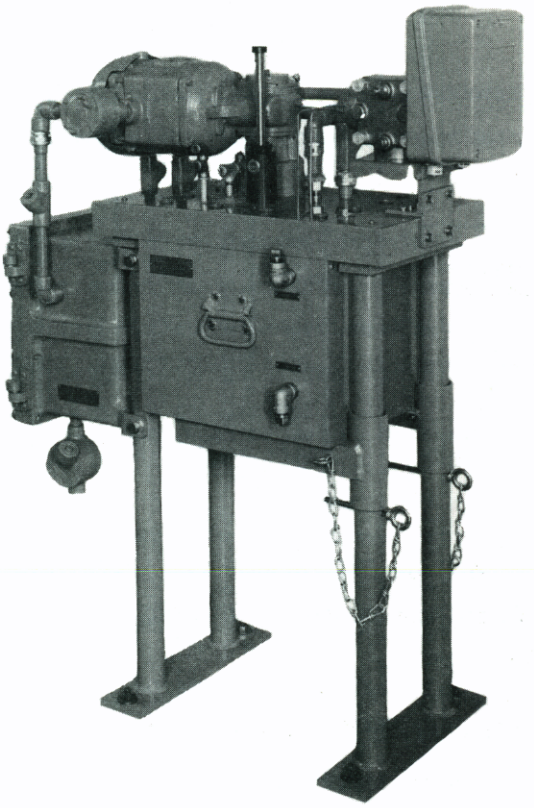
HALLIKAINEN Instruments
INDUSTRIAL and SCIENTIFIC
750 NATIONAL COURT, RICHMOND, CALIFORNIA, 94804

CONTINUOUS VISCOMETER

In a typical refinery control laboratory, investigation has shown that approximately 300 determinations of viscosity are made per twenty-four hour day in order to control quality and specifications. Most of the determinations, about 90%, are made on lubricating oils with the balance on fuel oils, jet fuels, diesel fuels, hydraulic oils and various types of asphalts. While the percentage and total number of viscosity determinations may vary at each refinery, nevertheless considerable time and effort is expended on laboratory tests. An instrument installed in the plant to record and/or control the viscosity of a stream would:

1. Decrease the costs of laboratory analyses.

2. Provide rapid, accurate and continuous record and/or control of viscosity for closer control of refining operations.



Model 1077S22

Various older designs of the Hallikainen CONTINUOUS VISCOMETER have been field tested for over fifteen years and the present design for more than five years. This instrument has been successfully applied to miscellaneous refining streams, including:

1. Continuous Lube Oil Blending — In some instances the instrument is used to monitor the final stream blended by a precision blender; in other instances, and with great success, the instrument itself is used as a blending control instrument to control the blending of lube oils, fuel oils, etc.

2. Vacuum Tower Distillation — A CONTINUOUS VISCOMETER provides immediate information as to product output and thus enables tight control on product specifications. By continuously monitoring the tower output, the product may be directed to further processing without storage in hold-up tanks while a laboratory analysis is being performed.

3. Deasphalting — When scheduling requires a change in product, a CONTINUOUS VISCOMETER indicates the changes and allows accurate switching of tanks. In this manner product contamination is reduced.

4. Lube Oil Dewaxing — Many changes in feed stocks normally characterize the dewaxing of lubricants. It is desirable to recognize the change immediately in the product stream for minimum product degradation. A CONTINUOUS VISCOMETER may be used to detect product changes.

5. Crude Oil Residuals — The blending of heavy vacuum tower bottoms and gas oil using a CONTINUOUS VISCOMETER eliminates the need for further tank blending and possible over-dilution.

