®

Model 35 Viscometer Instruction Manual

Part No. 354960001EA

Rev. F

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SECTION 1
DESCRIPTION

The FANN® Model 35 viscometer are drect reading instruments which are available in six speed and 12 speed designs for use on either 50 Hz or 60 Hz electrical power. The standard power source is 115 volts but all of the models may be fitted with a transformer which makes operation with 220/230 volts possible.

These are true Couette coaxial cylinder rotational viscometer since the test fluid is contained in the annular space (shear gap) between an outer cylinder and the bob. Viscosity measurements are made when the outer cylinder, rotating at a known velocity, causes a viscous drag to be exerted by the fluid. This drag creates a torque on the bob, which is transmitted to a precision spring where its deflection is measured and then compared with the test conditions and the instrument's constants. This system permits the true simulation of many of the significant flow process conditions encountered in industrial processing.

Viscosity as measured by a Couette type viscometer such as the Model 35 is a measure of the shear stress caused by a given shear rate. This relationship is a linear function for Newtonian Fluids, i.e. a plot of shear stress vs. shear rate is a straight line. In many instances, while the fluid of interest may not be Newtonian, its rheology is near enough to Newtonian that this viscometer can be used and the viscosity calculated as though it were Newtonian. It should be noted that the recommended calibration of the Model 35 is a linear or Newtonian calibration. This means that if the sample fluid characteristics are extremely Non-Newtonian the linear method of calculating the viscosity cannot be used. In this case the Model 35 dial reading and speed along with the dimensional data on the rotor and bob used will have to be calculated using an appropriate formula for a non-linear shear stress / shear rate relationship that closely fits the characteristics of the fluid.
These instruments have been designed so that viscosity in centipoise (or milli-Pascal seconds) of a Newtonian fluid is indicated on the dial with the standard rotor, bob, and torsion spring operating at 300 rpm. Viscosities at other test speeds may be measured by using multipliers of the dial reading. A simple method of close approximation of viscosity in a plastic fluid, such as a drilling fluid is described in Section 6B.

The range of shear rates may be changed by selecting rotor speed and using various rotor-bob combinations. A variety of torsion springs are available and designed to be easily interchanged in order to broaden shear stress ranges and allow the measuring of viscosity in a wide variety of fluids.

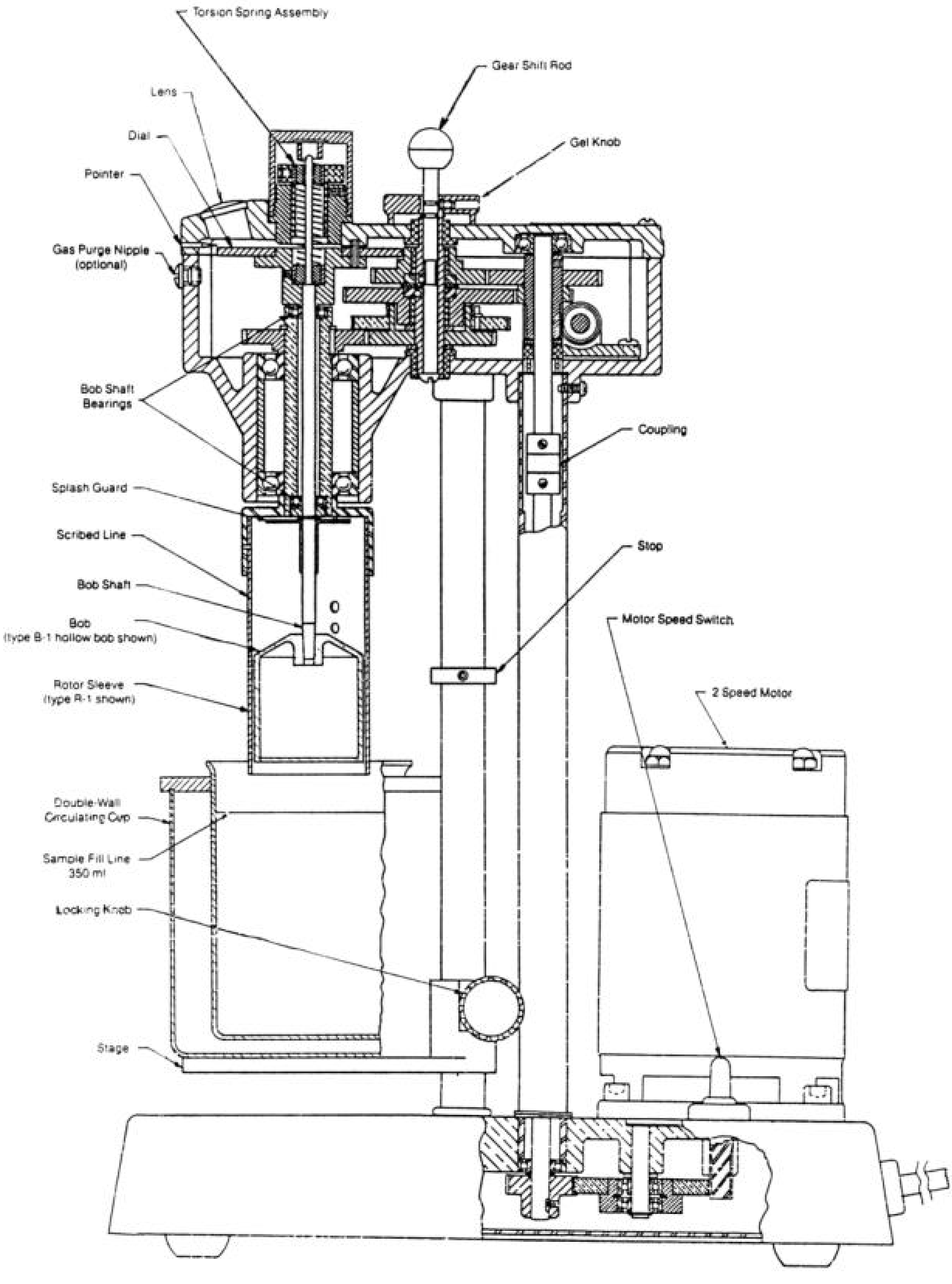


Fig. 1
Model 35 Viscometer

SECTION 2
SAFETY CONSIDERATIONS

A. SAFE OPERATION

The safe operation of the FANN Model 35 Series Viscometer requires that the laboratory technician be familiar with the proper operating procedures and potential hazards associated with the instrument. This instrument is driven by 115 volt or 230 volt electrical power. Keep hands, clothes and other objects away from the rotating parts of the machine

The optional heated sample cups and recirculating sample cups are electrically heated. Make sure the power cord and other wiring associated with these cups is no good condition and properly grounded.

