NS 777C
(2000)

INSTRUCTION BOOK

VISCOSITY-TRANSMITTER UNIT

NSNo.E1330

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NAKAKITA

MODEL NS777C VISCOSITY-TRANSMITTER UNIT

Contents

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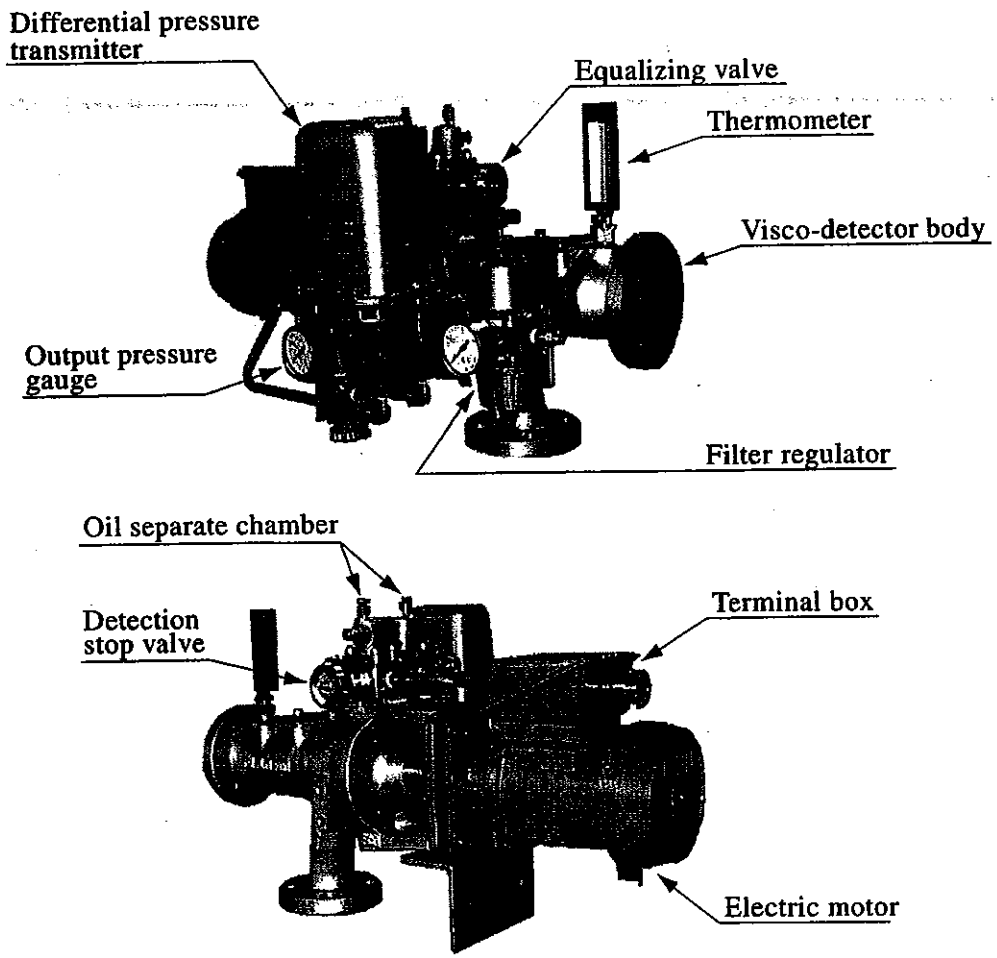
1. OUTLINE

This device is a viscosity-transmitter unit which detects the viscosity of fuel oil fed mainly to diesel engines or boiler burners of shipping and which is used for remote indication or in an automatic controller regulating the rate of supply of steam to a fuel oil heater to keep the viscosity of the oil at a constant level.

The configuration of this device is as shown in the picture drawing.



