished with intake filters of ample size to assure that 99% particulate-free air is admitted to the compressor.

Generally, the intake filter cartridge (see Fig. 1.2) should be cleaned or replaced at least every 30 days, depending on the cleanliness of the air entering the system. More frequent service may be required if the filter is located where excessive amounts of dust and dirt are allowed to enter the intake. If the compressor is located where excessive dirt or

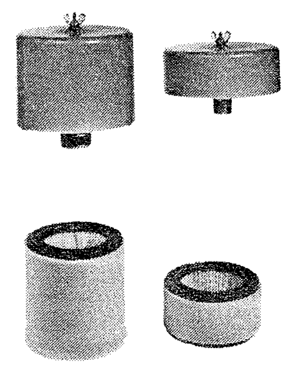


Fig. 1.2: Intake Air Filters

moisture is present, pipe the intake filter outside or to a less hostile environment. See Table 1.1 for pipe sizes and lengths.

Note: Do not substitute an oil bath or oil wetted filter for the intake filter furnished with the compressor.

A pressure drop across the inlet filter will increase oil pumping by increasing the vacuum in the cylinders on the intake stroke and by decreasing the compressor output (higher percent on-time). The filter should be checked regularly and replaced if required. The effects of an inlet filter pressure drop on oil carryover and pump output are illustrated in Figs. 1.3 and 1.4.

Table 1.1: Compressor Suction Line Size (Inches)

	Compressor Horsepower	1/4	1/2	3/4	1	1-1/2	2	3	5	7-1/2	10	15	20
Maximum Length of Line	10	1/2	5/8	3/4	1	1-1/2	1-1/2	1-1/2	2	2-1/2	2-1/2	3	3
	20	1/2	3/4	1	1-1/4	1-1/2	1-1/2	2	2-1/2	2-1/2	3	3	4
	30	1/2	3/4	1-1/4	1-1/4	1-1/2	2	2	2-1/2	3	3	4	4
	50	1/2	1	1-1/4	1-1/2	2	2	2-1/2	3	3	4	4	5
	75	5/8	1	1-1/2	1-1/2	2	2	2-1/2	3	4	4	4	5
	100	5/8	1-1/4	1-1/2	2	2	2-1/2	2-1/2	3	4	4	5	5
	150	3/4	1-1/4	1-1/2	2	2-1/2	2-1/2	3	4	4	5	5	6
	200	3/4	1-1/2	2	2	2-1/2	2-1/2	3	4	4	5	5	6
	300	1	1-1/2	2	2-1/2	2-1/2	3	4	4	5	5	6	7

Note: Sizes listed are the approximate inside diameters required. For copper tubing and iron pipe, the values listed are nominal sizes. If O.D. copper tubing dimensions are used, select the next larger size. For iron pipe, use nominal sizes listed in the table except use 3/4 in. wherever 5/8 in. is indicated. In the larger sizes, round or the equivalent rectangular ducts are suitable. Metric conversions: Inches x 25.4 = millimeters, feet x .3048 = meters.

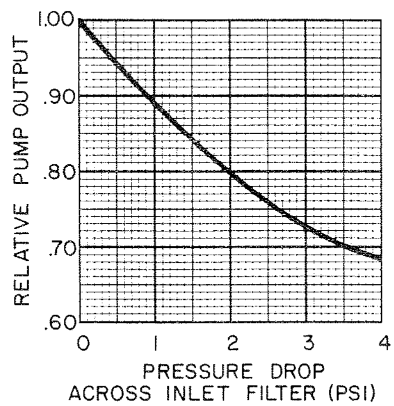


Fig. 1.3: Compressor Output vs Inlet Filter Pressure Drop

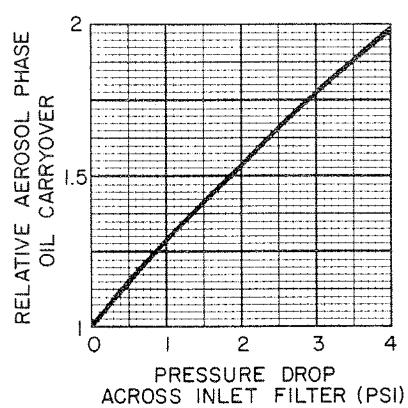


Fig. 1.4: Oil Carryover vs Inlet Filter Pressure Drop

Crankcase Discharge (A-3000 and A-5000 Series)

The air near the compressor may contain a substantial amount of oil discharged from the crankcase. In a confined area or where the smell of oil is apparent, the discharge from the crankcase should be vented away from the intake filter. On 1 hp and 1-1/2 hp models, piping should be attached to the fitting located on the pump inside the flywheel, to vent the contaminated air away from the intake filter.

Belt Tension

Belt tension should be checked after 50 hours on-time and on a regular basis as indicated in the maintenance checklist. Use a belt tension adjuster (purchased locally) to check for the proper tension. The belt should deflect approximately 1/4 in. (6 mm) under 3-1/4 lb (14.5 N) of force (see Fig. 1.5).

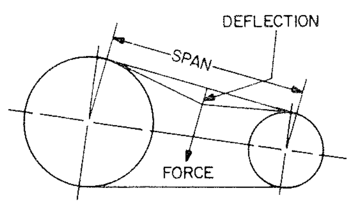


Fig. 1.5: Belt Tension Check

To adjust the tension, loosen the bolts securing the motor to the bracket. Then turn the V-belt adjustment to position the motor for proper belt tension and retighten the mounting bolts (see Fig. 1.6). Be sure to keep the pulley aligned with the flywheel.

When checking the belt tension, examine the belt closely for excessive wear or cracks. Keep a spare belt handy.

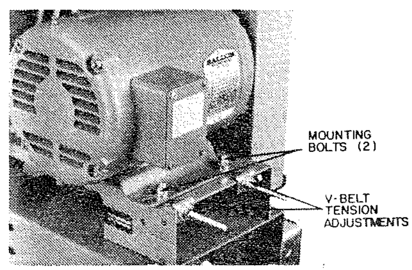


Fig. 1.6: Belt Tension Adjustment

Pulley Alignment

Check the pulley alignment by placing a straightedge against the compressor flywheel (see Fig. 1.7). Measure the distance from the straightedge and the center of the drive belt grooves at points A, B, and C. The distance should be the same at all three points. If any of the measurements vary, there is a misalignment which must be corrected before running the compressor. Misalignment of less than 1/16 in. per foot of center distance is allowable.

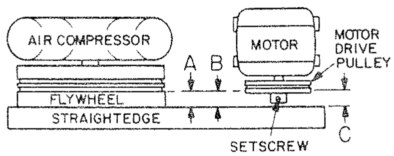


Fig. 1.7: Pulley Alignment

Safety Valves

Tank mounted air compressors are shipped from the factory with safety valves installed in the receiver manifold (see Fig. 1.8). The flow capacity of the valve is equal to or greater than the capacity of the air compressor(s). The pressure setting of the safety valve must be a least 10 PSI (70 kPa) less than the maximum working pressure of the air receiver. The safety valve should be manually operated every six months to check for sticking or freezing.

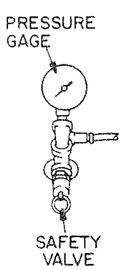


Fig. 1.8: Safety Valve

Lubrication

The compressors are shipped with a proper fill of SAE 30W oil (Johnson Controls F-1000-203) in the crankcase. See Fig. 1.9 for proper oil fill level.

The oil furnished in the crankcase will yield best results in ambient temperatures from 32 to 115°F (0 to 46°C). If the ambient temperature at the compressor is between 0 and 32°F (-18 and 0°C), drain the crankcase and substitute a heavy duty, non-detergent 10W oil. For ambient temperatures below 0°F (-18°C), use 5W oil.

Oil Level

The oil level must be maintained between the LOW and the HIGH marks on the dipstick or the oil fill gage. Never overfill the crankcase; this will increase the probability of pumping oil into the system.

When adding oil during routine maintenance, use Johnson Controls F-1000-203 oil. This is an optimum viscosity SAE 30W oil best suited to ambient temperatures between 32°F (0°C) and 115°F (46°C). If this oil is not available, use a heavy duty non-detergent oil best suited to the ambient temperature.

Note: Synthetic oil is NOT RECOMMENDED. There is no advantage in lubrication, life, or carryover. Furthermore, any synthetic oil carried into the system will damage certain plastic components.

Changing oil is only necessary every 2,000 hours of on-time or once per year, whichever comes first. Tests have proven that fresh oil is more likely to cause oil vapor carryover.

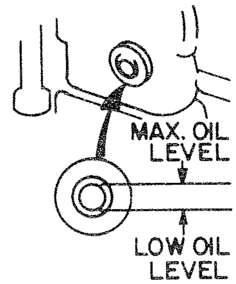


Fig. 1.9: Oil Fill Gage for AS-XXX and AD-XXX

"Aged" oil (used over 100 hours on-time) has less oil vapor carryover.

Overfilling the Crankcase

If the crankcase is filled to a level above the full mark on the dipstick, oil pumping will increase. This is especially true on a compressor with a splash or dip-ring lubrication system. Oil pumping can increase dramatically to a level two or more times than if the oil were at the full mark. Overfilling the crankcase can also cause liquid oil to push out of the crankcase vent. This oil, vaporizing on the hot compressor block, will raise the oil content of air drawn into the compressor inlet and be pumped into the air lines. Oil puddling on the compressor body could also be misinterpreted as an oil leak.

Table 1.2: A-3000 and A-5000 Crankcase Oil Capacities

Compressor Model	Full Capacity Pints / Ounces	LOW to HIGH Mark Ounces
A-X025, A-X033, A-X050	1/4 / 4	1.2
A-X075	1-3/4 / 28	7.0
A-X100, A-X150	1-3/8 / 22	3.0
A-X250	1-3/4 / 28	—
A-X400	3-1/2 / 56	—
A-X650	5 / 80	—

Table 1.3: AS-XXX and AD-XXX Crankcase Oil Capacities

Compressor Model	Full Capacity Pints / Ounces	LOW to HIGH Mark Ounces
AX-005	1 / 8	6-9
AX-010	3/4 / 12	9-14
AX-020/030	1-1/16 / 17	13-21
AX-075	1-3/8 / 22	17-27
AX-100	1-7/8 / 30	24-36
AX-150/200	8 / 128	110-128

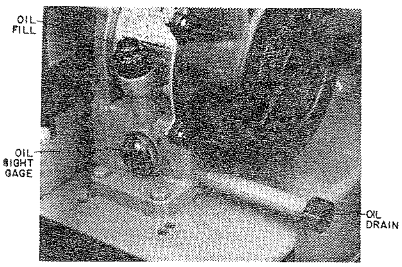


Fig. 1.10: Lubrication Components for AS/AD-005 and -015 Compressors

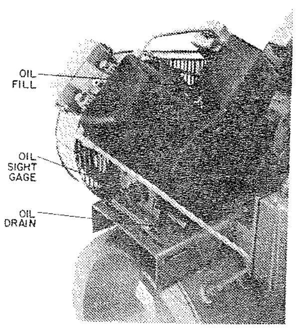


Fig. 1.11: Lubrication Components for AS/AD-020 through -100 Compressors

Table 1.2 lists the crankcase oil capacities for the A-3000 and A-5000 Series Compressors.

Table 1.3 lists approximate crankcase capacities and amounts of oil required to fill the AS-XXX and AD-XXX crankcases from the LOW to HIGH mark on the sight glass of the 1/2 through 10 hp models, or bottom thread on 15 and 20 hp models.

When adding oil during routine maintenance, use oil of proper viscosity as outlined in the Lubrication section.

Oil Pressure

For the A-3000/5000 Compressors, maintain an oil pressure between 15 and 18 PSIG (105 and 126 kPa). The oil pressure adjusting screw is located on the side of the compressor body on 1 and 1-1/2 hp models. (Oil pressure adjustment is not necessary on 1/4 to 3/4 hp models since they are splash lubricated.) Loosen the locknut and turn the screw inward to increase or outward to decrease the oil pressure. Remember to tighten the locknut after adjusting the oil pressure.

AS/AD-015 and -020 Compressors have an oil pressure gage. This gage reading should be between 20 and 40 PSIG. **Note: Low oil level will cause low oil pressure.** In the event that low oil level occurs, the unit will run unloaded until the oil level is resumed. However, this feature does not protect the compressor from damage in the event of insufficient oil level.

Percent On-Time

Johnson Controls air compressors, using an A-4000 Oil Removal Filter and PRV Station, are designed for best performance operating between 33 and 50% on-time for each compressor. However, 50% or more on-time could result in objectionable levels of oil carryover if proper oil filtration procedures are not followed.

Table 1.4: A-3000 and A-5000 Compressors Pump-Up Time (One Pump Running)

Compressor Model	Nominal Pump-Up Time (Minutes) 0-90 PSIG	Nominal Pump-Up Time (Minutes) 70-90 PSIG	Tank Size Gallons
A-X025	29.0	7.0	30
A-X033	23.0	6.0	30
A-X050	15.0	4.0	30
A-X075	8.0	2.5	30
A-X100	6.5	1.5	30
A-X150	5.0	1.0	30
	10.0	2.0	60
A-X250	6.5	1.5	60
	9.0	2.0	80
A-X400	5.0	1.5	80
A-X650	4.5	1.0	120

Table 1.5: AS/AD-XXX Compressors Pump-Up Time (One Pump Running)

Compressor Model	Nominal Pump-Up Time (Minutes)		Tank Size Gallons
	0-90 PSIG	70-90 PSIG	
AX-005	11.4	2.4	30
AX-007	14.0	2.5	60
AX-010	11.1	2.0	60
AX-015	7.9	1.6	60
AX-020	6.7	1.6	80
AX-030	4.6	1.1	80
AX-050	3.6	0.8	120
AX-075	2.6	0.6	120
AX-100	3.5	0.8	200
AX-150	2.2	0.5	200
AX-200	1.9	0.3	200

Common causes of excessive on-time are:

1. Air leaks in the system.
2. Water in the compressor tank.
3. Extra controls added to the system which require more capacity than the system was designed to deliver.
4. Inefficient compressor operation.

If the compressor is properly sized for the application and on-time exceeds 50%, check the compressor efficiency as follows:

Close off the compressor from the control system and bleed off the air in the tank. Also drain the water from the tank. Record the pump-up time required to pressurize the tank from 0 to 90 PSIG (0 to 630 kPa). If the time required exceeds the recommended pump-up time from Tables 1.4 or 1.5, check the compressor for worn or broken rings, faulty valves, or a dirty intake filter. Replace the parts if necessary (honing is required when rings are replaced).

If the pump-up time is satisfactory and excessive run time is still observed, check the system for leaks.

Table 1.6: Maintenance Checklist

Task	Frequency
1. Check oil pressure (15 and 20 hp)	Daily
2. Check oil level	Daily
3. Drain tank*	Weekly
4. Check percent on-time	Monthly
5. Check air distribution system for leaks	Monthly
6. Operate safety valves	Monthly
7. Check and replace intake filter (more often if necessary)	Monthly
8. Check belt tension	Monthly
9. Inspect valve assemblies	Every 6 months
10. Check PE switch settings	Annually
11. Inspect all electrical contacts	Annually
12. Check amp draw on motors	Annually
13. Check pump-up times	Annually
14. Measure oil carryover (A-4000 oil indicator)	Annually
15. Change oil	Every 2000 running hours or once a year; whichever comes first
16. Grease motor	Every 2 years

*** It is suggested that the tank be drained more often on duplex compressors which are not alternated. This reduces the possibility of rust buildup in the discharge valve and cylinder of the lag pump. This can be accomplished using an automatic drain. Also, the lag pump should be run regularly to minimize any rust damage.**

Refrigerated Air Dryers

Refrigerated air dryers will provide clean, dry air for the control system. These dryers are designed for continuous operation. Routine maintenance, however, must be performed.

The automatic moisture removal trap on the A-4110 and A-4210 should be checked regularly for float operation and must be cleaned when a buildup of contaminants is noticeable. The condenser is factory adjusted and sealed and should not be tampered with.

The condenser should be checked periodically for dust buildup between the fins; this buildup could eventually lead to a reduction in heat transfer. If there is a buidup of dust, it can be removed using a vacuum cleaner.

Also, check the bypass valves periodically to make sure all flows are through the condenser and oil filter (see Fig. 1.12).

Drain Connections

Both the coalescing oil removal filter and the automatic condensate drain trap have 1/8 in. NPT drain connections. Tubing attached to these connections should be routed to the desired drain location, keeping the runs as short as practical in order to reduce back pressure on the automatic drains. Use separate drain lines for the automatic condensate

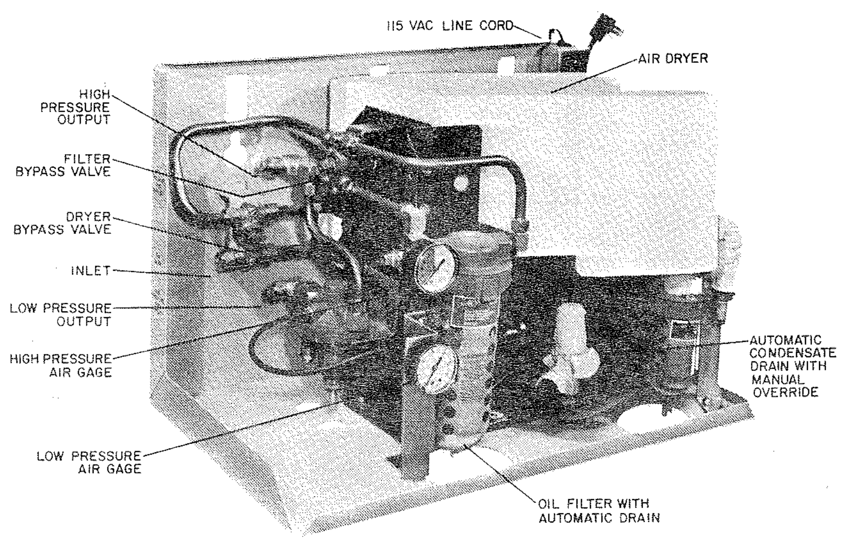


Fig. 1.12: Refrigerated Air Dryer

drain and the coalescing oil removal filter drain; NEVER CONNECT THE LINES TOGETHER.

Note: An override feature is incorporated in the automatic condensate drain trap which allows manual draining of the sump. For best results, override once a month.

To manually activate the A-4110 drain, insert a small probe (such as a paper clip) up through the fitting to drain the water from the unit. On the A-4210, momentarily depress the NPT connection or move the connection to one side to drain the sump.

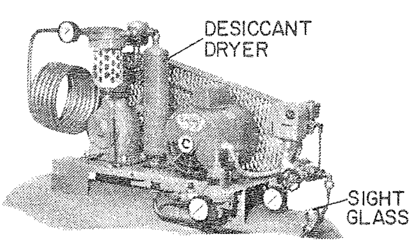


Fig. 1.13: Desiccant Dryer on A-3000 Compressor

Desiccant Dryer

The desiccant dryer requires little maintenance as long as it receives clean air. Clean the condensor coil and check the sight glass (see Fig. 1.13) regularly; if 2/3 of the indicator turns pink, the desiccant filter cartridge should be replaced.

Prefilter

A prefilter is a particle filter with a drain installed in the line just upstream of the coalescing oil removal filter. Its purpose is to remove particles which would plug the fine mesh of the oil removal filter. If it is necessary to change the oil removal filter frequently due to a high pressure drop, it would be advisable to install a prefilter. An alternate location for the prefilter is upstream of the dryer. Its capacity must be large enough so that the pressure drop does not pull down the pressure in the air dryer and raise the dew point.

Oil Removal and Pressure Reducing Stations

The A-4000 Series Oil Removal and Pressure Reducing Stations are available in single or dual PRV models in 10 or 20 SCFM (4.7 or 9.4 L/s) maximum flow capacities. In addition, each unit features a four-way bypass valve, coalescing and activated charcoal oil removing filters, and is completely piped with copper tubing which reduces friction, allows higher flow rates, and meets fire codes in mechanical equipment rooms. The filter combination removes both oil aerosols and vapors to provide clean, oil free air for pneumatic control systems. All models provide maximum performance for a period of one year at which time the coalescing and activated charcoal filter elements will need to be replaced. Gages are provided to monitor system operation and performance. All models can provide filtered, high pressure air to remote PRV stations. All models have a maximum input pressure rating of 150 PSIG (1050 kPa) and an upper temperature limit of 120°F (52°C). **Note: The air supply to these stations must be from a properly broken in air compressor producing less than 6 ppm aerosol oil (as measured by a Johnson Controls A-4000-120 Oil Indicator on the compressor tank outlet) and must also pass through a properly operating air dryer.**

Single PRV models are factory set for approximately 20 PSIG (140 kPa) and dual PRV models are factory set for approximately 15 and 20 PSIG (105 and 140 kPa). Dual 10 SCFM units have a maximum of 1 PSI (7 kPa) pressure drop with a

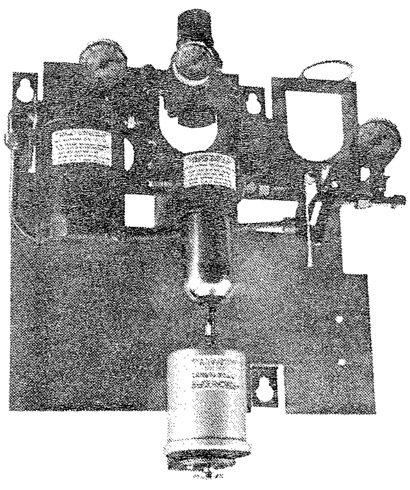


Fig. 1.14: A-4000-139
10 SCFM, Single PRV Station
(Shown with Optional Oil Reservoir)

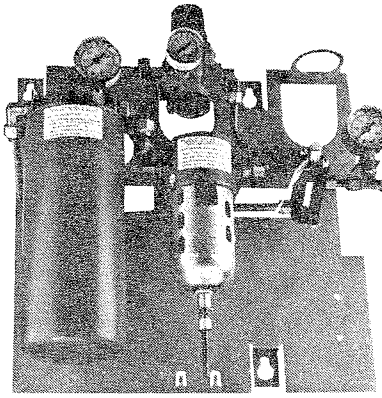


Fig. 1.15: A-4000-141
20 SCFM, Single PRV Station

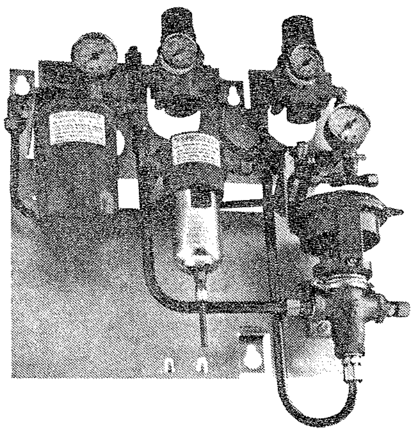


Fig. 1.16: A-4000-140
10 SCFM, Dual PRV Station

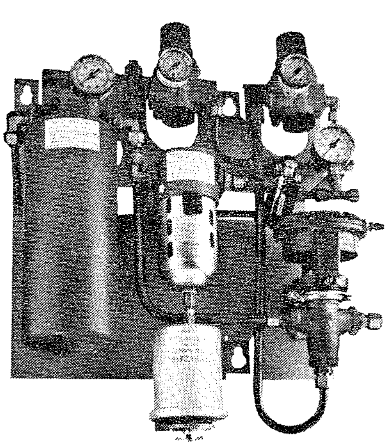


Fig. 1.17: A-4000-142
20 SCFM, Dual PRV Station
(Shown with Optional Oil Reservoir)

Table 1.7: Oil Removal and PRV Stations

Flow Consumption*	Compressor Horsepower (50% Running Time)	PRV's	Code Number
Up to a Maximum of 10 SCFM (4.7 L/s)	Johnson Controls 7-1/2 hp and Under	Single	A-4000-139
		Dual	A-4000-140
10 to 20 SCFM Maximum (4.7 to 9.4 L/s)	Other Manufacturers 7-1/2 hp and Under	Single	A-4000-141
		Dual	A-4000-142

* **Warning: If system air flow consumption increases beyond the maximum flow listed, oil will be forced through the coalescing filter and saturate the activated charcoal filter before its required replacement time.**

10 SCFM flow from the PRVs through the three-way air valve; dual 20 SCFM units have a maximum of a 2 PSI (14 kPa) pressure drop. The three-way air valve is equipped with a 1/2 in. O.D. compression fitting to furnish the dual supply air to the system. A 1/2 in. connection is furnished to provide a constant 20 PSIG (140 kPa) supply to local control panels and a 3/8 in. connection is furnished to provide filtered high pressure air to remote PRV stations.

Output Pressure

The pressure reducing station is located in the refrigerated air dryer or just downstream of the compressor (see Fig. 1.19). Check the reducing valve pressure once a week. Refer to the control drawing for recommended pressures and maintain these pressures within 0.5 PSI (3.5 kPa) at the output of the pressure reducing valve. The symbols indicating the pressures on the control drawing area are shown in Fig. 1.20.