Make sure the viscometer is turned off and unplugged from the source before cleaning or other repair or maintenance. Do not allow the Viscometer Base to get wet. If samples have been spilled or splattered, wipe clean with a damp cloth. Do not allow water to run into the base, as excessive water could cause damage to the electrical components.

B. STANDARD B1 BOB

The standard B1 Bob normally furnished with the Model 35 Series Viscometer is a hollow Bob and must not be to test samples hotter than 200°F (93°C). Solid Bobs are available for this type testing.

C. SAFE OPERATION OF THE OPTIONAL HEATED SAMPLE CUP

Precautions should be taken when testing heated samples using the optional heated sample cups to avoid possible burns from spilled hot sample, or from touching the hot sample cup.

When heated sample cups are being used, do not exceed 200°F

SECTION 3
VISCOSITY TEST

The stainless steel sample cup provided has a line at the proper 350 ml test fluid level. Fill the cup to that line with recently stirred test fluid. A scribed line on the rotor indicates proper immersion depth. Refer to Fig. 1. Damage to the bob shaft bearings may occur if this immersion depth is exceeded. If other sample holders are used, the space between the bottom of the rotor and the bottom of the sample holder should be one-half inch (1.27cm) or greater.

WARNING

THE STANDARD B1 BOB IS HOLLOW AND SHOULD NEVER
BE USED TO TEST SAMPLES HOTTER THAN 200°F. (93°C).

A. Model 35A and Model 35SA

The Model 35A and 35SA viscometer are instruments with the ability to test at six different speeds. Their range is from 3 rpm up to 600 rpm with the speed being determined by a combination of speed switch setting and viscometer gear knob placement. To select the desired speed, set the speed switch located on the right side of the base to the high or low speed position as desired. Then turn the motor on and move the viscometer gear shift knob located in the center of the top of the instrument to its desired position.

Table 1 lists the proper positions for the viscometer switch and the gear knob combinations to obtain the desired speed. The viscometer gear shift knob may be engaged while the motor is running. Read the dial for shear stress values.

TABLE 1

SIX-SPEED TESTING COMBINATIONS
MODEL 35A AND MODEL 35SA

Speed RPM	Viscometer Switch	Gear Knob
600	High	Down
300	Low	Down
200	High	Up
100	Low	Up
6	High	Center
3	Low	Center

B. SR-12 Model 35A/SR12 and 35SA/SR12

The Model 35A/SR12 and 35SA/SR-12 have twelve speed testing capabilities. To achieve this broader testing range (from 0.9 rpm up to 600 rpm) an additional gear box shift lever is used and it is located on the right side of the gear box. Refer to Fig. 2. Position this lever to the Left or Right as determined from Table 2.

CAUTION

NEVER CHANGE THIS GEAR BOX SHIFT LEVER WHILE THE MOTOR IS RUNNING. GEAR DAMAGE WILL RESULT.

Only the viscometer gear shift knob on the top of the instrument can be changed while the motor is running.

After preparing the instrument for 12-speed testing by setting the gear box shift lever, select the proper speed range with the speed shift switch on the right side of the base, then turn on the motor and set the viscometer gear knob on the top of the instrument. Refer to Table 2 for the correct combination of gear box shift lever setting; speed switch selection; and viscometer gear knob placement. The stress values will appear on the dial.

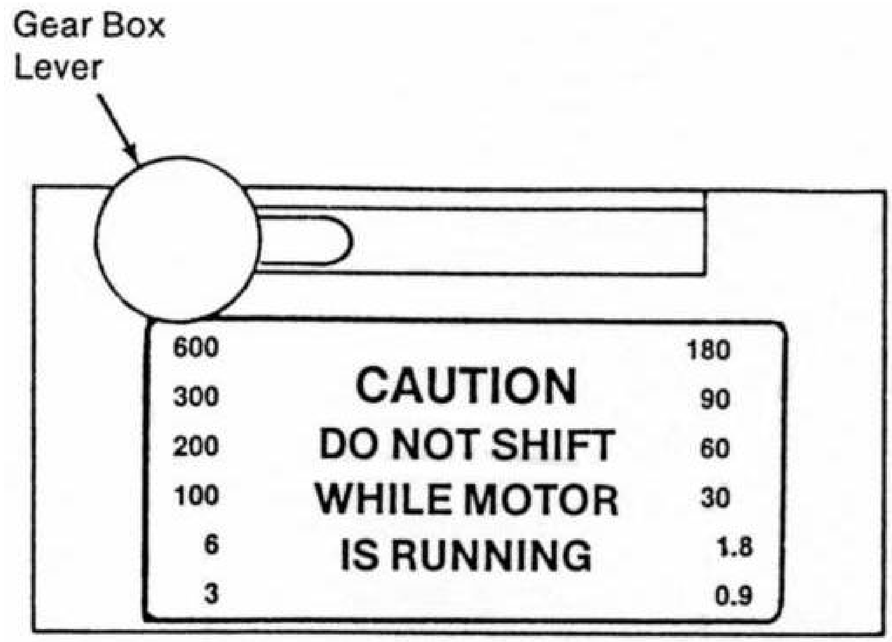


Fig. 2
Gear Box Lever

TABLE 2
TWELVE-SPEED TESTING COMBINATIONS
MODEL 35A/SR12 AND MODEL 35SA/SR12

RPM	Gear Box Lever	Speed Switch	Viscometer Gear Knob
600	Left	High	Down
300	Left	Low	Down
200	Left	High	Up
180	Right	High	Down
100	Left	Low	Up
90	Right	Low	Down
60	Right	High	Up
30	Right	Low	Up
6	Left	High	Center
3	Left	Low	Center
1.8	Right	High	Center
0.9	Right	Low	Center

C. GEL STRENGTH

Gel strengths are measured by first stirring the sample thoroughly at 600 rpm. Set gears to the neutral position and turn motor off. After desired wait period, turn gel knob, located below gear shift knob, refer to Fig. 1, slowly counterclockwise and read the dial at instant of the gel break (Peak Dial Reading). Gel reading is in lbs/100 ft^2.