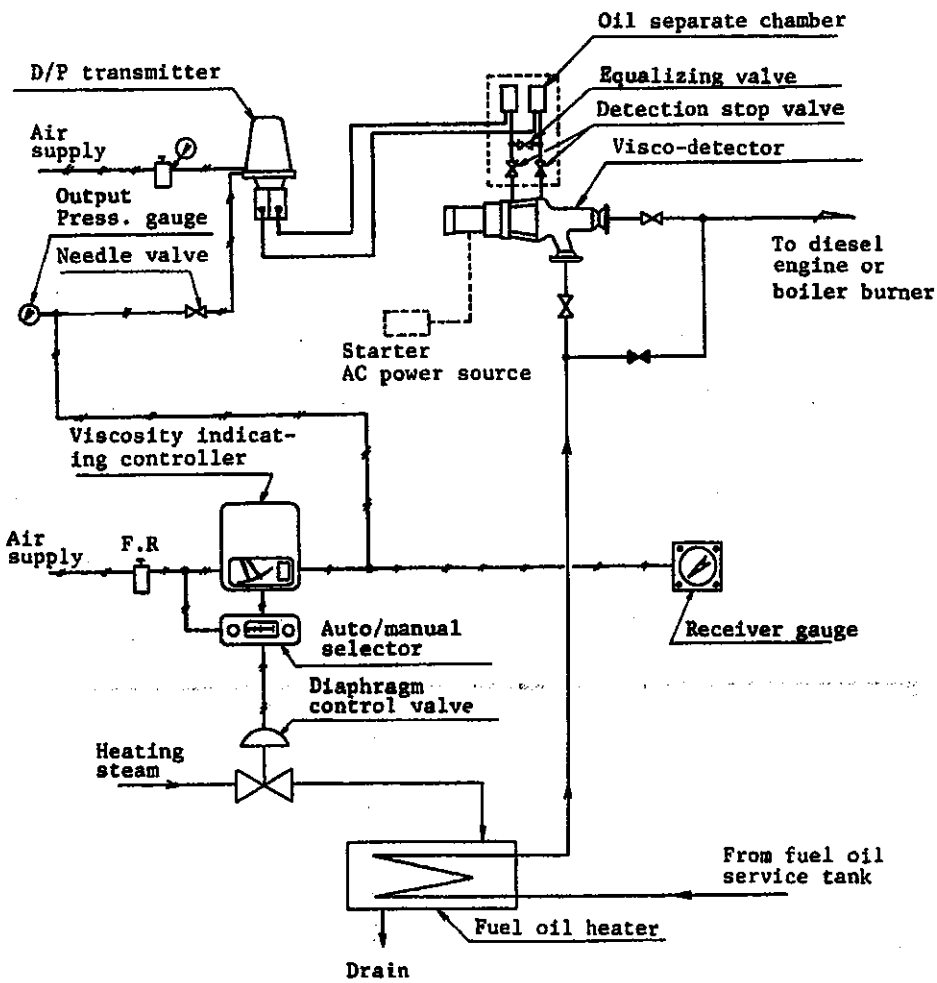
The viscosity detector uses the principle of the capillary tube type detector and transmits a differential pressure signal proportional to the viscosity measured.

This differential pressure is led into the differential pressure transmitter where it is converted to a pneumatic signal ranging from 20～100kPa to be transmitted to an indicator and a controller at a distance. The range of pneumatic signal is proportional to the measuring range of viscosity.

As shown in Fig.1, the lead pipes between the viscosity detector and the differential pressure transmitter are provided with oil separate chambers filled with sealing liquid (ethylene glycol) so as to prevent clogging which could be caused by the inflow of viscous fuel oil to the lead pipes and differential pressure transmitter on the downstream side.

Further, the output pressure line of the differential pressure transmitter is provided with a needle valve.When the effects of pulsating pressure noises generated from the fuel injection pump of a diesel engine can not be avoided, the noises are absorbed and reduced by the throttle effect of this needle valve.

Fig.1 Example of Installation

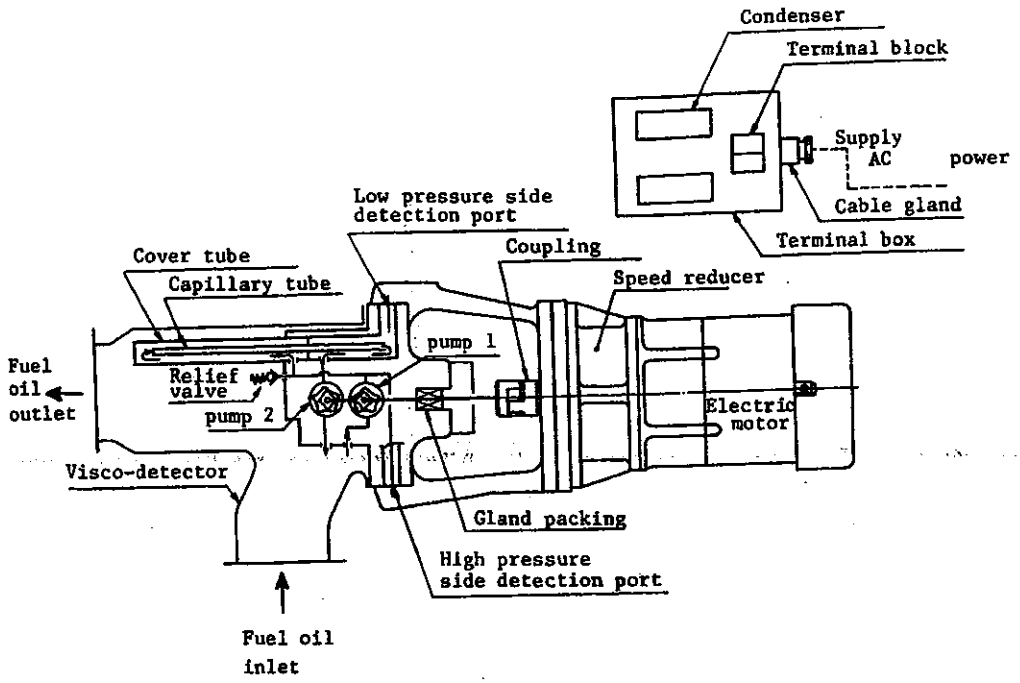


Note 1 : The instruction manual of the differential pressure transmitters and the viscosity indicating controller assembled in the viscosity transmitter unit is attached to this manual for your reference. (see CONTENTS chapter C, of cover page.)

Note 2 : For diaphragm control valve and other accessories, see separate instruction books.

