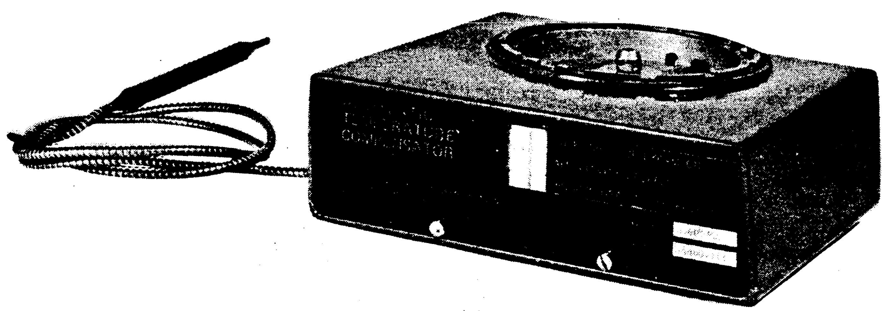
(S)X-4400
Revision 01

INSTALLATION
& OPERATING
INSTRUCTIONS

-Model 4400
Automatic Temperature Compensator



CAUTION: It is recommended that this publication be read in its entirety before performing any operation. Failure to understand and follow these instructions could result in serious personal injury and/or damage to the equipment.
Should this equipment require repair or adjustment, contact the nearest Brodie Sales Office. It is important that servicing be performed only by trained and qualified service personnel. If this equipment is not properly serviced, serious personal injury and/or damage to the equipment could result.

BRODIE
Brodie Meter Co., LLC
P.O. Box 450
19267 Highway North (30461)
Statesboro, GA 30459-0450
Phone: (912) 489-0200
Fax: (912) 489-0295
www.brodiemeter.com

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Section 1 INTRODUCTION

1-1 General

Brodie Automatic Temperature Compensators (ATC), when used with a metering and totalizing type register, provide a means for accurately measuring liquid flow while accounting for volumetric inaccuracies that result from variations in product temperature.

1-2 Description

The Automatic Temperature Compensator is a device that automatically and continuously corrects a meter counter to indicate the volume that a metered delivery would occupy at a selected base temperature of 60°F, 20°C, or 15°C (depending on ATC model selected). Each ATC is also equipped with a lockout position to provide an uncorrected readout with respect to the base temperature (a feature used primarily during calibration procedures).

1-3 Definition of Terms

GENERALIZED CRUDE OIL — As defined by the API Petroleum Measurement Tables.

GENERALIZED PRODUCTS — As defined by the API Petroleum Measurement Tables.

COEFFICIENT OF EXPANSION OR CONTRACTION — A number representing the ratio of change of volume per unit change of temperature.

AMBIENT TEMPERATURE — Atmospheric temperature or temperature of the surrounding environment.

PRODUCT TEMPERATURE — The temperature of the liquid product being metered.

BASE TEMPERATURE — The temperature selected as "standard" for metering product volume and calibration of metering devices.

CORRECTED VOLUME — The volume a liquid product would occupy at base temperature.

GROSS (UNCORRECTED) METER THRUPUT — The volume of metered liquid as indicated by an uncompensated counter.

NET METER THRUPUT — The volume that a metered liquid would occupy at a specific base temperature.

NET COUNTER — An ATC corrected counter which will display the net meter thruput.

GROSS COUNTER — A counter which will display the gross meter thruput.

1-4 Model Number Identification

The ATC model number appears on the name plate attached to the body of the ATC. The model number consists of a 4400, designating ATC type, and three variables that represent different combinations of the coefficient of expansion and base temperature, capillary length, and temperature range as illustrated in Table 1-1. ATC model number selection for some common products is exemplified in Table 1-2. Table 1-3 shows the respective coefficient of expansion and temperature ranges for the standard ATC models.

The serial number is stamped on the base plate of the ATC and on the outside of the housing.

1-5 Specifications

Ambient Temperature Range: −25°F to +125°F
−32°C to +52°C

Product Temperature Range: −30°F to +450°F
−34°C to +232°C

Span per Model: Approximately 200°F (111°C). Refer to Table 1-3.

Base Temperature Available: 60°F, 20°C, or 15°C. Dependent on ATC model (Refer to Table 1-3).

Coefficient of Expansion Setting Available: .0003 to .002/°F (.00054 to .0036/°C). Coefficient range dependent on ATC model selected (Refer to Table 1-3).

Scale: Coefficient of Expansion
API Gravity Degrees
Specific Gravity - Petroleum

Capillary Tube Length: 48" or 84" (1219.2 mm or 2133.6 mm) Standard. Other lengths available - consult factory.

Maximum Input Speed of Operation: 250 RPM

Maximum Driving Torque to Accessory Items: 30 in. oz.

Linearity: ±1°F/100°F (±.5°/50°C). Refer to Figure 1-1.

Hysteresis: Less than .25°F (.15°C)

Response Time: Refer to Figure 1-2.

Dimensions: See Figure 2-1.

Materials of Construction

Base Plate and Cover	Die Cast Aluminum
Gears	Brass, Bronze, Stainless Steel
Bushings	Garlock Multilube 31
Bearings	Stainless Steel - Radial Ball Bearing and Roller Thrust Bearings
Springs	Stainless Steel
Window	Acrylic Plastic
Screws and Nuts	Stainless Steel, Brass, Cad. Plated Steel
Bellows	Copper Alloy
Bulb	Copper Alloy
Capillary Tube	Copper Alloy
Thermowell	Aluminum or Stainless Steel
Levers, Slides, etc.	Stainless Steel, (Black Oxide Coating)

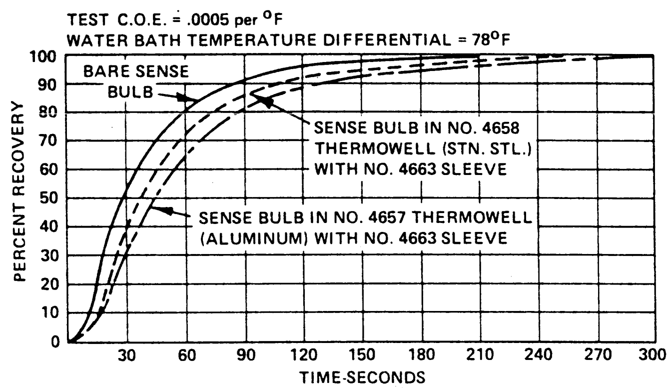


Figure 1-2 Typical Response Time to Product Temperature Change

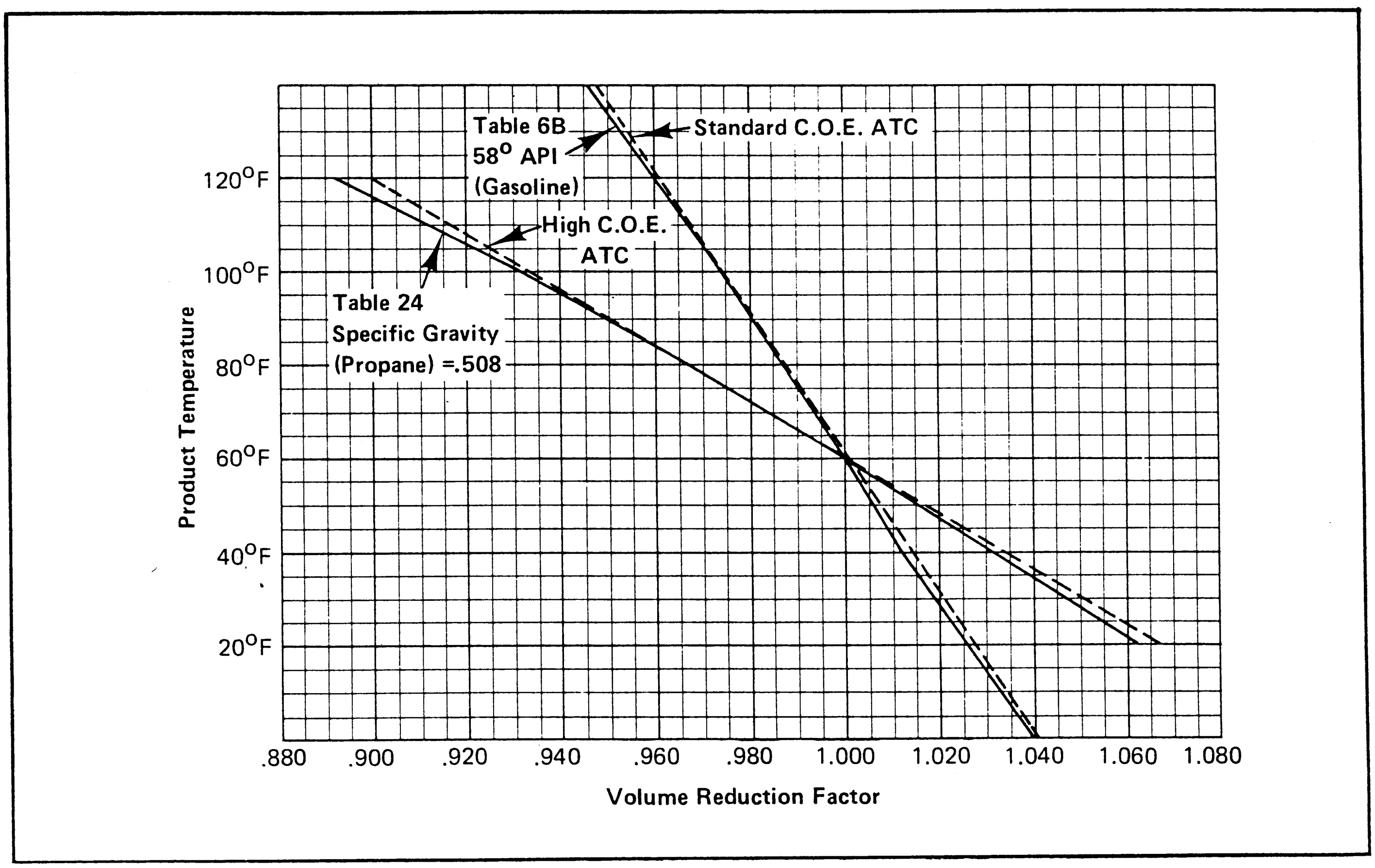


Figure 1-1 Linearity - ATC vs. ASTM Tables

Table 1-1 ATC Model Number Designation

4400 - X X X

Temperature Range (See Table 1-3)

1 = -30° to 150°F or -34° to 66°C
2* = 50° to 250°F or 10° to 121°C - with modified adjustor setting (.0004/°F Max.)
3* = 150° to 350°F or 66° to 177°C -
With Gear Changer 5900 - 896 (.0005/°F Max.)
With Gear Changer 5900 - 940 (.0003 – .0004/°F)
4* = 250° to 450°F or 121° to 232°C - With Gear Changer 5900 - 896 (.0004/°F Max.)
5* = 50° to 250°F or 10° to 121°C - With Gear Changer 5950 - 105 (.0005/°F Max.)