Supply pressure on Johnson Controls systems is usually 20 PSIG (140 kPa) for single temperature systems, or 15/20 PSIG (105/140 kPa) for dual temperature systems. Different temperature control manufacturers use different supply pressures ranging from 13 to 25 PSIG (91 to 175 kPa). In most

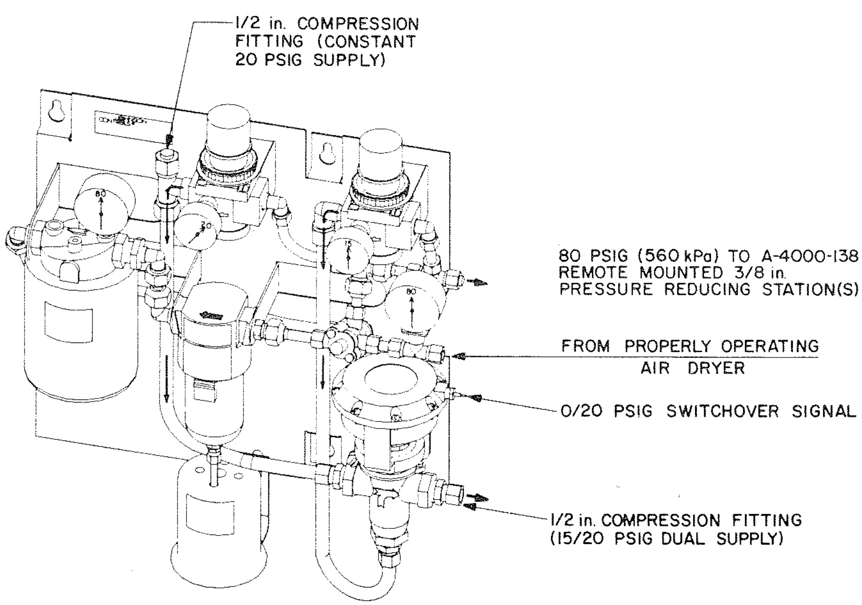


Fig. 1.18: Flow Path Through Three-Way Air Valve on Dual Oil Removal and Pressure Reducing Stations (Shown with Optional Oil Reservoir)

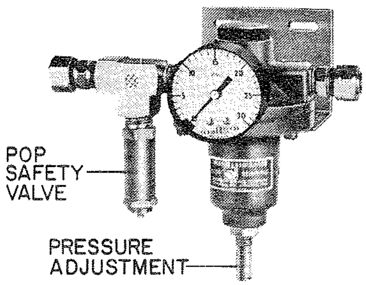


Fig. 1.19: Discontinued Version of Pressure Reducing Station

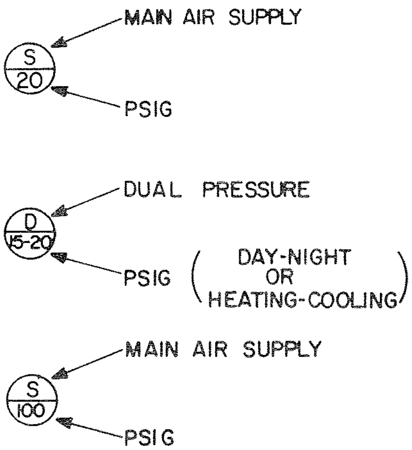


Fig. 1.20: Air Supply System Pressure Symbols

cases, Johnson Controls equipment is compatible with these systems; check with the local Johnson Controls office on specific systems.

Line losses from 0.5 to 2 PSI (3.5 to 14 kPa) can occur over the course of a long run. This does not necessarily mean that air leaks are present. Controllers and auxiliary devices do not always pass all of the pressure through the line. For this reason, it may be wise to increase the supply air slightly if necessary to compensate for line losses; consult the local Johnson Controls office for more information.

Pressure Reducing Station

The A-4000-138 Remote Mounted 3/8 in. Pressure Reducing Station (see Fig. 1.21) comes completely assembled with a wall mounting bracket, 0 to 30 PSIG gage, safety relief valve, and 3/8 in. O.D. compression elbow fittings on the high and low pressure sides. The desired output pressure can be easily adjusted between 0 and 30 PSIG by turning the black knob on the top of the unit. The factory set safety relief valve relieves overpressures exceeding 25 PSIG (175 kPa). Pressure adjustments up to 50 PSIG (350 kPa) can be made; however, the 0 to 30 PSIG gage must be replaced with one having a higher scale and the safety relief valve must be readjusted to the required higher value. Designed to handle input pressures up to 300 PSIG (2100 kPa) at air flows in excess of 20 SCFM (9.4 L/s), this pressure reducing station regulates an output pressure within a 0.2 PSI (1.4 kPa) variation with a 20 PSI (140 kPa) variation in input pressure.

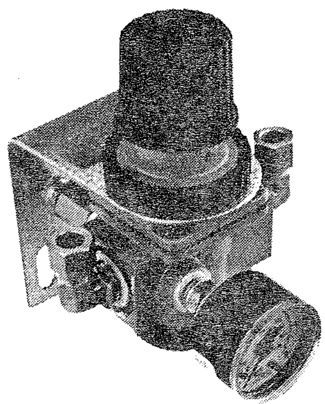


Fig. 1.21: A-4000-138 Remote Mounted 3/8 in. Pressure Reducing Station

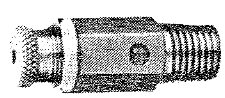


Fig. 1.22: A-4000-144 Safety Relief Valve

Oil Reservoir

The A-4000 Oil Reservoir provides a means of identifying excess oil pumping (compressor maintenance) as well as water entrainment (air dryer maintenance). If either occurs,

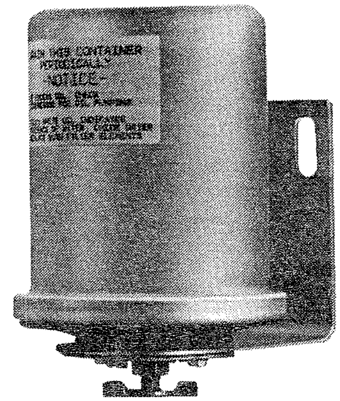


Fig. 1.23: A-4000-145 Oil Reservoir with Bracket

replacement of the oil removal elements is required. The oil reservoir also provides a means of collecting the coalesced oil for proper disposal.

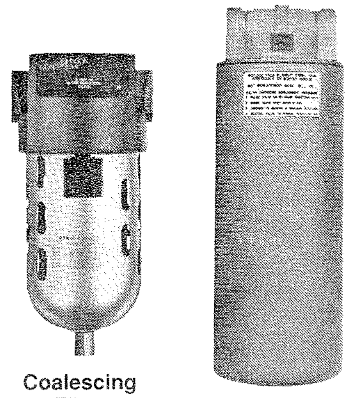
Oil Removal Filters

The combination of coalescing and activated charcoal filters in series removes both oil aerosols and vapors to provide clean, oil free air for pneumatic control systems. These filters have a maximum input pressure rating of 150 PSIG (1050 kPa) and an upper temperature limit of 125°F (52°C).

Note: The air supply to this filter combination must be from a properly broken-in air compressor producing less than 6 ppm aerosol oil (as measured by a Johnson Controls A-4000-120 Oil Indicator on the compressor tank outlet) and must also pass through a properly operating air dryer.

Table 1.8: Filters

Description	Code No.
Coalescing Filters:	
10 SCFM (4.7 L/s)	A-4000-148
20 SCFM (9.4 L/s)	A-4000-149
40 SCFM (18.9 L/s)	A-4000-601
Charcoal Filters:	
10 SCFM (4.7 L/s)	A-4000-147
20 SCFM (9.4 L/s)	A-4000-146

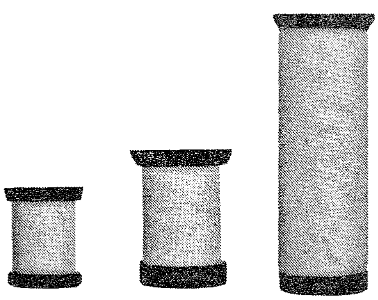


Coalescing Filter Charcoal Filter

Fig. 1.24: Oil Removal Filters

Table 1.9: Filter Elements

Description	Code No.
Coalescing Filter Elements:	
10 SCFM (4.7 L/s)	A-4110-604
20 SCFM (9.4 L/s)	A-4000-604
40 SCFM (18.9 L/s)	A-4000-605
Charcoal Filter Elements:	
10 SCFM (4.7 L/s)	A-4000-632
20 SCFM (9.4 L/s)	A-4000-633
Filter Auto-Drain Kit (All Coalescing Filters)	A-4000-610



A-4110-604 (10 SCFM) **A-4000-604 (20 SCFM)** **A-4000-605 (40 SCFM)**

Fig. 1.25: Coalescing Filter Elements

Servicing Procedure for Coalescing Filters

All coalescing filters are equipped with an automatic drain from which accumulations of entrapped liquids are automatically blown out. The filter element should be replaced when the leaving air pressure gage (mounted on the PRV station charcoal filter head) indicates less than 50 PSIG (350 kPa), the differential pressure between the leaving and input gages is 15 PSI (105 kPa) or more, or after one year of service – whichever occurs first.

To replace the filter element refer to Fig. 1.26 and proceed as follows:

1. Turn the air supply OFF.
2. Depress the lever on the filter bowl clamp and turn 1/8 of a revolution. Drop the clamp, bowl guard, and bowl to expose the filter element which needs to be replaced.
3. Remove the old filter element by turning it clockwise.
4. Clean the small screen around the drain seat of the automatic drain valve by turning the filter bowl upside down and tapping it lightly on a table top.
5. Clean the bowl and drain valve assembly using household detergent or any solvent that is not harmful to polycarbonate.
6. Install the new filter element and bowl O-ring, then reinstall the bowl and guard.

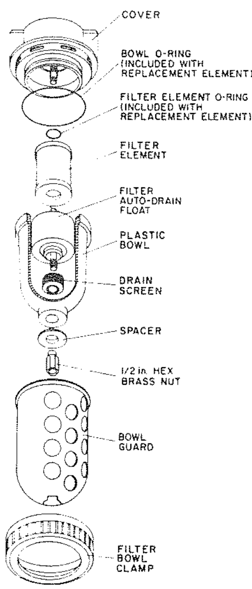


Fig. 1.26: Coalescing Filter Elements

Filter Auto-Drain Replacement A-4000-610

Release the pressure in the system and remove the bowl guard and the plastic bowl. Insert a 7/64 in. Allen wrench up through the bottom of the external 1/2 in. hex brass nut to prevent the float assembly from turning when loosening the 1/2 in. hex brass nut to remove the old auto-drain assembly.

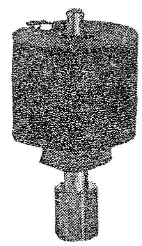


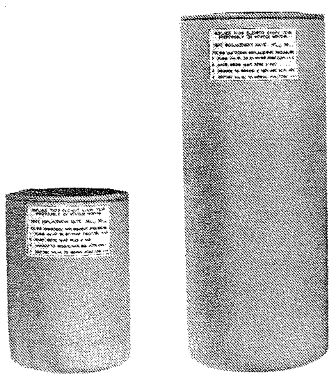
Fig. 1.27: A-4000-610 Filter Auto-Drain

Install the replacement auto-drain assembly. Turn the hex brass nut finger-tight while restraining the float assembly from turning by holding it with the 7/64 in. Allen wrench.

Caution: While tightening the 1/2 in. hex nut, it is important not to hold the float assembly. Holding the float assembly may cause the float arm to twist, resulting in a malfunctioning of the auto-drain.

Activated Charcoal Filters

Some smaller oil particles will pass through any coalescing filter. Our tests show that under certain conditions, some of this oil will condense at points where it could menace the system. Even with the best coalescing filters, there could be a slow build-up of oil and dirt until control ports, regulators, and/or orifices are affected, causing drift in the instruments. Operating at a reduced flow rate through the filter (such as on weekends or periods where parts of the system are shut down) would aggravate the problem since filter efficiency may be reduced. While the amount of oil carried into the system during these periods would be minimal due to the low flow, it will be concentrated in the active control ports and orifices. The only way to positively eliminate oil contamination is to use an absorbent filter such as an activated carbon filter after the coalescing filter. A carbon filter absorbs and holds the oil it removes and has a specific capacity and life. When a cartridge removes so much oil that its efficiency begins to drop, it should be replaced.



A-4000-632 (10 SCFM)

A-4000-633 (20 SCFM)

Fig. 1.28: Charcoal Filter Elements

If you accidentally pump solvent vapors through the carbon filter (for example, spray painting or cleaning in the equipment room), change the filter immediately since performance may be dramatically affected.

Pressure drops across these filters will have to be considered when installing the carbon filter.

The pressure drop across a charcoal filter should be less than 20 PSIG (140 kPa) at a 20 SCFM (9.4 L/s) flow rate.

There is no minimum flow limit on these filters.

A DRYER AND A GOOD COALESCING FILTER MUST PRECEDE THE CARBON FILTER.

Replacement of a Johnson Controls charcoal filter must be done on a yearly maintenance schedule.

Note: After the activated charcoal filter element has been replaced, apply the white service label included and record the next replacement date (month and year).

Oil Indicator

The A-4000 Oil Indicator is a calibrated measuring instrument used to detect aerosol-mist levels of oil entrainment that may be present in compressed air systems. Sensitivity of the indicator is limited only by the total number of hours it is allowed to remain on the air supply system. The indicator is sensitive enough to measure a concentration of oil entrainment as low as .01 PPM (.012 mg/m^3) in a compressed air system. It can be used in systems with line pressures between 10 and 125 PSIG (70 and 875 kPa).

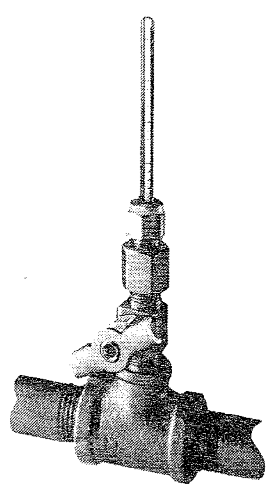


Fig. 1.29: A-4000 Oil Indicator Installed in Air Line

Application

Oil entrainment in the control air supply to the pressure reducing valve may eventually have an adverse effect on the control system performance. Since some oil entrainment is inherent to lubricated compressors, all oil lubricated compressor installations must include factory approved oil filters to be reliably acceptable. The indicator can be used in two ways. Either it can be used to check for oil carryover from the compressor or it can be used to check out any filtered air supply source before connecting it to the system and also every few months after the system becomes operative. Once the needle valve of the oil indicator has been opened, one continuous uninterrupted exposure is recommended for greatest accuracy.

Operation

When the needle valve of the oil indicator is open, less than 2 SCIM/PSIG (.08 mL/s/kPa) will flow through the calibrated plastic tube. Any oil present in the air will then carry a red oil soluble dye up the tube, coloring a white material in the tube. The rate of color travel will be proportional to the amount of oil present. The parts per million (PPM) value of oil entrained in the air can be determined using the conversion chart included with the instrument. After use, the needle valve should be closed and left in the line and the cartridge remove. At the time of the next test, a replacement cartridge will need to be installed on the needle valve fitting.

Installation

In order for the oil indicator to properly measure a given oil entrainment, sufficient exposure time is required. The length of exposure time is inversely proportional to the pressure at the point of installation.

When using the indicator to check for oil carryover from the compressor, it should be installed at the discharge of the tank. When using the indicator to measure oil entrainment in the air supply system, it should be installed between the coalescing oil removal filter and the pressure reducing valve (PRV). At this point, dry high pressure air will be present, resulting in the best accuracy and fastest indication. **Note: In humid air, moisture may wash traces of dye up the tube, creating a light pink area above the dark red area. When calculating oil entrainment, measure only to the top of the dark red column.** Locations involving excessive moisture, temperature, or velocity should be avoided. The indicator valve should remain closed except during the measuring period. For pressures above 125 PSIG (875 kPa) or below 10 PSIG (70 kPa), consult the factory.

WARNING

IF THE PRESSURE EXCEEDS 125 PSIG (875 kPa) OR THE RETAINING NUT IS LOOSENED, THE OIL INDICATOR TUBE COULD BLOW OUT OF THE COMPRESSION FITTING, CREATING A HAZARDOUS CONDITION.

The indicator must be mounted within 45° of an upright position for best possible performance. Fittings (1/8 in. NPT) are provided on both high and low pressure sides of all A-4000 Series Filter and Reducing Station Assemblies. Any other mounting location will require a 1/8 in. NPT mounting tee.

Before installing a replacement cartridge, first check that the needle valve on the existing installation is closed all the way by making sure that the needle valve handle is fully rotated in a clockwise direction.

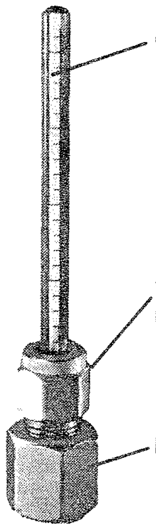


Fig. 1.30: A-4000-121 Replacement Cartridge

Install the replacement cartridge (see Fig. 1.30) by tightening the lower 1/8 in. nut in place. **Note: Do not disturb the factory adjusted torque on the upper 3/8 in. retaining nut that holds the plastic tube in place. Also make sure that the indicator scale can be conveniently viewed before tightening the cartridge in place.**

Readings and Measurements

1. Before taking a measurement, fill out the record tag furnished with the oil indicator. Record the line pressure of the average pressure (if it varies at the point of installation).
2. Fully rotate the needle valve handle (see Fig. 1.31) counterclockwise to open it and record the time that the needle valve was opened on the record tag. Slide the record tag over the oil indicator to avoid misplacing it.
3. At the following times and locations, visual inspections of the oil indicators should be made:
   A. When checking for compressor oil carryover, inspections should be made after 4 hours at the compressor discharge.
   B. When checking for oil entrainment in the air supply, inspections should be made after 40 hours between the oil filter and the PRV.
4. Judging from the rate of color travel established at the time of the first inspection, schedule the final reading of the indicator (and needle valve shutoff) at approximately 1 unit (marked "1.0" on the scale), and preferably not more than 1-1/2 units (marked "1.5" on the scale).
5. Close the needle valve, remove the oil indicator cartridge, and record the time. Leave the needle valve in the air line for future testing purposes.
6. Record the units of color travel (as read from the indicator scale) and the total time in hours.

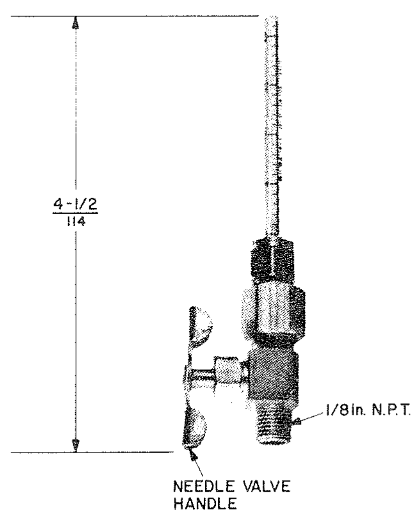


Fig. 1.31: Dimensions $\frac{in.}{mm}$

Oil Concentration Determination

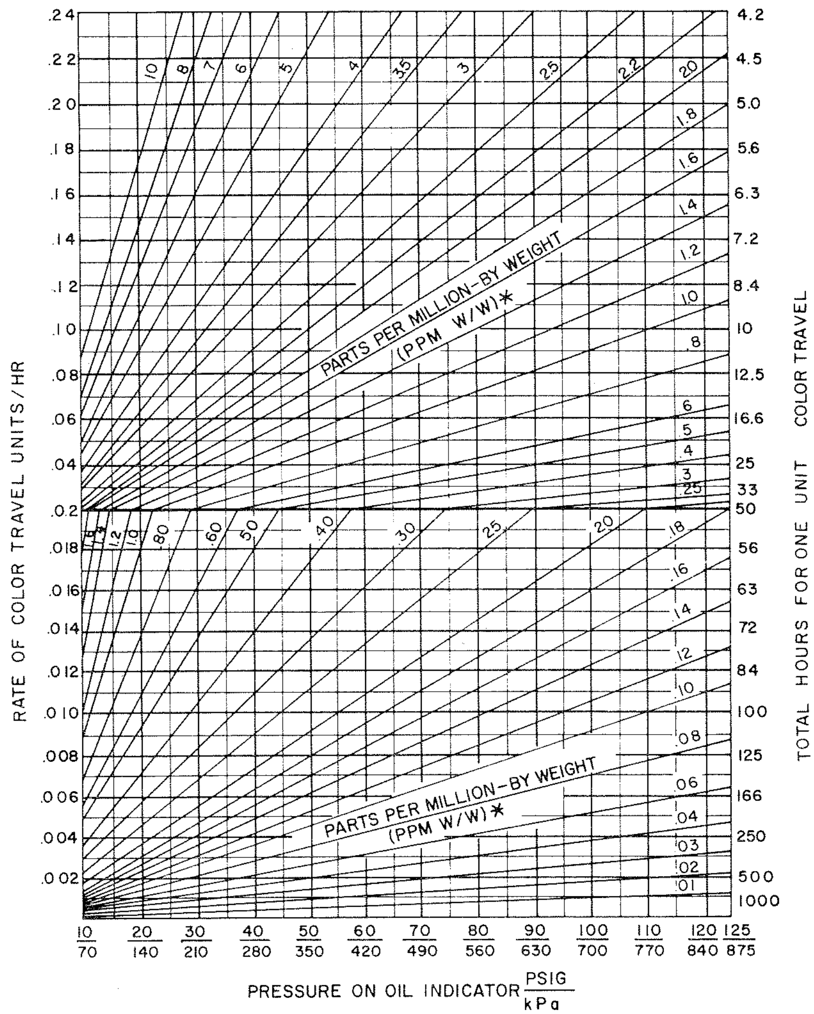
1. If color travel is 1 unit at the final reading time, find the Total Hours on the right side of the conversion chart and the Pressure on the bottom of the chart. The point where Hours and Pressure intersect is the parts per million of oil concentration.

2. If the final reading occurs at other than 1 unit of color travel, divide the units traveled by the total hours to find the Rate of Color Travel.

3. Find the Rate of Color Travel on the left side of the conversion chart and the Pressure on the bottom of the chart. The point where Rate and Pressure intersect is the parts per million of oil concentration.

For any Rate of Color Travel beyond 0.24 units/hour, the measured rate should be divided by any factor which will bring it into the range of the chart. This number should then be used to determine the oil concentration (PPM). This concentration must then be multiplied by the same factor used previously to determine the actual oil concentration.

Example: The Rate of Travel on the high pressure side of a PRV (80 PSIG [560 kPa]) is found to be 0.5 units/hour. Divide this rate by five (0.5 ÷ 5 = 0.1 units/hour) to bring it into the range of the conversion chart. Locate this new rate on the chart, showing a concentration of 1.4 PPM. Multiply this concentration by the previous factor (1.4 × 5 = 7.0 PPM) to obtain the actual oil concentration in the air being tested.



* W/W = Weight of Oil per Weight of Air

Note: Multiply PPM by 0.12 to obtain oz/100,000 SCF
Multiply PPM by 1.2 to obtain mg/m^3

Fig. 1.32: Conversion Chart for Oil Indicator

Air Compressor Troubleshooting

WARNING

ALL ELECTRICAL HOOKUPS SHOULD BE MADE BY A QUALIFIED ELECTRICIAN.

All wiring should be completed in accordance to national and local codes.