2. CONSTRUCTION AND OPERATION

Fig.2 Viscosity-Detector



Fuel oil continuously sampled by the interlocked double gear pump,which is driven at a constant speed by the synchronous motor via reduction gear, flows from the suction port of the pump①, through the cover tube and the capillary tube. The fuel oil is then discharged into the body of the viscosity-detector by the pump②.

The interlocked double gear pumps installed before and after the capillary tube cut off pulsating pressure noises of the main line from the capillary tube by the shielding effect of the pumps themselves.

The relief valve installed between the pump① and the cover tube prevents abnormal pressure rise when this device is started up at an abnormally high viscosity.

The viscosity-detector is designed to satisfy the formula of Hagen • Poiseuille $\mu = \frac{\pi r^4 \Delta P^*}{8lq}$, which represent a relationship that the differential pressure occurring between both ends of the capillary tube, when the flow inside the tube is a laminar flow, is in proportion to the fluid viscosity. The high pressure side (H.P.) of the differential pressure to be detected is present on the upstream side of the capillary tube. The low pressure side (L.P.) is detected on the downstream side of the capillary tube.

The differential pressure detected shows a specific value which is determined by the discharge rate of the pump, and the length and the inner diameter of the capillary tube. This differential pressure is led into the differential pressure transmitter to be converted to a pneumatic signal of 20 to 100 kPa proportional to the measuring range of the viscosity.

* Where π = ratio of the circumference of a circle to its diameter
r = radius of the inner bore of the capillary tube (mm)
ℓ = length of the capillary tube (mm)
q = flow rate through the capillary tube (m^3/s)
ΔP = differential pressure generated across the capillary tube (kPa)
μ = dynamic viscosity (Pa•s)
ν = kinematic viscosity (m^2/s){cSt}
ρ = density (kg/m^3)
$\nu = \mu / \rho$

3. SPECIFICATIONS

Measuring range : 0 to 30 (125), 0 to 40 (165) and 0 to 50 (200) cSt (sec. RW NO.1)

Viscosity of fuel oil measured : 1,500mm^2/s{cSt}(6,000 sec. RW NO.1)

Rated pressure : 1.6 MPa

Fluid temperature : 200℃ max.

Detected differential pressure : 55～135 kPa (planned value) *

Connection flange :

Size : 40 A (1 1/2B), 50 A (2B), 65 A (2 1/2B), and 80 A (3B)

Flange rating: JIS 5K, 10K, 16K, 20K, and ANSI 150 1b and 300 1b

Power supply : AC 100～115 V, 50 or 60 Hz, ϕ -1. 100 W

Output signal pressure : 20 to 100 kPa

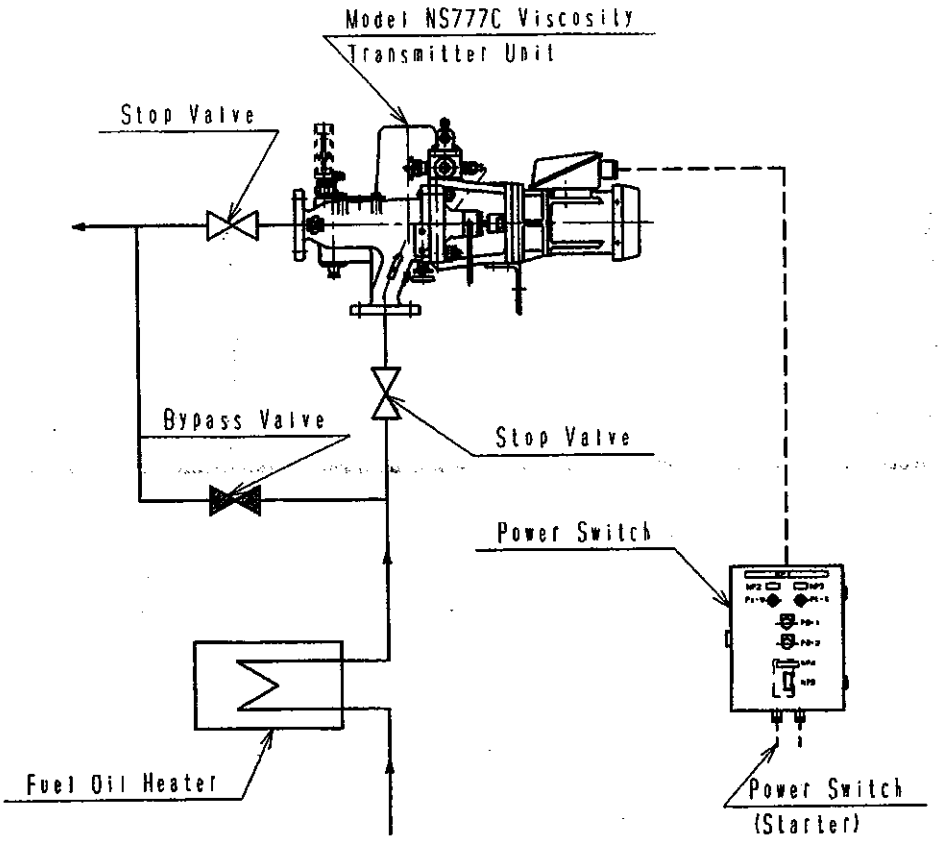
Supply air pressure : 140 kPa

Ambient temperature : 75℃ and under

* Detected differential pressure is determined by the capillary tube of the measuring range. This value (detected differential pressure at full scale) is stamped in the specification plate of the differential pressure transmitter and viscosity- ditector.