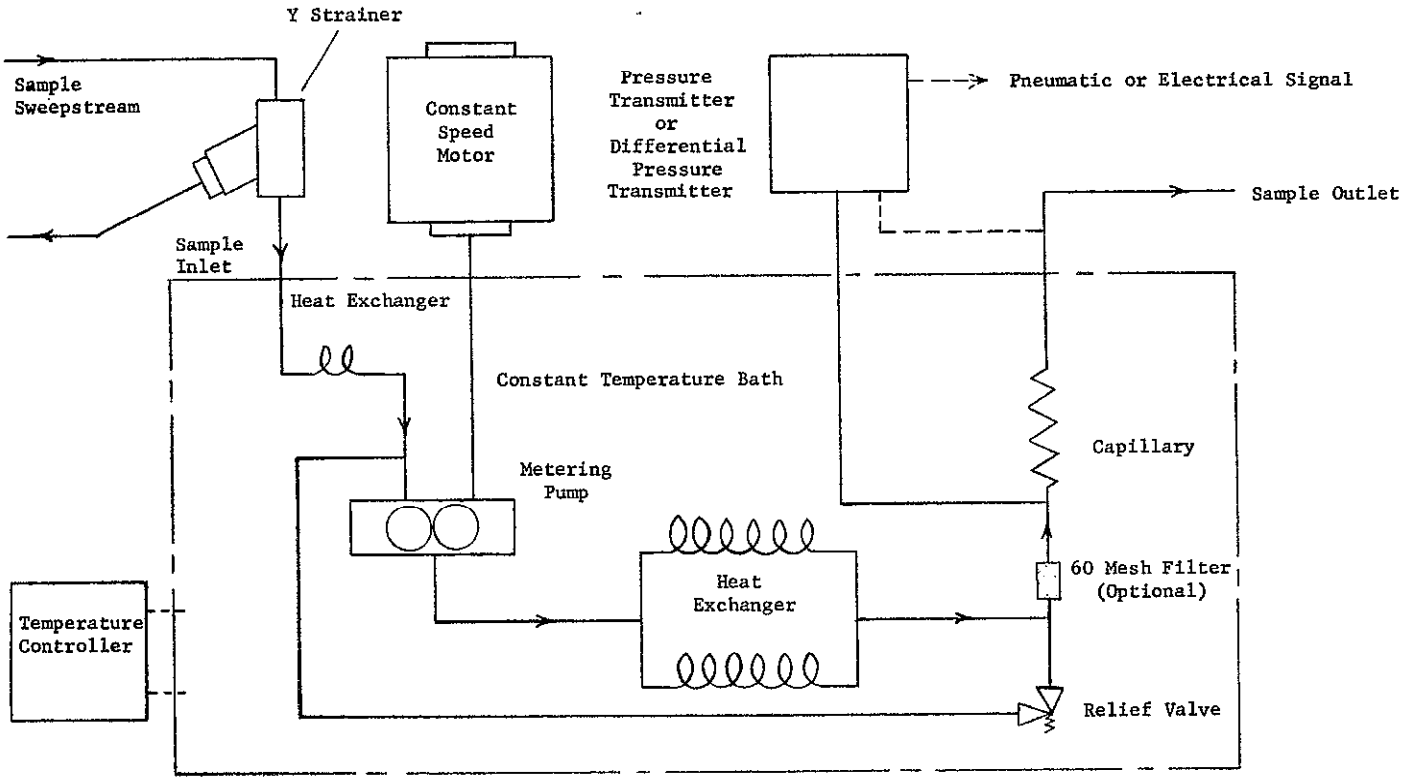


Figure 1 — Schematic Flow Diagram

6. Fuel Oil Production — A CONTINUOUS VISCOMETER is being used to control the blending of fuel oils. In this application, the closer control achieves a saving of 1% of premium furnace oil from a fuel oil stream of 17,000 Bbls/day.

PRINCIPLE OF OPERATION

The Hallikainen CONTINUOUS VISCOMETER is primarily designed to measure the viscosity of Newtonian products (fluids whose viscosity does not vary with shear rate) such as lubricating oils, etc. The instrument may be used to analyze non-Newtonian products (fluids whose viscosity varies with shear rate) if a viscosity determination at one shear rate will provide adequate information. The metering pump built into the instrument requires that the fluid to be measured have lubricating properties.

Figure 1 is a schematic flow diagram of the instrument. The externally mounted filter (supplied with the viscometer as standard equipment) is a large capacity Y strainer that provides a filtered sample to the instrument. A constant sample flow rate is achieved with the precision metering pump driven by a synchronous motor. The sample fluid then passes through a heat exchanger. It should be noted that the pump and capillary tube, as well as the heat exchanger, are immersed in a constant temperature oil bath. The temperature of this bath is regulated to ±.005°C. The sample fluid, now at constant temperature and constant volume, is forced to flow at a constant rate through a capillary tube. The pressure drop across the capillary tube is converted to a pneumatic or electrical signal that is a linear function of absolute viscosity (centipoise). A 60 mesh screen filter in front of the capillary tube (an optional part) is to protect the capillary against coke particles ttat might form in the heat exchanger. A relief valve protects the flow system against excessive pressure that might occur due to blockage of the capillary, etc.

The choice of capillaries and transmitters permits measurements to be made over a range of from 0 to 2500 centipoise at the bath temperature. After installation and adjustment, the CONTINUOUS VISCOMETER requires very little attention.

ACCURACY

The CONTINUOUS VISCOMETER has been thoroughly tested and proven. This Viscometer provides many years of reliable, trouble free plant use. Over-all accuracy of better than 1 % has been obtained in plant application.

DESCRIPTION

Housing—The oil bath and electronic controls are each contained in light weight aluminum explosion proof boxes suitable for use in Class 1, Group D, Div. 1 hazardous areas. The oil bath cover and box are insulated with Maranite and Fiberglas and enclosed in 16 gauge steel housings.

Motor—A ¼ h.p. 115/230 v, 50/60 cycle AC synchronous, gearhead, explosion proof motor is flange mounted on the oil bath cover. The motor shaft extends through the top cover, driving a precision metering pump and a bath stirrer through spur gears.