***Not Available in High Coefficient Models**

Capillary Length

2 = 48 Inch
3 = 84 Inch
9 = Special Length Per Sales Order

Coefficient of Expansion and Base Temperature

Generalized Products

1 = Low Coefficient, (.0003 - .0010/°F) 60°F Base
2 = High Coefficient, (.0006 - .0020/°F) 60°F Base
3 = Low Coefficient, (.00054 - .0018/°C) 20°C Base
4 = High Coefficient, (.00108 -.00360/°C) 20°C Base
5 = Low Coefficient, (.00054 -.0018/°C) 15°C Base
6 = High Coefficient, (.00108 - .00360/°C) 15°C Base

Generalized Crude Oil

7 = Low Coefficient, (.0003 - .0010/°F) 60°F Base
8 = Low Coefficient, (.00054 - .0018/°C) 20°C Base
9 = Low Coefficient, (.00054 -.0018/°C) 15°C Base

EXAMPLE

4400 - 1 2 1

1 → Low Coefficient 60°F Base
2 → 48 Inch Capillary
1 → -30° to 150°F Range

Table 1-2 4400 ATC Model Selection for Some Common Products

GASOLINE – 58 API (Generalized Product)

Base Temperature: 60°F
Coefficient of expansion: .0006/°F
Temperature Range: -30°F to +150°F
Use ATC No.: **4400 - 1 X 1**

DIESEL or NO. 2 OIL – 43 API (Generalized Product)

Base Temperature: 60°F
Coefficient of Expansion: .0005/°F
Temperature Range: -30°F to +150°F
Use ATC No.: **4400 - 1 X 1**

PROPANE (Generalized Product)

Base Temperature: 60°F
Coefficient of Expansion: .0017/°F
Temperature Range: -11°F to +131°F
Use ATC No.: **4400 - 1 X 2**

ANHYDROUS AMMONIA (NH_3)

Base Temperature: 60°F
Coefficient of Expansion: .00132/°F
Temperature Range: -24°F to +144°F
Use ATC No.: **4400 - 1 X 2**

CRUDE OIL (Generalized Crude Oil)

Base Temperature: 60°F
Coefficient of Expansion: .0004/°F
Temperature Range: +50°F to +250°F
Use ATC No.: **4400 - 5 X 7**
Use Gear Changer: No. 5950-105

"X" Designates Capillary Tube Length As Indicated in Tables 1-1 and 1-3

Table 1-3 Standard Models

The standard ATC models listed below each have a maximum and minimum temperature and coefficient limits. A specific coefficient setting determines the temperature limits for a particular model.

With the exception of three models listed in paragraph D, an ATC for temperatures of 250°F or higher requires a gear changer to provide the proper ratio at the midpoint of the temperature range. When a gear changer is required its model number is listed with the proper ATC.

All models except those listed in paragraph D can be used on meters equipped with only a net counter or with both net and gross counter.

A. FOR MAXIMUM TEMPERATURES from 120° to 150°F or 49° to 66°C

Generalized Products

No. 4400 - 1 X 1 – Base Temp. 60°F
No. 4400 - 1 X 3 – Base Temp. 20°C
No. 4400 - 1 X 5 – Base Temp. 15°C

Generalized Crudes

No. 4400 - 1 X 7 – Base Temp. 60°F
No. 4400 - 1 X 8 – Base Temp. 20°C
No. 4400 - 1 X 9 – Base Temp. 15°C

Coefficient of Expansion		Product Temperature			
		°Fahrenheit		°Centigrade	
Per °F	Per °C	Min.	Max.	Min.	Max.
.0003	.00054	-30	+150	-34	+66
.0004	.00072	-30	+150	-34	+66
.0005	.0009	-30	+150	-34	+66
.0006	.00108	-30	+150	-34	+66
.0007	.00126	-25	+145	-32	+63
.0008	.00144	-15	+135	-26	+57
.0009	.00162	- 5	+125	-21	+52
.0010	.0018	0	+120	-18	+49

No gear changer required.

B. FOR MAXIMUM TEMPERATURES from 120° to 150°F or 49° to 66°C

No. 4400 - 1 X 2 – Base Temp. 60°F
No. 4400 - 1 X 4 – Base Temp. 20°C
No. 4400 - 1 X 6 – Base Temp. 15°C

Coefficient of Expansion		Product Temperature			
		°Fahrenheit		°Centigrade	
Per °F	Per °C	Min.	Max.	Min.	Max.
.0006	.00108	-30	+150	-34	+66
.0007	.00126	-30	+150	-34	+66
.0008	.00144	-30	+150	-34	+66
.0009	.00162	-30	+150	-34	+66
.0010	.00180	-30	+150	-34	+66
.0015	.00270	-20	+140	-29	+60
.0020	.00360	0	+120	-18	+49

No gear changer required.

C. FOR MAXIMUM TEMPERATURES of 250°F or 121°C

Generalized Products

No. 4400 - 5 X 1 – Base Temp. 60°F
No. 4400 - 5 X 3 – Base Temp. 20°C
No. 4400 - 5 X 5 – Base Temp. 15°C

Generalized Crudes

No. 4400 - 5 X 7 – Base Temp. 60°F
No. 4400 - 5 X 8 – Base Temp. 20°C
No. 4400 - 5 X 9 – Base Temp. 15°C

Coefficient of Expansion		Product Temperature			
		°Fahrenheit		°Centigrade	
Per °F	Per °C	Min.	Max.	Min.	Max.
.0003	.00054	+50	+250	+10	+121
.0004	.00072	+50	+250	+10	+121
.0005	.0009	+50	+250	+10	+121

Gear Changer No. 5950-105 required.

D. FOR MAXIMUM TEMPERATURES of 250°F or 121°C

Generalized Products

No. 4400 - 2 X 1 – Base Temp. 60°F
No. 4400 - 2 X 3 – Base Temp. 20°C
No. 4400 - 2 X 5 – Base Temp. 15°C

Generalized Crudes

No. 4400 - 2 X 7 – Base Temp. 60°F
No. 4400 - 2 X 8 – Base Temp. 20°C
No. 4400 - 2 X 9 – Base Temp. 15°C

Coefficient of Expansion		Product Temperature			
		°Fahrenheit		°Centigrade	
Per °F	Per °C	Min.	Max.	Min.	Max.
.0003	.00054	+50	+250	+10	+121
.0004	.00072	+50	+250	+10	+121

No gear changer required. Can be used on meters with net counter only. Gross pulsers cannot be used. To provide the proper gear ratio, the coarse adjustment knob of the 4000 or 4200 Adjustor should be pushed in two notches or about 1.2% from normal setting.

E. FOR MAXIMUM TEMPERATURES of 350°F or 177°C

Generalized Product

No. 4400 - 3 X 1 – Base Temp. 60°F
No. 4400 - 3 X 3 – Base Temp. 20°C
No. 4400 - 3 X 5 – Base Temp. 15°C

Generalized Crudes

No. 4400 - 3 X 7 – Base Temp. 60°F
No. 4400 - 3 X 8 – Base Temp. 20°C
No. 4400 - 3 X 9 – Base Temp. 15°C

Coefficient of Expansion		Product Temperature			
		°Fahrenheit		°Centigrade	
Per °F	Per °C	Min.	Max.	Min.	Max.
.0003	.00054	+150	+350	+66	+177
.0004	.00072	+150	+350	+66	+177
.0005	.0009	+150	+350	+66	+177

Gear Changer No. 5900-940 required for Coefficients .0003 and .0004.

Gear Changer No. 5900-896 required for Coefficient .0005.

F. FOR MAXIMUM TEMPERATURES of 450°F or 232°C

Generalized Products

No. 4400 - 4 X 1 – Base Temp. 60°F
No. 4400 - 4 X 3 – Base Temp. 20°C
No. 4400 - 4 X 5 – Base Temp. 15°C

Generalized Crudes

No. 4400 - 4 X 7 – Base Temp. 60°F
No. 4400 - 4 X 8 – Base Temp. 20°C
No. 4400 - 4 X 9 – Base Temp. 15°C

Coefficient of Expansion		Product Temperature			
		°Fahrenheit		°Centigrade	
Per °F	Per °C	Min.	Max.	Min.	Max.
.0003	.00054	+250	+450	+121	+232
.0004	.00072	+250	+450	+121	+232

Gear Changer No. 5900-896 required.

NOTE: "X" Designates Capillary Tube Length: 2 = 48", 3 = 84", 9 = Special Order

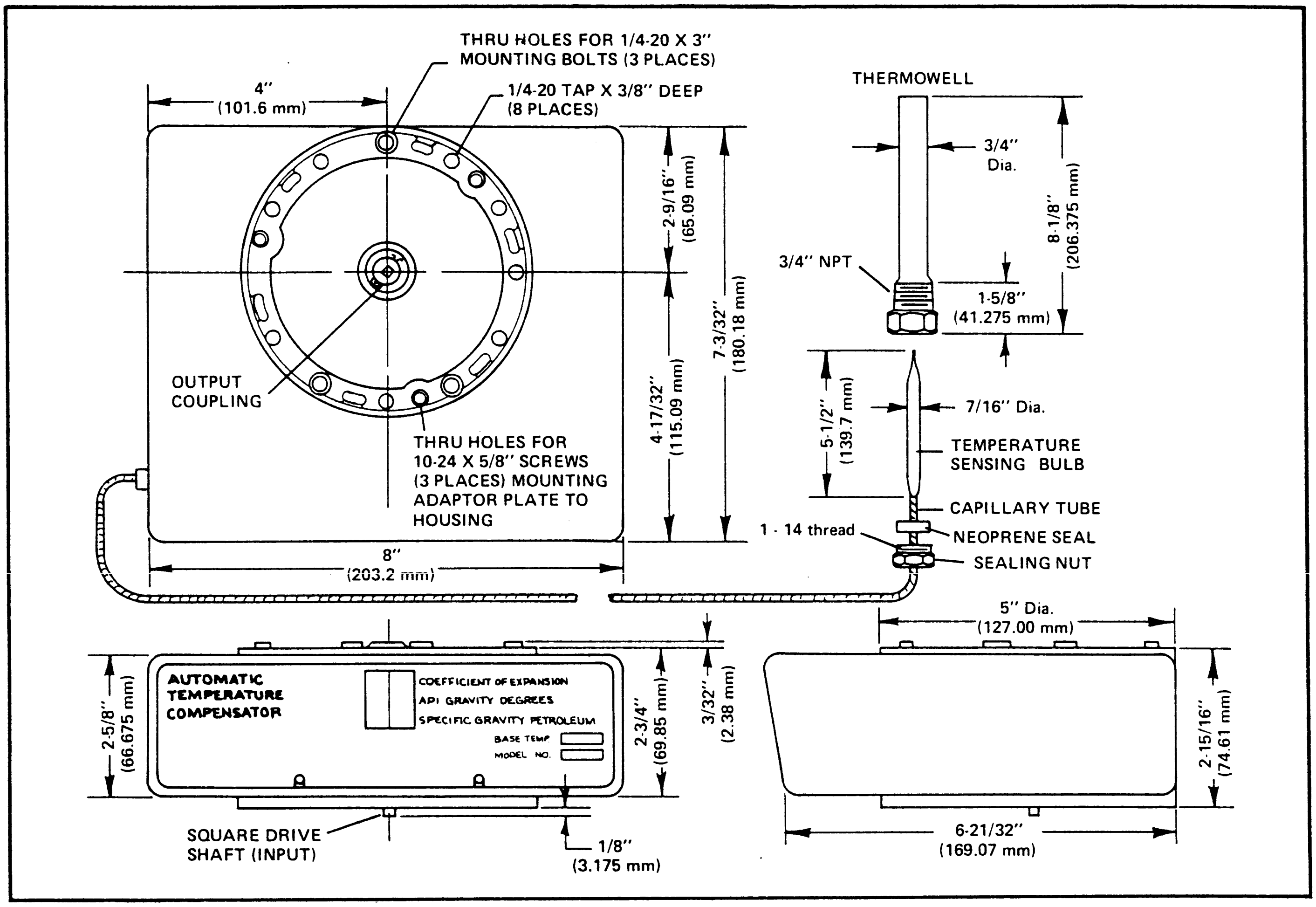


Figure 2-1 Dimensions

Section 2 INSTALLATION

2-1 General

This section contains the procedures for the receipt, return, and installation of the Automatic Temperature Compensator.