4. INSTRUCTIONS FOR INSTALLATION

4.1 Method of Installation and Space



4.1.1 Install the device just downstream the heater so as to reduce the timelag of detection.

4.1.2 Always install a strainer just upstream the viscosity-transmitter unit to prevent clogging of the pumps and the capillary tube.

4.1.3 Provide the fuel oil main line with stop valves and a bypass valve for maintenace.

4.1.4 As for the installation position of the divice, install the divice so that the electric moter is set in horizontal position. Arrange the divice in such a way that fuel oil flows form the lower flange to the side flange.

4.1.5 Use the bracket fixed on the bottom of the bonnet to support the viscosity-transmitter unit.

4.1.6 The gland is provided with a leak-off connection port so that fuel oil leaked from the gland, if any, can be collected. necessary piping to the collecting point.

4.1.7 Secure a sufficient space for maintenance. (More than 300mm around the divice.)

4.1.8 Install the power switch near the diveice. Also provide a 3A-fuse, although the motor is provided with a thermostat for prrotection against overload.

4.2 Atmosphere Around the Installation Side.

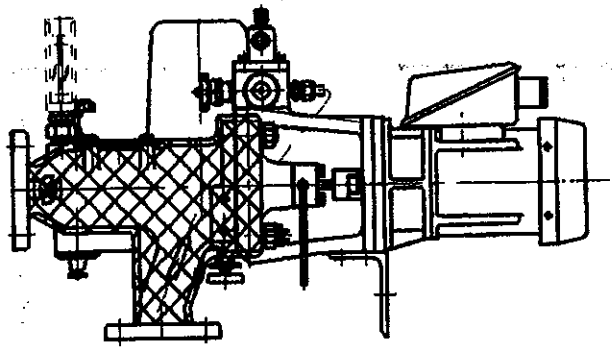
4.2.1 As some portions of the divice are of dripproof construction,never wet the divice.

4.2.2 Install the divice in a well-ventilated dry place with little corrosive gases, where temperature does not exceed 75℃.

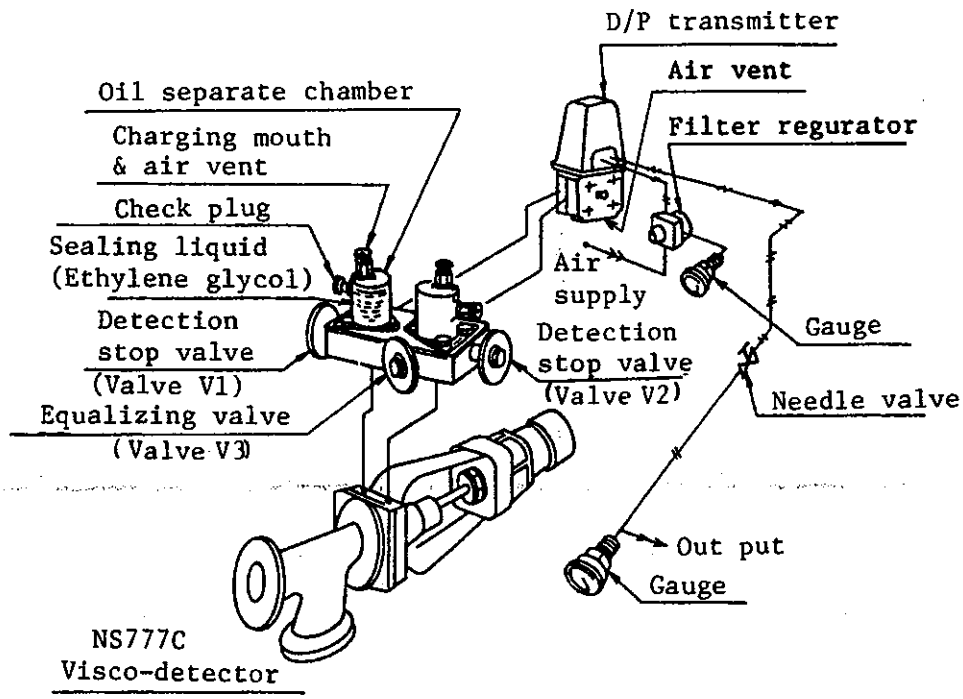
4.2.3 Install the divice in a place where maintenance and inspection can be made with case and there is little mechanical vibration.

4.3. Heat Insulation

4.3.1 If the heat insulation is not perfect, the heat rediation will reduce the sampling temperature for viscosity detecteor and produce measuring errors; therefore the body and all over the bonnet flange must be heat-insulated without fail. Where the heat insulation is required is shown by hatching in the following figure.



5. PREPARATION, ADJUSTMENT, MAINTENANCE AND INSPERECION



⚠Caution

In order to prevent the clogging of the capillary tube and damage of d/p transmitter, don't stop the motor during C-oil use.

5.1 Before start-up or periodically carry out the following check

In the manufacturer's works before delivery, the oil separate chamber has been filled with the sealing liquid {ethylene glycol ($HOCH_2CH_2OH$), G≒ 1.1, molecular weight = 62.07}.