Pump—A precision gear pump, with critical parts machined to a tolerance of 25 microinches, provides a constant sample flow of 64 ml/minute for 60 cycle operation (approximately one gallon/hour). To further assure accurate flow rates, the pump is lapped and run in at the factory before installation in the instrument. Because of the special attention given to the pump, it is recommended that replacement pumps be obtained from Hallikainen.

Heat Exchanger—The stainless steel heat exchanger has sufficient capacity to bring the sample to the viscosity measuring temperature.

Cooling Coil—A stainless steel cooling coil is provided in the oil bath for constant circulation of cooling water when and if required. The cooling coil will be used if the desired control temperature is approximately ambient and/or if the inlet sample temperature is greater than the instrument bath temperature.

Stirrer—Two stainless steel stirrers of special design (Hallikainen-Shell Jet Stir Impeller) are used to agitate the bath oil, minimizing the over-all time constant and temperature gradients of the oil bath. The hollow blade stirrers cause the bath oil to flow radially out through the blades with a high velocity as well as in directions normal and tangential to their blade surfaces.

Capillary Assembly—The maximum viscosity range that may be measured by the CONTINUOUS VISCOMETER is 0 to 2500 centipoise (0 to approx. 1300 SSF @ bath temperature or 0 to approx. 13000 SSU @ bath temperature based on sp. gr. of 0.9). The capillary tube is selected to measure the viscosity of a fluid over a particular range for a given measuring temperature. The range which may be covered by each capillary is determined by the range of the transmitter used. Each capillary is calibrated and clearly marked at the factory and an approximate calibration curve provided. The capillary assembly is designed so that it may be changed in one minute or less without the need for special tools.

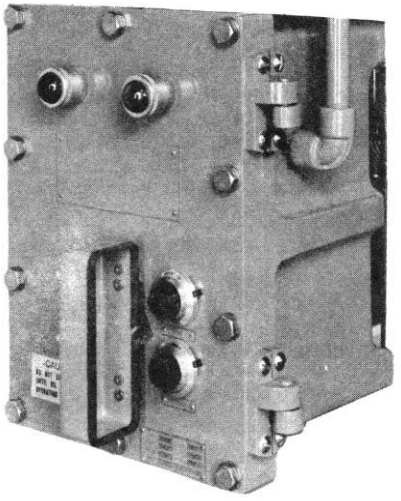
Relief Valve—A stainless steel relief valve is placed between the capillary tube inlet and pump inlet, to protect the instrument against excessive pressure due to the possible failure of the heaters, accidental starting of the pump before the bath has reached operating temperature, clogging of the system or the use of an incorrect capillary tube. The valve is set to open when the pressure exceeds 115 psi (on most models), causing the sample fluid to circulate through the metering pump. Viton "O" rings are used which are capable of withstanding temperatures of 450°F.

Filters—The instrument is provided with one Y strainer (see Figure 1) and one 60 mesh corrosion resistant screen filter (optional) located at the capillary inlet to prevent blocking of the capillary tube by particles which may have formed in the heat exchanger due to coking.

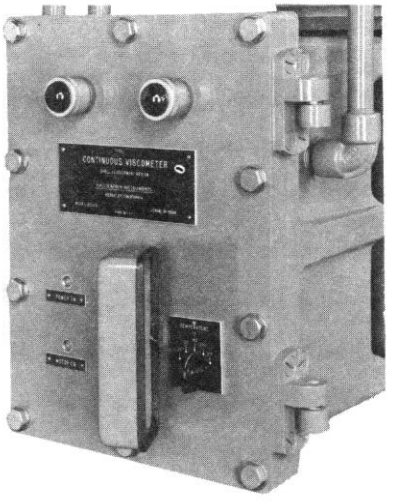
The Y strainer is normally installed so as to be self cleaning. The Y strainer has cast steel body with 100 mesh stainless steel screen.

Oil Bath Temperature Control—The oil bath is temperature controlled by a Hallikainen-Shell THERMOTROL Temperature Controller. The controller utilizes a fast-acting (0.8 seconds response time) resistance thermometer as the sensing element. An electric heating element (tubular type immersion heater—1000 or 2000 watt) supplies the necessary heat.

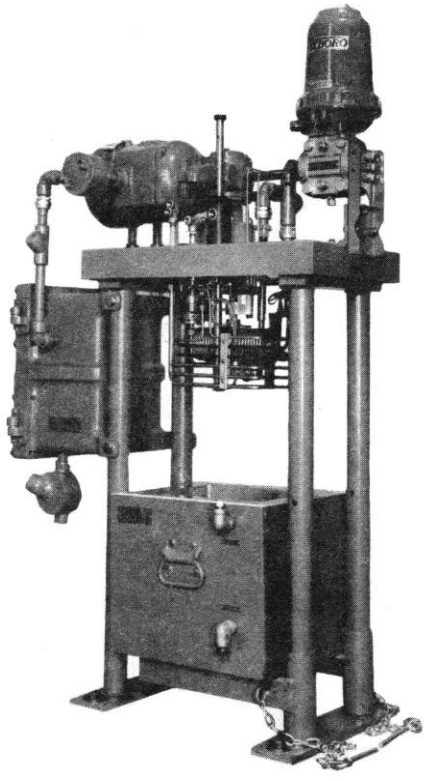
The THERMOTROL Temperature Controller, incorporating proportional and reset control modes, is capable of controlling the bath medium to ±.005°C. of the desired bath temperature. (See separate brochure on the THERMOTROL for additional details.)