2-2 Receipt of Equipment

When the equipment is received, the outside packing case should be checked for any damage incurred during shipment. If the packing case is damaged, the local carrier should be notified at once regarding his liability. A report should be submitted to the Products Service Department, Brodie Meter Co., LLC , Statesboro, Georgia 30458.

Remove the envelope containing the shipping list. Carefully, remove equipment from packing case and inspect for damaged or missing parts. Be sure spare parts or accessories are not discarded with packing material.

2-3 Return Shipment

To be able to process returned goods quickly and efficiently, it is **IMPORTANT** that you provide essential information. **Do not return any assembly or part without an "R.M.R." (Returned Materials Report) or a letter which describes the problem, corrective action (if any) and the work that is to be performed at the factory.** "R.M.R." forms can be obtained from Brodie District Sales Offices or the Service Department, Brodie Meter Co., LLC, Highway 301 North, Statesboro, Georgia 30458.

Place a copy of either of the above inside the shipping container and attach it physically to the material being returned. A copy of your packing list should be placed inside an envelope and attached to the outside of the shipping container or placed inside the container.

Failure to follow the above procedure can result in considerable delay because items either have not been properly identified or have not been identified at all.

2-4 General Installation Information

(Refer to Figure 2-2)

CAUTION: The Brodie 4400 ATC is a precision instrument and care must be exercised during handling and installation to avoid damage to precision components. Any damage or alterations of thermostatic bulb, capillary tube, or bellows will affect the characteristic volume of sensing fluid and impair the accuracy of the instrument.

The ATC may be installed directly on a meter or "stack-up" by positioning the unit with the three mounting holes aligned properly, and installing the three mounting screws (Item 32). A single counter can be mounted on the ATC to indicate net meter thruput (or gross meter thruput during base temperature lockout operation). Dual counters and an adaptor may be incorporated in order to indicate net and gross thruput simultaneously.

The thermowell (Item 77) provided with the ATC should be installed in the meter housing or in adjacent piping. Pass the temperature sensing bulb (Item 1A) through the opening in the sealing nut (Item 73) with sealing nut threads facing the bulb. Insert the bulb into the thermal conductive sleeve (Item 76) and then place it in the thermowell. The corrugated surface of the thermal conductive sleeve provides multiple metal to metal contact between the bulb and thermowell to insure rapid response and accuracy of compensation. Place the neoprene thermowell seal (Item 75), with a back-up washer (Item 74) on each side, on the capillary tube (Item 1B), between the sealing nut and sensing bulb. Tightening the sealing nut to the thermowell will help to provide a weather-proof seal for the bulb. The capillary tube is armored and weather proofed for long life, but should be located to provide adequate protection from damage.

CAUTION: Input speed to the ATC should not exceed 250 RPM, and driving torque required for operating accessory items in a "stack-up" above the ATC should not exceed 30 in. oz.

Failure to comply with the specifications and performance characteristics, and with the proper installation, operation and maintenance instructions, may result in damage to the unit and will void the warranty.

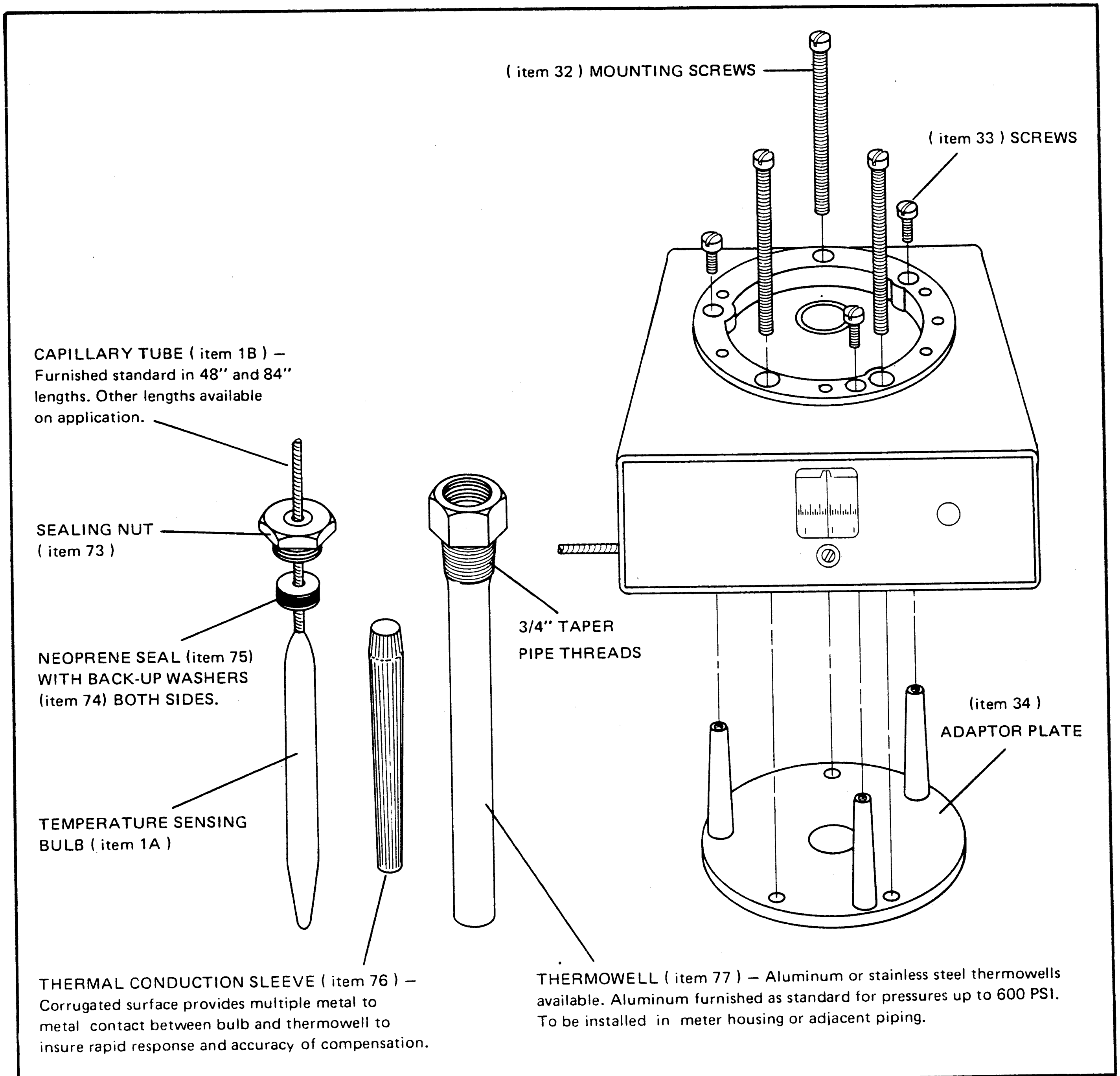


Figure 2-2 Installation Diagram

Section 3 OPERATION

3-1 General

The ATC has been completely assembled, checked, and calibrated at the factory to the coefficient of expansion setting indicated on the scale. Refer to the respective sections for readjustment, if necessary, and maintenance procedures.

3-2 Principle of Operation (Refer to Figure 3-1)

The Brodie Model 4400 Automatic Temperature Compensator utilizes a thermal system in conjunction with a gear train to provide a register drive that compensates a register readout for the effects of thermal expansion and contraction of the metered liquid.

The ATC operates on the principle of subtraction. Rotational input from a meter is increased in velocity through the ATC gear train, and the thermal system determines the exact amount to be subtracted for proper, compensated, rotational output to a register.

Figure 3-1 illustrates how temperature compensation is accomplished. During ATC operation, input from a meter is transmitted from the compound input gear (1) through the compound idler gear (2) where the rotational velocity is increased. This speed-up is applied to the output gear (3) through four planetary gears (4).

In the thermal system, the temperature sensing bulb (5), which is installed in the meter housing or adjacent piping, senses changes in product temperature directly through the thermowell and thermal conduction sleeve. Product temperature changes are transmitted by the bulb through the capillary tube (6) to the product bellows (7). The ambient bellows (8) compensates for changes in the temperature of the surrounding environment affecting the capillary tube and product bellows in such a manner that the movement of the friction roller on the platform gear is a reflection of product temperature changes only. In other words, the ambient bellows cancels any effect of ambient temperature changes on the product bellows and capillary tube.

Changes in product temperature are relayed by the expansion and contraction of the product bellows to position the friction roller (10) on the platform gear (11). This action takes place across a variable pivot point (9). The pivot point is representative of the coefficient of expansion setting indicated on the scale.

The compound input gear drives the platform gear through an idler gear (12), and the platform gear drives the friction roller. The friction roller drives the external teeth of the planetary ring gear (16) through the worm gear (13), worm wheel and spur gear assembly (14), and idler gear (15). The internal teeth of the ring gear are also in contact with the four planetary gears.

As product temperature increases, the product bellows expands, the friction roller moves outward on the platform gear, the ring gear rotates faster, and more is subtracted from the rotational output so that a register would indicate the correct (or compensated) amount.

As product temperature decreases, the product bellows contracts, the friction roller moves inward on the platform gear, the ring gear rotates more slowly, and less is subtracted from the rotational output so that a register would indicate the correct (or compensated) amount.

During base temperature lockout operation, the compound input gear drives the base temperature lockout gear (18) directly through the lockout gears (17). This provides a direct (uncompensated) 1:1 gear ratio drive through the ATC, thus overriding the temperature compensating system. Changing from the ATC mode of operation to lockout operation is accomplished by moving a lever at the rear of the Automatic Temperature Compensator which engages or disengages the lockout gears.

Section 4 COEFFICIENT OF EXPANSION AND SPECIFIC GRAVITY ADJUSTMENT PROCEDURE

Refer to Figure 7-1. The ATC has been calibrated at the factory to the coefficient of expansion setting indicated on the scale (Item 27), and sealed with seal wire (Item 18) and a lead seal (Item 19). In actual use, readjustment of this setting may become necessary. The 4400 ATC incorporates a coefficient selector that can be adjusted, within the limits of a specific model, to the coefficient of thermal expansion of the product to be metered.