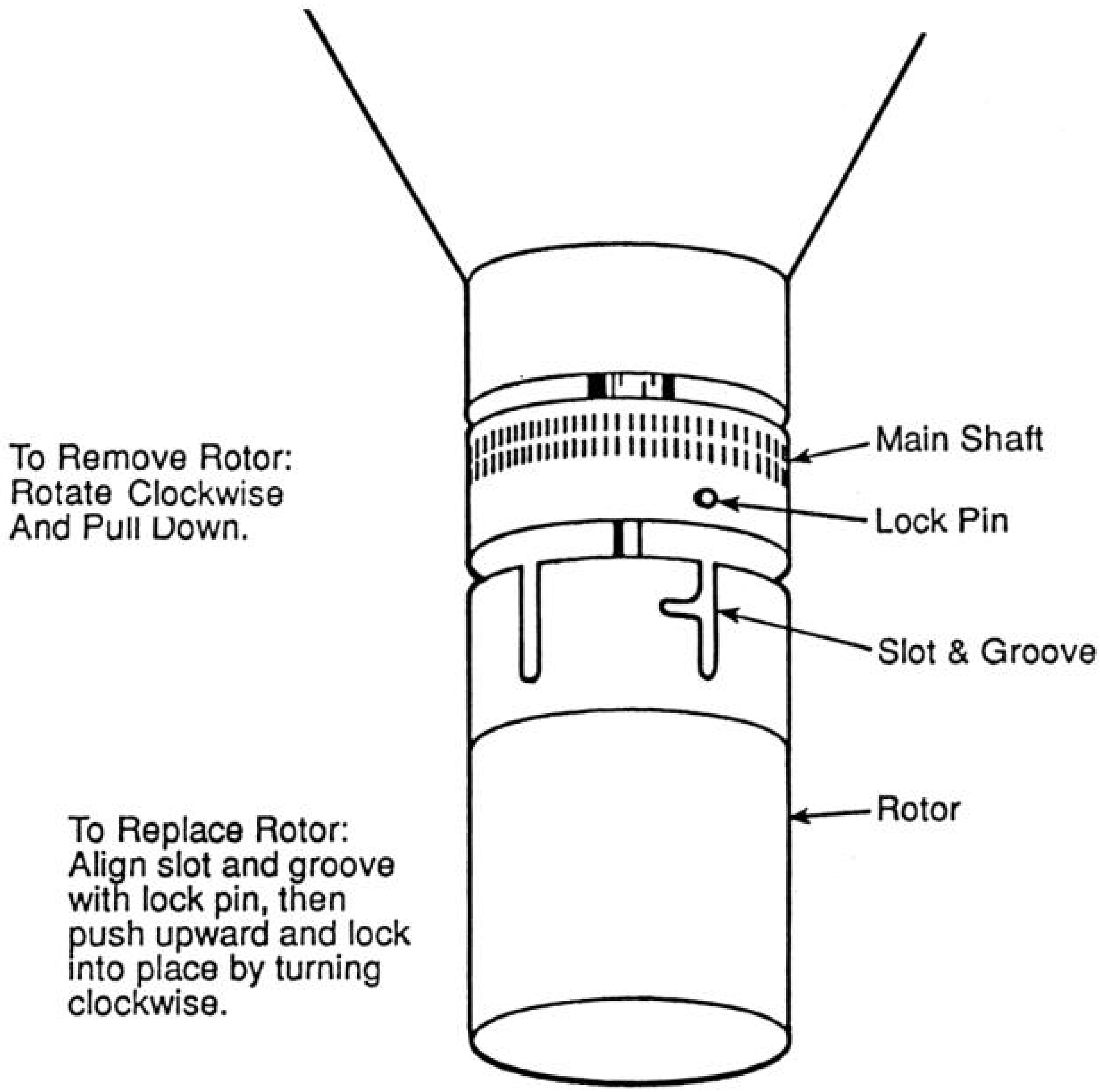


Fig. 3
Rotor Removal / Installation

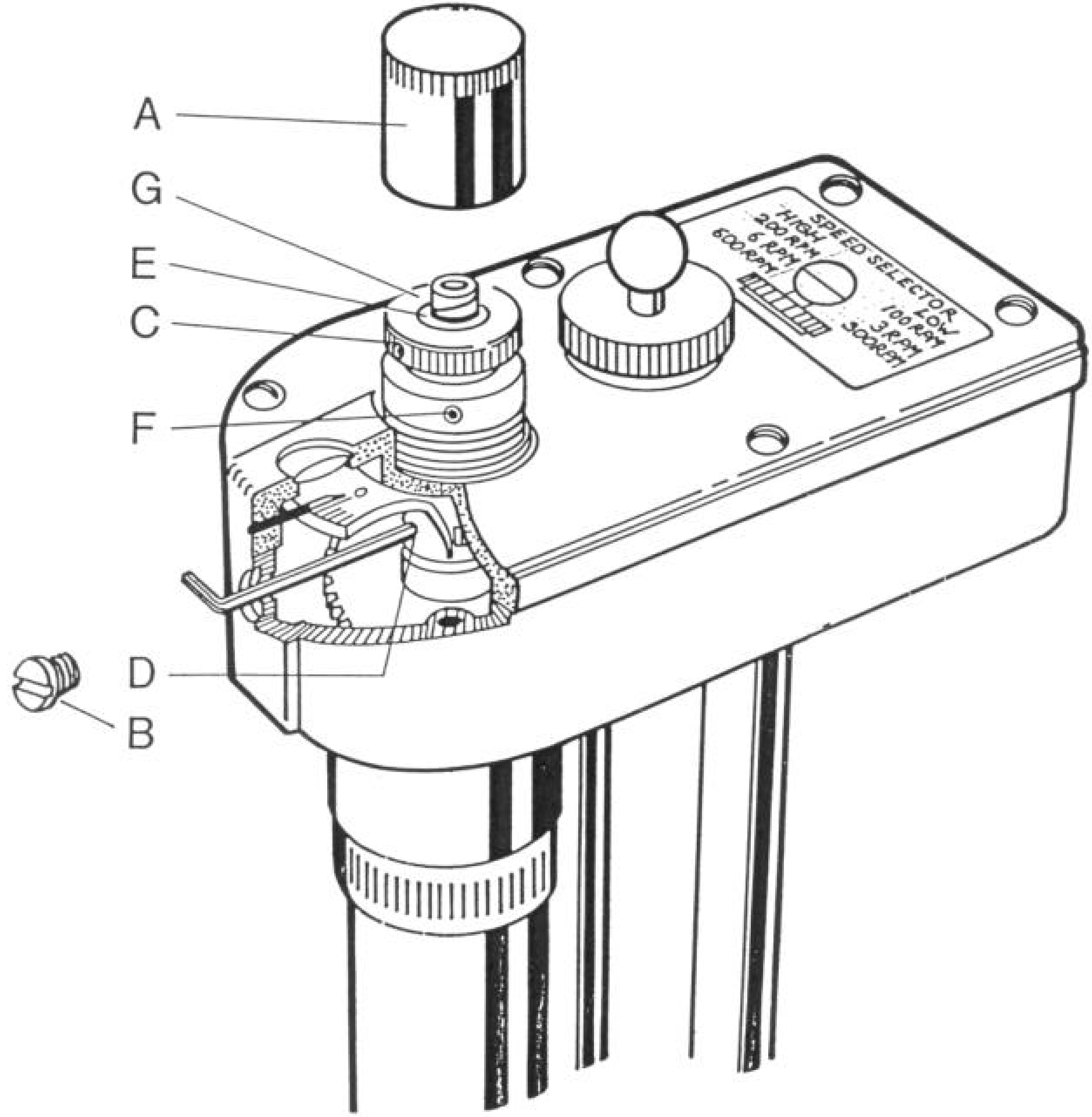


Fig. 4
Torsion Spring Removal and Replacement

SECTION 4
CHANGING ROTORS, BOBS, AND TORSION SPRING

The R1-B1-F1 rotor-bob-torsion spring combination is standard for all FANN viscometer. Other rotor-bob combinations may be used, provided shear rates are calculated for the fluid being tested. Use of rotor-bob combinations which result in large gap sizes can lead to shear stress dial readings not consistent with readings from a smaller gap.

A. Rotor removal and Replacement

The rotor can be removed from its socket by twisting counterclockwise, when viewed from above, while gently pulling straight down. Refer to Fig. 3. The rotor may be replaced by aligning the rotor slot and groove with the lock pin in the main shaft socket. Push the rotor upward and lock it into position by turning it clockwise.

B. Bob removal and Replacement

The bob shaft end that fits into the Bob is tapered and fits into a matching tapered hole in the bob. To remove the bob twist the bob clockwise while pulling downward. To install the bob, twist it clockwise while pushing upward.

C. Torsion Spring Removal and Replacement

Refer to Fig. 4 for identification of parts.

1. Remove the dust cap [A] and plug screw [B].

2. Loosen set screws [C] and [D] about 1/2 turn. The spring can now be lifted out. Be careful not to stretch the spring.

3. Insert the new spring, making sure the bottom mandrel is properly oriented and seated. Set screw [D] should line up with the point at which the spring leaves the bottom mandrel. A notch cut into the upper end of the bottom mandrel will help locate this point. Tighten set screw [D], so that it presses against the split ring to hold the bottom mandrel of the spring.

   NOTE: Before tightening set screw [C] be positive that the top of the adjustable mandrel is flush with the top of clamp [E]. It may be necessary to <u>slightly</u> compress or stretch the spring to accomplish this.

4. Tighten set screw [C]. The slot in the top of the adjustable mandrel should line up with clamping set screw [C].

5. Loosen set screw [F] to zero dial under index, then rotate knob [G] as required for alignment, then adjust knob [G] vertically to allow the spring to be clamped in a "free" position, neither stretched or compressed.