Table 1.10: Compressor Troubleshooting Checklist

Trouble	Probable Cause	Suggested Remedy
Low Discharge Pressure	1. Air leaks	1. Listen for escaping air. Apply soap suds solution to all fittings and connections. Bubbles will appear at points of leakage. Tighten or replace leaking fittings or connections.
	2. Leaking valves	2. Remove valve assemblies from the head, disassemble and inspect component parts for valve breakage, scarred valve seats, etc. Replace inoperative parts and reassemble.
		Warning: Be sure that old valve assembly gaskets are removed from the head valve pockets and that they are replaced with new ones each time the valve assemblies are removed from the head.
	3. Restricted air intake	3. Replace the intake filter. Check for unnecessary elbows in the intake line and remove if they are restricting the flow of intake air to the compressor.
	4. Slipping belts	4. Adjust belt tension.
	5. Blown gaskets	5. Replace gaskets proven faulty on inspection.
	6. Low compression	6. Low pressure can be due to worn rings and cylinder walls. Correction is made by replacing the cylinder and installing new rings.
Knocking	1. Loose motor or compressor pulley	1. Loose motor or compressor pulleys are a very common cause of compressor knocking. Tighten pulley clamp bolts and set screws.
	2. Lack of oil in crankcase	2. Check for proper oil level. If low, check for possible damage to bearings.
	3. Oil pump not functioning (15 to 20 hp)	3. Check the operation of the oil pump and pressure gage. If low oil pressure, check oil level. If oil level is sufficient, remove pipe plug at right side of distribution block located below oil pressure gage. Prime pump by squirting oil in 1/8 in. NPT hole, reinstall plug, check oil pressure. Replace oil pump if this is not successful.
	4. Worn piston pin bushing	4. Remove rod and piston assemblies from the compressor and inspect for excessive wear. Replace excessively worn piston pin and/or bushing.
	5. Burned out bearing	5. Replace worn or burned out bearings and remedy cause of failure.
	6. Check valve	6. Note: 15 and 20 hp units — the discharge check valve may sound like a knock. Check valve noise is normal for those units.
	7. Loose valve assemblies	7. Remove the valve assembly and valve assembly gasket from the head. Replace the valve assembly gasket with a new one and reinstall the valve assembly after examining the valve pockets in the head and tighten the valve hold-down screws sufficiently (to hold the valve solidly in place).
	8. Piston hitting the head	8. Remove the compressor head and inspect for carbon deposits or other foreign material on top of the piston. Replace the head with a new head gasket.
Over-Heating	1. Poor ventilation	1. Relocate the compressor to an area where an ample supply of cool, clean, dry, and well circulated air is available.
		Note: Avoid locations near boilers or other areas where there is a high ambient temp.
	2. Dirty cooling surfaces	2. Clean the cooling surfaces of the cylinder and intercooler.
	3. Incorrect pulley rotation	3. Check the arrow on the pulley for correct rotation. If incorrect, have a competent electrician reverse the motor rotation.
Stall	1. Overload motor	1. Have a competent electrician examine the motor and wiring, then proceed with his recommendation.
	2. Low voltage	2. Check the current draw at 85 to 90 PSIG (595 to 630 kPa) and during startup.
Excessive Belt Wear	1. Pulley out of alignment	1. Realign the motor pulley with the compressor pulley.
	2. Belt too loose or too tight	2. Adjust the tension on the belt.
	3. Pulley wobbles	3. Check for worn crankshaft, keyway, or pulley bore resulting from running a bent crankshaft.
Oil in Discharge Air	1. Worn piston rings	1. Replace with new rings and cylinder.
	2. Comp. air intake restricted	2. Replace the intake filter and check for other restrictions in the intake system.
	3. Restricted breather valve	3. Clean and check the breather valve for free operation.
	4. Excessive oil in compressor	4. Drain down to full mark on oil level gage.
	5. Wrong oil viscosity	5. Refer to the Lubrication section of this manual for the correct viscosity.

Table 1.11: Compressor Troubleshooting Checklist (Duplex)

Trouble	Probable Cause	Suggested Remedy
Neither Comp. is Running	1. Both starter overloads out	1. Press the RESET button and check for the cause of the overload.
Both Compressors Running on Consecutive Starts	1. Pressure setting of lead PE switch is below setting of lag PE switch	1. Reset the lead PE switch ON at 70 PSIG (490 kPa) and the lag PE switch ON at 60 PSIG (420 kPa).
Failure to Alternate	1. One starter overload out	1. Press the RESET button and check for the cause of the overload.
	2. Faulty starter	2. Check the coil and power contacts and repair or replace them.
	3. Faulty alternator coil	3. Check the alternator coil. Replace if necessary.
	4. Burned out starter contacts	4. Check the contacts for continuity and replace if necessary.
	5. Loose connection in alternator lines (no voltage)	5. Trace the lines using an ohm/voltmeter and repair where necessary.
	6. Faulty motor	6. Check for proper power connections. Replace the motor if necessary.

Date	Oil Added	Oil Change	Intake Air Filter Change	Belt Adjustment	Pump Up Time	Coalescent Filter Change	Charcoal Filter Change	Air Dryer Refrigerant Pressure Check	Oil* Carryover Measurement	Comments

*Use the Johnson Controls A-4000 Oil Indicator to measure oil carryover at or near the tank outlet. If this measurement exceeds 4 PPM, contact your local Johnson Controls branch office for special servicing instructions.

Section II: Controllers, Transmitters, and Receiver-Controllers

Information in this section pertains to the following Johnson Controls devices, some of which may have been discontinued:

- C-100, C-200, C-2000, C-5000, and C-9000 Series Cumulators.
- H-100, H-350, H-1210, H-4000, and H-5000 Series Humidistats.
- P-5200 and P-8000 Series Pressure Controllers.
- R-20, R-300, R-870, and R-970 Series Pressure Regulators.
- T-200, T-300, T-400, T-800, T-900, T-1200, T-3000, T-4000, T-5000, T-8500, and T-9000 Series Thermostats.

Calibrating Discontinued Instruments

Modern technology, coupled with Johnson Controls' commitment to product innovation, has prompted evolution and change in many of our devices over the years. Fortunately, the older model instruments and the current instruments are serviced and calibrated in much the same way with a few exceptions.

The information on Pin Valve Adjustment, Pivot Adjustment, Lid Alignment, and Sensitivity Adjustment applies to the following discontinued instruments:

- C-100 Series.
- H-100, H-350, and H-1210 Series.
- P-8500 Series.
- R-20, R-300, R-870, and R-970 Series.
- T-200, T-300, T-400, T-800, T-900, T-1200, and T-8500 Series.

Pin Valve Adjustment

One of the distinct characteristics of the discontinued controllers is the adjustable pin valve (see Figs. 2.1 and 2.2). Pin valves are factory set and normally require no further adjustment. To check for proper operation of the relay, proceed as follows:

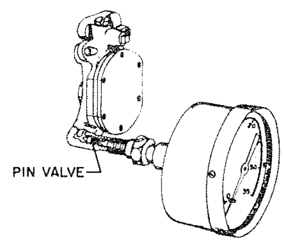


Fig. 2.1: Pin Valve Adjustment

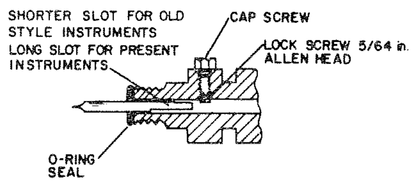


Fig. 2.2: Test Gage Adjustment

1. Lift the control port lid off the control port. The output pressure should drop to less than 0.5 PSIG.
2. Close the control port. The output pressure should rise to within 0.5 PSI of the supply pressure.

If the instrument does not respond as described above, adjust the pin valve using the JC 5311 Pin Valve Test Gage.

1. Remove the pin valve cap screw.
2. Lift the control port lid off the control port.
3. Insert the screwdriver attachment into the pin valve opening so that the bit engages in the slot and the O-ring seal seats against the opening. **Note: If the bit does not engage or the O-ring does not seal, remove the cap screw on the stem of the gage and reposition the bit to fit the instrument (see Fig. 2.2).**
4. Turn the complete assembly (gage and adapter) while applying a steady pressure on the gage to assure seating. Adjust to the pin valve pressure indicated in Table 2.1.
5. Remove the test gage and replace the pin valve cap screw.

Table 2.1: Pin Valve Settings

Supply Pressure	Relay Instruments	Non-Relay Instruments
15 PSIG	5 to 7 in. WG	1.25 PSIG
20 PSIG	7 to 9 in. WG	1.50 PSIG

Pivot Adjustment

Pivots are adjusted at the factory with the proper amount of end play, and normally never need to be adjusted in the field. However, if it becomes necessary to adjust the pivots, use a small screwdriver and locknut wrench and proceed as follows:

1. Loosen one of the pivot screws.
2. Adjust the opposite pivot screw until the lid assembly is centered over the control port, and lock the pivot screw.
3. Hold the end of the lid assembly pin into the locked pivot screw and adjust the lid pivot screw at the other end of the pin until a slight amount of end play exists between the pivot screws and the lid assembly.

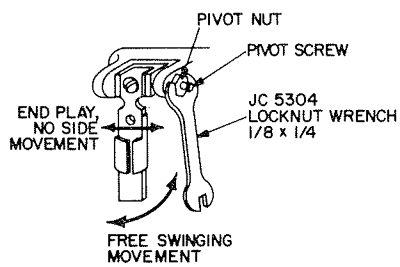


Fig. 2.3: Adjusting Pivots

CAUTION

DO NOT TIGHTEN THE PIVOT SCREW UP SNUG AND THEN LOOSEN IT TO OBTAIN THE SLIGHT "END PLAY" REQUIRED.

This method will damage the pivots. When the proper amount of end play exists, see that both of the pivot screws are locked.

Lid Alignment

The two lid aligning tools included in the JC 5300 Kit are to be used as a pair when aligning the lid extension to obtain proper seating. By using the two tools as a pair (one to hold the lid while doing the twisting or bending with the other), the lid extension pivots are less likely to be damaged.

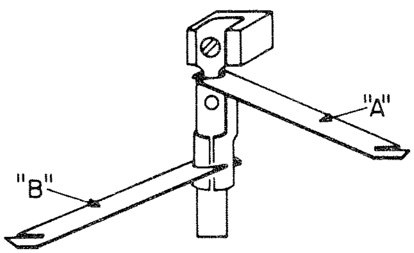


Fig. 2.4: Lid Alignment

Each tool has two slots of different sizes. One slot (as in "A") fits over the lid extension. The other slot (as in "B") which fits over both the lid extension and the seat holder, is to be used only on short lids when the lid cannot be grasped at any other point.

Sensitivity Adjustment

Sensitivity: the change or number of PSI the controller output changes per unit change in the controlled variable. Example: Δ PSI/degree temperature.

The sensitivity of any controller should be as high as possible without producing excessive hunting or cycling. Most thermostats were originally factory set at 2.5 PSI/1F°. If it becomes necessary to adjust the

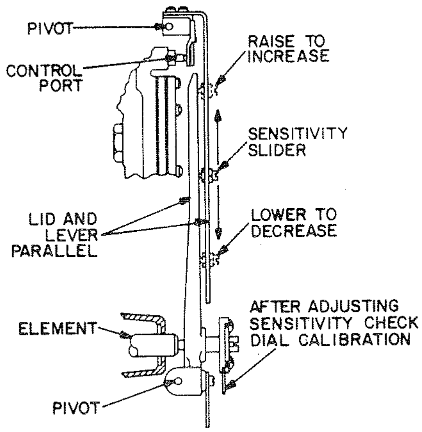


Fig. 2.5: Sensitivity Adjustment

sensitivity, be sure that the sensitivity arm is parallel to the transfer lever on the instrument. Most instruments have a locknut and screw in conjunction with the sensitivity slider. Figure 2.5 shows the parts of a typical discontinued relay instrument.

Changing the sensitivity may change the instrument set point and/or control point. If the sensitivity is changed, the instrument should be readjusted.

Four Basic Calibration Steps

The next few pages include calibration instructions on some of the more common discontinued instruments. If complete calibration instructions for a particular instrument are not given in this manual, calibrate the instrument using the following four basic steps of calibration:

1. Determine the actual value (temperature, pressure, or humidity) at the sensing element.
2. Turn the set point dial to that value.
3. Turn the output adjusting screw until the output pressure (read on the test gage) is at the mid spring range of the controlled device.
4. Turn the set point dial to the desired set point.

R-317 Air Flow Controller (Also Discontinued R-316 and R-318 Controllers)

If the unit must be checked to determine the actual air delivery or control point of the R-317, obtain a draft gage, tubing, and tee fittings, refer to Fig. 2.6, and proceed as follows:

1. Attach the tee fittings to the high and low pressure measuring lines.
2. Use the pressure drop indicated on the draft gage and the calibration curve to determine the actual air delivery.
3. If the pressure drop indicated on the gage is above or below the value indicated on the dial, loosen the small set screw on the dial and turn the dial face until it corresponds to the pressure drop indicated on the gage. Tighten the set screw and turn the adjusting post until the dial indicates the desired pressure difference. **Always use a screwdriver to turn the dial adjusting post. Do not remove the dial stop screws.**

Other Air Systems

Connect a draft gage into the measuring line of the R-317 and, with the fan running, turn the adjusting dial of the R-317 until it controls at the desired pressure (static, velocity, or total).

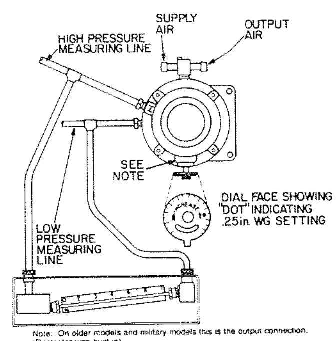


Fig. 2.6: Calibration of R-317 and Discontinued R-316 and R-318

1. Determine Action And Sensing Line Location

Right Side Connection		Left Side Connection	
Controlled Pressure Above Reference Pressure		Controlled Pressure Below Reference Pressure	
Action		Action	
DIR	REV	DIR	REV
REV Relay	DIR Relay	DIR Relay	REV Relay

2. Furnish Supply Pressure 13 to 25 PSIG.
3. Check Pin Valve Setting (1-1/4 PSIG @ 20 PSIG).
4. Set Gain Adjustment.
5. Turn Adjusting Screw Until The Output Changes And The Desired Static Pressure Is Maintained.
6. Loosen The Two Holding Screws; Center Pointer and Tighten Screws.

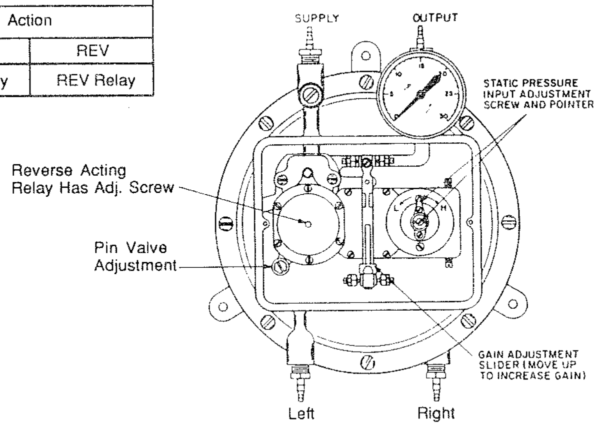
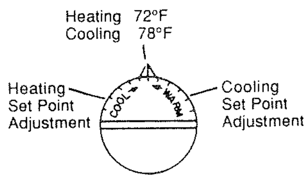
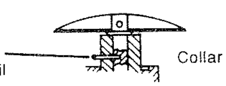


Fig. 2.7: R-302 Static Pressure Regulator

1. Example: Actual Temperature 76°F
   Desired Temperature
   Heating 72°F
   Cooling 78°F



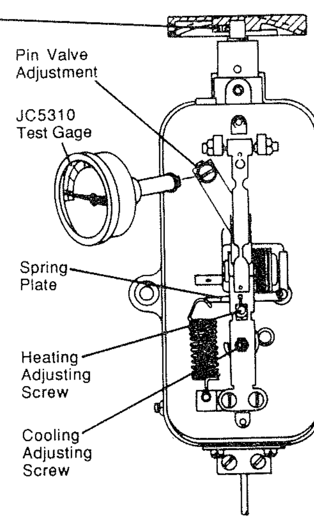
2. Align Dial With Dial Post. Insert Small Pin or Paper Clip Into Hole In Collar. Rotate Dial Slowly Until Pin Slips Into Dial Post.



3. Loosen Dial Set Screw, Center Dial and Retighten. Remove Pin From Step 2.
4. Change To Cooling Supply Air Pressure, 20 PSIG.
5. Remove Cap Screw; Using JC5311 Adjusting Gage, Adjust Pin Valve. (1-1/4 PSIG With Control Port Open).
6. Attach JC5310 Test Gage After Adjusting Pin Valve.

The Following Adjustments Will Produce A Center Dial Setting Of 78°F Cooling and 72°F Heating.

7. Rotate Dial 2F° Counterclockwise to Correspond to Actual Temperature, 76°F.
8. Turn Cooling Adjustment Screw Until Test Gage Reads 7 PSIG.
9. Set Dial At Desired Set Point; (clockwise 2F°).



10. Change to Heating Supply Air Pressure, 15 PSIG.
11. Rotate Dial 4F° Clockwise To Correspond To Actual Temperature, 76°F.
12. Test Gage Should Read 7 PSIG; If It Does Go To Step 14. If It Does Not, Go To Next Step.
13. Lift Spring Plate And Turn Heating Adjusting Screw, Release Spring Plate And Check Test Gage Reading. If Not 7 PSIG Repeat This Procedure Until 7 PSIG Is Obtained. Note: During This Adjustment The Pivot Point Cylinder Should Be Held In The Groove Of The Heating Adjusting Screw.
14. Set Dial At Desired Set Point, Counterclockwise 4F° to 72°F Heating And 78°F Cooling.
15. Remove Test Gage And Replace Cap Screw.

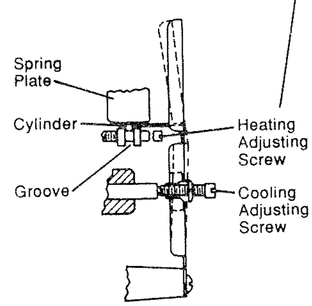


Fig. 2.8: T-271 Heating-Cooling Thermostat

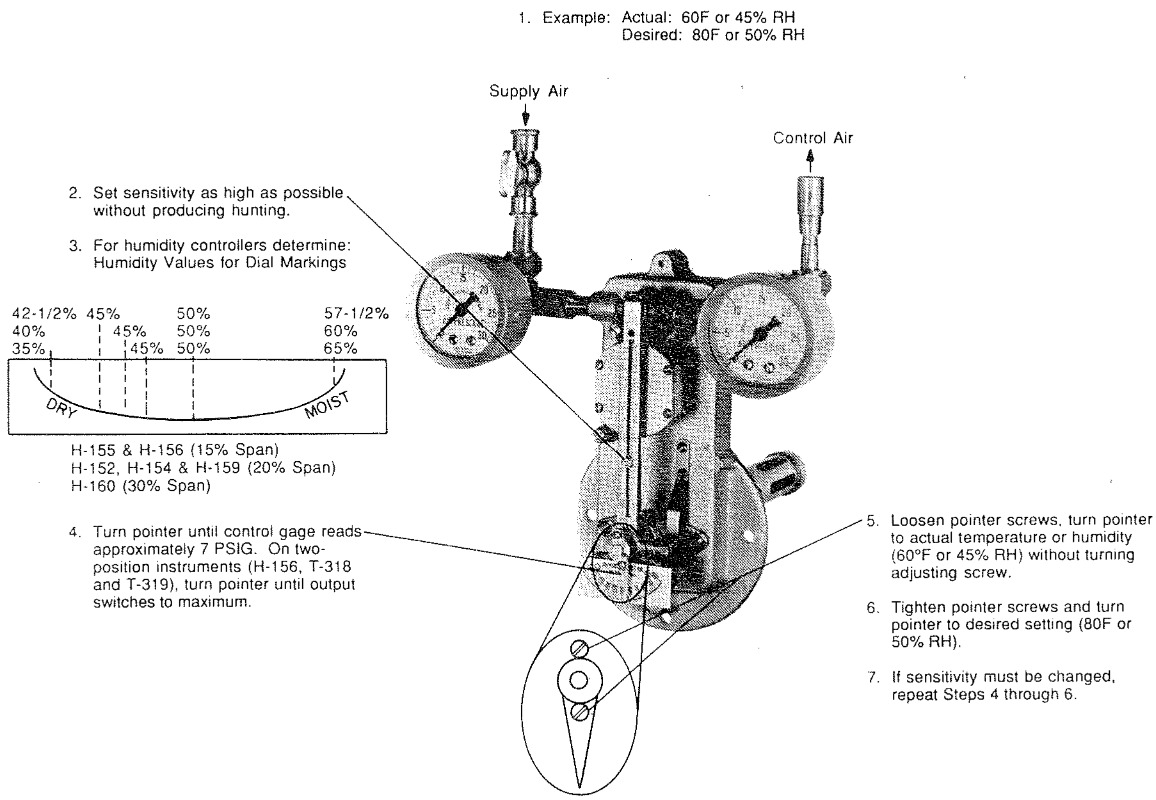


Fig. 2.9: Insertion or Immersion Type Controllers; T-316, T-317, T-318, T-319, H-152, H-154, H-155, H-156, H-159, H-160, and R-325

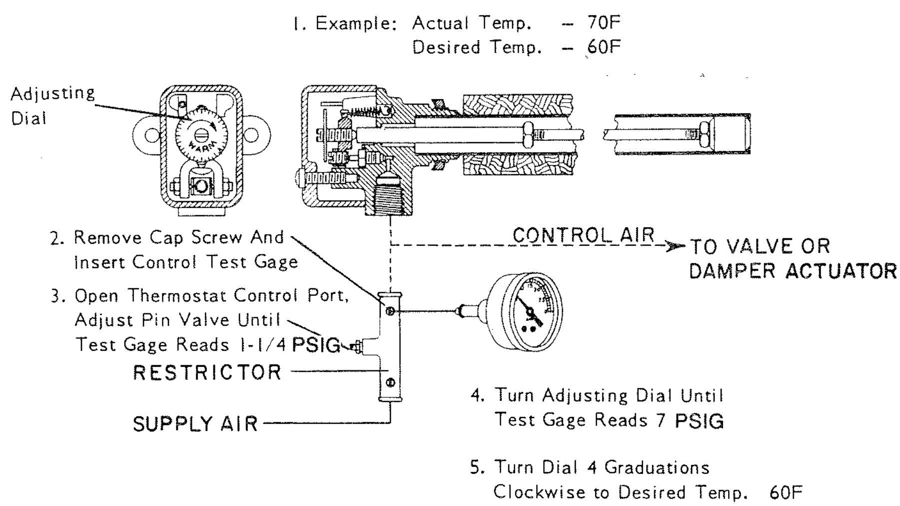
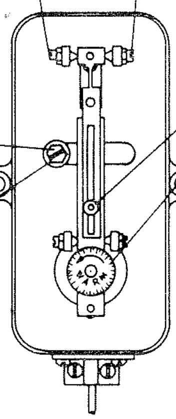


Fig. 2.10: T-320 Non-Relay Airstream Thermostat

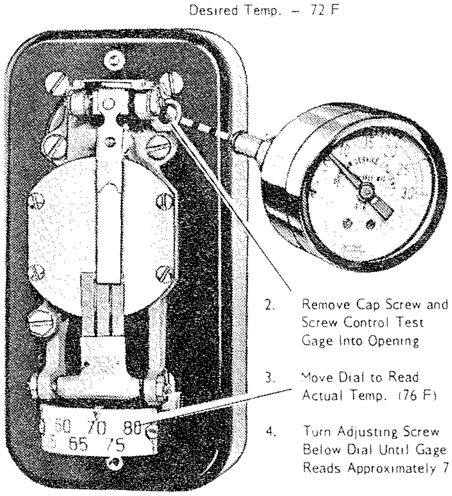


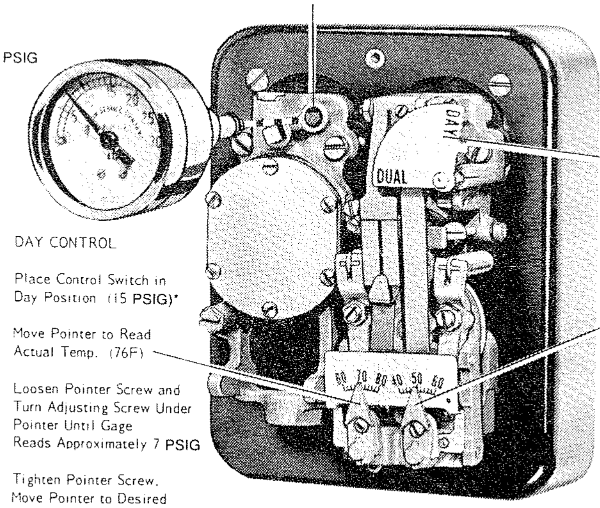
Note: The T-333 Converts The Relay (High Volume) Signal Into A Non-relay (Low Volume) Signal. Any Leaks Between The T-333 And The Controlled Device Will Not Allow The T-333 Output To Match The Input Pressure When The Control Port Is Seated.

Fig. 2.11: T-333 Airstream Thermostat

(Left)
Fig. 2.12: Single Set Point Room Controllers; T-400, T-401, T-403, T-425, T-441, H-102, H-103, H-105, and H-107

Note: For T-315 and H-101 Submaster Controllers, set the submaster pressure to 9 PSIG before calibrating.