NOTE: Adjustment and/or calibration procedures necessitate breakage of the ATC seal. Proper measurement and regulatory officials must be notified prior to seal breakage, and upon installation of new seal when adjustments are completed.

The 4400 Series ATC incorporates three scales graduated in units pertaining to the coefficient of thermal expansion, API gravity degrees, and the specific gravity of petroleum. Any of these scales may be used when setting the selector indicator.

The coefficient of expansion scale provides the most accurate setting and should be used whenever the coefficient for a particular product is known.

Whenever the API gravity of a product is known, the corresponding coefficient of expansion may be found by the use of the chart provided in Figure 4-1. This chart is quite accurate, but greater accuracy may be obtained by the use of API standard 2540-Tables 6A, 6B, 24-A and 24-B.

Examples:

Assume the gravity = 21 A.P.I. (Generalized Crude)

A. Locate 21 A.P.I. gravity on the horizontal scale of the chart (see Figure 4-1).
B. Follow this point vertically to intersect the curve for Generalized Crude.
C. Follow this point of intersection horizontally to the coefficient scale on the left hand side of the chart.
D. Note that the coefficient scale indicates a coefficient of .0004 per degree Fahrenheit for an A.P.I. gravity of 21.

Assume the gravity = 72 A.P.I. (Generalized Product)

A. Locate 72 A.P.I. gravity on the horizontal scale of the chart (see Figure 4-1).
B. Follow this point vertically to intersect the curve for Generalized Product.
C. Follow the point of intersection horizontally to the coefficient scale at the left.
D. Note that the coefficient scale indicates a coefficient of .00075 per degree Fahrenheit for an A.P.I. gravity of 72.

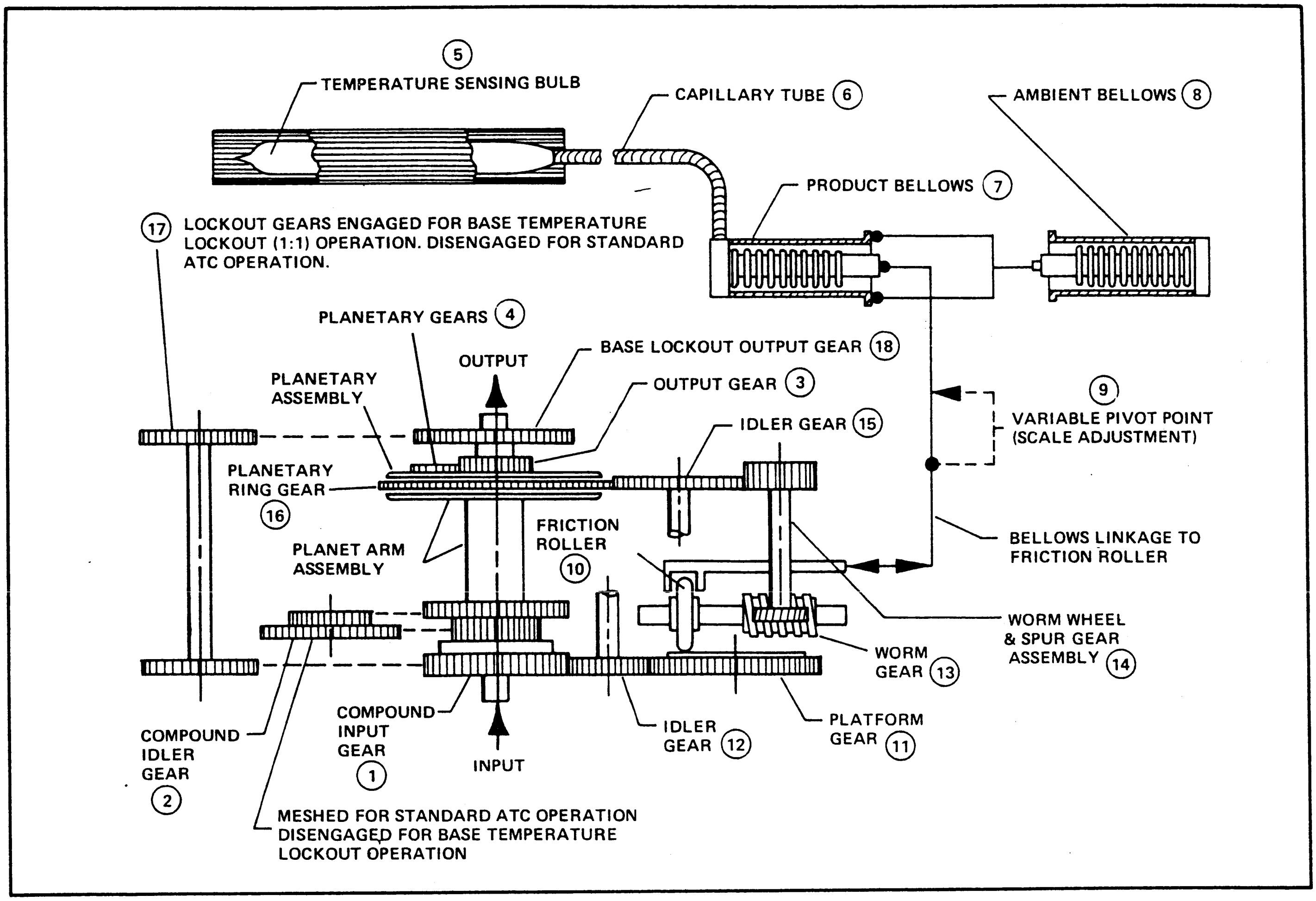


Figure 3-1 ATC Schematic Diagram

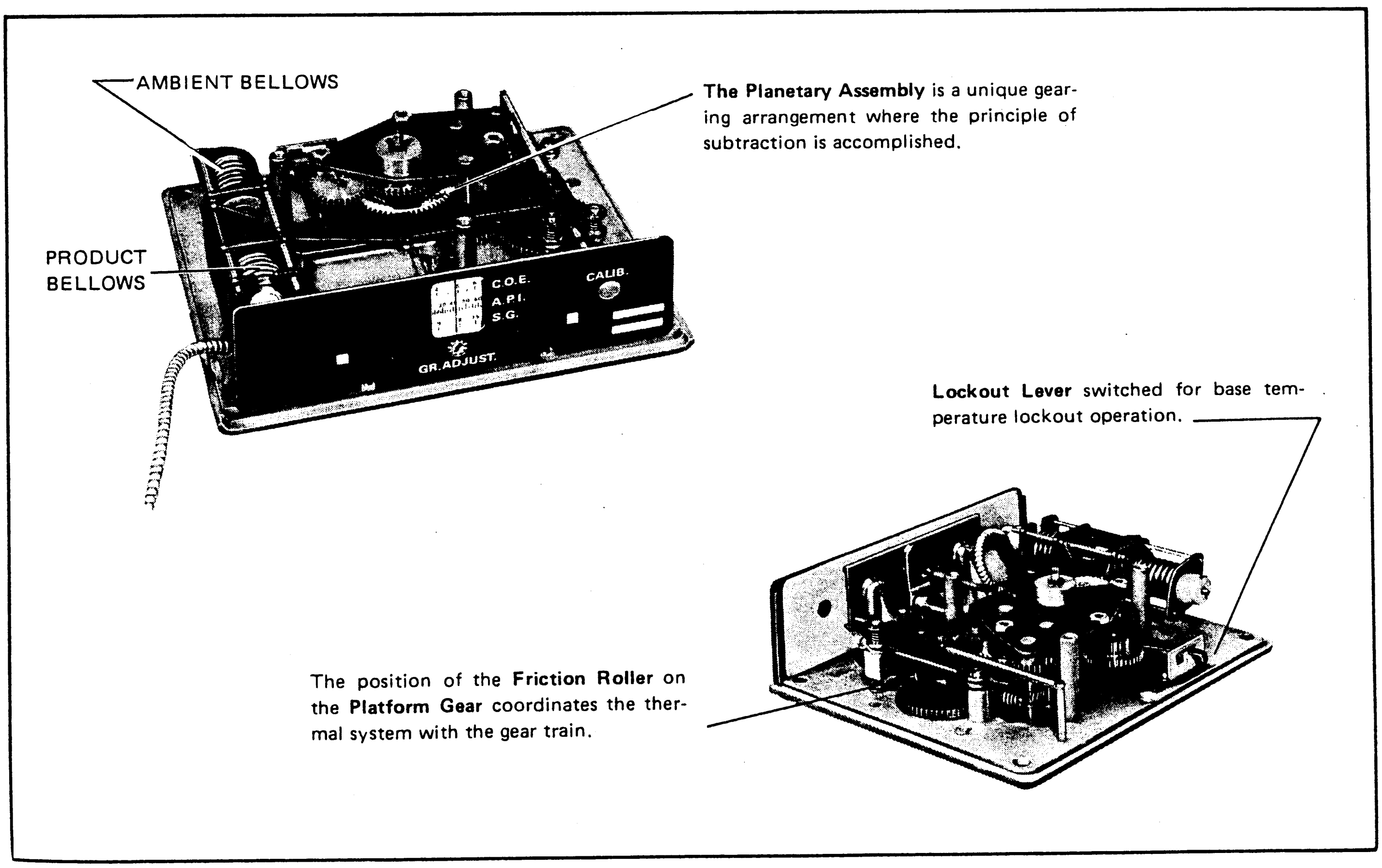


Figure 3-2 ATC with the Housing Removed Illustrates the Layout of the Thermal System and Gear Train