6. Tighten set screw [F] and replace the dust cap [A].

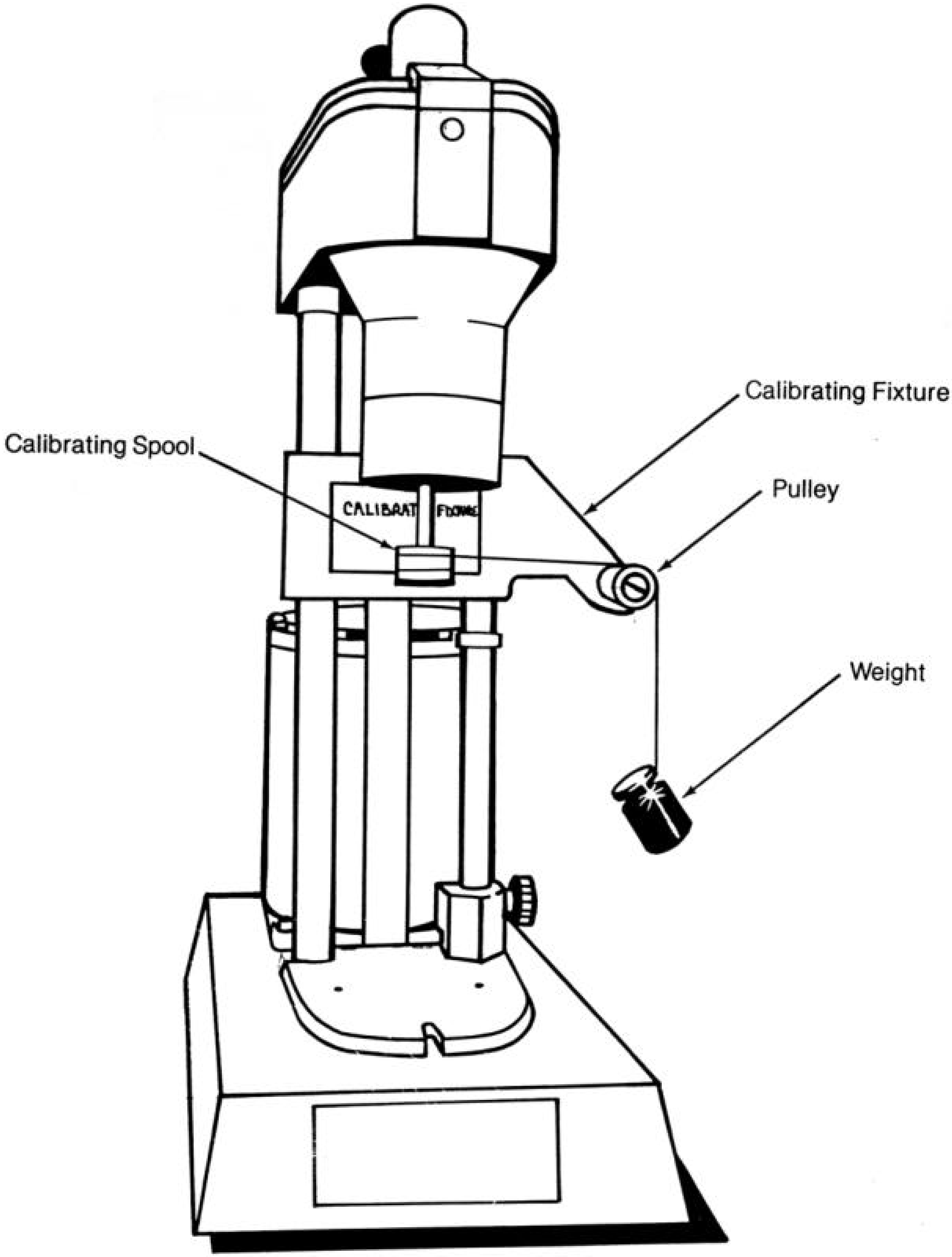


Fig. 1
Dead Weight Calibration
DW-3 Calibration Fixture

SECTION 5

INSTRUMENT CALIBRATION

Periodically the Model 35 Series Viscometer should be checked for proper calibration and if found in error the viscometer should be calibrated or repaired. Continued accuracy of measurements requires the instrument be properly calibrated. The calibration is checked by applying know torques to the bob shaft. For any applied torque, within the torque range of the spring, there should be a specific dial reading plus or minus a small tolerance. Two methods of calibration are described.

The Dead Weight Calibration is easier to perform and if the spring requires adjustment, the proper setting can easily be verified. The Standard Fluid Calibration check verifies the complete instrument is operating properly. It will determine problems of bent bob shaft, rotor eccentricity, and/or runout of the rotor or bob more effectively than the Dead Weight method. Refer to Section 5-B.

A. Dead Weight Calibration Check Using Model DW3 Calibration Kit. Refer to Fig. 5.

1. Remove rotor and bob. Refer to Section 3-A and 3-B. Be sure that the tapered end of the bob shaft is clean, then install the calibrating spool.

2. Install the DW-3 calibrating fixture by clamping it onto the upper portion of the viscometer support legs.

3. Select a weight according to Table 3. Insert the bead at the end of the thread into the recess in the top of the calibrating spool. Wrap the thread a little more than once around the spool and then drape the thread over the pulley.

4. Hang the selected weight on the thread and adjust the calibrating fixture up or down until the thread from the spool to the pulley is horizontal. Compare the dial reading with the reading on Table 3.

5. If necessary, adjust the torsion spring. Refer to Section 5-C, "Adjusting Torsion Spring".

Factory tolerances for F1 spring only are 127 ± 1/2° for 50 g and 254 ± 1/2° for 100 g. A movement of ± 1/2° is permissible when the main shaft is turning. This movement will generally be dampened out when a fluid is being tested. Check the linearity of the dial reading with at least three weights. If the spring appears to be non-linear it is usually a sign that the bob shaft is bent. An instrument with these characteristics needs additional service and/or repair.

TABLE 3
Dial Deflection For Calibration Weights And Torsion Spring Assemblies

Torsion Spring Assembly (with R1-B1 combination)	Torsion Spring Constant, K_1 Dynes/cm/° def	Weight in Grams				
		10	20	50	100	200
		Dial Reading				
F-0.2	77.2	127.0	254.0	-	-	-
F-0.5	193.0	50.8	101.6	254.0	-	-
F-1	386.0	25.4	50.8	127.0	254.0	-
F-2	772.0	-	25.4	63.5	127.0	254.0
F-3	1158.0	-	-	43.0	84.7	169.4
F-4	1544.0	-	-	-	63.5	127.0
F-5	1930.0	-	-	-	50.8	101.6
F-10	3860.0	-	-	-	-	50.8

B. Fluid Calibration Check

This procedure is to be used for calibration using only Newtonian certified calibration fluids. Fann Calibration Fluids are available in nominal 20, 50, 100, 200, and 500 cP. All are traceable to ASTM standards and each bottle of fluid is furnished with a viscosity temperature chart certifying that batch of fluid.

1. The instrument being checked must be clean before immersing the rotor and bob into the calibration fluid. If necessary, remove the rotor and thoroughly clean the bob, bobshaft, and rotor. Make sure the bob shaft and rotor are straight and have not been damaged.

CAUTION

The batch number on the label of the calibration fluid must match the number on the viscosity/temperature chart.

2. Fill the sample cup to the scribed line with calibration fluid and place it on the instrument stage. Elevate the stage so that the rotor is immersed to the proper immersion depth. Refer to Fig. 1.

3. Place a thermometer into the sample until the bulb touches the bottom and then secure it to the side of the viscometer to prevent breakage.

4. Operate the instrument at 300 rpm for three (3) minutes. This will equalize the temperature of the bob, rotor and the fluid.

5. Read the dial at 300 rpm and 600 rpm. Record these numbers, and the temperature from the thermometer to the nearest 0.1° C,(0.15° F).

The viscosity from the temperature chart at the recorded temperature should be within ±2 cP of the 300 rpm reading. Twice the cP viscosity from the chart should be within ± 3 of the 600 rpm reading. Plot the 300 rpm reading and the 600 rpm reading then draw a straight line from zero through these two points. If zero, 300 and 600 points do not fall in a straight line, probably either the rotor, bob or bobshaft is bent or other eccentricity exists. Points at 100 rpm and 200 rpm can be plotted if verification is needed. Readings outside the specified limits are indications that the instrument should be either calibrated or repaired. Refer to Section 5-C for procedure to calibrate the spring. After completion of the calibration check, carefully wipe clean the rotor inner and outer surfaces, the bob, the thermometer, the sample cup, and work area.