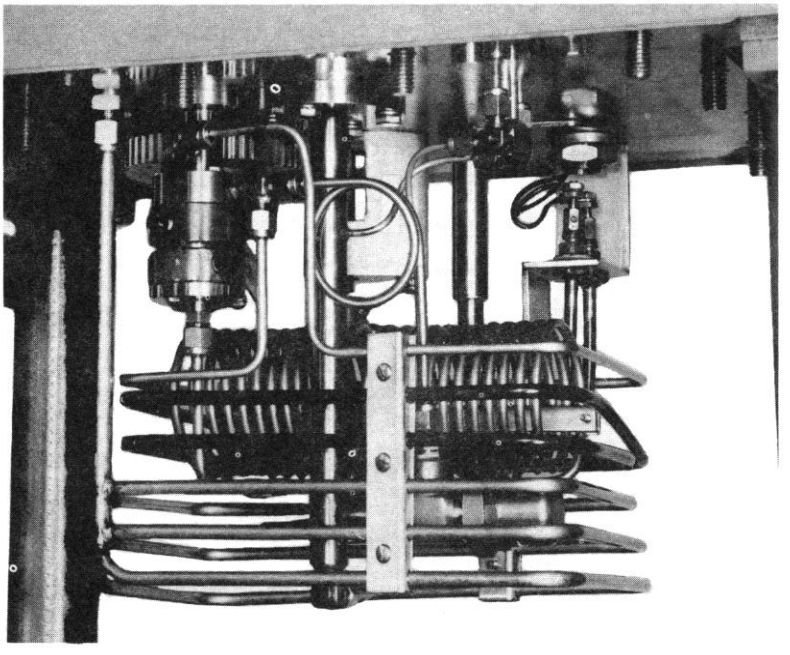
On the standard THERMOTROL, (photo at left) two ten-turn potentiometers are used to adjust the desired oil bath set point temperature. A decade switch which permits selection of five fixed temperature control points (e.g. 100, 122, 140, 180 and 210°F., or any other combination of fixed temperatures) is available on special order (photo at right).



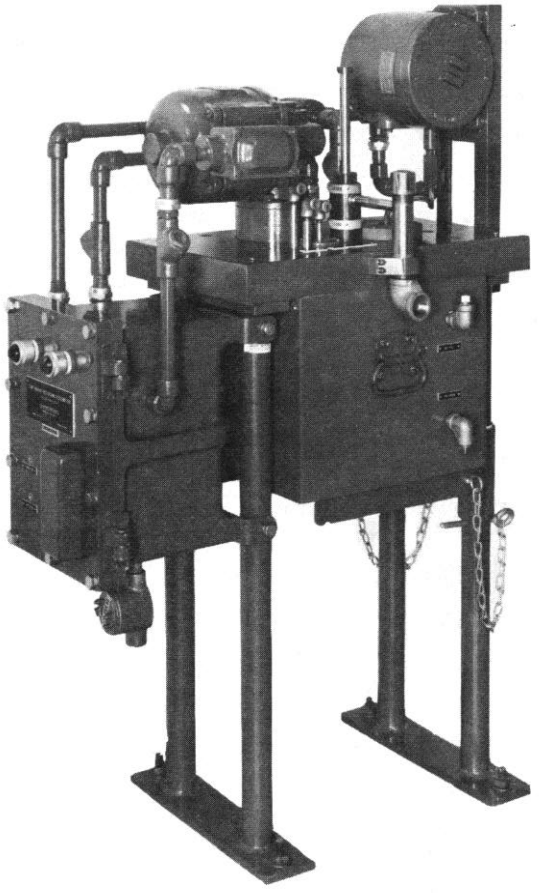
Sample Fluid Temperature Measurement—A special etched stem viscosity thermometer is provided to read the sample fluid temperature at the capillary discharge. It is inserted in the thermometer and capillary holder and positioned so that the bulb of the thermometer is directly above the capillary tube.