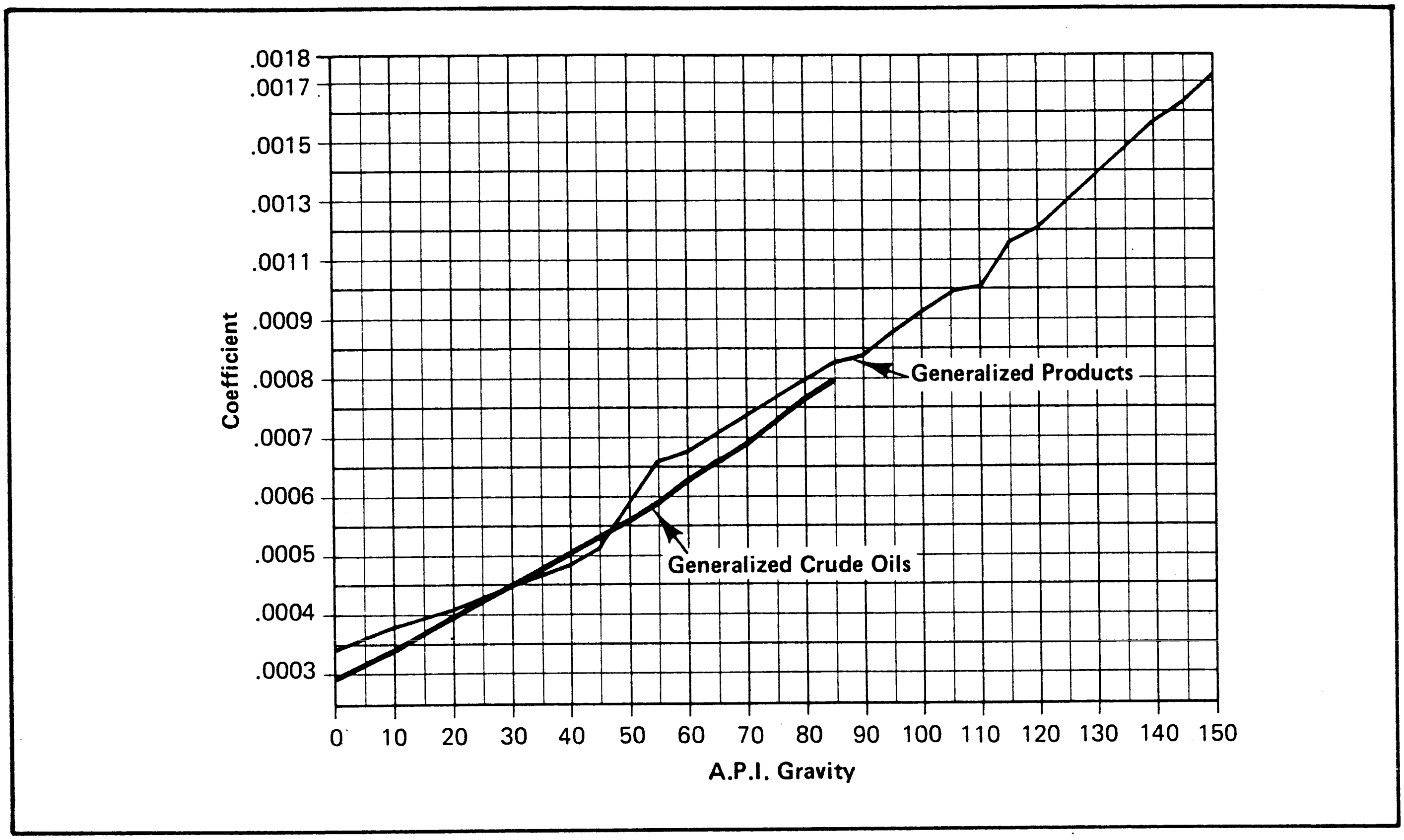


Figure 4-1 Coefficient of Expansion vs. A.P.I. Gravity Chart

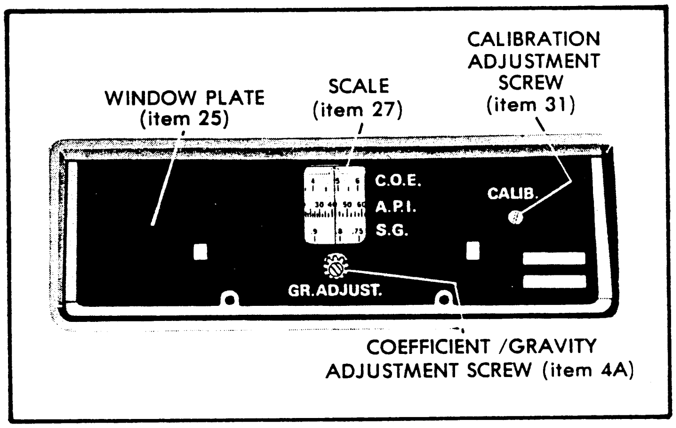


Figure 4-2 ATC with Front Window Removed Provides Access to Adjustments

Refer to Figure 4-2 and 7-1. To readjust the coefficient of expansion or gravity setting, remove the two window mounting screws (Item 20) and shims (Item 21), and remove the window (Item 22). This will expose the window plate (Item 25) as illustrated in Figure 4-2. Turn the coefficient/gravity adjustment screw (Item 4A) until the desired setting is indicated on the scale. **NOTE: A change in coefficient setting of high temperature models will require recalibration of the ATC.** Replace the window and secure by installing two window mounting screws with shims.

Section 5 CALIBRATION PROCEDURE

5-1 Preliminary Calibration Information

The 4400 ATC is designed for use within the product and ambient temperature ranges designated by the model number. The unit is calibrated for the base compensation temperature (shown on the window and also specified by the model number - see Tables 1-1 and 1-3), at the coefficient of expansion indicated on the scale, and sealed with seal wire and a lead seal.

Good process engineering practice requires the establishment of a suitable proving schedule performed at definite intervals to determine if recalibration is necessary. In this way only can the high accuracy, of which the instrument is capable, be maintained.

NOTE: Calibration procedure and base temperature lockout operation necessitate breakage of the ATC seals. Proper measurement and regulatory officials must be notified prior to seal breakage, and upon installation of new seals when adjustments are completed.

The proper methods and equipment must be employed when proving meters with ATC in order to obtain the high degree of accuracy required. Points that should be particuarly stressed are as follows:

1. Prover tanks must be equipped with accurate mercury-in-glass thermometers or mechanical (dial type) temperature indicators properly spaced to give true average temperature.
2. An accurate mercury-in-glass or dial type thermometer should be provided adjacent to meter.
3. Thermometers should be graduated for reading to 1/2 degree or less and interpolated to the nearest 1/10 of a degree F.

4. Counters reading in barrels must be read to the third decimal place (1/1000 barrel).
5. Make certain the ATC is adjusted for the proper coefficient of expansion. If readjustment is necessary, refer to the coefficient of expansion and specific gravity adjustment procedure, Section 4.
6. Flow rate when proving should be same as normal operation.
7. For highest degree of accuracy, mechanical counters should not be reset at any time during the proving cycles to avoid introduction of gear train backlash.
8. Uniformity of test procedures and careful recording of data is very important. The interval of time between tests should be the same for all runs. Reading of prover volume and thermometers should be timed with a stop watch and taken after the same interval on each test. The same person should take the same readings each time.
9. If a meter has been idle for some time, product should be run through it to stabilize the line temperature before proving to adjust the gross counter.
10. If an adjustor is incorporated in the meter assembly "stack-up", it should be used to prove the meter volumetrically prior to ATC calibration. Make certain adjustor is used with reference to a gross counter (on dual counter installations) or a net counter with the base temperature lockout engaged.

5-2 ATC Calibration with Net Counter Only

Refer to Figure 7-1. Remove the two screws (Item 29) and the lockout cover assembly (Item 30) from the back of ATC, and switch the lockout control lever (16A) of the lockout assembly (Item 16) to provide a 1:1 ratio, uncorrected readout to the net counter (base temperature lockout operation).

NOTE: Care should be taken to account for any non-unity gear changer ratios in the accessory "stack-up" between meter and counter when using the base temperature lockout.

The net counter can now be used to indicate gross thruput to prove the meter volumetrically. Running a specific volume through the meter should result in a net counter readout equal to the quantity of liquid indicated by the volumetric prover. Proper temperature correction factors must be incorporated for product temperature differences between the meter and the prover.

If there is a discrepancy between meter readout and prover readout, adjustment is necessary. Compensation for the percent discrepancy can be accomplished according to the type of adjustment devices incorporated in a particular system (such as an adjustor, gear changers, etc.; or by establishing a a meter factor - desirable in some pipeline installations).

Once the meter has been proven, shift the lockout control lever (16A) of the base temperature lockout assembly (Item 16) back to the temperature correcting position. Running a specific volume through the meter, at a product temperature within the operating range of the ATC, should now result in a counter readout of net meter thruput (the volume of metered liquid corrected by calculation, with respect to the base temperature). If there is a discrepancy between actual readout and the calculated amount, adjustment is necessary. Remove the two screws (Item 20), shims (Item 21), and window (Item 22) from the face of the ATC. This will expose the window plate (Item 25) as illustrated in Figure 4-2. Compensation for the percent discrepancy can be accomplished by turning the calibration adjustment screw. Turning the screw in a clockwise direction will decrease the net counter readout, while counterclockwise adjustments increase counter readout. Each 1/4 turn of the calibration adjustment screw equals approximately 0.10%. See ATC calibration example, Table 5-1.

Table 5-1
ATC Calibration Example

Assume the following:

Coefficient of Product	=	.0006/^{o}F
Gross Counter Reading of Proving Run	=	655 Gallons
Net Counter Reading of Proving Run	=	653.95 Gallons
Line Temperature During Proving Run	=	66^{o}F
ATC Base Temperature	=	60^{o}F
Temperature Change	=	66-60 = 6^{o}F
Corrected Gross Counter Reading	=	655 -(655 x .0006 x 6)
	=	655 - 2.36
	=	652.64

Comparison of net counter with corrected gross counter reading indicates a net counter error:

Net Counter Error	=	653.95 - 652.64
	=	1.31
Percent Error	=	1.31/652.64 x 100
	=	0.20%

Corrective adjustment would be approximately 1/2 turn clockwise of the calibration adjustment screw. (Each 1/4 turn equals approximately 0.10%).

5-3 ATC Calibration with Dual (Net and Gross) Counters

Before attempting to calibrate the ATC, it is necessary to prove the meter volumetrically. Running a specific volume through the meter, at a product temperature equal to the base temperature, should result in a gross counter readout equal to the quantity of liquid indicated by the volumetric prover. Proper temperature correction factors must be incorporated for product temperatures other than that of the base temperature.

If there is a discrepancy between meter readout of the gross counter and prover readout, adjustment is necessary. Compensation for the percent discrepancy can be accomplished according to the type of adjustment devices incorporated in a particular system (such as an adjustor, gear changers, etc.; or by establishing a meter factor - desirable in some pipeline installations).

Once the meter has been proven, the ATC can be checked and calibrated if necessary. Running a specific volume through the meter, at a product temperature within the operating range of the ATC, should now result in a net counter readout of net meter thruput. In other words, the net counter should display the gross counter readout corrected, by calculation, with respect to the base temperature. If there is a discrepancy between net counter readout and the calculated amount, adjustment is necessary. Remove the two screws (Item 20) shims (Item 21), and window (Item 22) from the face of the ATC. This will expose the window plate (Item 25) as illustrated in Figure 4-2. Compensation for the percent discrepancy can be accomplished by turning the calibration adjustment screw. Turning the screw in a clockwise direction will decrease the net counter readout, while counter-clockwise adjustments increase counter readout. Each 1/4 turn of the calibration adjustment screw equals approximately 0.10%. See ATC calibration example, Table 5-1.

5-4 Instrument Shop Test Calibration

Inspection and calibration should be performed at regular intervals by the instrument shop. When removing an ATC for calibration, other accessory equipment should be checked for freeness of operation.

The interval of time between inspection varies with the type of installation and should be determined through experience.

The first step in preventive maintenance is to test the ATC for malfunction prior to disassembly for inspection, cleaning and lubrication (refer to Section 6).