C. Torsion Spring Calibration

Refer to Fig. 4 for identification of parts.

NOTE: Make sure the bob shaft is not bent before attempting to adjust the torsion spring,

1 Remove dust cap [A], then loosen set screw [C] about 1/2 turn.

2. Insert the calibration tool into the spring and rotate the adjustable mandrel (inside the spring) slightly. Turn the mandrel counterclockwise if the dial reading is too low or turn the mandrel clockwise if the dial reading is too high.

   NOTE: Before tightening set screw [C] check the top of the upper threaded mandrel and be positive that it is flush with the top of the clamp [E]. To accomplish this, it may be necessary to adjust the spring by slightly compressing or stretching the spring.

3. Tighten set screw [C]. The slot in the top of the adjustable mandrel should line up with clamping set screw [C].

4. Loosen set screw [F] to zero dial under index, then rotate knob [G] as required for alignment, then adjust knob [G] vertically to allow the spring to be clamped in a "free" position, neither stretched or compressed.

5. Tighten set screw [F] and replace the dust cap [A].

SECTION 6
DATA REDUCTION

A. Newtonian Viscosity Calculations

Newtonian Viscosity in centipoise may be read directly from the dial when viscometer is run at 300 rpm with R1-B1-F1 combination. Other springs may be used providing the dial reading is multiplied by the "f" factor (spring constant).

To rapidly determine Newtonian viscosities in cP with FANN viscometer, use the following formula:

$?_N$ = S x ? x f x C

where,

S = Speed factor (Refer to Table 5)
? = Dial reading
f = Spring factor (Refer to Table 3)
C = Rotor-bob factor (Refer to Table 4)
$?_N$ = Newtonian viscosity - cP

Example: Using an R2-B1 combination at a speed of 600 rpm with an F5.0 spring, and a dial deflects to 189.

$?_N$ = 0.5 x 189 x 5 x .315 = 149 cP.

NOTE: Combinations with the larger gaps are likely to give results that differ from these figures. For best accuracy, calibrate with a standard fluid having a viscosity near the range of interest and using the R-B-F combination to be used in the test.

TABLE 4
Calculated C values from rotor-bob dimensions

Rotor-Bob Combination	R-B Factor C
R1-B1	1.000
R1-B2	8.915
R1-B3	25.392
R1-B4	50.787
R2-B1	.315
R2-B2	8.229
R2-B3	24.707
R2-B4	49.412
R3-B1	4.517
R3-B2	12.431
R3-B3	28.909
R3-B4	57.815

TABLE 5
Speed Factor S base 300 rpm = 1

Rotor rpm	Speed Factor S
.9	333.3
1.8	166.6
3	100
6	50
30	10
60	5
90	3.33
100	3
180	1.667
200	1.5
300	1.0
600	.5

B. Approximation of Plastic Viscosity and Yield Point

Using R1-B1-F1 components, test a sample running the viscometer at 600 rpm and note the dial reading. Change the speed to 300 rpm and note the dial reading. Determine the PV and YP using the following equations. PV represents the slope of a straight line between the two dial readings. YP represents the theoretical point at which the straight line, when projected, will intercept the vertical axis.

PV (plastic viscosity, (lbs/100 ft^2)/300 rpm) = $?_{600} - ?_{300}$

YP (yield point in lbs/100 ft^2) = $?_{300}$ - PV

CAUTION

A spring other than F1 may be used if the dial readings are multiplied by the proper "f" factor, but the other rotor-bob combinations can not be used for this rapid, two point method.

C. Calculation of the Spring Constant (Dead Weight Method)

$$K_1 = \frac{Grg}{?}$$

Where K_1 = spring constant - dynes/cm/degree deflection

G = Load in grams

g = 981 = gravitational constant (cm/sec^2)

r = Radius arm = 1 cm

? = Dial reading in degrees

Example: The required setting for the F1 spring is 386 dynes/cm/degree deflection with the R1-B1 combination. Using the 50 gm weight supplied with the fixture, the formula is:

$$K_1 = \frac{50 \text{ x } 981 \text{ x } 1}{386} = 127?$$

SECTION 7
MEASURING RANGE

TABLE 6
Measuring Range for FANN Direct Indicating Viscometer

ROTOR-BOB	R1 B1	R2 B1	R3 B1	R1 B2	R1 B3	R1 B4
BASIC DATA						
Rotor Radius, $R_{0,}$cm	1.8415	1.7588	2.5866	1.8415	1.8415	1.8415
Bob Radius. R_1, cm	1.7245	1.7245	1.7245	1.2276	0.8622	0.8622
Bob height, L, cm	3.800	3.800	3.800	3.800	3.800	1.900
Shear Gap in Annulus, cm	0.1170	0.0343	0.8621	0.6139	0.9793	0.9793
Radii Ratio, R_1/R_0	0.936	.09805	0.667	0.666	0.468	0.468
Maximum Use Temperature, °C (°F)	93(200)	93(200)	93(200)	993(200	93(200)	93(200)
Minimum Use Temperature, °C (°F)	0(32)	0(32)	0(32)	0(32)	0(32)	0(32)
Overall Instrument Constant, K	300.0	94.18	1355	2672	7620	15,200
Standard F1 Torsion Spring ? = Kfq/N						
SHEAR STRESS RANGE						
Shear Stress Constant for Effective						
Bob Surface K_2,cm^{-3}	0.01323	0.01323	0.01323	0.0261	0.0529	0.106
Shear Stress Range, dynes/cm^2 t = K_1K_2q						
F0.2 q = 1°	`1.02	1.02	1.02	2.01	4.1	8.2
F0.2 q = 300°	307	307	307	605	1225	2450
F0.5 q = 1°	2.56	2.56	2.56	5.04	10.2	20.4
F0.5 q = 300°	766	766	766	1510	3060	6140
F1 q = 1°	5.11	5.11	5.11	10.1	20.4	40.9
F1 q = 300°	1533	1533	1533	3022	6125	12,300
F2 q = 1°	10.22	10.22	10.22	20.1	40.8	81.8
F2 q = 300°	3066	3066	3066	6044	12,250	24,500
F3 q = 1°	15.3	15.3	15.3	30.2	61.3	123
F3 q = 300°	4600	4600	4600	9067	18,400	36,800
F4 q = 1°	20.4	20.4	20.4	40.3	81.7	164
F4 q = 300°	6132	6132	6132	12,090	24,500	49,100
F5 q = 1°	25.6	25.6	25.6	50.4	102	205
F5 q = 300°	7665	7665	7665	15,100	30,600	61,400
F10 q = 1°	51.1	51.1	51.1	100.7	204	409
F10 q = 300°	15,330	15,330	15,330	30,200	61,200	123,000
SHEAR RATE RANGE						
Shear Rate Constant K_3, sec^{-1} per rpm	1.7023	5.4225	0.377	0.377	0.268	0.268
Shear Rate Range,sec^{-1} g = K_3N						
N = 0.9 rpm	1.5	4.9	0.4	0.4	0.24	0.24
N = 1.8 rpm	3.1	9.8	0.7	0.7	0.48	0.48
N = 3 rpm	5.1	16.3	1.1	1.1	0.80	0.80
N = 6 rpm	10.2	32.5	2.3	2.3	1.61	1.61
N = 30 rpm	51.1	163	11.3	11.3	8.0	8.0
N = 60 rpm	102	325	22.6	22.6	16.1	16.1
N = 90 rpm	153	488	33.9	33.9	24.1	24.1
N = 100 rpm	170	542	37.7	37.7	26.8	26.8
N = 180 rpm	306	976	67.9	67.9	48.2	48.2
N = 200 rpm	340	1084	75.4	75.4	53.6	53.6
N = 300 rpm	511	1627	113	113	80.4	80.4
N = 600 rpm	1021	3254	226	226	161	161