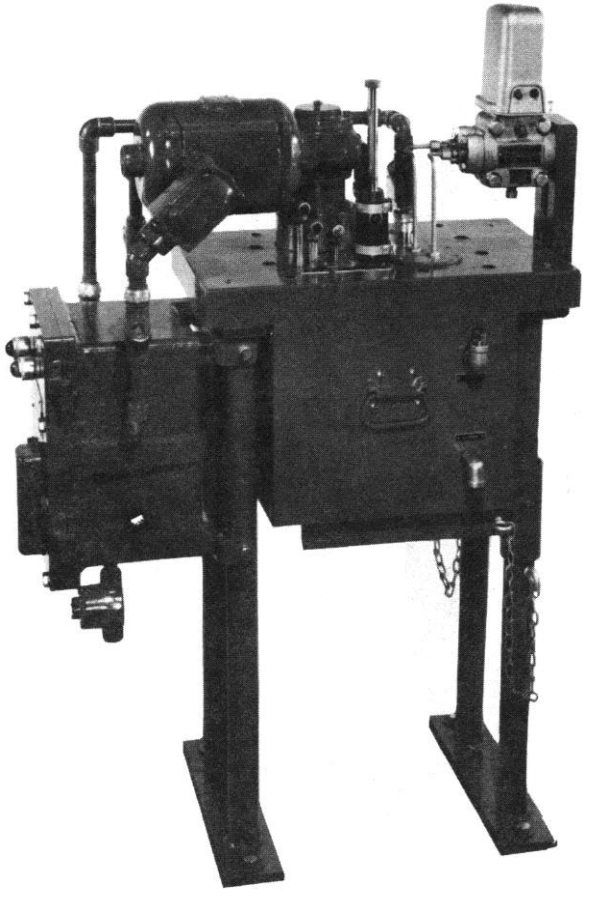
Bath Box Lowered



Close-up of Inner Parts



Model 1077S4

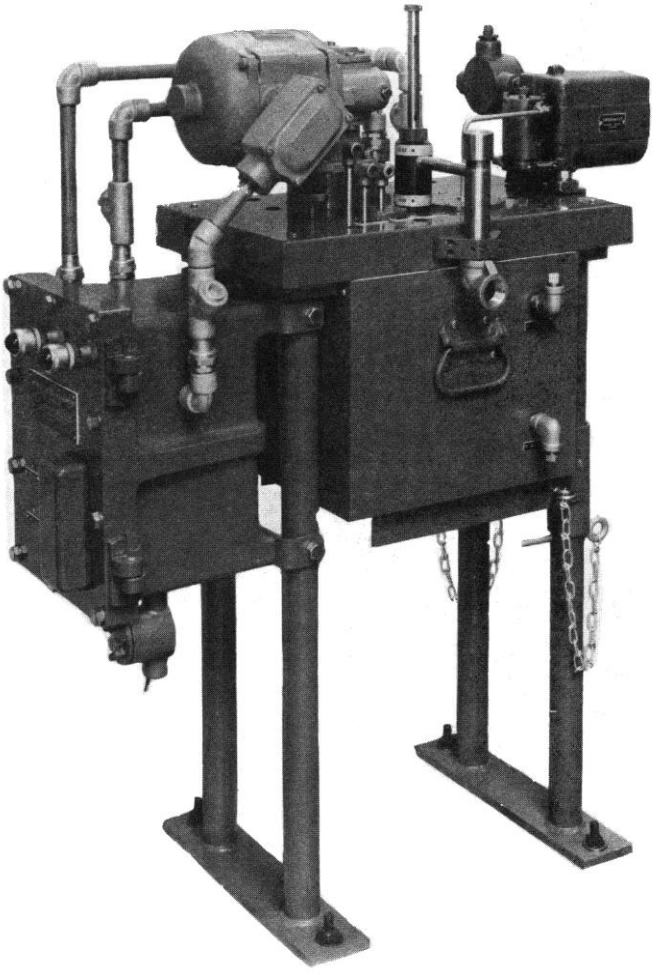


Model 1077S7

VISCOSITY MEASUREMENT

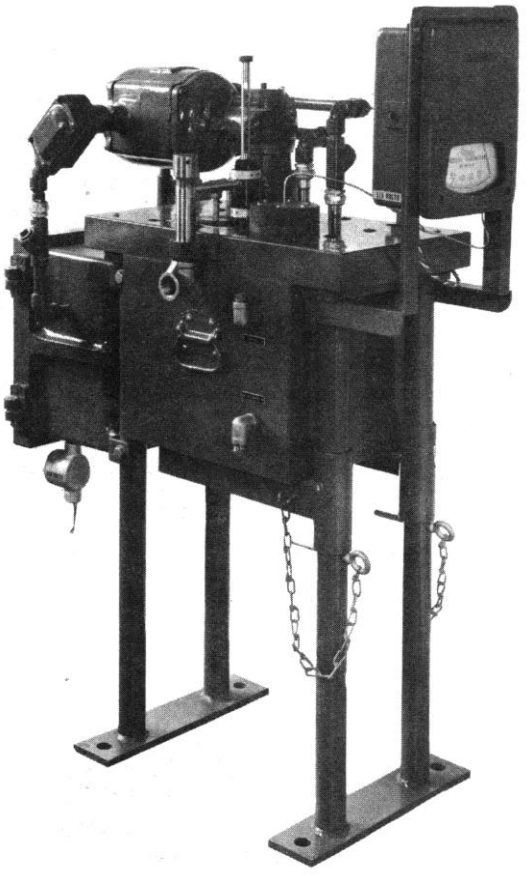
Absolute viscosity in centipoise is directly proportional to the pressure drop across the capillary tube. Several types of transmitters are available to measure the pressure drop across the capillary tube. The selection of a particular transmitter should be based on the following considerations:

1. When a pressure transmitter is used, only the pressure on the upstream side of the capillary is measured; the downstream side of the capillary is discharged to atmosphere. Differential pressure transmitters are the more popular type used. These transmitters measure the pressure drop across the capillary. With differential pressure transmitters, the sample may be pumped back into the sample line by the metering pump in the instrument.



Model 1077S10

2. Chemical Seals for Transmitters—These are recommended for most measurements, but definitely are required where the sample is of a wax or pitch base and/or



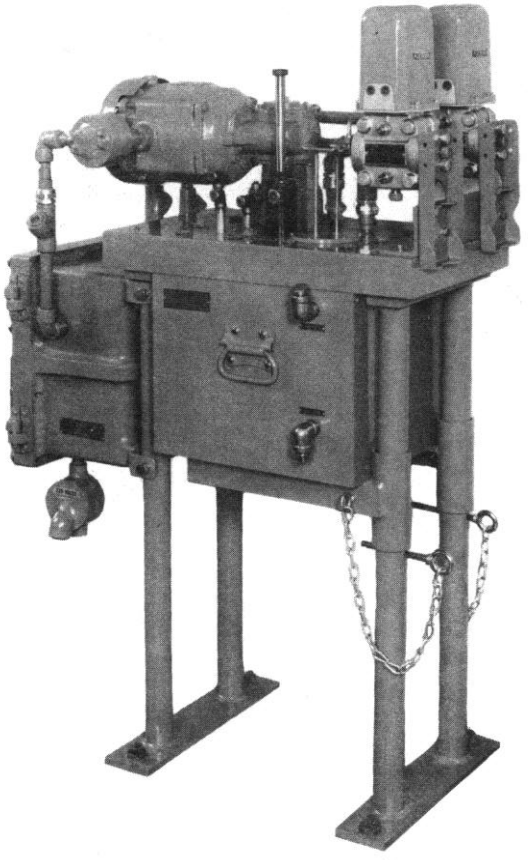
Model 1077S8

would have a tendency to congeal in the sample lines. The use of chemical seals is desired since the diaphragm of the sealed system contacts the sample in the temperature controlled bath and transmits the pressure measurement through the solidly filled chemical seal to the pressure measuring element in the transmitter. Of lesser importance, but also of value, is the reduction of dead space occupied by the sample fluid when chemical seals are used. Steam tracing of pressure lines to transmitters without seals is available.

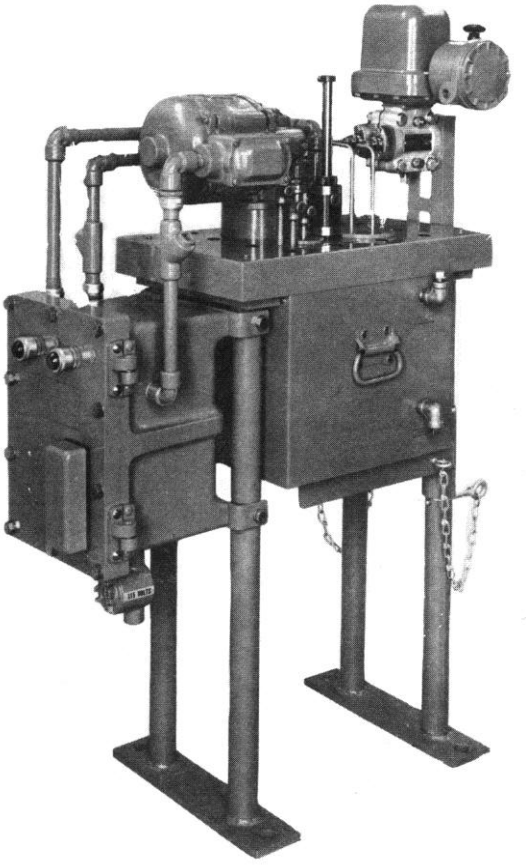
3. The transmitter output signal may be **pneumatic** or **electric** depending on customer preference.

4. The range and span of the transmitter determines the range of a single capillary in absolute viscosity units or centipoise. The viscosity range of a capillary can vary from a minimum ratio of 1.09 (maximum to minimum depending on process conditions) to infinity with a maximum range of 0 to 2500 centipoise at the bath temperature.