1. To calibrate the ATC requires a test fixture to drive the unit, net and gross counters to monitor the ATC input and output shaft revolutions and 3 controlled temperature baths in which the product temperature sensing bulb may be immersed. Temperature baths should be controlled closely, and be equipped with precision thermometers graduated to 1/2 degree or less. For accurate calibration bath temperatures must remain stable over the course of the test. It is recommended that one bath temperature be maintained at approximately mid-point of the ATC temperature range, with the other two baths at approximately 30°F to 50°F above and below the mid-bath temperature. For example, the bath temperatures for an ambient temperature ATC might be 32°F, 60°F and 110°F. For ambient temperature ATC's the mid-temp. bath should always be at the base temperature (60°F, 20°C or 15°C). Bath temperatures for a high temperature unit (No. 4400-321 for example) might be 200°F, 250°F and 300°F.
2. With the ATC, net counter and gross counter installed on the test fixture, set the speed control so that the gross counter runs at approximately 50 RPM. (Make all tests at this speed and of 100 revolution duration). If the unit is a high temperature model requiring a gear changer, be sure the proper gear changer is included in the stack-up under the ATC.
3. Immerse the product temperature sensing bulb in the mid-temp bath and allow the unit to run at least five minutes to stabilize temperature in the bulb and system. NOTE: The unit should always be running when making any adjustments.
4. To check alignment of the main lever turn the gravity adjustment screw to the lowest scale setting and make two or three runs of 100 revolutions each as indicated by the gross counter. Record the net counter readings after each run.

   Turn the coefficient/gravity adjustment screw to the highest scale setting and again make two or three runs, observing the net counter reading after each run. If the lever is properly aligned, readings on the net counter will be the same within .0010 when the gravity adjustment is at either end of the scale travel. If the readings are not the same the adjustment screw at the end of the product bellows stem must be adjusted and the above procedure repeated until the readings are within the acceptable limits.
5. With the temperature bulb still in the mid-temperature bath and with the unit running, turn the coefficient/gravity adjustment screw until the desired coefficient of expansion setting is indicated on the scale. Make several runs of 100 revolutions as indicated by the gross counter, checking the net counter to determine if the unit is properly "zeroed". If the mid-temperature bath is equal to the base temperature, net and gross counter readings should be the same within .02%. If the mid-temperature bath is not equal to the base temperature (high temp. ATC's, etc.), the net counter reading may be calculated with the following equation: $V_n = V_g - V_g\,(t - t_o)c$

   In which: V_n = Net Counter Reading
   V_g = Gross Counter Reading
   c = Coefficient of expansion/°F
   t = Actual Bath Temperature (°F)
   t_o = Base temperature eg. 60°F, 15°C (50°F) or 20°C (68°F)

   Note that all temperature values are in degrees Fahrenheit.

   If net counter readings are not within acceptable limits, the unit may be corrected by means of the calibration adjustment screw. Turning the screw clockwise will decrease net counter readings, and conversely, counter-clockwise will increase net counter readings. One turn of the screw will change the net counter reading approximately .4%. Continue adjustments until net counter readings are within acceptable limits.
6. Remove the temperature bulb from the mid-temperature bath and immerse it in the highest temperature bath. Run the unit for at least 5 minutes to allow the temperature system to stabilize.
7. After the stabilization period make several runs comparing net counter reading with a computed net quantity using the equation in Step 5 and the actual temperature of the high temperature bath. Net counter readings should be within ± .0005 or ± 1°F X C.O.E. (whichever is larger) of the calculated value. For example, if coefficient of expansion (C.O.E.) is .0004/°F the net counter reading should be within ± .05%. If the COE is

.0008/°F the net reading should be within ± .08% of the calculated value. If net readings are not within the allowable tolerance of the calculated figure adjust the coefficient/gravity adjustment screw and repeat this step until readings of the net counter are within allowable limits of the calculated figure.

8. Remove the temperature sense bulb from the high temperature bath and immerse it in the mid-temperature bath. After a 5 minute (min.) stabilization period, make two or three runs observing the net counter reading to be sure the unit returns to the mid-temperature reading. Net counter reading should agree with the calculated values obtained in Step 5 within .05%. If necessary the calibration adjustment screw may be adjusted to bring the net reading within specs. However, this will require repeating Steps 6 and 7 to be sure this adjustment did not change the high temperature setting.

9. Next remove the bulb from the mid-temperature bath and immerse it in the lowest temperature bath. After at least a 5 minute temperature stabilization period, make several test runs, again comparing net counter readings to a computed value using the equation in Step 5 and the actual temperature value for the low temperature bath, as in the high temperature bath, net readings should agree with the computed value within .0005 or 1°F X COE whichever is larger.

10. Return the temperature sense bulb to the mid-temperature bath and after 5 minutes of stabilization, again check the net counter readings to be sure the unit returns properly from a low temperature direction. Net readings should be within .05% of the calculated values for this bath temperature.

    On 4400-2XX Models only. After the calibration procedure has been completed and with the sense bulb in the mid-temperature bath, the calibration adjustment screw should be rotated counter-clockwise approximately 3 turns until the net reading is 1.2% greater than the calculated net reading using the equation in Step 5.

11. If it was necessary in Step 7 to adjust the coefficient adjustment screw, the coefficient scale can be adjusted to the hairline by loosening the small set screws holding the scale drive gear to the coefficient adjustment screw. The set screws (incorporated in the indicator assembly Item 26) tighten to the indicator shaft assembly (item 4) behind the scale, and are accessible once the housing has been removed (refer to Removal/Disassembly).

Section 6 MAINTENANCE

6-1 General

As with all precision instruments, it is important to establish preventive maintenance and inspection procedures in order to insure high sustained accuracy of the Brodie 4400 ATC.

CAUTION:

No attempt should be made to disassemble and/or service the 4400 ATC with the exception of lubrication and bellows assembly replacement. Maintenance procedures should be performed by qualified personnel.

Exchange information and conditions are specified in a separate bulletin, Price List Section 4, available from Brodie Meter Co., LLC. Consult Brodie Service Department for additional information.

NOTE: **Lubrication and bellows assembly replacement procedures necessitate breakage of the ATC seals. Proper measurement and regulatory officials must be notified prior to seal breakage, and upon installation of new seals as procedures are completed.**

6-2 Removal/Disassembly

Refer to Figure 7-1 and Table 7-1.

1. Unscrew the sealing nut (Item 73) and remove the temperature sensing bulb (1A) from the thermowell (Item 77). **Use care not to dent or damage bulb or capillary tube.**
2. Remove three mounting screws (Item 32) from the top of the ATC and remove the entire unit from the "stack-up".
3. Remove three screws (Item 33) from the top of the ATC that hold the adaptor plate (Item 34) and remove the adaptor plate.
4. Remove the cotter pin (Item 35) from the coupling (Item 36) and remove coupling and slinger (Item 37). **Do not remove O-Ring (Item 38). Note: When the ATC is assembled at the factory, shims (Item 64) are installed under the O-Ring as required so that the O-Ring must be compressed upon installation of the slinger, coupling and cotter pin, providing a waterproof seal. If the O-Ring and shims are removed during disassembly, sufficient shims must be installed during reassembly in order to retain the waterproof seal.**
5. Remove the two index screws (Item 39) and two shoulder screws (Item 40) from the ATC base plate to separate the base plate (Item 41) from the housing (Item 42). Remove the housing. Note the location of the index screws and shoulder screws (see Figure 7-1) during disassembly. The location of these screws must be retained upon reassembly and installation.

6-3 Lubrication

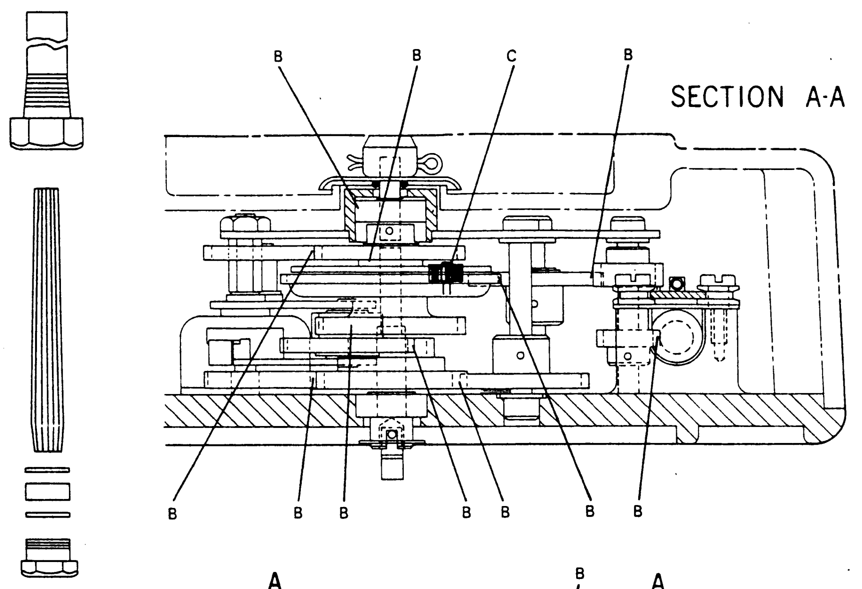
The points of lubrication are labeled in Figure 6-1, and the corresponding lubricants are given in Table 6-1.

The drive surface of the platform gear and the surface between the control yoke and the friction roller should be lubricated lightly with a multi-purpose grease, such as Mystik JT-6 or equivalent.

All gear meshes, ball bearings, and any sliding or moving parts within the bellows linkage should be lubricated with a silicone base lubricating grease, such as G.E. G-322L or the equivalent.

Table 6-1
Lubricants

A.	Mystik JT-6 (Multi-purpose Grease) Capitol Supply Co. 3480 Brownsville Road Atlanta, GA
B.	G-322L (Silicone Lubricating Grease) Southeastern Radio Supply Co. 414 Hillsborough Street Raleigh, NC
C.	Lubri Plate No. 1 (Light Oil) Any General Supply House



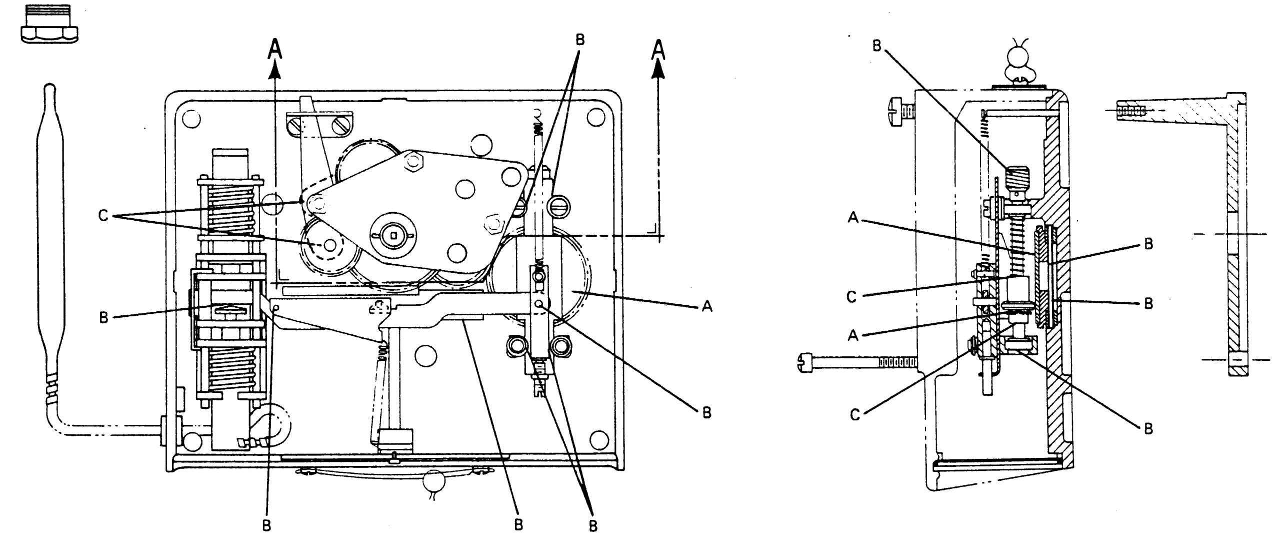


Figure 6-1 Points of Lubrication

A light oil, such as Lubriplate No. 1 or the equivalent, should be used to lubricate the planetary gear shafts within the planetary assembly, the roller shaft at each side of the friction roller, and the lockout shaft bushing in the lockout assembly.