Accordingly, the device can be started up by fully opening the detection stop valves; valve V_1(H) on the high pressure side, and valve V_2(L) on the low pressure side. However, for caution's sake, make sure the chamber is filled with sufficient sealing liquid and release the residual air through the air vent valve.

(When the sealing liquid is to be replenished, remove the air vent valve in the upper portion of the oil separate chamber and replenish the liquid through the opening. Replenish it till the liquid starts to flow out of the sheck plug on the side of the oil separator chamber.)

5.2 Adjustment and check after the pressure of the oil feed pump has been applied to the fuel oil main line

5.2.1 Air venting of the lead pipe system

Air venting is made by slightly opening the air vent valve in the upper portion of the oil separate chamber. Close the air vent valve just when oil starts to flow out.

5.2.2 When the pneumatic signal of the differential pressure transmitter is unstable due to the effects of pulsating pressure noises generated by the fuel injection pump of the diesel engine, reduce the opening of the needle valve till the amplitude of fluctuation in reading of the pressure gauge installed in the pneumatic signal line of the d/p transmitter gets very small.

5.2.3 For checking the level of the oil separate chamber, slightly open the check plug to make sure the sealing liquid drips. If the sealing liquid drips from the plug, close the check plug immediately to complete the check. If the fuel oil drips from the plug, refill the sealing liquid without delay, according to the instructions given in section 5.1.

5.2.4 Zero adjustment of differential pressure transmitter

Carry out the zero adjustment according to the following order of the procedures.

(1) Fully close the detection stop valves; valve V_1(H) of the high pressure side, and valve V_2(L) of the lower pressure side.

(2) Fully open the equalizing valve V_3.

When the pressure can not be equalized by the above mentioned method due to high viscosity of the fuel oil, then, open the air vent valve of each oil separator. Under this condition, the input differential pressure of the d/p transmitter will become zero.

Under this condition, if the output pressure of the d/p transmitter is 20 kPa and the viscosity indicator reads zero, the zero adjustment is correct.

If the reading on the indicator is not zero and the output pressure of the d/p transmitter is not 20 kPa, make calibration by adjusting the zero adjustmant screw of the d/p transmitter so that the output pressure becomes 20 kPa. If the reading on the indicator alone is not correct, cali-

brate the indicating controller according to its manual.

After completing the adjustmant, restore the device to its normal operating condition according to the following procedures.

(3) Fully close the equalizing valve V_3.

(4) Fully open the detection stop valves; valve V_1(H) of the high pressure side, and valve V_2(L) of the lower pressure side.

Now the zero adjustment has been completed.

5.2.5 Make sure there is no leakage of fluid from any seals of the device and joints. If any laekage is detected from seals, completely stop it.

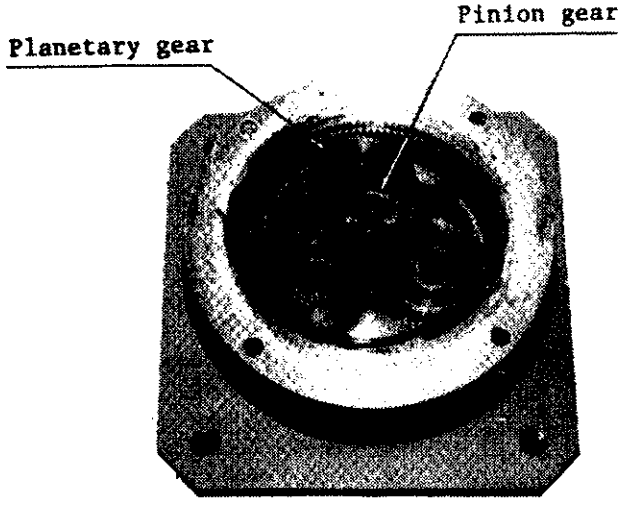
5.3 Grease in Speed Reducer

5.3.1 Brands

The grease used in the speed reducer, which is directly coupled to the motor, has been selected for semi-permanent use. However, if it is necessary to replace grease, say after inspection for abnormality, select one from the following brands :

	Grease in use	Equivalent ones		
Maker	DAITO JUNKATU	NIPPON OIL	SHELL OIL	MOBIL OIL
Trade Name	LIQUI.MOLY L-GREASE LM47	MOLY NOCK GREASE 2	RETINAX AM	MOBIL GREASE SPECIAL

	Equivalent ones		
Maker	MARUZEN OIL	GULF	
Trade Name	MOLY MAX	GULFLEX MOLY EP	



5.3.2 Procedures for replacement

(1) Wash off the old grease with a solvent such as thinner and clean the inside of the gearcase.

(2) Coat the engaging portions of the pinion and the planetary gear with new grease.

(3) Rotate the pinion gear clockwise and counterclockwise so that the grease spreads to all of the gears. Limit grease coating to the gear faces.

[For the procedures for the speed reducer disassembly, follow the instructions given in section 6.1.1]

5.4 Maintenance and Inspection Table

Periodically carry out maintenace and inspection according to the detailed explanation given in the preceding sections 5.1 and 5.2 as well as Table 1.