5. Indicating or non-indicating transmitters may be supplied as listed in the following table.



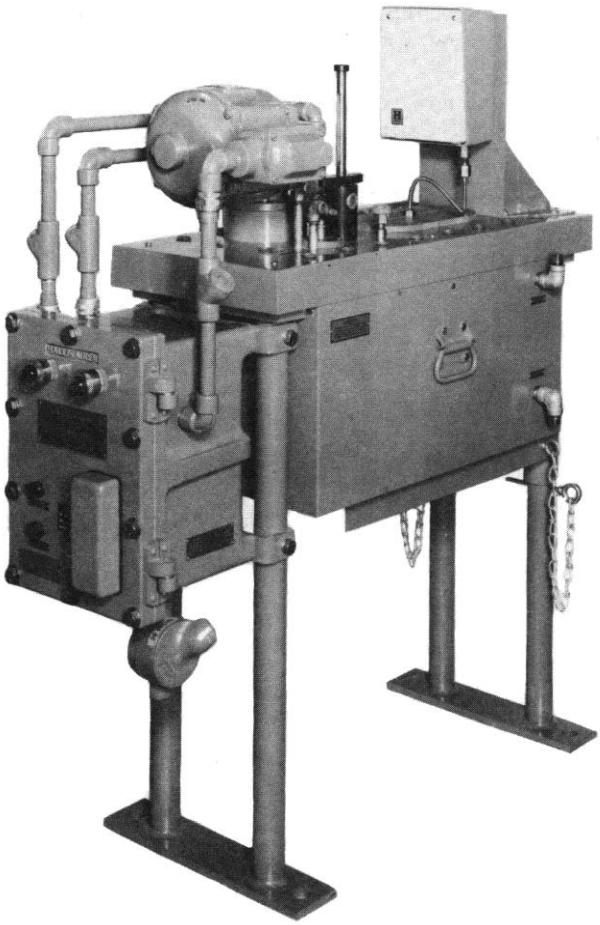
Model 1077S7/7



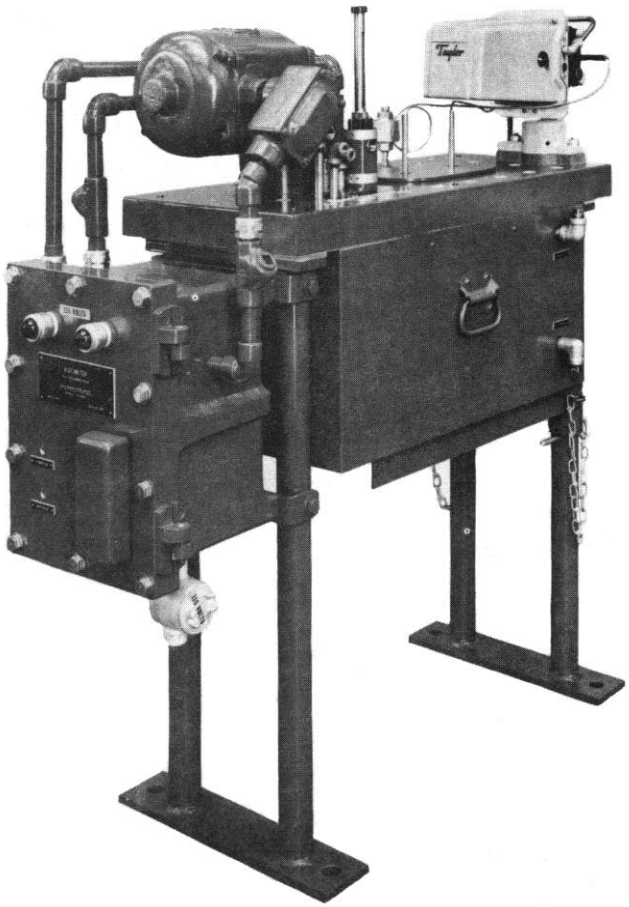
Model 1077S12

Viscometer Model No.	Transmitter Description	Output Signal	Chemical Seal	Oil Bath Temp. Range	Transmitter
1077	Taylor TRANSAIRE	Pneumatic	Yes	*Ambient to 240°F.	Pressure
1077S4	Microsen Type 145-3	Electric	Yes	*Ambient to 240°F.	Pressure
1077S6	Taylor Type 226R	Pneumatic	Yes	*Ambient to 240°F.	Pressure
1077S7	Foxboro Type 13A	Pneumatic	No	*Ambient to 240°F.	Diff. Pressure
1077S7/7	Two Foxboro 13A	Pneumatic	No	*Ambient to 240°F.	Diff. Pressure
1077S8	Foxboro Type 631-1	Electric	Yes	*Ambient to 240°F.	Pressure
1077S10	Swartwout P2T/4	Electric	No	*Ambient to 240°F.	Pressure
1077S12	Foxboro Type 613	Electric	No	*Ambient to 240°F.	Diff. Pressure
1077S13	Swartwout D2T	Electric	No	*Ambient to 240°F.	Diff. Pressure
1077S20	Honeywell 30310	Electric	No	*Ambient to 240°F.	Diff. Pressure
1077S22	Taylor 213TD	Pneumatic	No	*Ambient to 240°F.	Diff. Pressure
1077S26	Honeywell 29211	Electric	No	*Ambient to 240°F.	Diff. Pressure
1251	Taylor Type 206	Pneumatic	Yes	*Ambient to 240°F.	Diff. Pressure
1251S4	Honeywell 30210	Electric	Yes	*Ambient to 240°F.	Pressure
1251S20	Taylor 225TN	Pneumatic	Yes	†Ambient to 350°F.	Diff. Pressure
1251S25	Honeywell 738N1-C1	Pneumatic	Yes	*Ambient to 240°F.	Pressure