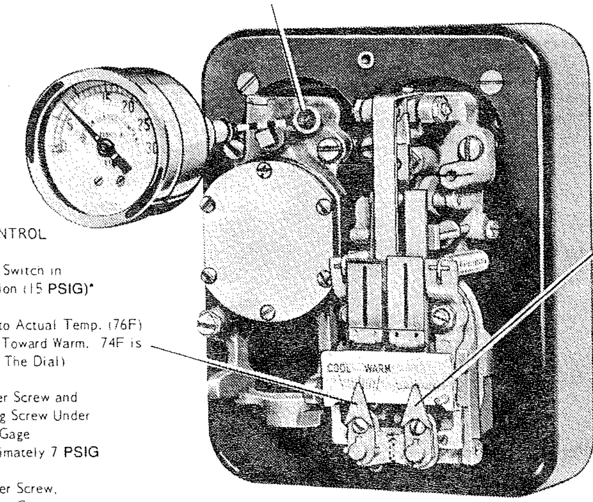


(Right)
Fig. 2.13: Day-Night Controllers; T-405, T-460, T-461, T-462, and T-465

SINCE THERE ARE NO NUMERALS ON THE DIALS IT IS ASSUMED THAT THE DESIRED SETTINGS ARE IN THE CENTER (EACH GRADUATION IS 2 F°)

1. Example: Actual Temp. – 76F
   Desired Heating – 74F
   Desired Cooling – 78F

2. Remove Cap Screw and Screw Control Test Gage Into Opening



HEATING CONTROL

3. Place Control Switch in Heating Position (15 PSIG)*
4. Move Pointer to Actual Temp. (76F) (1 Graduation Toward Warm. 74F is The Center of The Dial)
5. Loosen Pointer Screw and Turn Adjusting Screw Under Pointer Until Gage Reads Approximately 7 PSIG
6. Tighten Pointer Screw. Move Pointer to Center of Dial (Desired 74F)

COOLING CONTROL

3. Place Control Switch in Cooling Position (19 PSIG)*
4. Move Pointer to Actual Temp. (76F) Note: For This Pointer, Cool is to Right (76F is 2F° Cooler Than The Desired 78F Which is Represented By The Center of The Dial). The Heating Pointer Will Also Move But This Does Not Affect Previous Calibration
5. Loosen Pointer Screw And Turn Adjusting Screw Under Pointer Until Gage Reads Approximately 7 PSIG
6. Tighten Pointer Screw. Move Pointer to Center of Dial (Desired 78F)

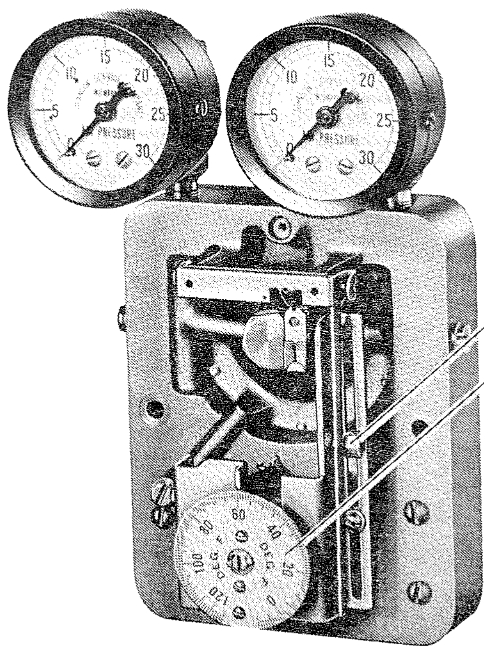
* Some Existing Installations Use 13 & 17 PSI Dual Supply Air Pressure

Fig. 2.14: Heating-Cooling Controllers; T-432 and T-445

1. Example: Actual Temp. – 70F
   Desired Temp. – 60F

Supply Air

Control Air



2. Set Sensitivity Slider 1/3 Distance From Pivots to Top of Adj. Slot
3. Turn Dial Until Control Gage Reads Approximately 7 PSIG
4. Loosen Dial Screws And Turn Dial to Actual Temp. (70F)
5. Tighten Dial Screws And Turn Dial to Desired Temp. (60F)
6. If Sensitivity Must Be Changed Repeat Steps 3 thru 5

Fig. 2.15: 800 Series Controllers; R-870, T-800, T-802, T-804, T-5310, and T-5314

Master-Submaster Control

The Master-Submaster calibration information pertains to the following instruments:

- Master Controllers:
  T-900 and T-8500.
- Submaster Controllers:
  T-901 and T-8501.

Example:

Outside Air: 0°F to 70°F.

Hot Water Temp: 200°F to 70°F.

Supply Air: 15 PSIG (20 PSIG since 1965).

Use Form 561.

Remote Element Master Thermostat

The Remote Element Master Thermostat employs pneumatic feedback to provide extremely accurate proportional control even at low sensitivities. This accuracy makes it an ideal master controller in a master-submaster control system. It is also used for direct temperature control. Models are available in either direct or reverse acting. A simple field change of pivot location can change the action of the instrument.

A. Move the sensitivity slider all the way up.
   1. Pneumatic feedback.

B. Select the proper pivots.
   1. Inner pivots:
      "A" direct acting.
      "B" reverse acting.
   2. Outer pivots:
      Diagonally opposite; "C" goes with "B" and "D" goes with "A".

C. Sensitivity = $\frac{\text{Change in Master Pressure}}{\text{Change in Temperature}}$
   1. Upper dial adjustment.

D. Setup procedure for master.
   1. To determine the sensitivity of the master, first determine the span of temperature (0 to 70°F) and second,

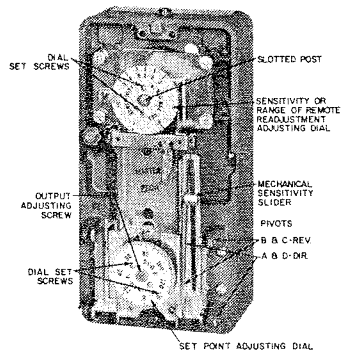


Fig. 2.17: Master Thermostat

determine the difference in master pressure (0 to 15 PSIG).

Sensitivity = $\frac{\text{Change in Master Pressure}}{\text{Change in Temperature}}$

Sensitivity = $\frac{15\text{ PSI}}{70\text{F}^\circ} = .214\text{ PSI/F}^\circ$

This value is set on the upper dial.

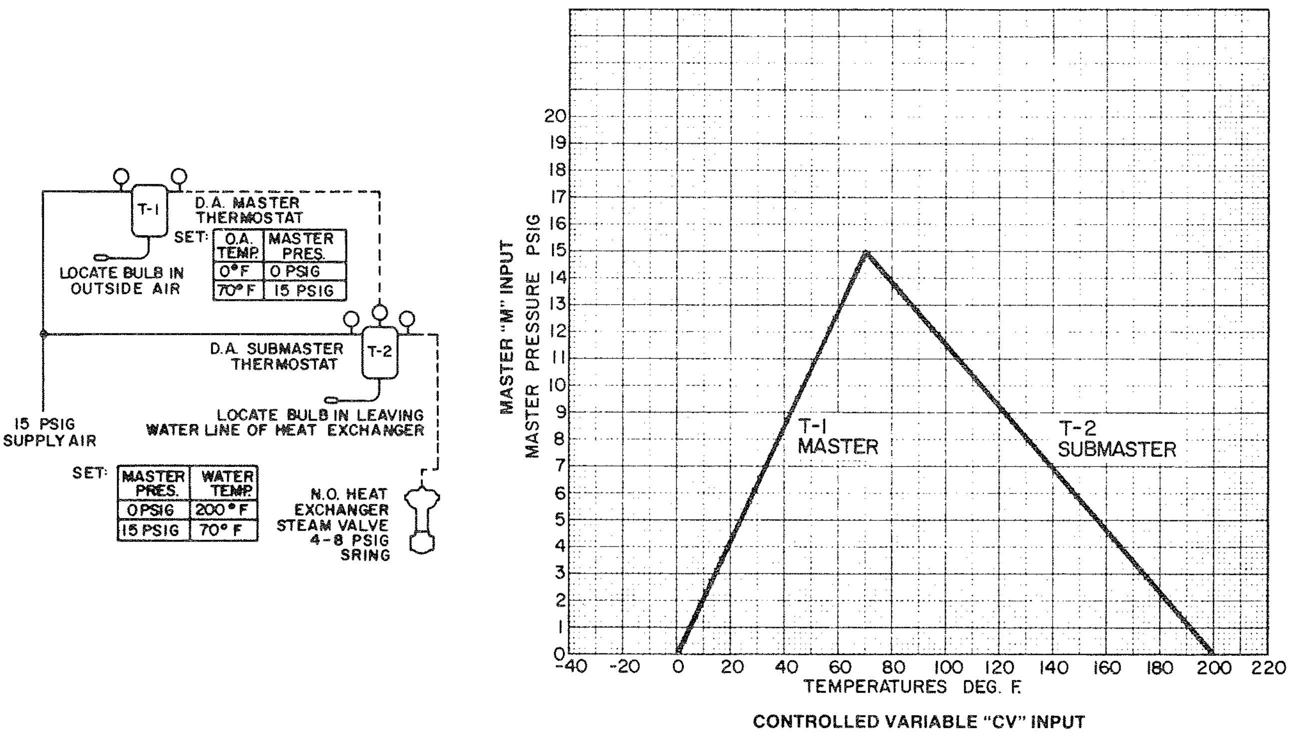


Fig. 2.16: Master-Submaster Application

2. To set the proper output master pressure for a temperature read at the bulb, a graph (Form 561) must be drawn showing the corresponding temperatures and pressures. In this example, the outside temperature is +40°F at the bulb. From the graph, it can be determined that an output (master) pressure of 8.6 PSIG would be required. This is adjusted by turning the output adjusting screw located in the center of the lower dial. Once adjusted, the dial may then be set to the temperature read at the bulb and tightened down, being sure not to disturb the output pressure.

3. The master is now adjusted and will produce pressures which correspond to temperatures measured at the bulb over the range in this example.

Remote Element Submaster Thermostat

The Remote Element Submaster Thermostat is provided with automatic readjustment of the set point by a remote master controller. The set point will vary as the pressure from the master controller varies. An adjusting dial permits manual readjustment of the set point at the instrument.

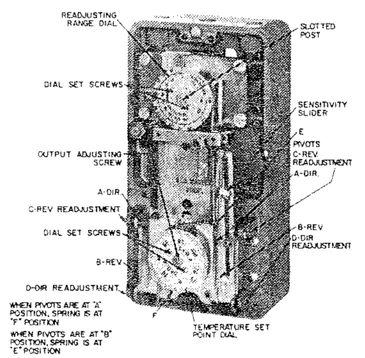


Fig. 2.18: Submaster Thermostat

A. The sensitivity slider should be set to the highest point without causing hunting.

B. Determine the readjusting range.

C. Select the proper pivots.
   1. Inner pivots:
      "A" direct acting
      "B" reverse acting
   2. Outer pivots:
      "C" reverse readjustment
      "D" direct readjustment

D. Setup procedure for submaster.
   1. Determine the direction of readjustment (direct or reverse) and confirm its setup by checking the outer pivots on the thermostat. In this example, reverse readjustment is required since the set point is lowered as the outside air temperature (and master pressure) increases.
   2. Determine the readjusting range (the warmest to coldest temperatures of the water). In this example, 200°F to 70°F is the readjusting range required, which amounts to a span of 130F°. This value is set on the upper dial.

      Note: There are two scales provided on the readjusting range dial: the outer scale is for a 0 to 20 PSIG master pressure signal and the inner scale is for a 0 to 15 PSIG master pressure signal.

   3. Perform the four steps of adjustment to the lower dial. The desired temperature (fourth step) is the value from the graph for the master pressure, read at the top of the instrument. In this example, 8 PSIG corresponds to a temperature of 130°F.

Receiver-Controllers

Receiver-controllers position controlled devices based on the input signal from a pneumatic transmitter. Single input receiver-controllers function just like the controllers.

Dual input receiver-controllers are used in master-submaster or reset applications.

The T-9000 Series instruments include a final supply air filter to provide clean air entering the unit. The filter which used to be located in the upper left module has been replaced with an external filter which can be visually checked through the clear plastic cartridge. Refer to the Repair Parts bulletin for the order number. **Note: If the T-9000 is contaminated with oil, it must be replaced.**

These calibration procedures apply to the following discontinued receiver-controllers:

- T-5300, T-5302, T-9001, T-9005, and T-9006 Single Input.
- T-5301, T-5303, T-9010, T-9011, T-9020, and T-9021 Dual Input.

To calibrate receiver-controllers, use Test Kit JC 5383 (formerly X-200-173), Hypodermic Needle Test Probe JC 5361 (formerly X-200-140), and the appropriate test gage (see Table 2.2).

Ask your local Johnson Controls branch office for bulletin T-5800-B; it explains how to use the Test Kit JC 5383.

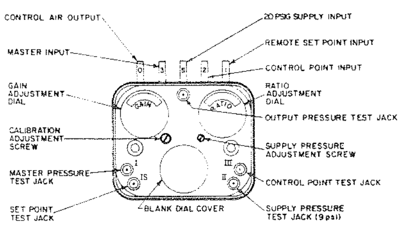
If the instrument is completely out of adjustment, rebalance it to its original factory standards (see Table 2.3).
Inputs = 9 PSIG;
Gain Dial = 10.1, and
Ratio = 1:1.

Table 2.2: Test Gages

	Scales	
F°	50 to 150	JC 5385
	0 to 100	
	20 to 120	
	-40 to 160	
	60 to 85	JC 5386
	40 to 240	
	40 to 65	
	50 to 100	
C°	10 to 35	JC 5387
	-15 to 35	
	10 to 60	
	0 to 100	

Table 2.3: Original Factory Settings

Gain Dial (Factory Setting)	10:1
Ratio Dial (Factory Setting)	1:1
Supply Pressure	20 PSIG
Internal Supply "IS"	9 PSIG
Integral or Remote Set Point Dial "I"	9 PSIG
High Pressure Transmitter Input "III"	9 PSIG
Low Pressure Transmitter Input "II"	9 PSIG
Output Pressure "O"	9 PSIG

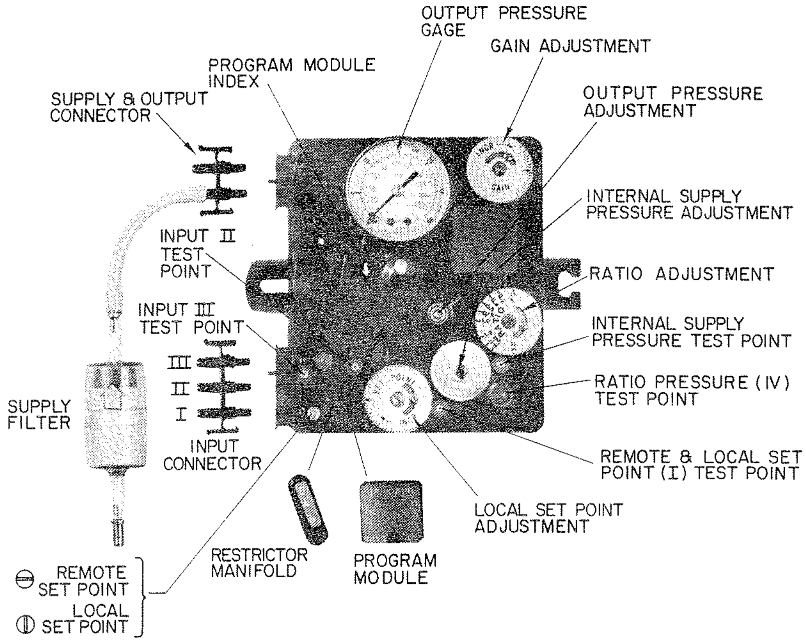


T-9010 Single Input, Remote Set Point
T-9011 Single Input, Local Set Point
T-9020 Dual Input, Remote Set Point
T-9021 Dual Input, Local Set Point

Fig. 2.19: Discontinued "Gray" Receiver-Controllers

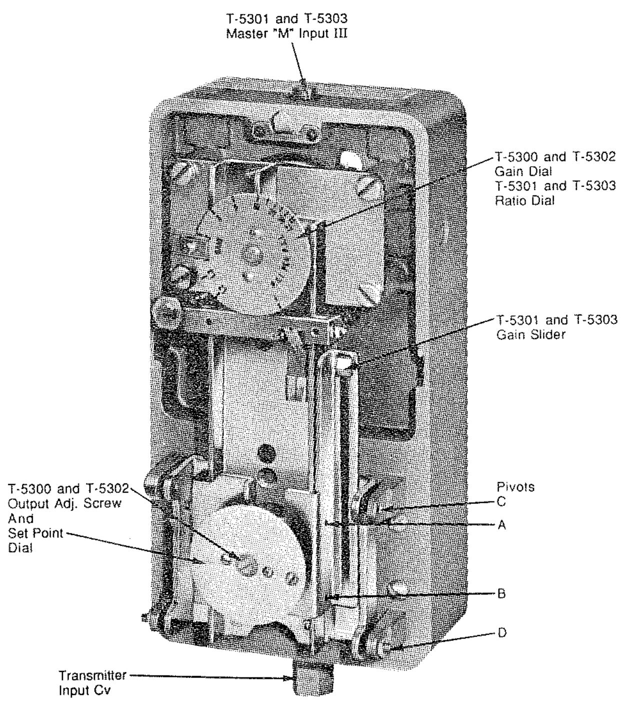
Table 2.4: Local Set Point Dial Graduation Values for All Receiver-Controllers

Span of Transmitter (F°, C°, PSI, %RH)	Value per Graduation
25	1/2
50	1
100	2
200	4



T-9001 and T-9005 Single Input Models
T-9002 and T-9006 Dual Input Models

Fig. 2.20: Discontinued "Black" Receiver-Controllers



T-5300 and T-5302 Single Input Models
T-5301 and T-5303 Dual Input Models

Fig. 2.21: Discontinued T-5300 Series Receiver-Controllers

Single Input Controllers

1. Measure the condition at the controlling transmitter by taking a pressure reading at Test Point II with the hypodermic needle test probe.

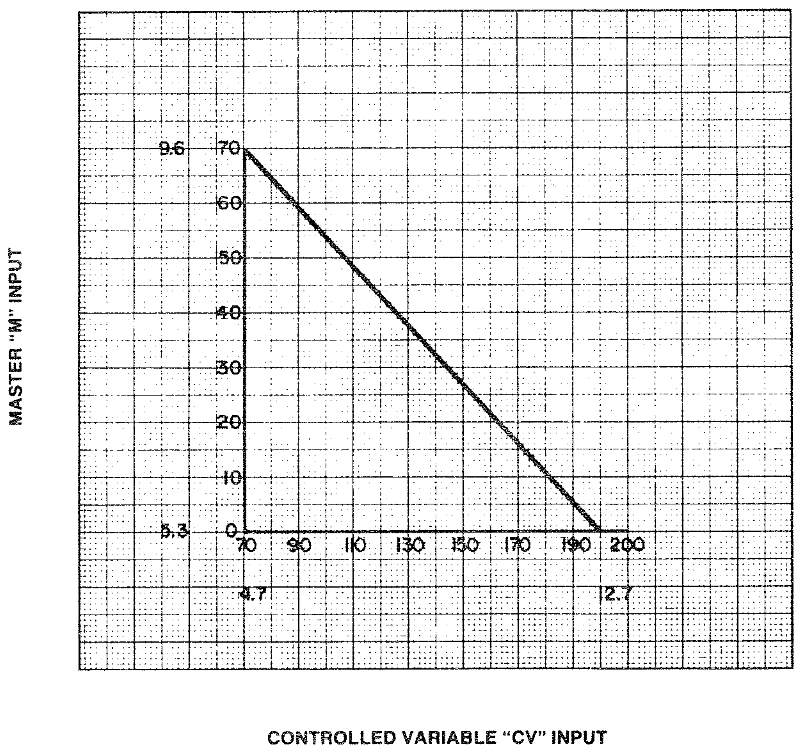
   For T-5300 and T-5302, use a remote test gage.
2. Set the local or remote adjuster to match the pressure reading in Step 1 at Test Point I.
3. Turn the output adjusting screw on the receiver-controller until the output pressure is at the mid spring range of the controlled device.
4. Turn the local or remote set point adjuster to the desired set point. Refer to Table 2.4 for the value of each graduation on the local set point dial.

Dual Input Controllers (Simplified Version)

All dual controllers should be set up and calibrated using Test Kit JC 5383. For Input Transmitter pressures, see the Controller Variable vs Output Pressure Charts on page 25.

1. From the control drawing and reset schedule, see Fig. 2.22 (Form 561), determine the following design conditions:
   - Minimum Outside Air Temperature: 0°F.
   - Maximum Outside Air Temperature: 70°F.
   - Minimum Controlled Variable Temperature: 70°F.
   - Maximum Controlled Variable Temperature: 200°F.
2. From T-5210 Temperature vs Output Pressure on page 25:
   - Outside Air Span = -40 to 160°F.
   - Transmitter Output at 0°F = 5.3 PSIG.
   - Transmitter Output at 70°F = 9.6 PSIG.
   - Controlled Variable Span = 40 to 240°F.
   - Transmitter Output at 70°F = 4.7 PSIG.
   - Transmitter Output at 200°F = 12.7 PSIG.
3. Set the Master Input III value of 5.3 PSIG and the controlled variable Cv value of 12.7 PSIG into the receiver-controller.
4. The remote or local set point should be 9 PSIG.

JOHNSON CONTROLS



Job	
Street	
City	
Date	
Control Diag. No.	
System or Unit No.	

Controlling Transmitter or Sensor

Location	
Hot water Supply	
Span: 200 F°	Limits: 40 to 240°F
Working Range: 70 to 200°F	

Master Transmitter or Sensor

Location	
Outside Air	
Span: 200 F°	Limits: -40 to 160°F
Working Range: 0 to 70°F	
Ratio or Aux. Auth.	

Master	CV
0°F	200°F
70°F	70°F

FORM 561 (Rev 4/86)

Printed in U.S.A.

Fig. 2.22: Reset Schedule

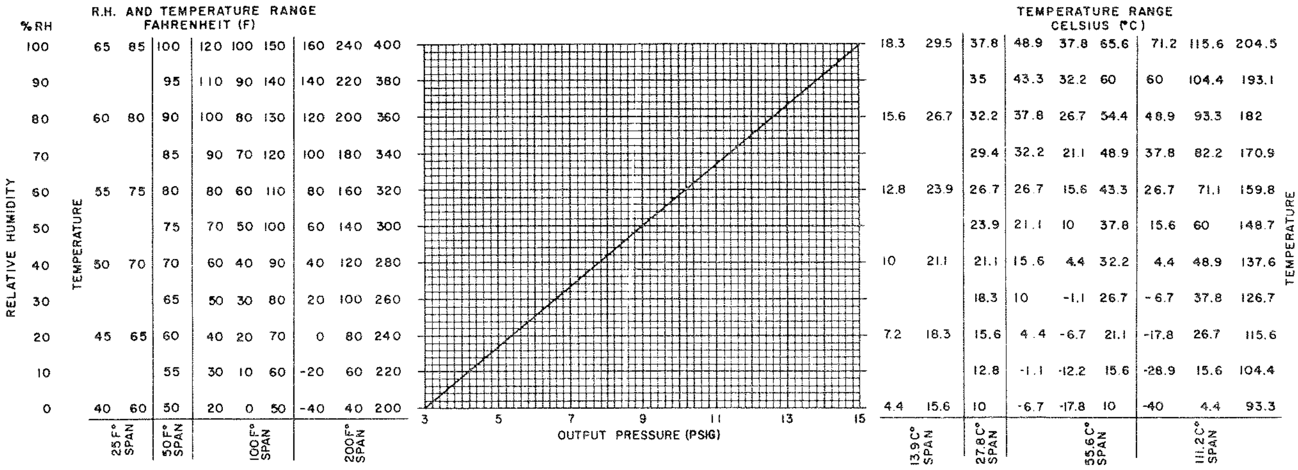


Fig. 2.23: Temperature and Relative Humidity vs Transmitter Output Pressure

5. Note the output reading and turn the calibration (Output) screw until this pressure is at the midpoint of the spring range of the controlled device (Example: 9 PSIG).
6. Set up the opposite conditions for Master Input III and Controlled Variable Cv (obtained from Step 2).
7. The output should return to the same value in Step 5. If not, increase or decrease the Ratio Dial a small amount and repeat Steps 3 through 6 until the two readings match.
8. After the steps have been completed, the receiver-controller can be reconnected to the system.
9. Set the gain to the highest value that does not cause system cycling.

Note: The set point dial should not be turned unless Cv settings different than those shown on Form 561 are required.

Room Controllers – Standard and Discontinued Models

Controllers are basically maintenance-free as long as they receive clean, oil free, dry air and are not abused. After the control system is installed, controllers usually do not require calibration unless they have been tampered with or application requirements change. Still, it is a good idea to check the operation of a controller occasionally by checking the output pressure with an accurate gage.