VISCOSITY RANGE IN CENTIPOISE[1]						
Minimum Viscosity[2]						
All models, 600 rpm maximum	0.5[3]	0.5[3]	2.3	4.5	12.7	25
Maximum Viscosity[4]						
For Model 34A & HC34A, 300 rpm minimum	300	94	1,350	2,700	7,620	15,000
For Model 35A & 35SA, 3 rpm minimum	30,000	9,400	135,000	270,000	762,000	1,500,000
For Model 35A/SR12 & 35SA/SR12,0.9 rpm minimum	100,000	31,400	400,000	890,000	2,550,000	5,000,000
Notes: (1) Computed for standard Torsion Spring (f = 1.) For other torsion springs multiply viscosity range by f factor. (2) Minimum viscosity is computed for minimum shear stress and maximum shear rate. (3) For practical purposes the minimum viscosity is limited to 0.5 cP because of Taylor Vortices. (4) Maximum viscosity is computed for maximum shear stress and minimum shear rate.						

Viscosity Computation

Viscosity can be computed in several ways:

1. In terms of an overall instrument constant

$$\eta = Kf\frac{\theta}{N}$$

where K is the overall instrument constant $\left(\frac{\text{dyne sec}}{\text{cm}^2}\right)\left(\frac{\text{rpm}}{\text{degrees deflection}}\right)$

f is the torsion spring factor
θ is the Fann Viscometer reading
N is the rate of revolution of the outer cylinder
η will be in centipoise

2. In terms of three instrument constants for torsion spring, bob surface, and shear gap.

$$\eta = \frac{k_1 k_2}{k_3}(100)\frac{\theta}{N}$$

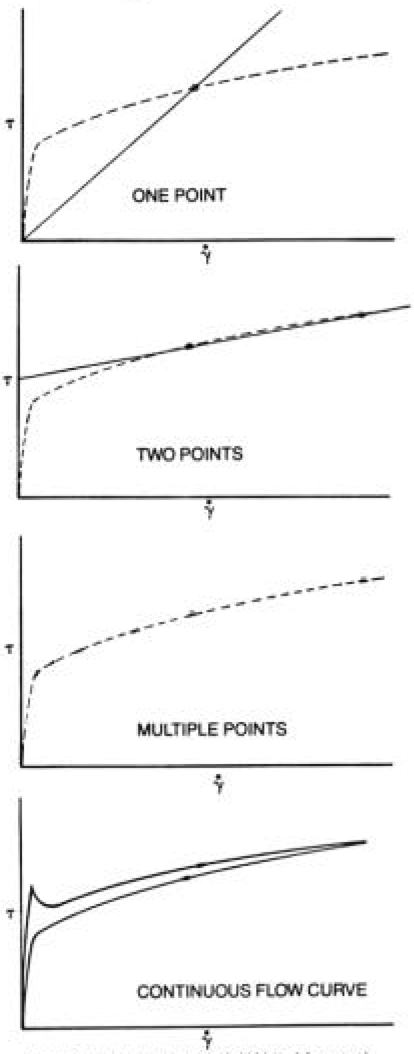
where k_1 is the torsion constant in dyne-cm/degree deflection
k_2 is the shear stress constant for the effective bob surface, cm³
k_3 is the shear rate constant, sec^{-1} per rpm
100 is a conversion factor
1 poise = 100 cP
η will be in centipoise

3. In terms of shear stress divided by shear rate

$$\eta = \frac{\tau}{\dot{\gamma}}$$

where τ is the shear stress in dynes/cm²
$\tau = k_1 k_2 \theta$
$\dot{\gamma}$ = shear rate in sec^{-1}
$\dot{\gamma} = k_3 N$
η will be in poise
1 poise = 100 cP

Viscosity Measurements



Viscosity measurements of a fluid (dotted rheogram) with different instruments: one-point; two-point; multiple points; continuous flow curve.