Plastic bushings in the base plate, bearing plate, and roller assembly are self-lubricating.

6-4 Bellows Assembly Replacement

Refer to Figures 3-1, 7-1 and 7-2. The accuracy of the ATC is dependent upon the condition of the temperature sensing bulb, capillary tube, product bellows and ambient bellows which make up the bellows assembly. Each bellows assembly is manufactured under precise tolerances and its components are carefully matched and thoroughly tested to assure accurate and reliable service. If any part of the bellows assembly becomes dented, damaged or physically altered in any manner, the entire bellows assembly must be replaced:

1. Follow Section 6-2 for Removal/Disassembly of the ATC.
2. (Refer to Figure 7-2). While rotating input shaft in a clockwise direction gradually pull on main lever assembly (Item 2) at point B directly above the platform gear (Item 6) towards the front of unit. This will cause the friction roller (5A) to travel to the outboard edge of the platform gear thus exposing the two bellows assembly mounting screws (Item 44). Remove the two mounting screws (Item 44). **CAUTION: Apply downward pressure at point A (Refer to Figure 7-2) on main lever assembly.** Carefully remove complete bellows assembly (Item 1) by gently lifting up and out.
3. Remove the grommet (Item 43) from the capillary tube and place it on the capillary tube of the replacement bellows assembly.
4. Place the new bellows assembly in position and secure with the two bellows assembly mounting screws.

NOTE: Upon reassembly of the ATC be certain to locate grommet correctly in the opening between the housing and the base plate.

BELLOWS ASSEMBLY REPLACEMENT REQUIRES RE-CALIBRATION OF THE ATC. (See Section 5).

6-5 Reassembly/Installation

For reassembly and installation, follow the reverse order of Steps 1 through 5 of the removal and disassembly procedure (Section 6-2).

Section 7 PARTS LIST - 4400 ATC

7-1 General

This section contains the necessary parts required to make-up any standard unit that is covered in this bulletin. Each parts list also contains the recommended spare and replacement parts denoted by an asterisk (*). To expedite the shipment of parts, specify the order or purchase order number, serial number, item number and part number in all correspondence. Reference Section 2, paragraphs 2-2 and 2-3.

Table 7-1 Parts List

ITEM	DESCRIPTION	No. REQ.	PART NUMBER
1	Bellows Assembly	1	See Table 7-2
1A	Temperature Sensing Bulb	1	
1B	Capillary Tube	1	
1C	Product Bellows	1	
1D	Ambient Bellows	1	
2	Main Lever Assembly	1	4435
3	Main Pivot Slide Assembly	1	4430
4	Indicator Shaft Assembly	1	4440
4A	Coefficient/Gravity Adj. Screw	1	
* 5	Roller Shaft Assembly	1	See Table 7-2
5A	Friction Roller	1	
5B	Roller-Shaft Spring	1	
5C	Worm Gear	1	
* 6	Platform Gear Assembly	1	4670
7	Control Slide Assembly	1	4425
8	Slide-Control Spring	1	4489
9	Shaft Assembly	1	796-00-330-03
10	Input Shaft Assembly	1	4455
11	Platform Drive/Input Gear Ass'y.	1	See Table 7-2
11A	Platform Drive Gear	1	
11B	Input Gear		
12	Input Idler Gear Assembly	1	4470
13	Worm Shaft Assembly	1	See Table 7-2
13A	Worm Wheel	1	
13B	Spur Gear	1	
14	Output Idler Gear Assembly	1	4475
15	Planetary Gear Assembly	1	4465
15A	Ring Gear	1	
15B	Planetary Gear	4	
15C	Planetary Plates	2	
15D	Output Reduction Gear	1	
16	Lockout Assembly	1	See Table 7-2
16A	Lockout Control Lever	1	
16B	Compound Gear Assembly	1	
16C	Lockout Gear	2	
17	Output Gear Assembly	1	4450
17A	Output Gear	1	
17B	Base Temperature Lockout Output Gear	1	
18	Seal Wire	As. Req.	155051
19	Lead Seal	2	151831
20	Screw 8-32 X 1/2 Fil. Hd.	2	150527-324
21	Shim	2	152540
22	Window	1	4447
23	Window Gasket-Bottom	1	4446
24	Window Gasket-Top	1	4448
25	Window Plate	1	4444
26	Indicator Assembly	1	4445
27	Scale	1	See Table 7-2
28	Spring	1	4443
29	Screw 8-32 X 5/16 Fil. Hd.	2	150524-324

ITEM	DESCRIPTION	NO. REQ.	PART NUMBER
30	Lockout Cover Assembly	1	4490
31	Calibration Adjustment Screw	1	4403
32	Screw 1/4-20 x 3 Fil. Hd.	3	150561
33	Screw No. 10-24 x 5/8 Fil. Hd.	3	150537
34	Adaptor Plate Assembly	1	4495
*35	Cotter Pin	1	153904
*36	Coupling	1	4125
37	Slinger	1	4532
38	O-Ring	1	152064
39	Screw 1/4-20 X 1/2 Fil. Hd.	2	150552
40	Shoulder Screw	2	4413
41	Base Plate Assembly	1	4405
42	Housing	1	4499
43	Grommet	1	4459
44	Screw 8-32 x 1/2 Fil. Hd.	2	150527
45	Screw 8-32 x 1/4 Round Hd.	2	150124
46	Lockout Bracket	1	4401
47	Bearing Plate Assembly	1	4420
48	Nut 8-32	3	151527
49	Screw 6-32 x 1/4 Bind Hd.	2	150630
50	Shoulder Screw	2	4411
51	Ball Bearing	1	155181
52	Ball Bearing	3	155195
53	Bearing	1	155153
54	Bearing Block	1	4402
55	Bearing Retainer	1	4458
56	Thrust Bearing Race	2	155154
57	Pivot Bushing	1	4432
58	Spacer Bushing	1	4439
59	Guide Bushing	4	4684
60	Retaining Ring	1	156483
61	Retaining Ring	1	156511
62	Retaining Ring	1	153955
63	Retaining Ring	2	156484
64	Shim	As Req.	152512
65	Shim	As Req.	152502
66	Shim	2	152530
67	Shim	1	152538
68	Spring	2	4483
69	Friction Spring	1	4484
70	Washer	2	152504
71	Dowel Pin	1	154018
72	Pillar	3	4449
73	Thermowell Seal Nut	1	4662
74	Backup Washer	2	4659
75	Thermowell Seal	1	4661
76	Thermal Conduction Sleeve	1	4663
77	Thermowell (Aluminum)	1	4657
	Thermowell (Stainless Steel)	1	4658

*Recommended Spare Parts

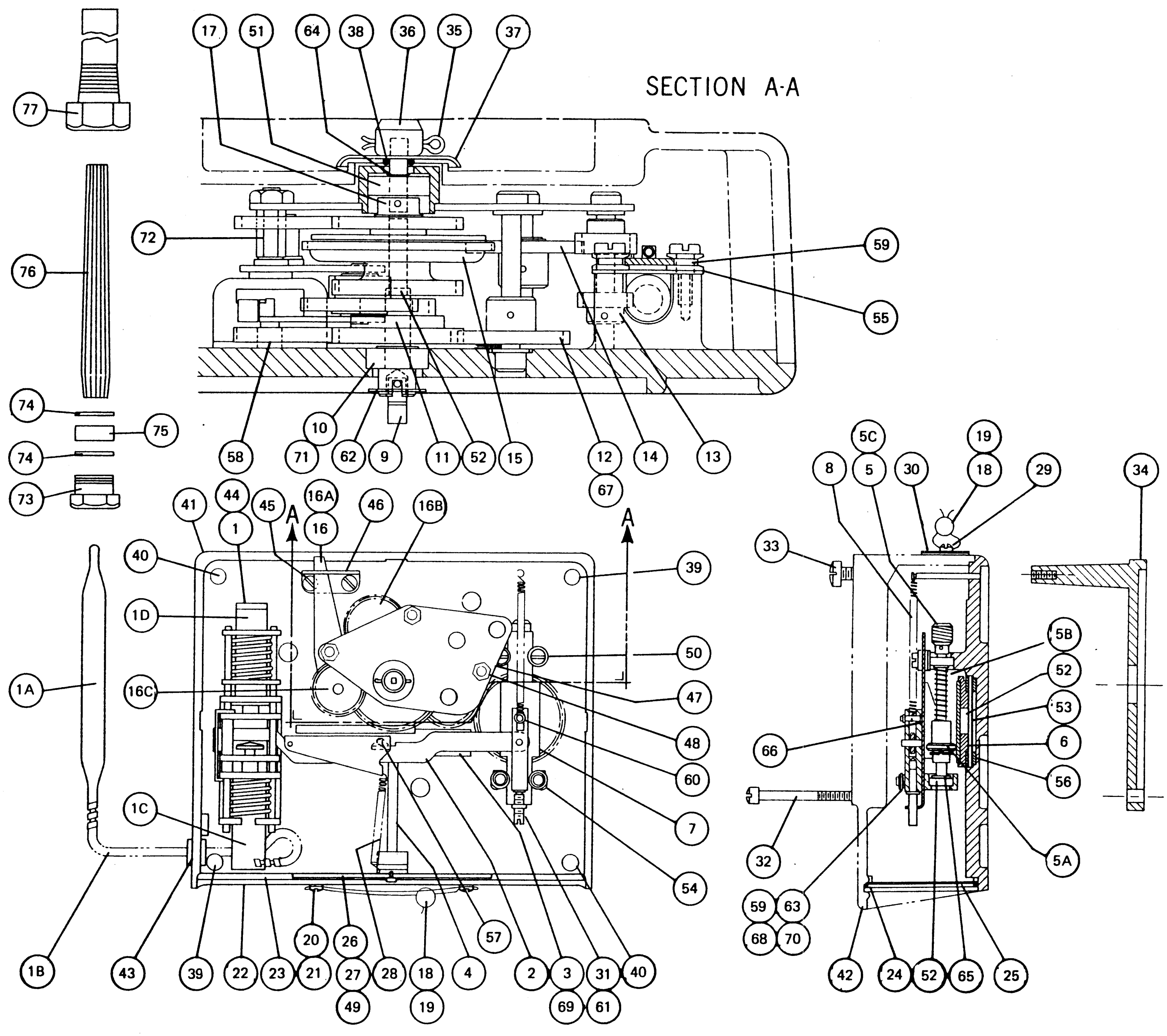


Figure 7-1 Parts Diagram

Table 7-2 Parts Required per ATC Model Number (Generalized Products)