The first evidence of trouble with an HVAC system is often a complaint from an individual who is too hot, too cold, or bothered by drafts. Experience has shown that, in most cases, the problem behind the complaint is not a malfunction of the control system, but rather a misunderstanding of the capabilities and applications of the control system. There are several common causes of occupant discomfort not involving the control system:

1. Sun Load.
   Direct sunlight on a thermostat will cause over-cooling or under-heating in a zone. Also, direct sunlight on individuals will cause them to feel warmer than the actual space temperature.
2. Zone Control.
   A person outside of a controlled zone may feel uncomfortable because the air distribution system is not delivering the full controlled medium to the space. Also, different zones may be controlling at different temperatures, requiring a period of adjustment when moving from zone to zone.
3. Covering of Grills.
   Frequently, occupants will cover part or all of a discharge grill causing improper heating or cooling. Whenever a grill is covered, the heating or cooling medium is not permitted to enter the space, causing an imbalance in the air distribution system.
4. Occupant Location.
   If occupants are located adjacent to an outside wall or windows, they may be subject to cold air leakage or radiant cooling or heating from the walls.
5. People and Equipment.
   Over-heating can result if more people or equipment occupy an area than was intended in the original design concept. This can occur when a meeting is held in an area not designed for that purpose.

6 Drafts.
In systems using air as a means of heating and cooling, there must be air movement. To many people, even slight air motion is uncomfortable. Minor problems can be solved by relocating a workstation or deflecting the air outlet. For more severe problems, the air distribution system may need to be rebalanced.

System Operation

Before recalibrating a controller, check to see if it is already operating properly. For example, if the temperature in the space is below the set point and the controller output signal is calling for more heat, do not recalibrate the controller. The instrument already recognizes the problem and is trying to remedy it. Below is a list of check points not involving the controller.

1. Check that the supply pressure is normal.
2. Check for proper operation of the controlled device (actuators).
3. Check to see if the control agent (water for example) is hot or cold enough to maintain the desired temperature.
4. Check for unusual or extreme loads in the space which may overpower the efforts of the controller to maintain control.
5. Check for leaks in air lines.
6. Check for appearance of oil leaks at fitting connections, etc.

Controller Operation

To check controller operation, first determine if it is a direct acting (DIR) or a reverse acting (REV) instrument. Room thermostats use a bimetal element sensing strip to measure space temperature. DIR strips have the bimetal marking code (stripes on T-4002) exposed toward the room. REV strips have the marking toward the wall and the plain side exposed. Check to see if the bimetal is free of dust and dirt or if oil is near the control port. Clean if necessary.

When a bimetal element strip moves towards or closes over the control port, the output pressure (shown on the test gage) will increase. Next, turn the dial to reposition the bimetal to determine the proper response. A lower temperature setting will increase the output pressure setting on DIR units or decrease the output on REV units. No response may indicate that either the calibration adjusting screw or the level adjusting screw at the sensitivity slider has been tampered with. This, or a bent bimetal strip, would move the bimetal strip out of the range of the control port. If the bimetal has been damaged, it (or the entire instrument) should be replaced. Do not waste time attempting to straighten a bimetal; it will then lose calibration capability with age. If the bimetal has been misadjusted, an experienced person should be able to relevel it properly or install a replacement.

Alignment Procedure (See Fig. 2.24)

1. Before the set point of the controller can be adjusted, it must first be checked for alignment of its levers.
2. Important points of aligning:
   a. The lever leveling screw must be resting against the feedback arm.
   b. The sensitivity slider must be positioned halfway between the slide limits.
   c. Viewing the instrument from the top down, the element strip should be visually parallel with the body and resting squarely on the pivot plate. If not, adjust both the lever leveling screw and the set point adjustment screw so that they are both centered through the lever holding them. Also make sure that the element strip is visually parallel with the controller body.
   d. As a result, the ouput pressure should be some value between 0 and 20 PSIG. If not, adjust the lever leveling screw slightly until the output pressure is some intermediate value.

If the output pressure stays at either zero or maximum when the bimetal opens or closes the control port nozzle as the dial is turned, this indicates the internal air passages or orifices may be plugged. If the orifice is severely plugged, a replacement kit should be installed or the instrument should be replaced. This is also an indication that the air supply system has not been maintained properly, which should be done before a repair or replacement is put into operation to

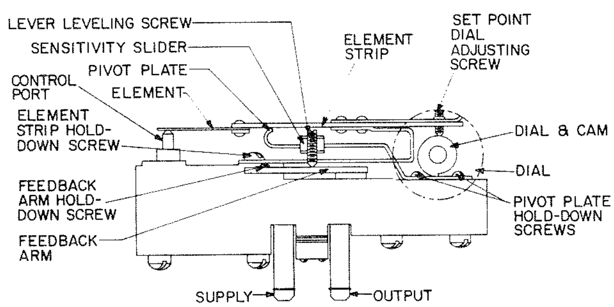


Fig. 2.24: T-4002 Alignment and Adjustment Points

to avoid reoccurance. Oil in the instrument will cause continued loss of calibration. If operation is restored or otherwise seems normal except that the output pressure is not in the mid range of the system spring ranges (usually 8 PSIG) at the original dial setting, then recalibration may be all that is necessary.

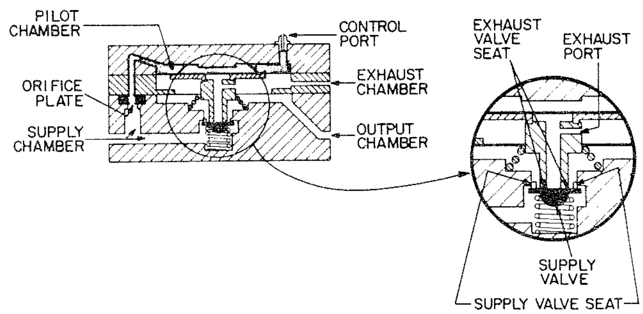
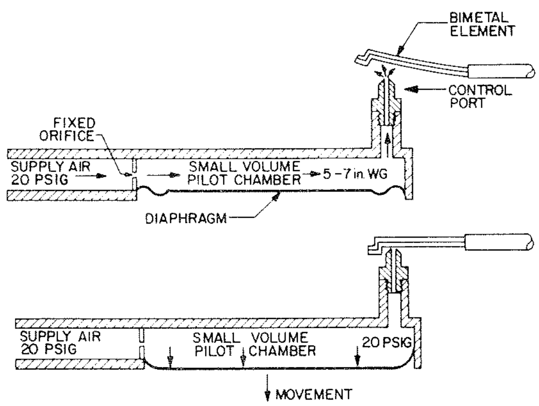


Fig. 2.25: Basic Sections of a Pneumatic Relay



The pilot chamber uses a restricted flow in a small area to respond quickly to changes dictated by the sensing element.

Fig. 2.26: Pilot Chamber Action

Calibrating Room Controllers

Johnson Controls offers a variety of temperature and humidity room controllers. The calibration procedure for all controllers is based on the following four basic steps:

1. Determine the actual value (temperature, humidity, or pressure) at the sensing element.
2. Turn the set point dial to that value.
3. Turn the output adjusting screw until the output pressure (read on the test gage) is at the mid spring range of the controlled device.
4. Turn the set point dial to the desired set point.

Relay and Non-Relay Controllers

All controllers are one of two basic types: relay and non-relay. The relay functions as a volume amplifier to provide large amounts of air to reposition actuators or where faster response is required. Many controllers can be more simple in form and function without a relay when a small bleed of air can provide the operation required. The basic construction differences are as follows:

Relay Type Controller (See Figs. 2.25 and 2.26)

A. Pilot Chamber: Admits air to the control port and pilot diaphragm.

B. Exhaust Chamber: Releases excess output air to the atmosphere.

C. Output Chamber: Admits air to the controlled device.

D. Supply Chamber: Admits air to the output chamber.

Examples of relay type controllers are the T-4002 and T-5800. Calibration or other maintenance of the relay components is not required.

Non-Relay Controller (See Fig. 2.27, Page 28)

A. Requires a restricted source of supply.

B. Has a low volume output.

C. Is a one-pipe device; the supply and output are one in the same.

D. Utilizes negative feedback for proper output pressure.

E. Examples of non-relay controllers:

1. T-4100 Single Temperature Thermostat.
2. T-3610 Low Limit Thermostat.
3. T-3000 Series Unit Mounted Thermostats.

Newer types of non-relay instruments have restrictors mounted external to the instrument and generally use an R-3710 restrictor fitting. This may become plugged due to a contaminated air supply and require replacement to restore operation.

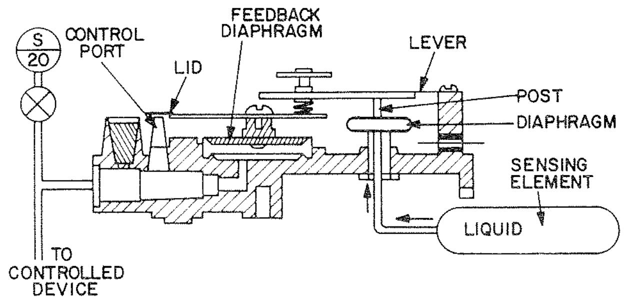


Fig. 2.27: Basic Sections of a Non-Relay Controller

Table 2.5: Dual Pressure Systems and Switchover Points

Manufacturer	Dual Pressures PSIG	Switchover Pressures PSIG
Barber Coleman	15/20	17.5
Honeywell	13/17	15
Powers	15/22	18
Robertshaw	16/25	20.5

Dual Temperature Controllers

On T-4000 Series Controllers, the switchover adjustment is located on the back of the controller. On T-3300 Series, the switchover adjustment is located in the switch stack under the cover.

To increase the switch point, turn the adjusting screw clockwise (not more than two turns); to decrease the switch point, turn the adjusting screw counterclockwise. When the correct switch point is established, it is suggested that the adjusting screw be spot-sealed with nail polish.

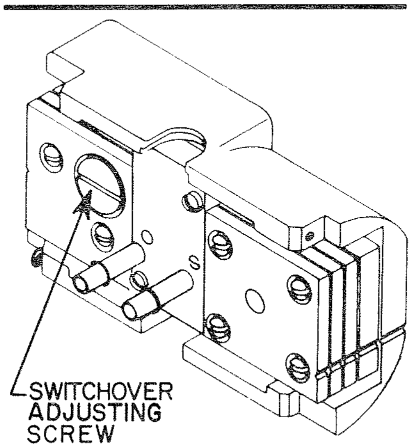


Fig. 2.28: T-4000 Series Controllers

The T-3300, T-4500, and T-4700 Series Dual Temperature Controllers are factory adjusted for Johnson Controls 15 to 20 PSIG dual air pressure supply systems. These controllers (Heating-Cooling or Day-Night, either wall or unit mounted) are set to switch function or action at 17.5 PSIG as the supply

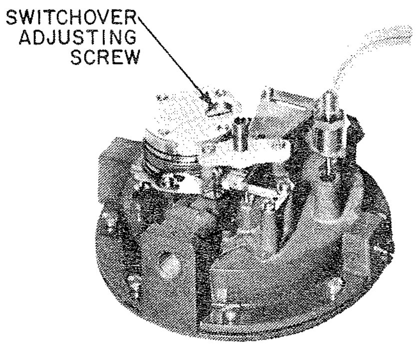


Fig. 2.29: T-3300 Series Controllers

air pressure is changed from 15 to 19 PSIG or vice versa.

If these controllers are to be used on any dual pressures from 13 to 25 PSIG (other than Johnson Controls), the switch points must be adjusted. Table 2.5 shows the required switch points for various dual pressure systems.

Generally, the older controllers have pressure gages installed on the input and output connections. Newer controllers have provisions for one of two types of test gages. Test points with a cap screw require a JC 5310 Screw-In Gage. Test points with a rubber insert require a JC 5361 Hypodermic Needle Test Probe with the appropriate gage (JC 5385, JC 5386, or JC 5387, see Fig. 2.30).

Wall Mounted Controllers

Single set point controllers such as the T-4002, T-4100, and H-4100 (Fig. 2.31 and Fig. 2.32) are the easiest to calibrate; use the four basic steps listed on page 27.

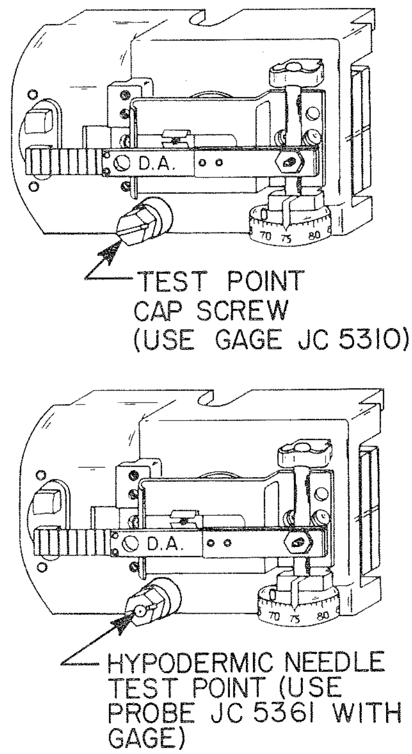


Fig. 2.30: Test Points

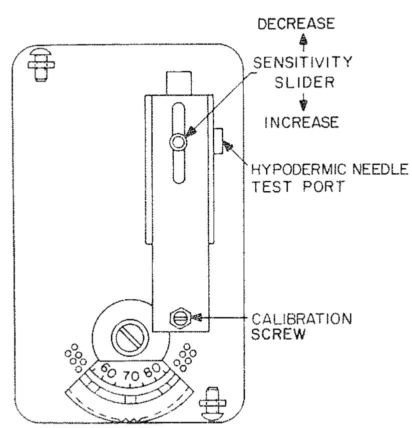


Fig. 2.31:
Low Volume Thermostat

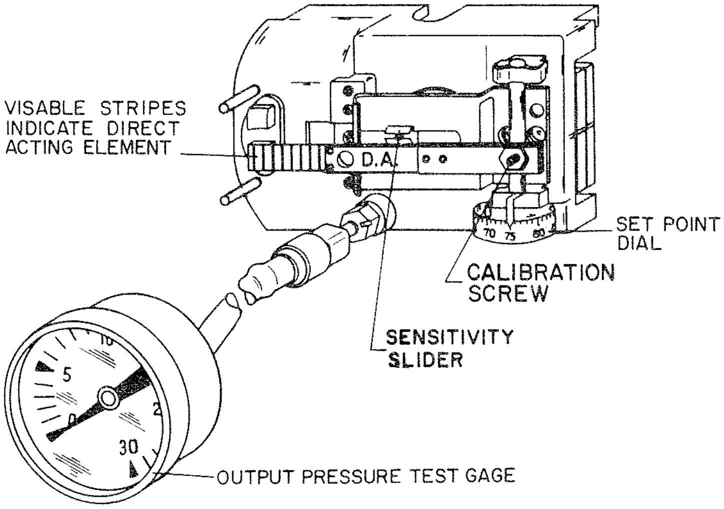


Fig. 2.32: Single Set Point High Volume Controller

Dual set point room controllers for day-night, heating-cooling, and remote readjustment applications are calibrated in much the same way with a few added steps.

Room Controllers with Remote Readjustment

Controllers with remote readjustment use master pressure from a master thermostat, gradual switch, or Facilities Management System to readjust the set point. Reverse readjustment will cause a proportional decrease in output pressure with respect to an increase in master pressure. Conversely,

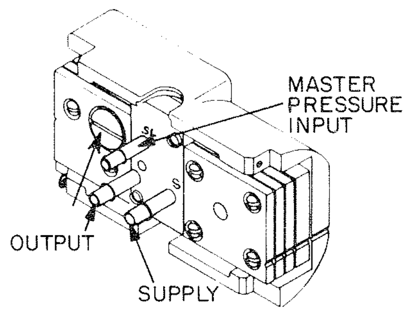


Fig. 2.33: Back of a Room Controller with Remote Adjustment

direct readjustment will cause a proportional increase in output pressure with respect to an increase in master pressure.

The range of remote readjustment is adjustable by means of the sensitivity slider. The remote readjustment setting is designated on the control drawing.

The T-4003 and H-4103 are examples of room controllers with remote readjustment. Remote adjustment (master pressure) signal is supplied through a third connection (see Fig. 2.33). They are calibrated according to the four basic steps with the following preliminary step:

Before calibrating, connect a variable pressure air source to the master pressure connection and set the master pressure to half of the supply pressure.

The T-4003 has a fixed sensitivity; the slider adjustment functions to provide the remote readjustment set point range. The range is adjustable by moving the slider and then readjusting the element lever level.

Day-Night Controllers

Day-Night controllers are furnished with two independent bimetal elements and output pressure adjustments to provide separate set points for day and night. Typically, the bottom element is used for day control with a 15 PSIG supply

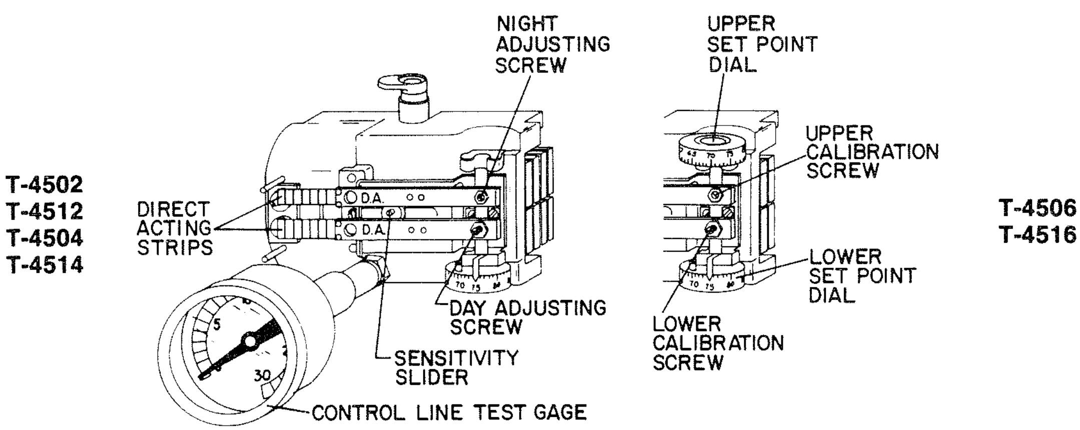


Fig. 2.34: Day-Night Room Thermostats

pressure and the top element is used for night control with a 20 PSIG supply pressure. The manual indexing switch furnished with some models is used to switch from night to day control when desired. The switch automatically unlatches at the start of the next regular day cycle.

The T-4502 and T-4512 have one set point dial; changing the day set point affects the night set point. The T-4504 and T-4514 have one set point dial but changing the day set point will not affect the night set point. The T-4506 and T-4516 have totally independent set points.

The T-4502, T-4506, and T-4512 are calibrated following the four basic steps of calibration using a 15 PSIG supply pressure for the day cycle. The night set point is calibrated as follows:

1. Furnish the night cycle supply pressure (20 PSIG).
2. Turn the upper dial on the T-4506 and T-4516 to read the actual temperature at the element.
3. For the T-4502 and T-4512, turn the set point dial up by the number of degrees difference between the day and night set points.
4. Turn the top element output adjusting screw to provide an output pressure at the mid spring range of the controlled device.
5. For the T-4502 and T-4512, return the set point dial to the desired day setting and restore day cycle supply pressure.

The T-4504 and T-4514 thermostats are similar to the T-4502, T-4506, and T-4512 with one major difference: The night (upper element) set point is not affected by changes in the day set point because the cam is round.

The day set point on these thermostats is calibrated according to the four basic steps of calibration. The night set point is calibrated as follows:

1. Furnish the night cycle supply pressure (20 PSIG).
2. Note the ambient temperature at the element.
3. Turn the night (upper element) output adjusting screw to provide an output pressure at the mid spring range of the controlled device.

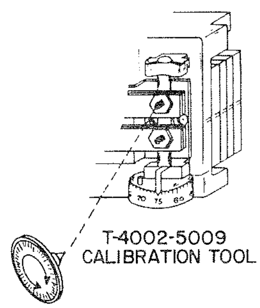


Fig. 2.35: Calibration of T-4504 and T-4514

4. Using a T-4002-5009 Calibration Tool, turn the night output adjusting screw to the desired night set point (see Fig. 2.35). Each graduation on the tool represents 1F°. Clockwise rotation decreases the set point on direct acting elements.
5. Restore the day cycle supply pressure to the instrument.

Heating-Cooling Controllers

Like the day-night thermostats, heating-cooling thermostats include separate sensing elements and adjustments for the heating and cooling set points.

The newest in the line of heating-cooling instruments are the T-4052 and T-4054 Deadband Thermostats. The deadband is the temperature range (between set points) over which the output pressure does not change. This eliminates heating-cooling overlap.

The T-4052 requires a lengthy and detailed procedure for calibration which should be performed only by Johnson Controls personnel. The T-4054, however, is more easily calibrated; use the following instructions.

T-4054 Deadband Pressure Adjustment

The deadband pressure should be set at the midpoint between the spring ranges of the heating and cooling controlled devices (typically 7.5 PSIG). To check or reset the deadband, proceed as follows:

Turn the lower set point dial to 85°F on direct acting models or 55°F on reverse acting models. Turn the upper set point dial to 55°F on direct acting models or 85°F on reverse acting models. Insert a hypodermic needle test probe into the test connection. The reading on the test gage is the actual deadband pressure. If it is necessary to adjust this pressure to meet application requirements, proceed as follows:

1. Remove the T-4054 from the mounting bracket and pull it away from the wall so that the deadband adjusting screw on the back of the instrument is exposed (see Fig. 2.36).

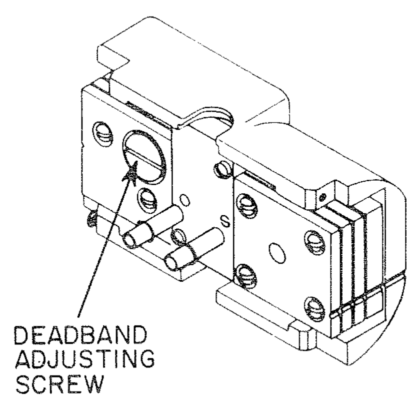


Fig. 2.36: Back of T-4054

2. Turn the screw clockwise to increase or counterclockwise to decrease the deadband pressure until the gage reads the desired pressure. Approximately one half of a turn will produce a 1 PSI (7 kPa) change in deadband pressure.
3. Return the set point dials to the original settings.

Set Point Calibration (See Fig. 2.38)

The T-4054 can easily be adjusted to suit the application by changing the settings on the heating and cooling dials. If the thermostat has been tampered with or is out of adjustment, proceed with the following instructions to recalibrate the instrument.

1. Set the lower set point dial to 85°F for direct acting models or 55°F for reverse acting models.
2. Note the temperature at the element.
3. Set the upper dial to this temperature.
4. Turn the upper adjusting screw until the control pressure is in the middle of the spring range of the controlled device.
5. Set the lower dial to the temperature noted in Step 2.
6. Turn the lower adjusting screw until the control pressure is in the middle of the spring range of the controlled device.
7. Turn the upper dial to the desired set point.
8. Turn the lower dial to the desired set point.
9. The difference in the dial settings is now the deadband. Remove the test gage.

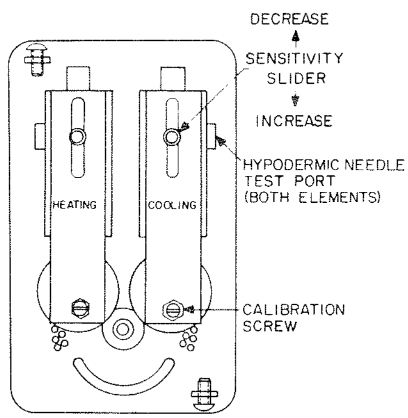


Fig. 2.37: T-4600 Heating-Cooling Low Volume Thermostat

The T-4600 Heating-Cooling thermostat (Fig. 2.37) is a low volume output thermostat. The difference between the independent set points results in a deadband to eliminate heating-cooling overlap.

The T-4600 is calibrated according to the four basic steps of calibration listed on page 27 for each element.

T-4572 has one set point; moving the dial will affect both set points.

T-4756 has totally independent heating-cooling set points.

The T-4752 and T-4756 Heating-Cooling Thermostats (see Fig. 2.39) switch from heating to cooling with a change in supply pressure, usually from 15 to 20 PSIG. The heating set point is usually made on the lower element according to the four basic steps of calibration. To calibrate the cooling set point, proceed as follows:

1. Furnish the supply pressure for the cooling cycle.
2. Note the temperature at the element.
3. Turn the set point dial (upper dial on T-4756) to that temperature.
4. For the T-4752, turn the set point dial down the number of degrees difference between the heating and desired cooling set points.
5. Turn the output adjusting screw on the cooling element to provide a pressure equal to the mid spring range of the cooling controlled device.
6. For the T-4752, turn the set point dial back to the heating set point.