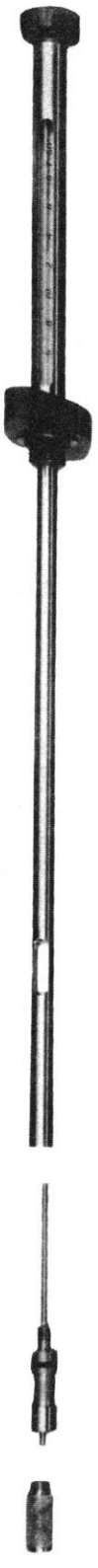
*Maximum Oil Bath Temperature may be increased to 300°F. by change in certain components.
†With transmitter specified and other modifications, units have been used to 350°F.



Model 1251S25



Model 1251



Exploded view capillary and thermometer holder for differential pressure transmitter instruments, showing capillary, capillary filter screen and thermometer.

GENERAL SPECIFICATIONS

Viscosity Range—0 to 2500 Centipoise at bath temperature (or fraction thereof depending on transmitter range and span).

Accuracy—1% or better.

Flow Rate—64 ml/minute (approx. 1 gal/hr) for 60 cycle power supply. 50 ml. per minute for 50 cycle.

Response Time—1.4 minutes (.8 min. dead time and .6 min. time constant). Special versions to as low as 15 second response time on special order.

Inlet Pressure Limitations—5 to 500 psig.

Inlet Temperature Limitations—Dependent on bath temperature may require external cooler.

Materials of Construction—All metal parts in contact with the sample are stainless steel except filter body.

Oil Bath Capacity—Model 1077 - 2½ gallons
Model 1251 - 5 gallons.

Filter Ratings—External Y strainer with 100-mesh screen
Capillary Filter - 60 mesh screen (optional).

Sample Inlet Connection—⅛" FPT

Sample Outlet Connection—On Models 1077, 1077S4, 1077S6, 1077S8, 1077S10, 1251S4 and 1251S25—outlet connection is 1" FPT. All others are ⅜" FPT.

UTILITIES

Electrical—Model 1077 - 115 or 230 volt (select one), 50/60-cycle, 1400 watts maximum.
Model 1251 - 115 or 230 volt (select one) 50/60 cycle, 1400 or 2400 watts depending on the bath operating temperature. These figures exclude power requirements of electrical transmitters, some of which require their own power supplies. Connections are for ½" conduit.

Air—A 20 psig clean instrument air supply is required on those transmitters providing pneumatic output signal. Connections are ¼" FPT.

Cooling Water—Requirements depend on operating conditions. Connections are ¼" FPT. Pressure regulation desirable. ½ gallon per minute maximum.

DIMENSIONS

Model 1077—(Approximate) 18" wide x 32" long x 57" high (Height depends on transmitter)

Model 1251—(Approximate) 18" wide x 45" long x 56" high (Height depends on transmitter)

WEIGHT

Model 1077—Net weight approx. 365 lbs. Shipping weight approx. 450 lbs.

Model 1251—Net Weight approx. 450 lbs. Shipping weight approx. 550 lbs.

STANDARD EQUIPMENT

Viscometer complete with transmitter as specified by the model number.

Filter for external mounting.

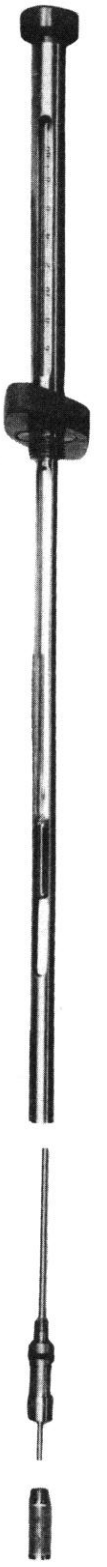
One capillary tube.

One special etched stem viscosity thermometer.

BATH MEDIUM

Bath medium is not included as standard equipment, but can be supplied at extra charge.

Recommended fluid is a medicinal type oil with low viscosity (below 25 csk at 100°F.) and a flash point above the maximum operating temperature, or a similar low viscosity silicone oil.



Exploded view capillary and thermometer holder for pressure transmitter instruments, showing capillary, capillary filter screen and themometer.