Table 1 Maintenance and Inspection Table

Maintenance or inspection period	Inspection item	Checks and measures
Monitoring under normal operation	1) Check the load pressures exerted on the viscosity-transmitter. a) Fluid pressure. b) Supply air pressure.	1) Check them with pressure gauge. a) It should be at the specified pressure or under. b) It should be at the specified pressure.
Every day	1) Leakage from pressure parts including the V-packing. 2) Check whether shafts of rotating units turn smoothly. Also check for any abnormal sounds.	1) Check for leakage. When a leak is detected, locate it and take necessary measures such as retightening clamping bolts and replacing or O-rings with new ones. 2) Confirm the cause of abnormality, if any, such as defective motor or speed reducer, catching of dirt in the pumps and take necessary measures such as overhaul or replacement of parts.
Every week	1) Check threaded connections for looseness.	1) Retighten them if any looseness is found.
1 to 3 months	1) Check of zero point of the d/p transmitter. 2) Check of the level of the oil separate chamber.	1) Make calibration, if necessary. 2) Replenish it, if necessary.
1 to 2 years	1) Disassemble the capillary tube unit and the pump unit. a) to check the capillary tube for clogging or adhesion of foreign matters over the interior b) to check the degree of wear on the sliding surfaces of the pump.	a) Clean the capillary tube with or without clogging by means of a solvent like thinner. Then, remove the adhering matters from the interior by air browing. b) Check the sliding parts of the pump for harmful wear or adhesion of foreign matters. If any abnormality is found, replace them with new ones.

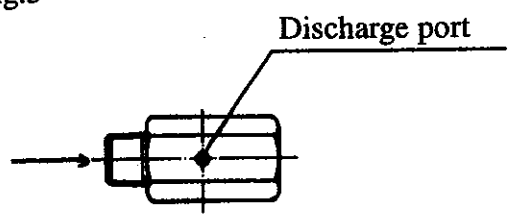
Maintenance or inspection period	Inspection i tem	Checks and measures
1 to 2 years (continued)		In order to make the most of the performance of the capillary tube, it is necessary to replace the pump unit and the capillary tube together as a pair at a time. {After the replacement, span adjustment of the d/p transmitter is required.}
	c) Check the contacting faces of the valve seat, and the rate of leakege of the relief valve.	c) See the paragraphs below the table. *
	d) Check the deterioration of the O-rings.	d) Check the O-rings for deformation, swelling, etc. If above-mentioned abnormality is detected on the O-rings, replace them with new ones. In principle, it is desirable to replace O-rings with new ones at each overhaul or every two years.
	2) Disassemble the gland.	
	a) to check the V-packing for scars and degradation.	a) If scars are found in the V-packings, or if the wear on the lips are excessive, replace them with a new ones.
	b) to check the shaft for wear.	b) If the wear on the shaft is excessive, replace it with a new one.
	c) to check the bearings for wear.	c) If the wear on the bearings is excessive, replace them with new ones.
	3) Replacement of gear lubricating oil in the speed reducer.	3) In accordance with 5.2.6.
During disassembly	1) Check the V-packing, and O-rings for any abnormality.	1) After disassembly, check the V-packing for scars, and wears and deformation of lips. Check the O-rings for deformation and swelling and other abnormalities. If any abnormality is found, replace them with new ones. (In principle, replace them with new ones at each periodic inspection.)

Maintenance or inspection period	Inspection Item	Checks and measures
During disassembly	2) Check the sliding parts for any abnormality.	2) Check the sliding parts of the shaft, pumps, bearings, etc. for abnormality. If any excessive abnormality is found, replace the part with a new one.

* c) Check the seating faces of the valve plug and the seat of the relief valve for any farmful scars or adhesion of foreign matters. If any abnormarity is found and can not be repaired, replace the defective part with a new one, in principle. However, if temporary repair is desirable, stop the connection port for the relief valve with a R 1/4 plug.
However, in this case, never start up the viscosity transmitter unit at 500mm²/s {cSt} (2000 RW NO.1) and over in viscosity.

Check and judgement of the rate of leakage of the relief valve
1 Apply a pneumatic pressure of 100 kPa to the valve.
2 Form a soap film over the discharge port.
If the film can be maintained without rupture for 2 to 3 seconds, the rate of leakage is within the permissible range.

Fig.5



6. INSTRUCTIONS FOR DISASSEMBLY AND PARTS REPLACEMENT

6.1 Disassembly

Refer to Figs. 7, 8 and 9 and follow the procedures shown below.

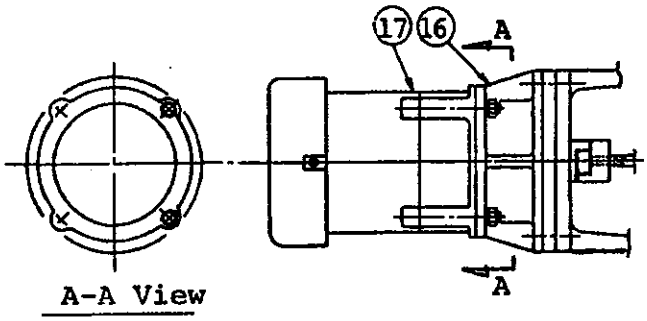
6.1.1 Disconnection of Motor and Speed Reducer

1 Turn the power off, and disconnect the wires for power supply and external connections in the terminal box ⑳.

2 Remove bolts and nuts ㉜ and dismount the motor and the speed reducer from the bonnet ②.

3 Loosen the set screws of the coupling ⑮, and disconnect the coupling.

4 The speed reducer ⑯ and the motor ⑰ can be separated from each other by removing four nuts which bind them together. (CAUTION Do not disassemble the speed reducer except for inspection and grease replacement.)