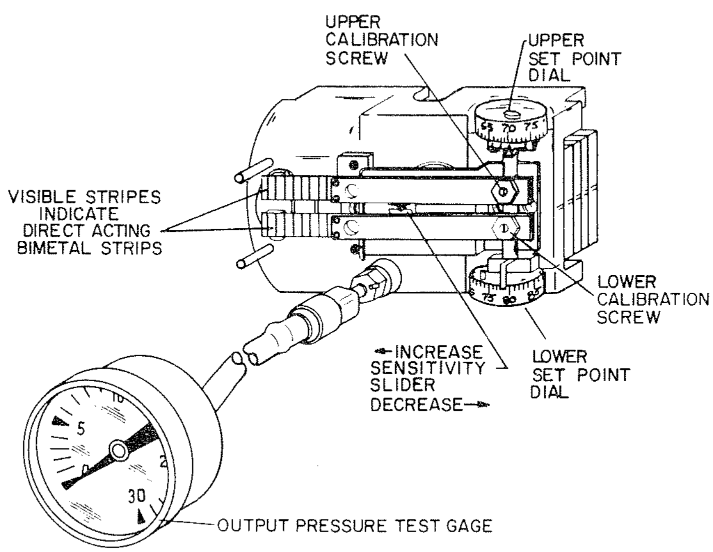


Fig. 2.38: T-4054 Heating-Cooling Deadband Thermostat

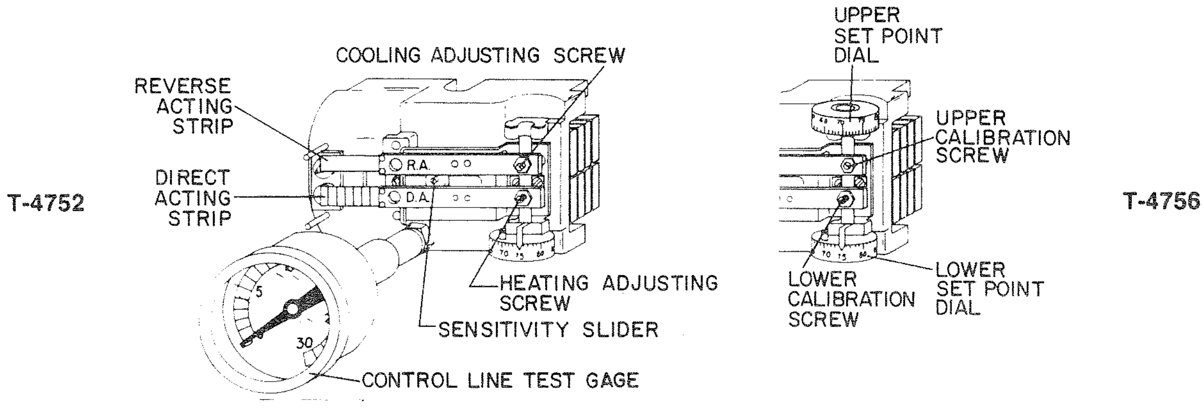


Fig. 2.39: Heating-Cooling Thermostat

Unit Mounted Controllers

The Johnson Controls T-3000 Series Thermostats are designed for use in unit ventilators and terminal air conditioning units. These controllers use a remote bulb or averaging element as the temperature sensor. Like the wall mounted thermostats, these instruments require little maintenance as long as they receive clean, dry air and are not tampered with.

All T-3000 Series Controllers are furnished with an output pressure test point. On the newer models, the test point is located outside the cover: on the older models, the test point is inside the cover (see Fig. 2.40).

Before calibrating these instruments, remove the set point knob (if furnished) using a JC 5309 Flexible Driver. Also, if the temperature at the element fluctuates widely during calibration, place the element in a bucket of water at about 75°F.

T-3100 Series
Single Temperature, Single Pressure (See Fig. 2.41)

1. Furnish supply air.
2. Turn the set point adjusting screw (Detail A, B, or C) until the output pressure is at the mid spring range of the controlled device.
3. Note the temperature at the element.

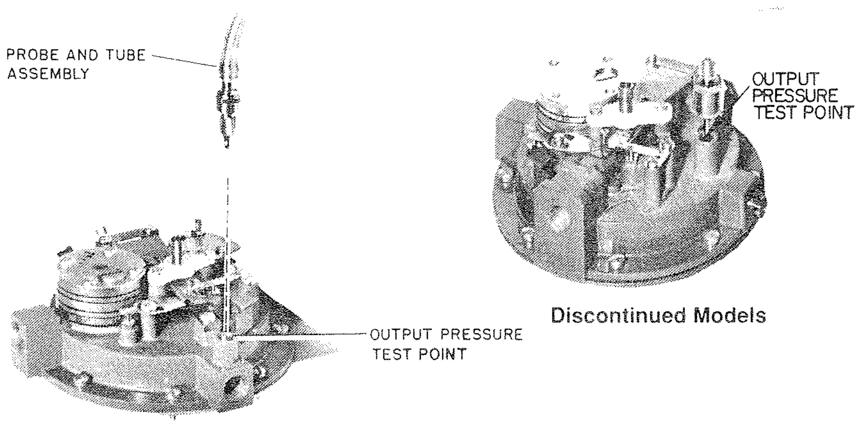


Fig. 2.40: Test Point Locations

4. External Adjustment: Place the dial on the dial post (do not tighten) and position it to the midpoint. Tighten the set screw on the dial and turn it to the desired set point. Each graduation represents 1F°.

   Concealed Adjustment: Use a JC 5360 Recalibration Tool to adjust the set point. Each graduation represents 1F°.

T-3200 Series
Single Temperature, Dual Pressure (See Fig. 2.41)

These instruments are used primarily as low limit controllers with the averaging element usually located in the discharge air. The low limit setting is usually 56°F.

1. Furnish supply air.
2. Turn the set point screw (Detail B) until the output pressure is in the mid spring range of the controlled device.
3. Note the temperature at the element.
4. Use a JC 5360 Calibration Tool to adjust the set point. Each graduation represents 9F°.

T-3300 Series
Dual Temperature, Dual Pressure

These instruments include adjustments for heating and cooling

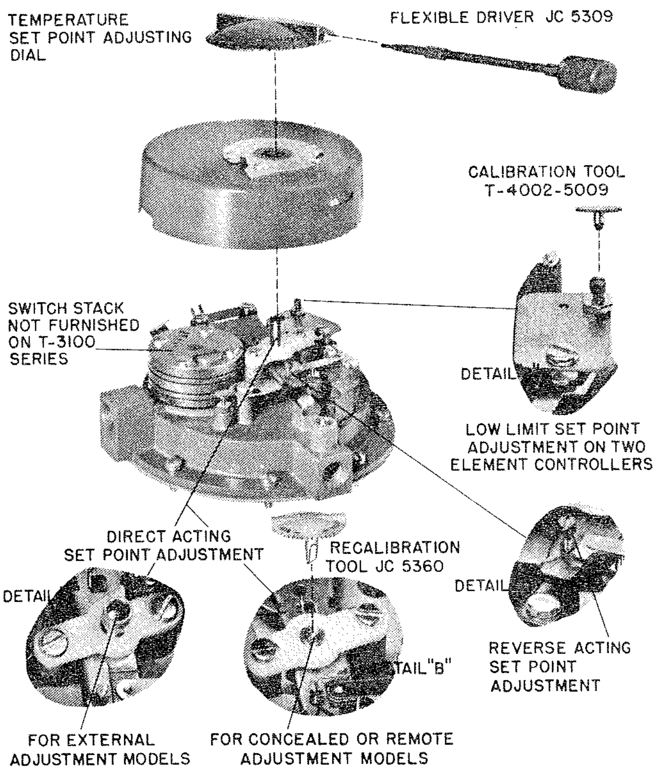


Fig. 2.41: T-3000 Series Unit Mounted Controller Adjustments

with a change in supply pressure.

1. Furnish the instrument with supply air for direct (DIR) operation.
2. Turn the DIR adjusting screw (Detail A) until the output pressure is in the mid spring range of the controlled device.
3. Furnish supply air for reverse (REV) operation.
4. Turn the REV adjusting screw (Detail C) until the output pressure is in the mid spring range of the controlled device.
5. Determine the temperature at the element.
6. Place the dial on the post (do not tighten) and position it to the temperature at the element.
7. Tighten the dial and turn to the desired temperature.
8. If different set points are required for DIR and REV operation, use the T-4002-5009 Calibration Tool to readjust the REV set point. Clockwise rotation increases the set point, and each graduation represents 1F°.

T-3350 Series Dual Temperature, Dual Pressure with Low Limit (See Fig. 2.41)

The T-3350 includes an averaging element for low limit control and a bulb element for temperature control. The DIR and REV set points are calibrated as outlined above, but first calibrate the low limit set point as follows:

1. Furnish supply pressure for DIR operation.
2. Turn the DIR adjusting screw (Detail A) until the output pressure is at maximum (within 0.5 PSI of supply pressure).
3. Turn the low limit adjusting screw (Detail D) until the output pressure is at the mid spring range of the controlled device.
4. Determine the temperature at the low limit (averaging) element located in the unit discharge air chamber.
5. Using the T-4002-5009 Calibration Tool, turn the low limit adjusting screw counterclockwise to the desired setting. Each graduation on the tool represents 3.5F°.
6. Make the DIR and REV set points as indicated under T-3300 Series instructions above.

T-3102 – Dual Temperature, Single Pressure

The T-3102 employs a deadband between heating and cooling set points similar to the T-4054 Wall Mounted Thermostat. For calibration instructions, refer to the T-3102-A Installation Data bulletin.

Old Style Unit Mounted Controllers

Use the cross reference in Table 2.6 to determine which instructions to follow for the old style T-200 and T-3000 Series Controllers.

Table 2.6: Old to New Cross Reference

Old Number	New Number
T-285, T-286 T-3020, T-3112, T-3210, T-3212, T-3214, T-3216	T-3100 Series
T-3412, T-3414, T-3416, T-3420	T-3200 Series
T-275, T-276 T-3320, T-3410	T-3300 Series
T-3218, T-3219, T-3318, T-3418, T-3419	T-3350 Series

Room Controller Repair Information

A number of repair parts are available for the wall mounted and unit mounted room controllers such as control ports, sensing elements, orifice plates, etc. Complete rebuild kits are also available; refer to the appropriate repair parts literature for details.

Room controllers are also eligible for replacement under the "Trade-In Exchange Program". Refer to the Counterline Pricing Guide for details.

Remote Element Controllers

Remote element controllers are used when the sensing element must be located where extreme conditions do not permit controller mounting, or where operational adjustments are inconvenient. These controllers are often mounted on a local control panel.

The following instructions may be followed for the P-8000, T-8000, and T-8020:

1. Determine the actual value (temperature, pressure, or humidity) at the element.
2. Turn the set point dial to that value.
3. Loosen the dial set screws.
4. Turn the output adjusting screw without turning the dial, until the output pressure equals the mid spring range of the controlled device.
5. Tighten the dial set screws and turn the dial to the desired set point.

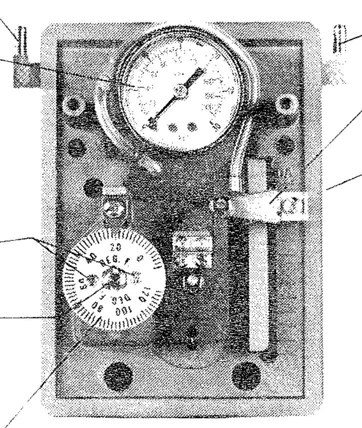


Fig. 2.42: T-8000, T-8020, and P-8000 Remote Element Controllers

Limit Controllers

T-3610 and H-3610 Low Limit Controllers (See Fig. 2.43)

1. Install a test gage in:
   a. The control line after the restrictor for models prior to 1983.
   b. The hypodermic needle test port for models after 1983.
2. Turn the set point dial or adjusting screw until the output pressure is at the mid spring range of the controlled device.
3. Use the T-4002-5009 Calibration Tool to adjust the set point for models before 1983.

   T-3610: Clockwise rotation increases the set point by 1.5F° for each graduation.

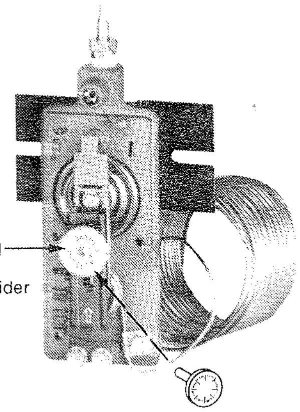


Fig. 2.43: Low Limit Controllers T-3610 and H-3610

H-3610: Counterclockwise rotation decreases the set point by 1% RH for each graduation.

T-3101 High Limit Controller (See Fig. 2.44)

1. Turn the set point knob to provide an output pressure equal to the mid spring range of the controlled device.
2. Note the temperature at the element.
3. Loosen the set point knob and position it to the temperature at the element. Each graduation represents 10F°. The center graduation will represent the desired set point.
4. Tighten the set point knob then turn it to the desired high limit set point.

Fig. 2.44: High Limit Controller

Transmitters

Transmitters are used in Pneumatic Transmission Systems to measure a condition (temperature, pressure, or humidity) and convert the measurement to a proportional 3 to 15 PSIG output signal. This signal is sent to an indicator, recorder, receiver-controller, or any combination of these devices.

Johnson Controls transmitters are factory calibrated with a fixed sensitivity. The only adjustment necessary is for shifting the span for special applications or for fine tuning the instrument.

The graph on page 25 is used to determine the proper transmission pressure for each standard range at a given temperature, pressure or humidity. For special applications, any range within the limits of the element can be written in along the vertical axis.

Room Transmitters and 5200 Series Transmitters

The following calibration instructions apply to the T-5002, H-5100, T-5210, T-5220, H-5210, and P-5210 Transmitters (see Figs. 2.45, 2.46, and 2.47).

1. Accurately measure the value (temperature, pressure, or humidity) at the element.
2. From the graph on page 25, determine the proper transmission pressure corresponding to the measured condition. Be sure to use the range on the graph which matches the range of the transmitter.
3. Turn the starting point adjusting screw until the output pressure corresponds with the measured value determined in Step 2.

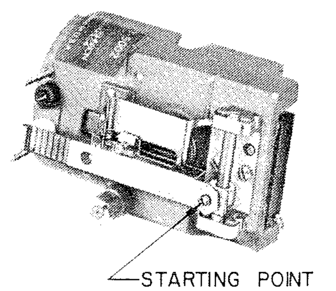


Fig. 2.45: Room Transmitters H-5100 and T-5002

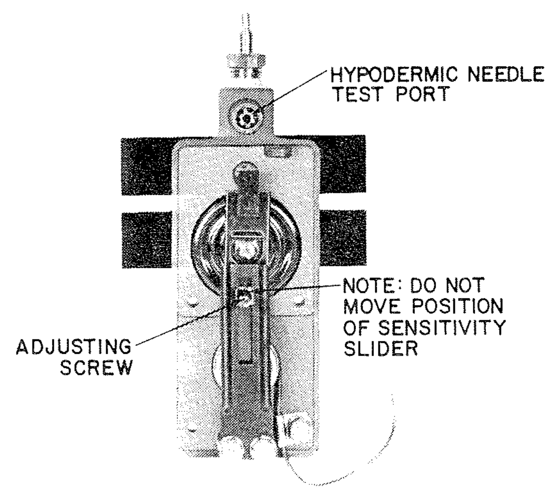


Fig. 2.46: Duct Transmitters H-5210 and T-5210

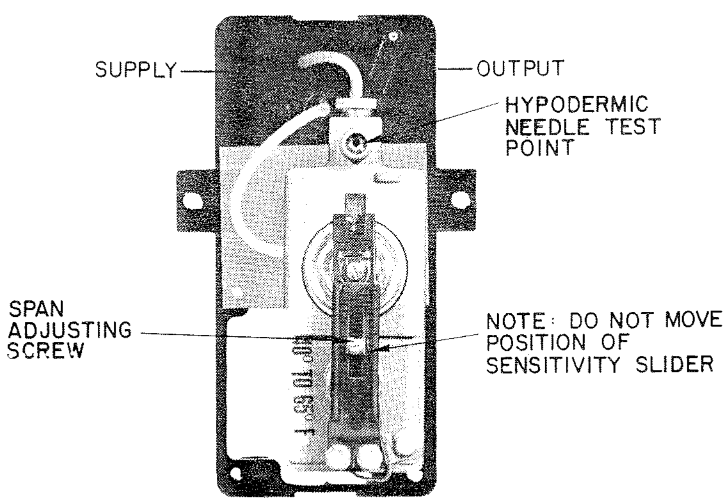


Fig. 2.47: T-5220 High Volume Temperature Transmitter

Section III: Auxiliary Devices and Networks

An auxiliary device is installed between a controller and controlled device to modify the control signal or to provide extra capacity to operate additional controlled devices. Table 3.1 describes the functions performed by the various Johnson Controls auxiliary devices.

The N-1000, N-9000, and PIC (Pneumatic Integrated Control) System are examples of logic networks (see Fig. 3.2). Through fluidic circuitry, networks receive inputs from typical pneumatic controllers and transmitters to perform a variety of energy conservation and fail-safe strategies.

Due to the complex nature of these networks, field calibration should only be performed by Johnson Controls personnel.

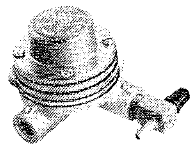
Table 3.1: Auxiliary Devices - Functions and Adjustments

Code No.	Title	Function	Adjustments	Discontinued	Current
C-130	Comparator	Compares two signals and determines the output signal for reset/override applications.	None		X
C-202	2:1 Ratio Cumulator	DIR: Increases output pressure at 2:1 ratio.	None		X
		REV: Converts action of controller from DIR to REV or vice versa at a 2:1 ratio.	Starting Point		X
C-208	Reverse Acting Cumulator	Converts action of controller from DIR to REV or vice versa.	Starting Point	X	
C-2040	Averaging Cumulator	Averages up to four input signals from controllers or transmitters.	None		X
C-2100	Adjustable Ratio Network	Reduces sensitivity or gain of controller or transmitter and provides offset.	Ratio and Offset	X	
C-2220	High-Low Signal Selector	Selects and transmits the highest and lowest signals from up to 19 zone input signals.	None		X
C-5222	Adding/Subtracting Repeater	Adds or subtracts up to 5 PSIG from input signal at a constant DIR 1:1 or 5:1 ratio.	Offset Value		X
C-5226	Signal Transmitter	Multipurpose device: Repeater, selector, limiter, switch.	None		X
C-5230	Signal Limiter	Imposes high and/or low limits on pneumatic signals and repeats signals between limits.	High Limit and/or Low Limit	(-1)X	
				(-2)	X
				(-3)	X
C-9115	Square Root Extractor	Converts output signal of static pressure transmitter to a signal that is linear with flow.	None	X	
C-9200	Sequencing Cumulator	Subtracts up to 9 PSIG from input signal.	Offset Value		X
C-9500	Two-Position Cumulator	Converts a proportional signal to a two-position signal below the set point.	Set Point, Differential		X
C-9502	Two-Position Cumulator	Converts a proportional signal to a two-position signal below cut-in setting.	Cut-In, Cut-Out	X	
C-9504	Two-Position Cumulator	Converts a proportional signal to a two-position signal below cut-in setting.	Cut-In, Cut-Out		X
C-9506	Air Switching Cumulator	Switches from zero to full supply pressure at a predetermined point.	Switch Point		X
D-9502	Positioner	Changes operating range of damper actuator for sequencing and provides additional power.	Starting Point, Span		X
N-1000	Logic Network	Economizer logic decisions.	Min. Position and Switchover	X	
N-1001	Logic Network	Economizer logic decisions.	Min. Position and Switchover		X
N-6000 Series	Transducers	Converts signal from pneumatic to electronic, or vice versa.	None		X
P-5232	Air Flow Switch	Switches from zero to full pressure when duct air flow reaches the switch point.	Switch Point	(Renumbered P40)	X
R-2080	Booster Relay	Amplifies output flow.	None		X
R-2090	Reverse Acting Booster Relay	Converts action of controller from DIR to REV or vice versa and amplifies output flow.	Starting Point	X	
R-3030	Reverse Acting Booster Relay	Converts action of controller from DIR to REV or vice versa and amplifies output flow.	Starting Point		X
V-9502	Positioner	Changes operating range of valve actuator for sequencing and provides additional power.	Starting Point, Span		X

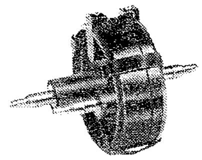
Calibration

The desired settings for the auxiliary devices that have adjustments can be found on the control drawing. Before making adjustments, check the settings to see if they are already at the desired values.

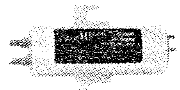
Note: When adjusting auxiliary devices, be sure that the change in output pressure during calibration does not disturb the system and cause damage such as freezing a coil, burning out a heater, or collapsing ductwork.



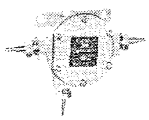
C-130
Comparator



R-2080
Booster Relay

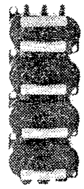


C-2040
Averaging Cumulator

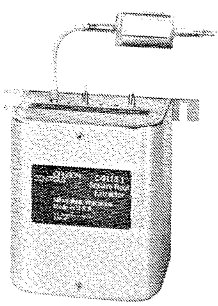


C-202
2:1 Cumulator DIR

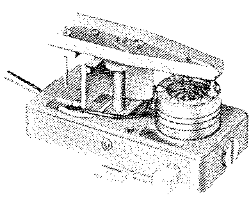
C-5226
Repeater



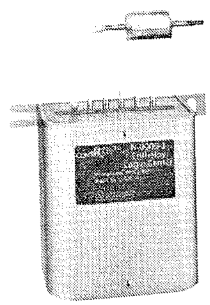
C-2220
Signal Selector



C-9115
Square Root Extractor

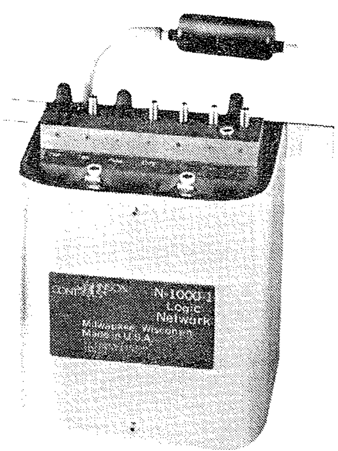


N-6800
Electro-Pneumatic Transducer

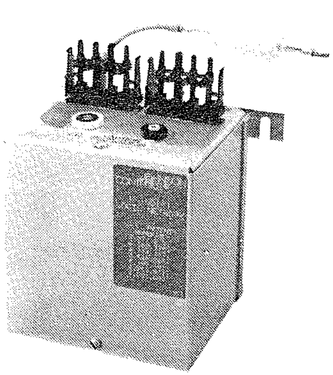


N-9000
Enthalpy Logic Center

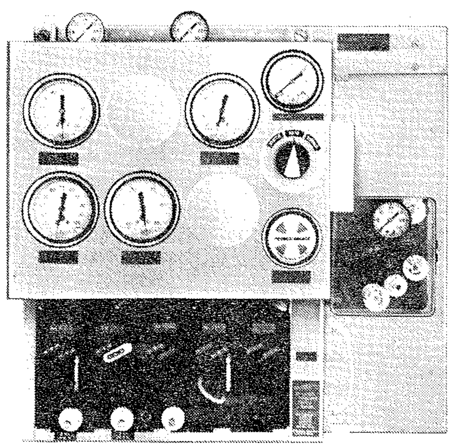
Fig. 3.1: Nonadjustable Auxiliary Devices



N-1000 Logic
Network (Discontinued)



N-1001 Economizer
Logic Network



PIC (Pneumatic Integrated
Control) System
(Discontinued)

Fig. 3.2: Logic Networks

C-202, C-208, R-2090, and R-3030 Reverse Acting Cumulators and Relays

The only adjustment required on these instruments is the starting point or the critical point indicated on the control drawing (for example 8 PSIG output at 2 PSIG pilot). To make this adjustment, simply furnish the appropriate pilot pressure and turn the starting point adjusting screw to the required pressure (see Figs. 3.3 and 3.4.).