<table>
<tr><th>BASE TEMP.</th><th>CAPIL-LARY TUBE LENGTH</th><th>ATC MODEL NO.</th><th>ITEM 1 BELLOWS ASS'Y</th><th>ITEM 5 ROLLER SHAFT ASS'Y</th><th>ITEM 11 PLATFORM DRIVE/INPUT GEAR ASS'Y</th><th>ITEM 13 WORM SHAFT ASS'Y</th><th>ITEM 16 LOCKOUT ASS'Y</th><th>ITEM 27 SCALE</th><th>GEAR CHANGER PART NO.</th></tr>
<tr><td rowspan="3">60°F</td><td>48"</td><td>4400-121</td><td>4410-120</td><td rowspan="9">4485-001</td><td rowspan="9">4460-001</td><td rowspan="9">4480-001</td><td rowspan="9">4415-001</td><td rowspan="3">4476</td><td rowspan="18">NONE REQUIRED</td></tr>
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<tr><td rowspan="3">20°C</td><td>48"</td><td>4400-123</td><td>-120</td><td rowspan="6">4478</td></tr>
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<tr><td>†</td><td>-193</td><td>-190</td></tr>
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<tr><td>†</td><td>-195</td><td>-190</td></tr>
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<tr><td>84"</td><td>-231</td><td>-230</td></tr>
<tr><td>†</td><td>-291</td><td>-290</td></tr>
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(For Coefficients)
.0003 and .0004°F
(.00054 to .00072°C)
5900-896
(For Coefficients)
.00041 to .0005°F
(.00072 to .0009°C)</td></tr>
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<tr><td>84"</td><td>535</td><td>-230</td></tr>
<tr><td>†</td><td>-595</td><td>-290</td></tr>
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† LENGTH TO BE SPECIFIED ON SALES ORDER.

Table 7-3 Parts Required per ATC Model Number (Generalized Crude Oil)

BASE TEMP	CAPIL-LARY TUBE LENGTH	ATC MODEL NO.	ITEM 1 BELLOWS ASS'Y	ITEM 5 ROLLER SHAFT ASS'Y	ITEM 11 PLATFORM DRIVE/INPUT GEAR ASS'Y	ITEM 13 WORM SHAFT ASS'Y	ITEM 16 LOCKOUT ASS'Y	ITEM 27 SCALE	GEAR CHANGER PART NO.
	48"	4400-127	4410-120						
60°F	84"	4400-137	4410-130					4476-001	
	†	4400-197	4410-190						
	48"	4400-128	4410-120						
20°C	84"	4400-138	4410-130	4485-001	4460-001	4480-001	4415-001		NONE
	†	4400-198	4410-190					4478-001	REQUIRED
	48"	4400-129	4410-120						
15°C	84"	4400-139	4410-130						
	†	4400-199	4410-190						
	48"	4400-227	4410-220						NO GEAR CHANGER REQUIRED. USE WITH NET CTRS. ONLY. PUSH ADJUSTOR COARSE ADJUSTMENT IN TWO NOTCHES (1.2%) FROM NORMAL SETTING TO PROVIDE GEAR RATIO.
60°F	84"	4400-237	4410-230					4476-001	
	†	4400-297	4410-290						
	48"	4400-228	4410-220						
20°C	84"	4400-238	4410-230	4485-001	4460-001	4480-001	4415-001		
	†	4400-298	4410-290					4478-001	
	48"	4400-229	4410-220						
15°C	84"	4400-239	4410-230						
	†	4400-299	4410-290						
	48"	4400-327	4410-320						5900-940
60°F	84"	4400-337	4410-330					4476-001	(For Coefficients)
	†	4400-397	4410-390						.0003 and .0004°F
	48"	4400-328	4410-320						(.00054 to .00072°C)
20°C	84"	4400-338	4410-330	4485-001	4460-001	4480-001	4415-001		5900-896
	†	4400-398	4410-390					4478-001	(For Coefficients)
	48"	4400-329	4410-320						.00041 to .0005°F
15°C	84"	4400-339	4410-330						(.00072 to .0009°C)
	†	4400-399	4410-390						
	48"	4400-427	4410-420						
60°F	84"	4400-437	4410-430					4476-001	
	†	4400-497	4410-490						
	48"	4400-428	4410-420						
20°C	84"	4400-438	4410-430	4485-001	4460-001	4480-001	4415-001		5900-896
	†	4400-498	4410-490						
	48"	4400-429	4410-420					4478-001	
15°C	84"	4400-439	4410-430						
	†	4400-499	4410-490						
	48"	4400-527	4410-220						
60°F	84"	4400-537	4410-230					4476-001	
	†	4400-597	4410-290						
	48"	4400-528	4410-220						
20°C	84"	4400-538	4410-230	4485-001	4460-001	4480-001	4415-001		5950-105
	†	4400-598	4410-290						
	48"	4400-529	4410-220					4478-001	
15°C	84"	4400-539	4410-230						
	†	4400-599	4410-290						

† LENGTH TO BE SPECIFIED ON SALES ORDER.

Section 8 TROUBLESHOOTING

8-1 General

The following improper performance conditions have been developed as an aid in locating trouble spots in the ATC only. Before performing troubleshooting procedures on the ATC, make certain the meter and all systems within a stack-up are operating properly. If trouble occurs, determine the probable causes in an effort to pinpoint the source of the problem, i.e., if a counter does not register at all, first make certain that there is flow through the meter.

Further troubleshooting of the ATC other than listed in Table 8-1 is not recommended. Reference Section 6, paragraph 6-1, page 14.

Table 8-1
TROUBLESHOOTING

Symptom	Possible Cause	Remedy
Counter indicates over-registration	Damaged Product bellows and/or capillary tube Friction roller slipping on the platform gear	Replace Bellows Assembly Refer to "Brooks Exchange Policy" (See Price List Section 4)
Counter indicates under-registration	Damaged ambient bellows Gross wear of the friction roller	Replace bellows assembly Refer to "Brooks Exchange Policy"
Small errors in counter readout	Lack of lubrication or presence of foreign materials	Perform proper lubrication and maintenance procedures
Gradual decline in ATC accuracy	Indicative of gross wear and need of ATC replacement	Refer to "Brooks Exchange Policy"

Guarantees

If at any time within one year after shipment but not thereafter it is proved that any part of the equipment furnished by us was defective when shipped by us we will replace the same free of charge F.O.B. our plant. Notice of this claim must be made to us within one year after delivery. Our liability is limited to replacement of such defective parts or equipment. There are no guarantees or warranty expressed or implied other than those herein specifically mentioned.

Brodie Meter Co., LLC shall not in any event be liable for any consequential damages, secondary charges, expenses for erection or disconnecting, or losses resulting from any alleged defect in the apparatus.

It is understood that corrosion or erosion of materials is not covered by our guarantee.

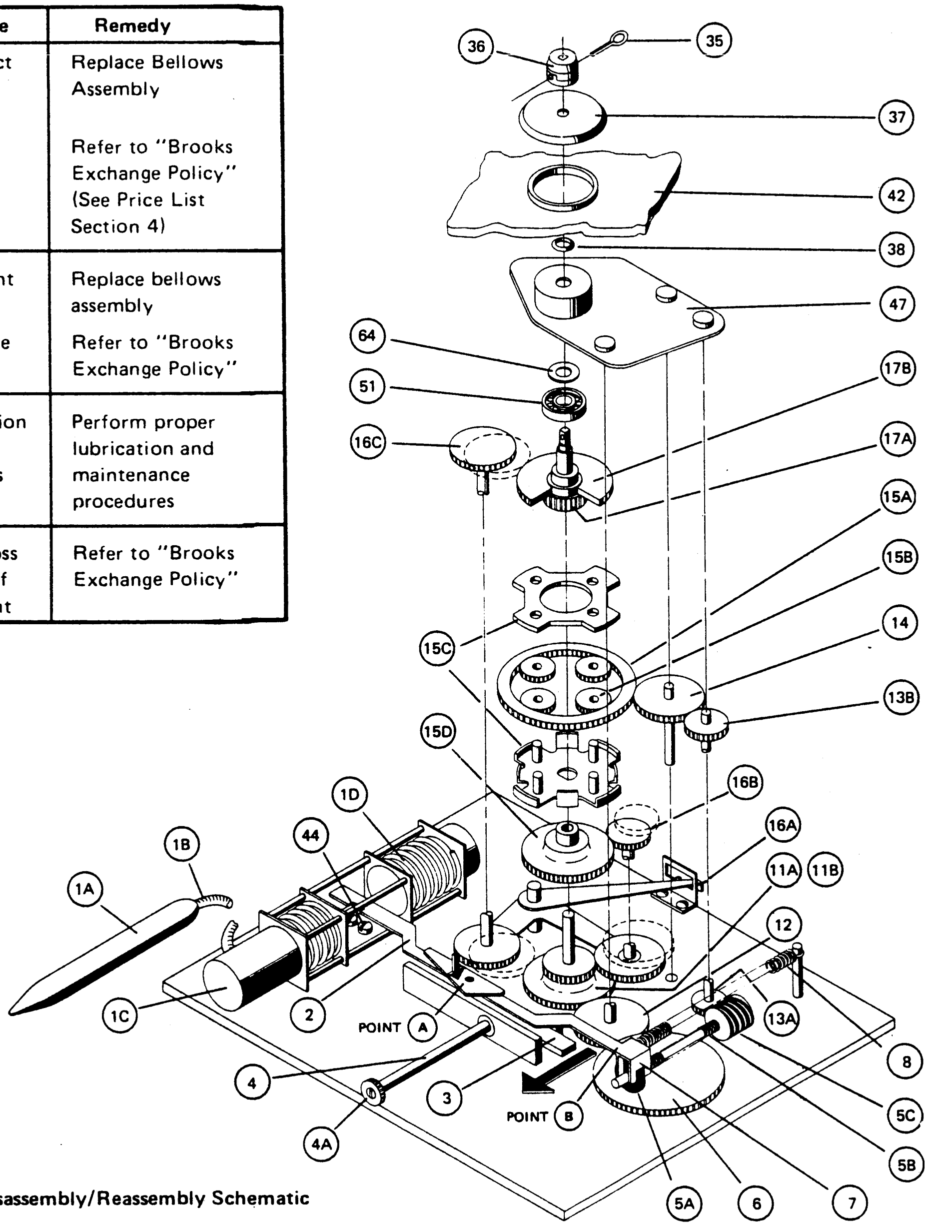

Figure 7-2 ATC Disassembly/Reassembly Schematic