6.1.2 Disconnection and Disassembly of Capillary Tube and Pump Unit

(1) Disconnection and Disassembly of Capillary Tube

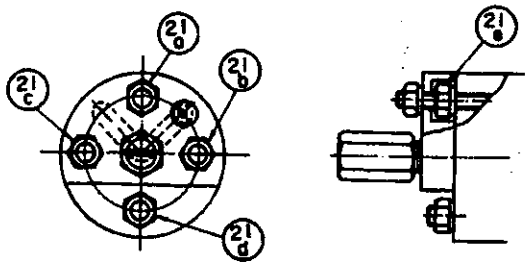
1 Disconnect the joints of the two lead pipes, one for high pressure and the other for low pressure, which are connected to the d/p transmitter 2 of Fig.9.

2 If a pipe is connected to the leak-off connecting port of the gland, remove the pipe.

3 Disconnect the bracket fixed on the bottom of the bonnet ②.

4 Remove the nuts ㉒, and draw out the capillary tube and the pump unit, together with the motor, from the body ①.

Fig.6



5 Romove three nuts ㉑a, ㉑b, and ㉑c. Remove the cover tube③ and the capillary tube⑦, in this order.

(2) Disconnection and Disassembly of Pump Unit

1 After disconnecting and disassembling the capillary tube as show 6.1.2 (1), disconnect and disassemble the pump unit according to the following order of procedures.

2 Remove two nuts ㉑d, and ㉑e. Then, remove the pump cover④, pump base⑤, and spacer ring⑥, in this order.

6.1.3 Disconnection and Disassembly of V-Packing

1 After disconnecting and disassembling the motor, the speed reducer and the pump unit, disconnect and disassemble the gland packing, with the following procedures.

2 Turn the coupling ⑮ counterclockwise and remove it from the shaft ⑪.

3 Draw out the shaft ⑪ to the pump side.

4 Remove the bolt ⑭b and remove the gland ⑭a.

5 If ⑫a, ⑫b and ⑫c, the header ring and the spacer ring do not pop out of the stuffing box by the force of the spring ⑬a, lightly push in the spring retainer ⑬b from the pump side to remove the V-packings.

Execute this work with extra care not to give any damage to the V-packings.

6.2 Check During Assembly

6.2.1 For assembly, reverse the procedures of disconnection and disassembly, except for the gland packing.

6.2.2 Checks after assembling the V-Packing, and assembling the pump and capillary tube

1 First put the shaft ⑪ through the stuffing box of the bonnet ②, then, assemble the V-packings. Exercise care not to damage the V-packings.

2 Screw the coupling ⑮ on the shaft ⑪.

3 When assembling the pump unit in position, turn the shaft by hand from the motor shaft side and position the pump so that the pump can turn smoothly, and tighten the nuts. ㉑d and ㉑e. Next, assemble the capillary tube ⑦ and the cover tube ③, and tighten the nuts ㉑a, ㉑b and ㉑c, in this order.

6.3 Replacement of Parts

6.3.1 Judgement whether parts replacement is required

See chapter 5.3.1 and chapter 7.

6.3.2 Instructions for parts replacement

See chapter 6.

7. TROUBLESHOOTING AND MEASURES

Malfunction		Causes	Measures	Page
Detected differential pressure or viscosity indication	Differential pressure can not be detected, or the value detected is too low.	1) Rotation of the pump is notnormal:	1)	
		a) Abnormal power supply	a) Restore it to normal.	A-5
		b) Abnormal motor or speed reducer	b) Replace it with a new one.	A-10～17
		c) Punctured condenser	c) Replace it with a new one.	A-4
		d) Catching of dusts ion the pump	d) Overhaul	A-12～17
		2) Sampling line is clogged:	2)	
		a) Through hole	a) Overhaul	A-12～17
		3) Detection stop valves are closed.	3) Fully open them.	A- 8～10
		4) The detection equalizing valve is open.	4) Fully close it.	A- 8～10
		5) The d/p transmitter is abnormal.	5) Restore it to normal.	B- 1～16
		6) Wear on the pump is excessive.	6) Make calibration or replace it.	A-12～17
		7) Leakage of relief valve.	7) Repair it or replace it with a new one.	A-12～14
	Value is high.	Clogging of the capillary tube	Cleaning	A-12～17
	Responce is too slow.	1) The line downstream the oil separate chamber is clogged with fluid of high viscosity: a) Lead pipe b) D/P transmitter	1) Clean a) or b) or refill the sealing liquid after air blowing.	A- 8～10
		2) Leakage of the sealing liquid from the oil separate chamber.	2) Refill it and restore it to the normal level.	A- 8～10
	Leaking from the V-packing	Wear on packings	Replace them with new ones.	A-12～17
		Wear on the shaft	Replace it with a new one.	A-12～17

8. CALIBRATION OF VISCOSITY-TRANSMITTER UNIT

After the viscosity-transmitter unit has been used continuously for a long period (3 to 5 years as a guideline), the discharge of the pump will become smaller due to wear on the pump, and the value of viscosity indicated will drop.