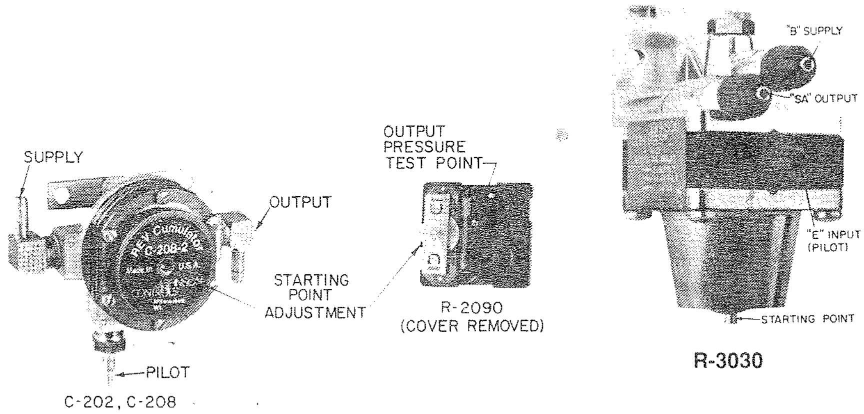
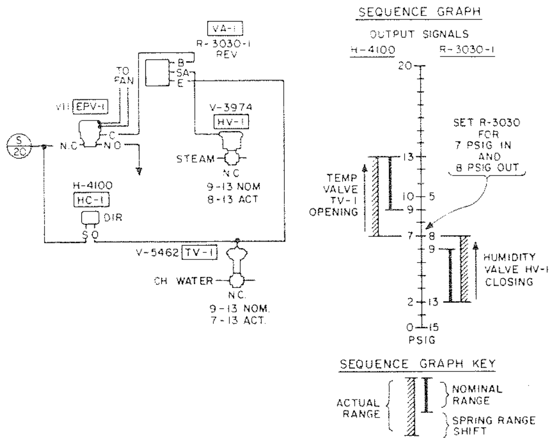


Fig. 3.3: Reverse Acting Cumulators and Relays



BILL OF MATERIAL

INST ID	CODE NO	DESCRIPTION	RANGE SETTING	REMARKS
SYSTEM MOUNTED EQUIPMENT				
HC-1	H-4100-201	ROOM HUMIDISTAT		DIRECT ACTING
HV-1	V-3974-X	STEAM VALVE	9-13	ACTUAL RANGE 8-13
TV-1	V-5462-X	CHILLED WATER VALVE	9-13	ACTUAL RANGE 7-13
PANEL MOUNTED EQUIPMENT				
EPV-1	V11-X	SOLENOID AIR VALVE		CONNECT TO FAN
VA-1	R-3030-1	REVERSING RELAY	7 IN 8 OUT	REVERSE ACTING

Fig. 3.4: Typical R-3030 Reverse Acting Application

C-5222 Adding/Subtracting Repeater (See Fig. 3.5)

The C-5222 Adding/Subtracting Repeater is a low volume output biased repeater. The device is adjusted to bias the output up or down.

Adjustment

Furnish a constant input pressure to the C-5222 and turn the adjusting knob to the desired offset between input and output pressures.

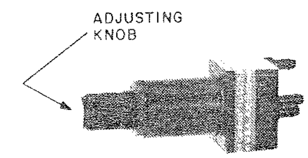
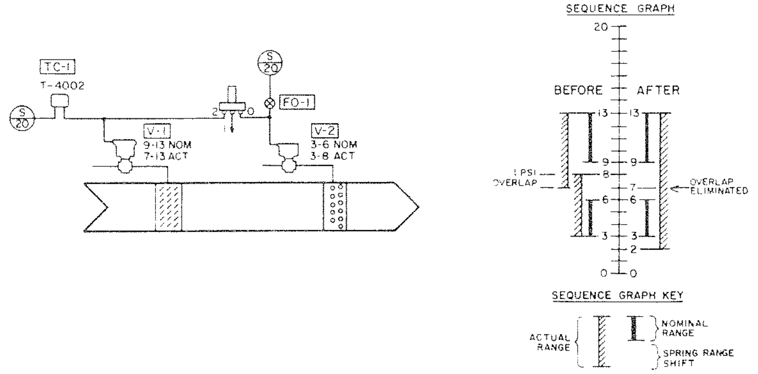


Fig. 3.5: C-5222 Adding/Subtracting Repeater



BILL OF MATERIAL

CODE NO	INST ID	DESCRIPTION	RANGE SETTING	REMARKS
T-4002	TC-1	ROOM T'STAT	—	DA
C-5222	PRA-1	ADDING REPEATER	+ 1	
V-3974-X	V-1	CHILLED WATER VALVE	9-13	ACTUAL 7-13
V-3854-X	V-2	HOT WATER VALVE	3-6	ACTUAL 3-8
R-3710	FO-1	.007 INLINE RESTRICTOR	—	—

Fig. 3.6: C-5222 Adding Application Controlling Heating and Cooling Valves in Sequence

C-5230 Signal Limiter

The C-5230 is designed to impose high and/or low limits on any pneumatic signal. It is used to limit signals within predetermined values. One example where the C-5230 would be used is with actuators on a heat exchanger, to prevent overranging (exceeding design criteria).

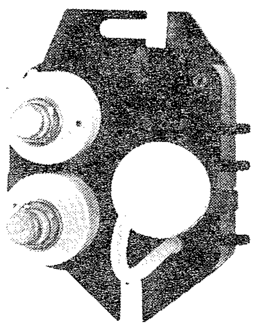


Fig. 3.7: C-5230 Signal Limiter

Calibration

High and/or low limits are an integral feature of the C-5230. The pressure regulator for the C-5230-2 is preassembled in the low limit configuration and preset at approximately 9 PSIG (63 kPa). The high and low limits for the C-5230-3 are factory set at approximately 15 and 5 PSIG (105 and 35 kPa) respectively. If adjustments are required, proceed as follows:

1. Furnish 20 PSIG (140 kPa) supply air to the C-5230 supply "S" connection **OR** cap the "S" connection and furnish a .007 in. restricted source of supply to the output "O" connection.
2. Insert a hypodermic needle test probe (JC 5361 ordered separately, connected to a 0 to 30 PSIG gage using a 1 in. length of polytubing) into output test point #1.
3. Set the input "I" connection to 0 PSIG.

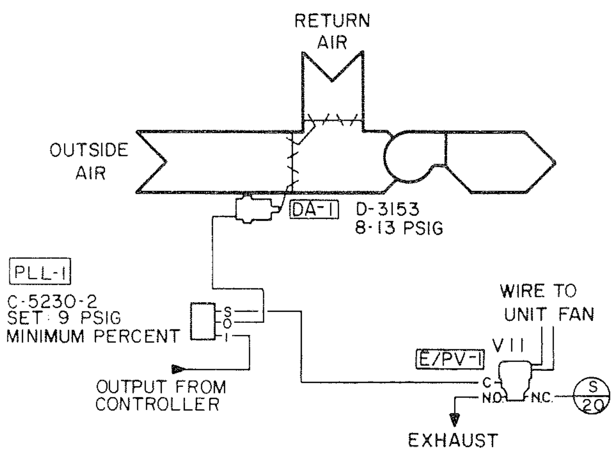


Fig. 3.8: Typical Low Limit Application

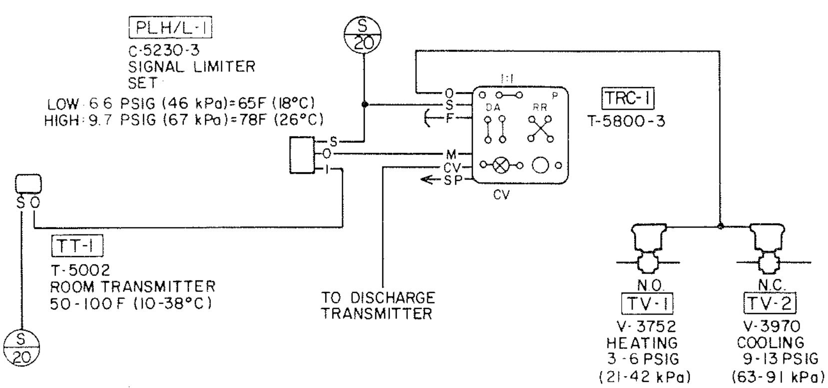


Fig. 3.9: Typical High and Low Limit Application

C-5230-2 Adjustments for Low Limit Only (See Fig. 3.8)

Follow Steps 1 through 3 above.

4. Adjust the low limit regulator until the desired low limit setting is noted on the output gage.

C-5230-3 Adjustments for High and Low Limits (See Fig. 3.9)

Follow Steps 1 through 3 above.

4. Turn the low limit regulator fully clockwise (approximately two turns).
5. Adjust the high limit regulator until the desired high limit is noted on the output gage.
6. Adjust the low limit regulator until the desired low limit setting is noted on the output gage.

C-9200 and C-9500 Cumulators (See Fig. 3.10)

Adjustment

1. Remove the bottom cap from the unit.
2. Furnish a variable pressure source to the input and dead-end the output.
3. Turn the spring adjusting screw until the desired set point or offset is reached. Check this value by blocking off the bottom opening. When the desired setting is obtained, replace the bottom cap.

Differential Adjustment (C-9500 only)

4. To check the differential, slowly decrease the input pressure until the output pressure drops to zero.

5. To reset the differential, loosen the locknut on top of the device and slowly turn the differential adjusting screw to the point at which the output pressure drops to zero. Retighten the locknut.

C-9502 Two-Position Pilot Cumulator (See Fig. 3.11)

Cut-In Setting

1. Furnish input pressure to the calibration port equal to the desired cut-in setting.

2. Slowly turn the cut-in adjusting knob until the output pressure just begins to increase from 1.5 PSIG (10.5 kPa).

Cut-Out Setting

Note: If minimum differential is desired, cut-out adjustment is not necessary.

3. Turn the cut-out adjusting knob counterclockwise four full turns.

4. Furnish an input pressure equal to the desired cut-out set point.

5. Slowly turn the cut-out adjusting knob clockwise in small increments until the output pressure just begins to fall towards zero.

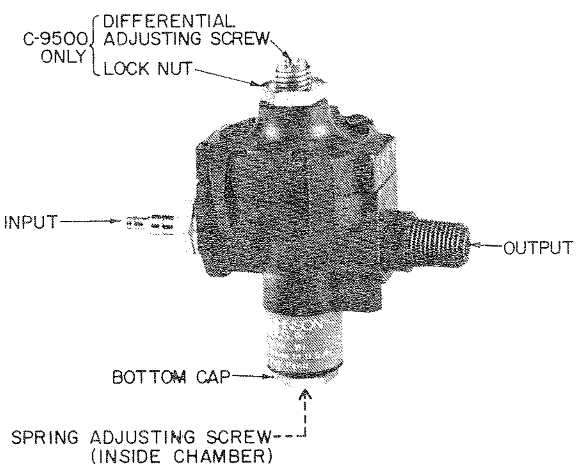


Fig. 3.10: C-9200 and C-9500 Cumulators

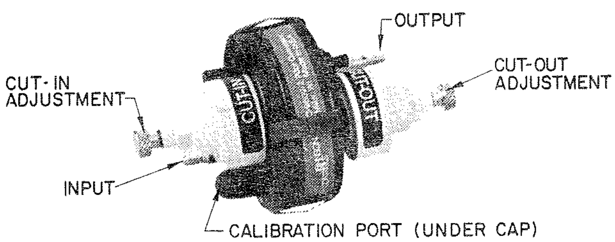


Fig. 3.11: C-9502 Cumulator

C-9504 Two-Position Cumulator (See Fig. 3.12)

The C-9504 can be field selected for a supply "S" powered configuration or an input "I" powered configuration. The output capacity for the "S" powered configuration is 45 SCIM (12.3 mL/s) and 2 to 8 SCIM (0.5 to 2.2 mL/s) for the "I" powered configuration.

Adjustment for "S" Powered Configuration

Install the green resistor on the underside of the base. Supply 20 PSIG (140 kPa) to the "S" connection.

Adjustments for "I" Powered Configuration

Close off the "S" connection with the yellow cap provided. Install the yellow resistor on the underside of the base.

Note: The output line should be as short as possible or the pressure buildup may appear as a proportional output signal.

1. Attach a 0 to 30 PSIG (0 to 210 kPa) test gage (G-2010-11, ordered separately) to the output "O" connection.

2. Furnish a 0 to 20 PSIG (0 to 140 kPa) low volume variable signal to the input "I" connection. If a high volume signal is used, a .007 in. restrictor must be installed at the input "I" connection.

High (Cut-In) Set Point

3. Adjust the variable input "I" signal to 0 PSIG.

4. Insert a hypodermic needle test probe JC 5361 (formerly X-200-140) with gage G-2010-11 (0 to 30 PSIG) into test point "P". Check that there are no leaks between the needle and the gage.

5. Increase the variable input "I" signal to the desired high set point.

6. Slowly rotate the high set point dial counterclockwise until the test gage pressure at test point "P" reaches 1.5 PSIG (10.5 kPa). At this point, the pressure will continue to increase to the desired high set point and the output "O" pressure will increase to its maximum input value (for the input "I" powered configuration) or supply pressure (for the supply "S" powered configuration).

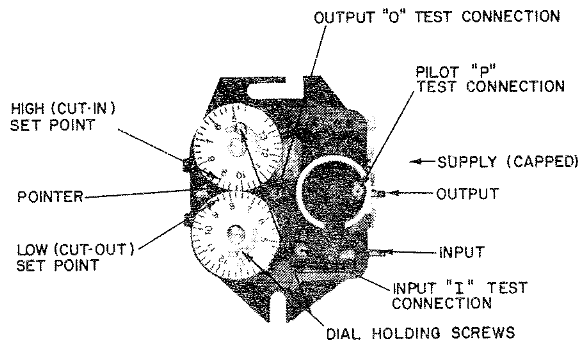


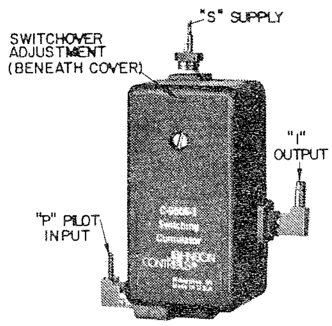
Fig. 3.12: C-9504 Adjustments

Low (Cut-Out) Set Point

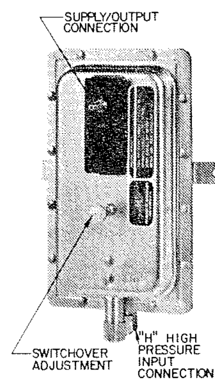
7. Decrease the variable input "I" signal to the desired low set point.
8. Slowly rotate the low set point dial clockwise until the test gage pressure at test point "P" just begins to drop. The output "O" pressure will decrease to 0 PSIG without further adjustment.

   Note: If the numbers on the high or low set point dials do not match the actual cut-in or cut-out values, loosen the dial holding screws, rotate the dials to the desired cut-in or cut-out setting, and retighten the holding screws.

9. Check the high and low set points by increasing and decreasing the input "I" pressure. Repeat Steps 3 through 8 to fine tune the instrument.



C-9506



P40 (Formerly P-5232)

Fig. 3.13: Switching Devices

C-9506 and P40 (Formerly P-5232) Switching Devices (See Fig. 3.13)

1. Furnish the device with 20 PSIG (140 kPa) supply air.
2. Apply the desired switch point pressure to the input connection. For the C-9506, use connection "P"; for the P40, use connection "H".
3. Turn the switch point adjusting screw until the output pressure switches from 0 to 20 PSIG (0 to 140 kPa).

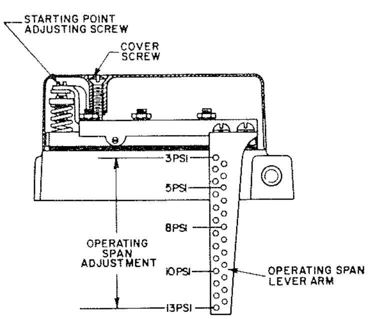


Fig. 3.14: Positioner Adjustments

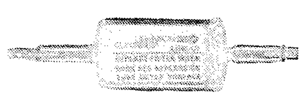


Fig. 3.15: Final Filter

D-9502 and V-9502 Positioners

The D-9502 and V-9502 Positioners include two adjustments: starting point and span. The starting point is the pressure at which the actuator begins to stroke (lower end of the spring range). The span is the additional amount of pressure required to fully stroke the actuator (the difference between the upper and lower limits of the desired operating range).

1. Place one end of the positioner spring in the hole of the lever arm which corresponds to the desired span (see Fig. 3.14). Attach the other end to the spring plate so that the spring is perpendicular to the lever arm.
2. Apply an input pressure to connection "I" equal to the desired starting point or lower end of the spring range.
3. Remove the cover of the positioner and turn the starting point adjusting screw until the actuator just begins to stroke.

Service and Maintenance

Like controllers and transmitters, most pneumatic auxiliary devices do not require maintenance as long as they receive clean, dry, oil free air. The only maintenance necessary is to check the external final filters furnished on the C-2100, C-2220, C-9115, N-1000, N-9000, and PIC (see Fig. 3.15).

Section IV: Controlled Devices

Information in this section pertains to the following controlled devices, some of which may have been discontinued:

- D-100, D-250, D-400, and D-3000 Series Damper Actuators.
- D-200, D-1100, D-1200, and D-2300 Series Dampers.
- V-10 Through V-200, V-1000, V-3000, and V-4000 Series Valves.

Damper Actuators

If the actuator will not stroke, check for a cracked or torn diaphragm (see Fig. 4.1).

WARNING

IF IT IS NECESSARY TO CHANGE THE DIAPHRAGM, BE SURE TO DISCONNECT THE AIR LINE TO THE ACTUATOR OR THE SPRING COULD SHOOT OUT AND CAUSE SERIOUS INJURY.

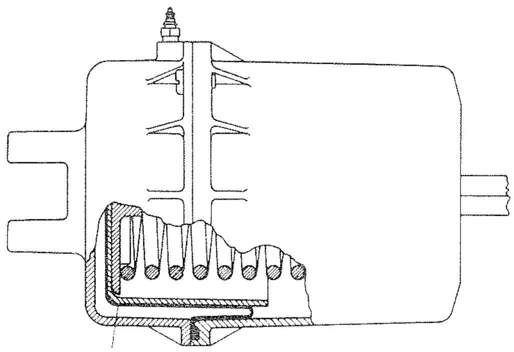


Fig. 4.1: Damper Actuator

Dampers

Because of their simple and rugged design, dampers and damper actuators give years of trouble free service with minimum maintenance. The quick checks below should be made once or twice a year, depending on the cleanliness of the air entering the system, to assure proper damper operation.

Stroke the damper from one extreme position to the other by applying a varying pressure to the actuator. If the damper blades do not rotate freely, check for binding linkage (see Fig. 4.2). If accessible, lubricate the damper linkage with a dry lubricant. **Note: Do not oil the bearings; dirt will collect on the oil and cause the bearings to wear.**

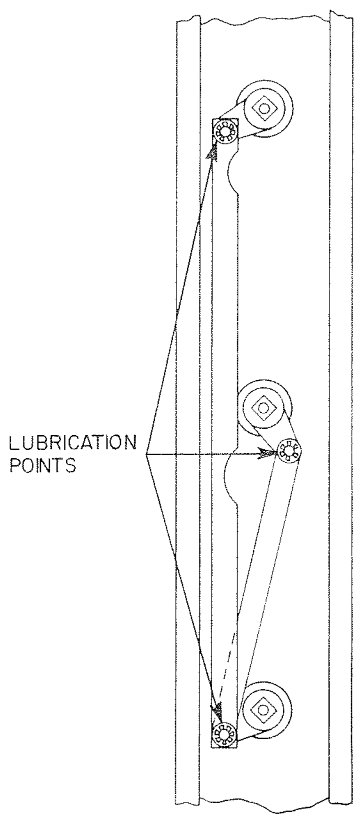


Fig. 4.2: Damper Linkage

Next, stroke the damper to its fully open position and inspect the damper blades. Clean with a mild detergent if necessary. Also, check the condition of the blade seals. If the seals need to be replaced, simply pull the old seals out of the blade and thread the new seals in along the channel of the blade (see Fig. 4.3).

Valves

Valve Maintenance

Johnson Controls valves are designed for maximum performance and ease of maintenance. The three types of valve actuators are the piston top (see Fig. 4.4), rubber diaphragm top (see Fig. 4.5), and rubber diaphragm top with encapsulated spring (see Fig. 4.6).

Note: The maintenance procedures that follow are intended for valves with piston tops and rubber diaphragm tops with encapsulated springs only.

Valves with rubber diaphragm actuators that do not have encapsulated springs require special tools and techniques; these valves should only be serviced by Johnson Controls personnel.

Safety Precautions

1. Remove air pressure to the actuator (except where noted in the instructions).
2. Keep head, hands, and body away from the top of the actuator at all times during servicing.
3. Follow all instructions completely as written. Do not skip steps or take short cuts.

The first step in checking for proper operation is to stroke the valve from one extreme position to the other. Do this by applying a varying pressure to the valve actuator. The valve stem should travel smoothly and evenly. If the stem sticks or if there is leakage around the stem, the packing should be replaced. Follow the instructions below for piston top and encapsulated spring actuators.

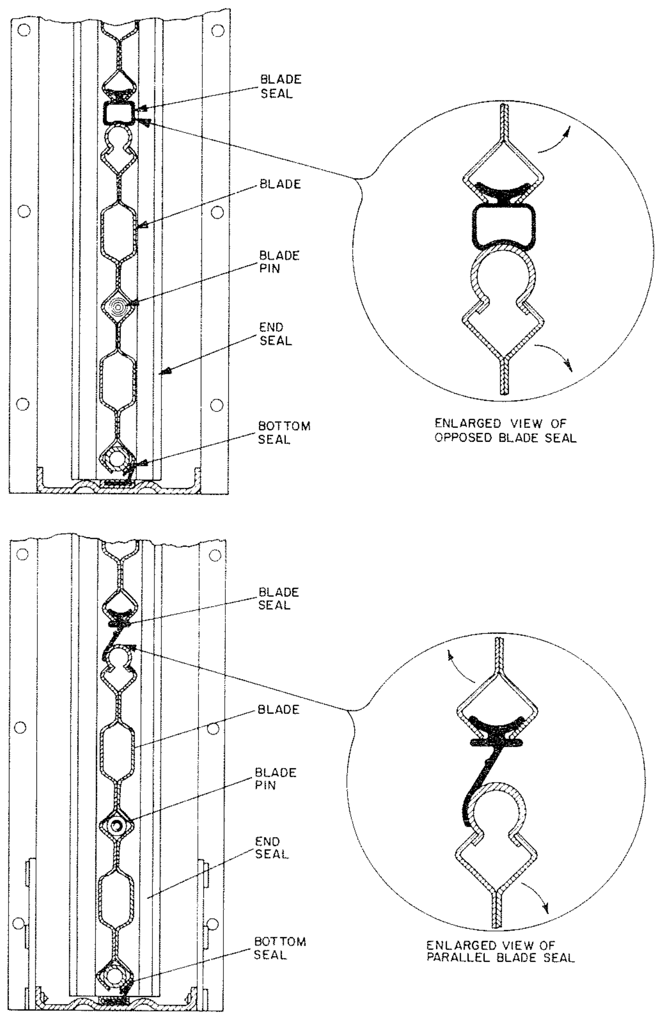


Fig. 4.3: Damper Cross-Sectional Views

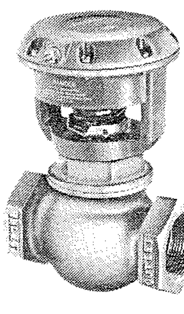


Fig. 4.4: Piston Top Valve

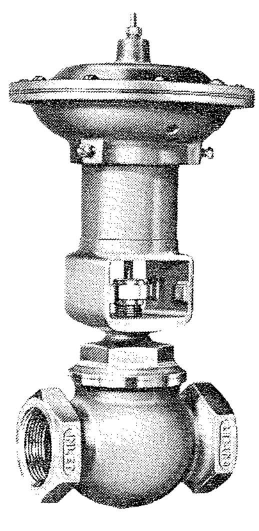


Fig. 4.5: Rubber Diaphragm Top Valve

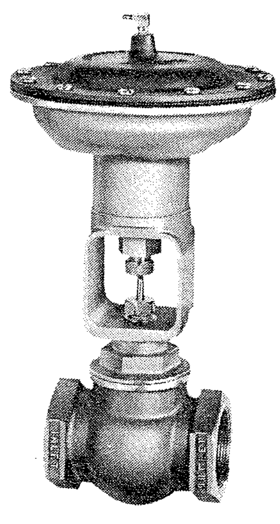


Fig. 4.6: Rubber Diaphragm Top Valve with Encapsulated Spring

Piston Top (V-3000) Valves

Removing Old Packing (See Fig. 4.7)

1. Disconnect the air line to the actuator.
2. Remove the actuator by loosening the set screw on the bottom of the lower diaphragm case. Lift the actuator off of the valve.
3. Use Spring Compression Tool JC 5389 (see Fig. 4.8) to compress the spring.
   a. Place the locking base over the valve spring assembly so that the base rests on the surface of the bonnet.
   b. Tighten the knurled set screws to fasten the locking base securely to the valve bonnet.
   c. Insert the spring compressor into the locking base and over the spring assembly.
   d. Apply enough hand pressure to the top of the spring compressor to engage the locking stud into the bottom notch of the base.
4. Using a 9/16 in. box-head wrench, hold the stem extension and loosen the stem locking screw with a small blade screwdriver. Then, using the box-head wrench, unscrew the stem extension.
5. ***Carefully*** apply enough hand pressure to disengage the spring compressor and then allow the spring to expand to its relaxed position.
6. Remove the spring compression tool and lift the upper spring plate and spring off the valve.
7. Remove and retain the packing nut. Remove and discard the stem guide, noting whether it is deep or shallow. Compare it to Fig. 4.9.

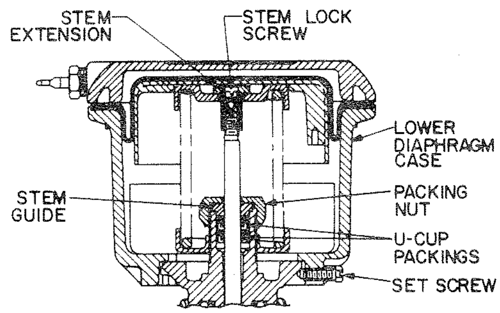


Fig. 4.7: Piston Top (V-3000) Valve

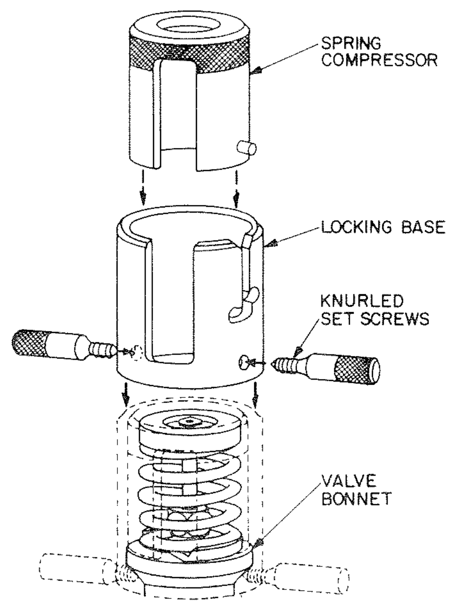


Fig. 4.8: Spring Compression Tool

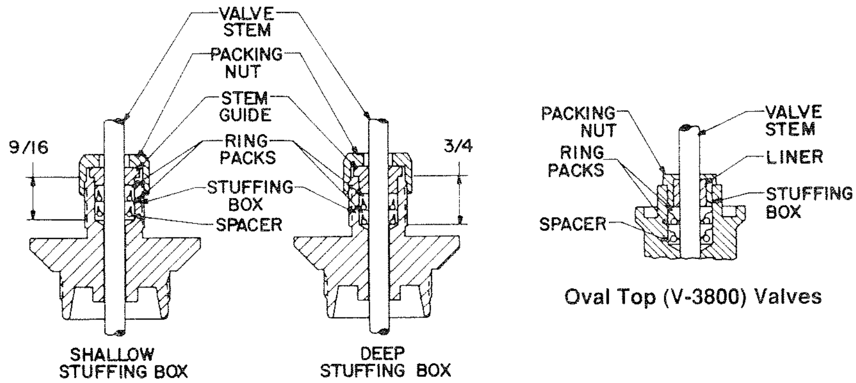


Fig. 4.9: Packings

8. Remove the old packings using the small end of the packing insertion/removal tool. Place the small end over the stem and apply enough pressure so that the barbs grasp the first packing. Lift the tool and the packing; repeat for the second packing.

   Note: If the packing insertion/ removal tool is not available, remove the packing with a sharp hooked tool, being careful not to damage the stem surface.

9. Pull up and clean the accessible portion of the valve stem with the crocus cloth provided. Wipe the stem with paper towel to remove any grit or debris. If the stem is still rough or marred, it must be replaced.

10. Apply a small amount of lubricant to the inside of the ring packs and the inside of the stuffing box. Be sure that the O-rings are already positioned in the U-cups before applying the lubricant.

11. Insert the ring packs (O-ring side down) into the stuffing box as described below.

   Non Oval Top (V-3000) Valves Using the Bullet (See Fig. 4.10A): Slide the bullet onto the stem. Place two ring packs onto the bullet and slide them onto the stem. Remove the bullet. Use the large end of the packing insertion/removal tool to push both of the packings down into the stuffing box.

   Note: If the bullet does not cover the entire threaded portion of the stem, the sleeve must be used instead of the bullet.

   Non Oval Top (V-3000) Valves Using the Sleeve (See Fig. 4.10B: Slide the ring packs onto the sleeve. Slide the sleeve over the threaded portion of the stem. Push both of the ring packs off of the sleeve and remove the sleeve. Push the ring packs down into the stuffing box.

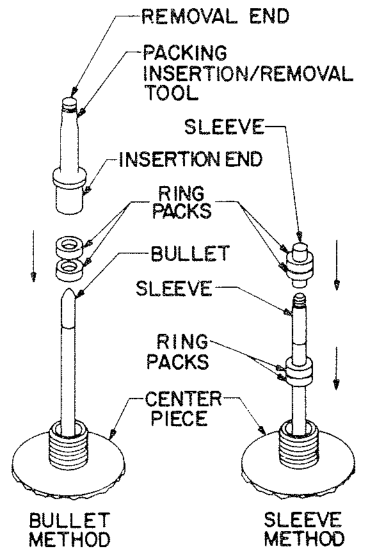


Fig. 4.10a: Non Oval Top (V-3000) Valves

Fig. 4.10b: Non Oval Top (V-3000) Valves

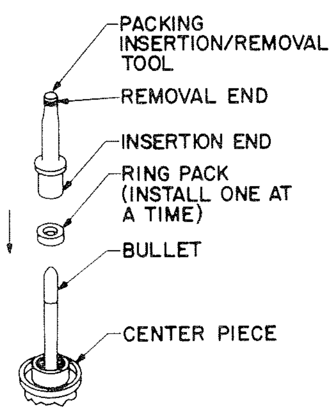


Fig. 4.10c: Oval Top (V-3800) Valves

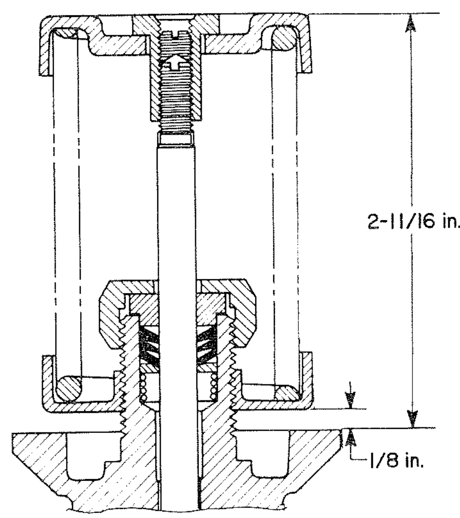


Fig. 4.11

Oval Top (V-3800) Valves Using the Bullet (See Fig. 4.10C): Slide the bullet onto the stem. Place one ring pack onto the bullet and slide it onto the stem. Remove the bullet. Use the large end of the packing insertion/ removal tool to push the ring pack down into the stuffing box. Repeat this procedure for the second ring pack.

12. Install the proper sized stem guide/liner into the stuffing box (see Fig. 4.9). Install the packing nut onto the stuffing box. Tighten the packing nut 1/8 of a turn past finger tight.

13. Move the stem up and down by hand to be sure that it operates freely. Reassemble the valve actuator.

14. Reassemble the spring and actuator, reversing the procedure in Steps 3 through 6. Verify the distance between the lower spring plate and the top surface of the bonnet. Readjust the spring plate if necessary (see Fig. 4.11).

Encapsulated Spring Valve Actuators

Removing Old Packing (See Fig. 4.12)

1. Apply enough control air pressure to stroke the valve to mid travel.
2. Remove the coupler nut and loosen the packing nut. Use a 1-1/4 in. wrench for 4R and 5R actuators. Use a 1-5/8 in. wrench for 8R actuators.
3. Reduce the control air pressure to zero and remove the control air line.
4. Remove the two stem jam nuts.
5. Remove the actuator (by unscrewing it from the packing box) along with the coupler nut and packing nut.
6. For valves with a 1/4 or 3/8 in. stem, use the removal end of the packing insertion/removal tool (furnished with the packing kit) to remove the old packings; refer to Steps 7 through 9 under V-3000 Valves. For valves with a 1/2 in. stem, use a small sharp hook to remove the packings, being careful not to damage the stem or the inside of the packing box.
7. For valves with 8R actuators and 1/2 in. diameter stems, a split-ring packing is used. Apply a light coating of lubricant to each of the packings. Carefully spread each ring and place it around the stem. Using the stem guide furnished in the packing kit, gently push each packing down into the packing box.
8. Repeat Step 7 for all six of the split-ring packings. ROTATE each packing 90° from the previous packing as it is inserted into the packing box. Doing so will assure that the splits in the packings are offset from each other.
9. Slide the stem guide down the stem into the packing box.

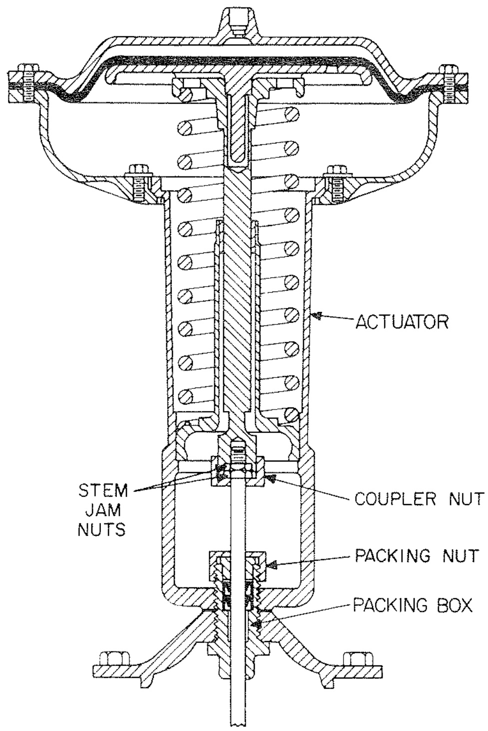


Fig. 4.12: Encapsulated Spring Valve Actuator

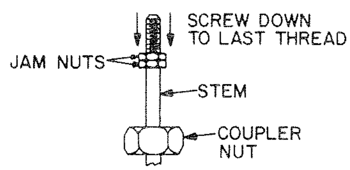


Fig. 4.13

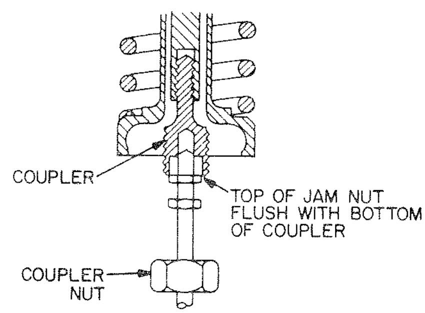


Fig. 4.14

10. Replace the actuator, the packing nut, and the coupler nut (see Fig. 4.12).
11. Tighten the actuator on the packing box.
12. Tighten the packing nut 1/8 of a turn beyond finger tight.
13. Screw the two stem jam nuts all the way down to the last thread (see Fig. 4.13).
14. Pull the stem all the way up into the coupler.
15. With the stem all the way up, screw the top jam nut up so that the top of the nut is flush with the bottom of the coupler (see Fig. 4.14).
16. Push the stem all the way down.
17. Screw the top jam nut up from the point reached in Step 15. On 4R and 5R actuators, the jam nut should be raised 1/4 in.; on 8R actuators, the jam nut should be raised 3/4 in.

18. Tighten the bottom jam nut against the top jam nut. Be sure not to change the position of the top jam nut.

    To check for proper position of the jam nuts, pull the stem all the way up. The lower jam nut should just disappear into the coupler (see Fig. 4.15).

19. Connect the air line to the actuator. Furnish enough air pressure to the diaphragm to move the coupler down at least 1/8 in. Tighten the coupler nut to the coupler.

20. Apply variable control air pressure to the valve and check to see that the valve strokes freely.

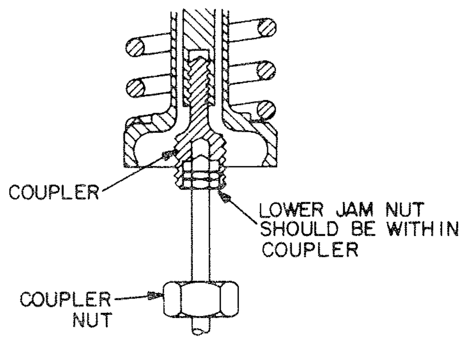


Fig. 4.15

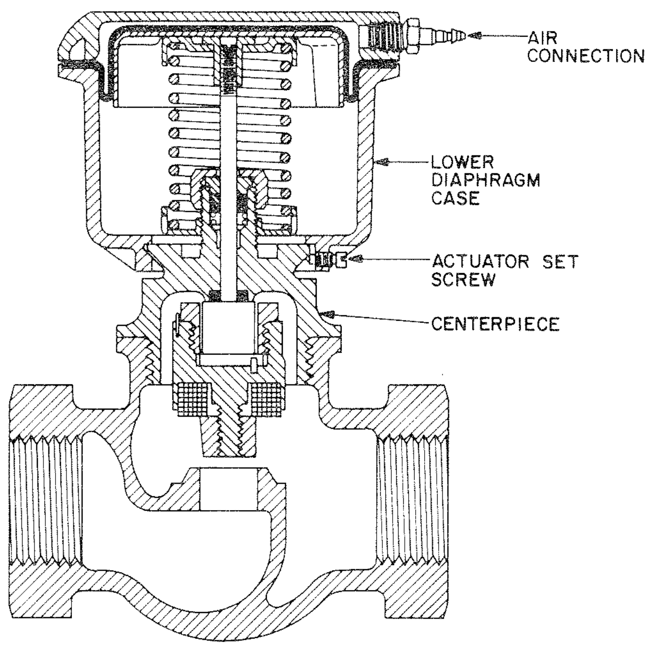


Fig. 4.16: N.O. Piston Top Valve

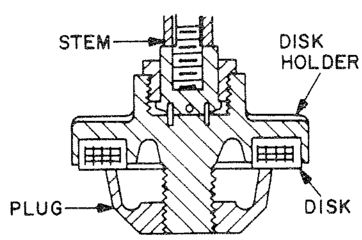


Fig. 4.17: Plug and Disc Detail

Tight Shutoff

The next step in valve maintenance is to check for tight shutoff. Leakage through the valve can be detected as follows:

Stroke the valve fully closed. If the temperature of the outlet piping remains hot on heating valves or remains cold on cooling valves, there is some leakage through the valve.

This leakage may be caused by a corroded disc, a corroded seat, or both. The procedure for disc replacement and seat inspection on piston top (V-3000) valves is given below. For disc and seat replacement for rubber diaphragm actuator valves, consult the local Johnson Controls branch office.

Note: On cage trim valves, the seat is integral with the cage and the disc is integral with the plug. If these parts are corroded, the entire plug and cage should be replaced.

Disc Replacement for N.O. Piston Top Valves (See Fig. 4.16)

1. Remove air pressure from the actuator.
2. Loosen the set screw on the lower diaphragm case and remove the actuator.
3. Remove the centerpiece from the valve body.
4. Grasp the disc holder with a locking pliers and use another locking pliers to unscrew the plug from the disc holder (see Fig. 4.17). Be careful not to nick or damage the finish of the plug with excessive locking force.
5. Remove the old disc and install the new disc.
6. Screw the plug into the disc holder.

7. Run your finger over the valve seat. If it feels rough and corroded, contact Johnson Controls to have the valve reseated.

8. With a center punch, stake the threads of the plug and disc holder in two places.

9. Reassemble the valve. The relative positions of the upper and lower spring seats are shown in Fig. 4.11.

10. Changing the packing is optional; refer to the replacement procedure described earlier.

Disc Replacement for N. C. Piston Top Valves (See Fig. 4.18)

1. Remove air pressure from the actuator.

2. Loosen the set screw on the lower diaphragm case and remove the set screw.

3. Hold the stem extension firmly with a 9/16 in. box-head wrench and, with a small screwdriver, loosen the stem locking screw.

4. For V-3000 valves, compress the spring using a JC 5389 Spring Compression Tool (see page 44). For V-3800 valves, compress the spring with hand pressure.

5. Using a 9/16 in. box-head wrench, unscrew the stem extension. Lift the spring and upper spring seat off the valve. Remove the spring compression tool if used.

6. Remove the bottom cap from the valve and pull the plug and stem out of the valve.

7. Replace the disc and reassemble the valve according to Steps 4 through 9 above.

Note: Before assembling the spring and actuator, the packing should be replaced; refer to the replacement procedure described earlier.

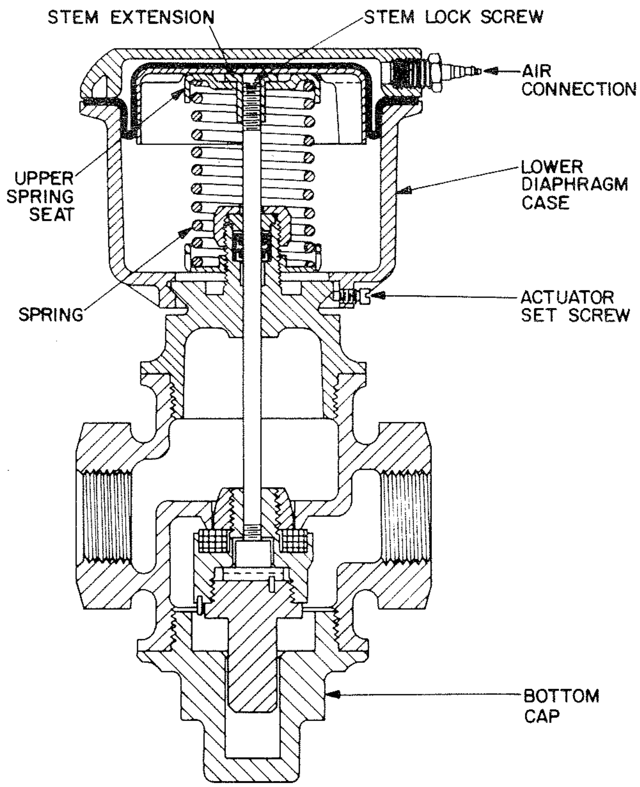


Fig. 4.18: N.C. Piston Top Valve

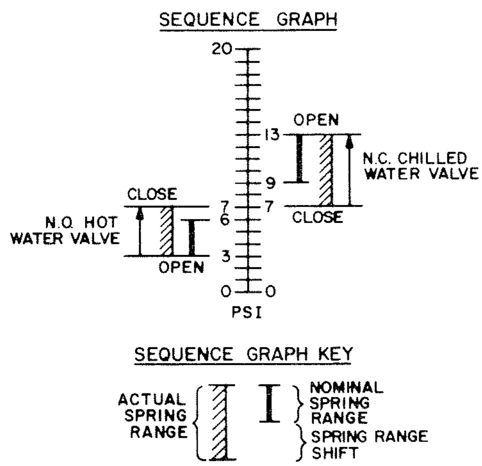


Fig. 4.19

Valve Spring Range Selection

When selecting a valve, it is important to remember that there is a choice of spring ranges to meet the requirements for the specific application. Various valve sizes and available spring ranges are listed in the Product Data sheets.

For applications that require a normally open heating valve, lower spring ranges are usually preferred. Johnson Controls offers normally open valves with spring ranges of 2 to 5 PSIG, 3 to 6 PSIG, and 9 to 13 PSIG.

For applications that require a normally closed cooling valve, the usual practice is to select spring ranges of higher values. Johnson Controls furnishes valves with a 9 to 13 PSIG spring range.

If a valve is to be sequenced with another valve, proper spring selection is necessary. It is very important that overlapping spring ranges be avoided (see Fig. 4.19).

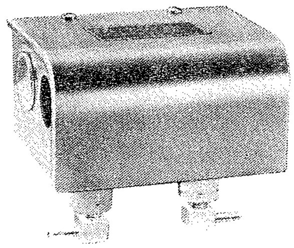
An important factor in spring range selection of valves is the valve close-off. For normally closed valves, the spring will seat the valve and keep it closed against system pressure. On normally open valves, the control pressure in the actuator (above the upper limit of the spring range) will cause the valve to close and remain closed against the system pressure.

The spring ranges listed for Johnson Controls valves are "nominal." Nominal range means that if the valve was to receive a control signal while sitting on a test bench, the valve would move through its spring range at the listed values. However, once the valve is placed in the system, the valve will have to work against the system pressure and there will be a change in control pressure required to operate the valve. This will be most evident at the closing end of the valve spring range. The new value is called "actual spring range."

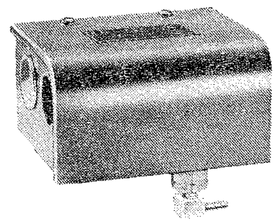
PE Switches and Step Controllers

Pneumatic/electric (PE) switches and step controllers (see Figs. 4.20 and 4.21) activate electrical equipment from a pneumatic signal. Cut-in and cut-out (make and break) settings turn the equipment on and off at preselected pressures indicated on the control drawings.

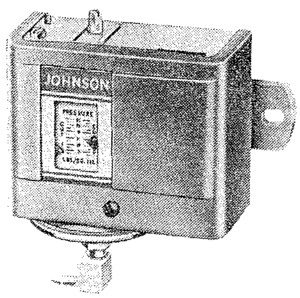
Generally, the settings do not need to be readjusted unless application parameters change or the settings have been tampered with. These



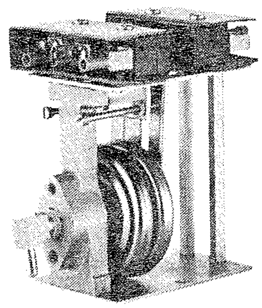
Duplex PE Switch



Two-Stage PE Switch

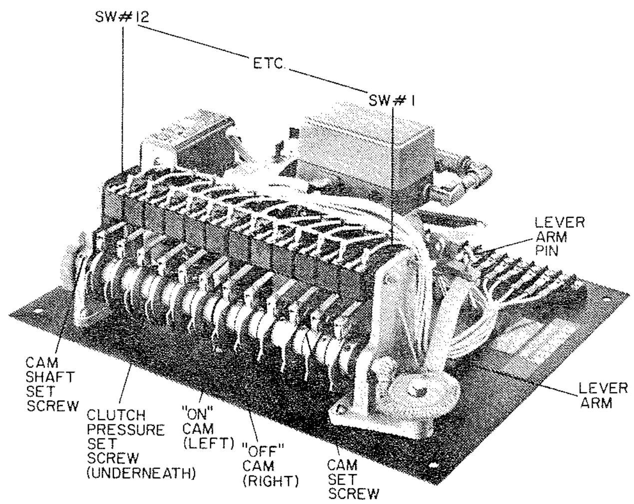


Low Range PE Switch

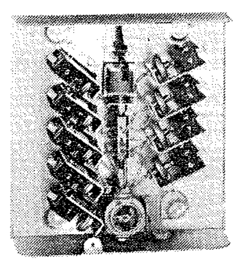


High-Low PE Switch

Fig. 4.20: Typical PE Switches



G-180 Twelve-Point Module



G-7185 Nine-Point Model

Fig. 4.21: Typical Step Controllers (Covers Removed)

settings should be checked once a year as follows:

PE Switches

1. Apply a variable pressure to the air connection.
2. Slowly increase the pressure and listen for the contact transfer or use a voltmeter to determine the cut-in setting. For mercury switches, watch the mercury bulb through the window.
3. Check the actual cut-in point with the desired cut-in point on the control drawing. Readjust if necessary.
4. Slowly decrease the pressure and listen for the contact transfer or use a voltmeter to determine the cut-out setting. For mercury switches, watch the mercury bulb through the window.
5. Check the actual cut-out point with the desired cut-out point on the control drawing. Readjust if necessary.

Step Controllers

1. Apply a variable pressure to the air connection.
2. Slowly increase the pressure and watch the lever arm or use a voltmeter to see at which pressures the cams are activated. Readjust if necessary.

For more detailed instructions on specific PE switch models and step controllers, refer to the appropriate Product Data sheet.

THE JOHNSON CONTROLS MISSION

EXCEEDING YOUR EXPECTATIONS

At Johnson Controls, we have a single mission: forging lasting alliances with our customers through performance that exceeds their expectations.

Our strategy is simple: We know that 80% of our business comes from people we have served before – people we have helped to succeed in even the greatest facility management challenges.

Our resources are complete: We have on staff a worldwide network of 21,000 employees qualified to tackle any of *your* challenges. From engineers to contractors, software developers to service and training specialists, we represent a unique blend of unparalleled expertise.

Our solutions are thorough: We are equipped to support every aspect of a project, from analysis, design and construction through installation, training, service and management; providing as much support as the challenge requires in a flexible, mutually-beneficial alliance.

And we are equipped with the best: These efforts are backed by service technologies and field-proven products that have made us the world's leading supplier of facility control systems and services.

Your alliance with Johnson Controls: By definition, it's a relationship you can rely on. Today, and for many years to come.

JOHNSON CONTROLS

Controls Group
Milwaukee, WI 53201-0423
414/274-4000

Printed in U.S.A.

Publication 2054