When this actually takes place, the viscosity-transmitter unit can be calibrated again as an emergency measure.

A practical and simple method of calibration is shown below. In executing the calibration, make sure the conditions for calibration are all satisfied.

8.1 Conditions for Calibration

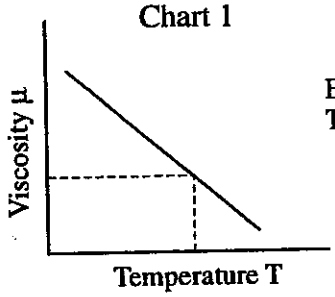
8.1.1 The fuel oil in use (fuel oil to be used in calibration) is correctly known in its properties. Its viscosity values are guaranteed by a certificate or have been actually measured, and the relationship between viscosity and temperature can be easily checked.

8.1.2 Before calibrating the viscosity-transmitter unit, eliminate all factors which many cause errors in calibration, such as clogging of the through holes of the capillary tube and the pump unit (adhesion of scale), and leakage from the relief valve. According to 6.1.2 and 6.1.3 and 5.3 "Maintenance and Inspection Table", overhaul the capillary tube and the pump unit and other components. After restoring the viscosity detector unit to the normal operational condition, operate the unit and make measurements for calibration.

8.2 Calibration procedures

8.2.1 According to the properties of the fuel oil in use (fuel oil to be used in the calibration), obtain the temperature corresponding to the target viscosity from the viscosity-temperature chart.

Chart 1

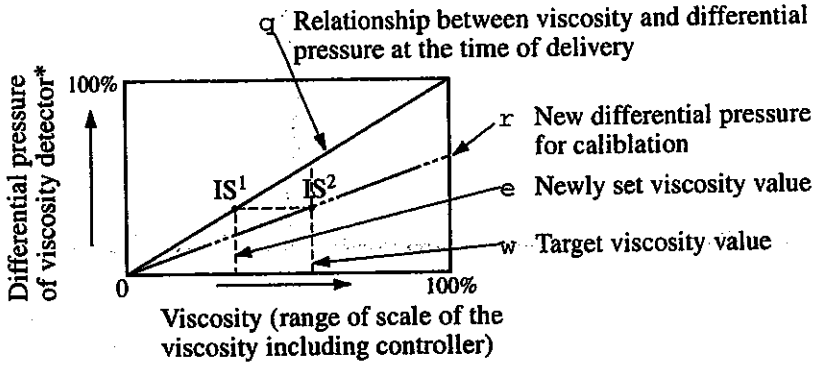


Example of Viscosity-Temperature Chart

8.2.2 Gradually lower the set value (viscosity) of the viscosity indicating controller till it matches the corresponding temperature obtained in section 8.2.1. Make sure that the newly set viscosity value matches the specified temperature and has been fully stabilized.

8.2.3 Using Chart 2, obtain the new differential pressure for calibration, from the newly set viscosity value and the target viscosity value.

Chart 2



* Differential pressure of the viscosity detector is the differential pressure stamped on the viscosity detector and on the d/p transmitter.

Procedure for Obtaining the New Differential Pressure for Caliblation

1 Draw the line ① according to the differential pressure stamped on the viscosity detector and the d/p transmitter, and the range of scale of the viscosity indicating controller.

2 Plot the values of ② and ③, and extend a vertical line from ③ to find an intersection, IS^1, of the line ① and the vertical line.

3 Draw a horizontal line from IS^1 to the vertical line of ② and find IS^2.

4 Draw a line from the origin through IS^2 to obtain the differential pressure for calibration ④.

8.2.4 Next, calibrate the differential pressure range of the d/p transmitter. Make zero adjustment of the d/p transmitter at the same time.

Fig.7

PARTS No.	PARTS NAME	QTY	REMARKS
1	BODY	1	
2	BONNET	1	
3	COVER TUBE	1	
4	PUMP COVER	1	
5	PUMP BASE	1 SET	
6	SPACE RING	1 SET	
7	CAPILLARY TUBE	1 SET	
8	PUMP GEAR	2	
9	BEARING	1	
10	BEARING	1	
11	SHAFT	1	
12 a	SEAT RING	1	
12 b	V-PACKING	3	
12 c	SPACE RING	2	
12 d	SEAT RING	1	
13 a	SPRING	1	
13 b	SPRING SEAT	2	
14 a	GLAND	1	
14 b	BOLT	2	
15	CUPLING	1	
16	REDUCATION GEAR		
17	SYNCHRONOUS MOTOR	1	
18	RELIEF VALVE	1	
19	THERMO METER	1	
20	TERMINAL BOX	1	
21	STUD BOLT, NUT	4 SETS	
22	STUD BOLT, NUT	4 SETS	
23	O - RING	1	
24	O - RING	1	
25	O - RING	4	
26	O - RING	1	
27	O - RING	1	
28	O - RING	1	
29	O - RING	2	
30	GASKET	1	
31	NAME PLATE	1	
32	BOLT, NUT	4 SETS