Torsion Springs

TORSION SPRING ASSEMBLY	TORSION SPRING CONSTANT k_1 (dyne-cm/deg. defl)	f	MAXIMUM SHEAR STRESS WITH B1 BOB (dynes/cm²)	COLOR CODE
F0.2	77.2	0.2	307	Green
F0.5	193	0.5	766	Yellow
F1	386	1	1,533	Blue
F2	772	2	3,066	Red
F3	1,158	3	4,600	Purple
F4	1,544	4	6,132	White
F5	1,930	5	7,665	Black
F10	3,860	10	15,330	Orange

Conversion Factors

SI UNITS	SYMBOL	UNIT	ABBR.	CONVERSION
Shear Stress	τ	Pascal 1 Pascal = 1 Newton/meter²	Pa	1 Pa = 10 dynes/cm²
Shear Rate	$\dot{\gamma}$	Reciprocal Second	s^{-1}	1 s^{-1} (no change)
Viscosity	η	Pascal Second or Milli Pascal Second	Pa · s mPa · s	1 Pa · s = 10 poise 1 mPa · s = 1 cP
OILFIELD UNITS (R1 Rotor, B1 Bob and F1 Torsion Spring)				
Shear Stress (exact)	τ	dynes/cm²	—	1° Fann = 5.11 dynes/cm²
Shear Stress (exact)		lb/100 ft²	—	1° Fann = 1.065 lb/100 ft²
Shear Stress (approx.)		lb/100 ft²	—	1° Fann = 1 lb/100 ft²
Shear Rate	γ	Reciprocal Second	1/sec	1/sec = 1.7023 N
Viscosity	μ	centipoise	cP	$\mu = \frac{5.11\theta}{1.70\,N}(100) = 300\frac{\theta}{N}$
Effective Viscosity	μ_e	centipoise	cP	$\mu_e = 300\frac{\theta}{N}$
Plastic Viscosity	PV	centipoise	cP	$PV = \theta_{600} - \theta_{300}$
Yield Point	YP	lb/100 ft²	—	$YP = \theta_{300} - PV$

SECTION 8
TROUBLE SHOOTING AND MAINTENANCE

A. Troubleshooting

Symptoms	Causes
Erratic dial motion	1. Contaminated bob shaft bearings 2. Bent bob shaft 3. Rotor out of alignment 4. Incorrectly adjusted main shaft
Out of calibration	1. Contaminated bob shaft 2. Bent bob shaft 3. Bent rotor 4. Friction in bob shaft bearings 5. Damaged or incorrectly installed torsion spring 6. Motor needs replacement
Excessive noise	1. Lubrication failure or contamination in gears 2. Worn center shaft bushing 3. Top cover can create a bind in gear train if set improperly
Excessive run-out of rotor	1. Damaged rotor 2. Contamination in main shaft recess
Sticking support legs	1. Corrosion/contamination within support legs 2. Broken spring 3. Legs out of adjustment
Loose gear housing	1. Bolts attaching gear housing to support legs are loose

B. Maintenance

The bob and rotor should be cleaned after each test and examined periodically for dents, abrasion or other damage. Oiling or greasing of the viscometer is not required in normal service. Always remove the bob from the bob shaft when transporting instrument to avoid bending bob shaft.

Periodically test the bob shaft bearings. Operate the instrument at 3 or 6 rpm with no sample around the rotor and bob. Observe movement of the dial. It should not move more that +/- 1 division. Rough bob shaft bearings should be replaced.

Instrument should be serviced by qualified personnel only. If factory service is required, contact Fann for return authorization.

SECTION 9
SPECIFICATIONS

Part No.	Model No.	Speeds RPM	Power Req.	Size				Weight	
					H	W	D	LB	KG
30164	35A	3, 6, 100, 200 300 and 600	115 Volts, 60 Hz, .075 Amps	In. Cm.	15.2 39	6 15	10.5 27	15	6.8
30165	35SA	3, 6, 100, 200 300 and 600	115 Volts, 50 Hz, 0.75 Amps	In.	15.2	6	10.5	15	6.8
30166	35A/SR-12	.09, 1.8, 3, 6, 30, 60, 90, 100, 180, 200, 300 and 600	115 Volts, 60 Hz, 0.75 Amps	In. Cm.	15.2 39	6 15	10.5 27	17	7.7
30167	34SA/SR-12	0.9, 1.8, 3, 6, 30, 60, 90, 100, 180, 200, 300 and 600	115 Volts, 50 Hz, 0.60 Amps	In. Cm.	15.2 39	6 15	10.5 27	17	7.7

TABLE 7

Rotor-Bob Dimensions

Unit	r-cm	Length-cm	Cyl. Area-cm^2 x Radius-cm
B1	1.7245	3.8	71.005
B2	1.2276	3.8	35.981
B3	0.86225	3.8	17.751
B4	0.86225	1.9	8.876
R1	1.8415		
R2	1.7589		
R3	2.5867		

SECTION 10
ACCESSORIES

Torsion Springs				
Part No.	F.	Constant	Max Shear Stress	Color Code
31068	F0.2	77.2	307	Green
31069	F0.5	193	766	Yellow
30752	F1	386	1,533	Blue
31070	F2	772	3,066	Red
31071	F3	1,158	4,600	Purple
31072	F4	1,544	6,132	White
31073	F5	1,930	7,665	Black
31074	F10	3,860	15,330	Orange

Rotors	
30847	R1, Chrome-plated Brass
30849	R2, Chrome-plated Brass
30851	R3, Chrome-plated Brass
31716	R1, 303 Stainless Steel
31718	R2, 303 Stainless Steel
31720	R3, 303 Stainless Steel
35617	R1, Closed-end, Stainless Steel
35619	R2, Closed-end, Stainless Steel

Bobs	
30844	B1, 303 Stainless Steel, Hollow
30843	B2, 303 Stainless Steel, Solid
30842	B3, 303 Stainless Steel, Solid
30841	B4, 303 Stainless Stell, Solid

Sample Cups	
31203	Thermocup, 115 Volts, 50/60 Hz, 2 amps
31204	Thermocup, 230 Volts, 50/60 Hz, 1 amp
31759	Double-Wall Circulating Cup
35283	Insulated Sample Cup
30929	Stainless Steel Sample Cup

Circulators	
35293	Heat-only Circulator, 90°- 212°F, four-liter cap., 115 Volts, 60 Hz, 1,000 Watt
35294	Refrigerated Circulator, 0°- 210°F, five-liter cap., 115 Volts, 60 Hz. Heater Capacity 1,000 Watt

Calibration	
31517	DW3 Dead Weight Calibration Fixture
28696	Calibration Reference Fluid, 10 cP, 16 oz (475 ml)
28691	Calibration Reference Fluid, 20 cP, 16 oz (475 ml)
28692	Calibration Reference Fluid, 50 cP, 16 oz (475 ml)
28693	Calibration Reference Fluid, 100 cP, 16 oz (475 ml)
28694	Calibration Reference Fluid, 200 cP, 16 oz (475 ml)
28695	Calibration Reference Fluid, 500 cP, 16 oz (475 ml)

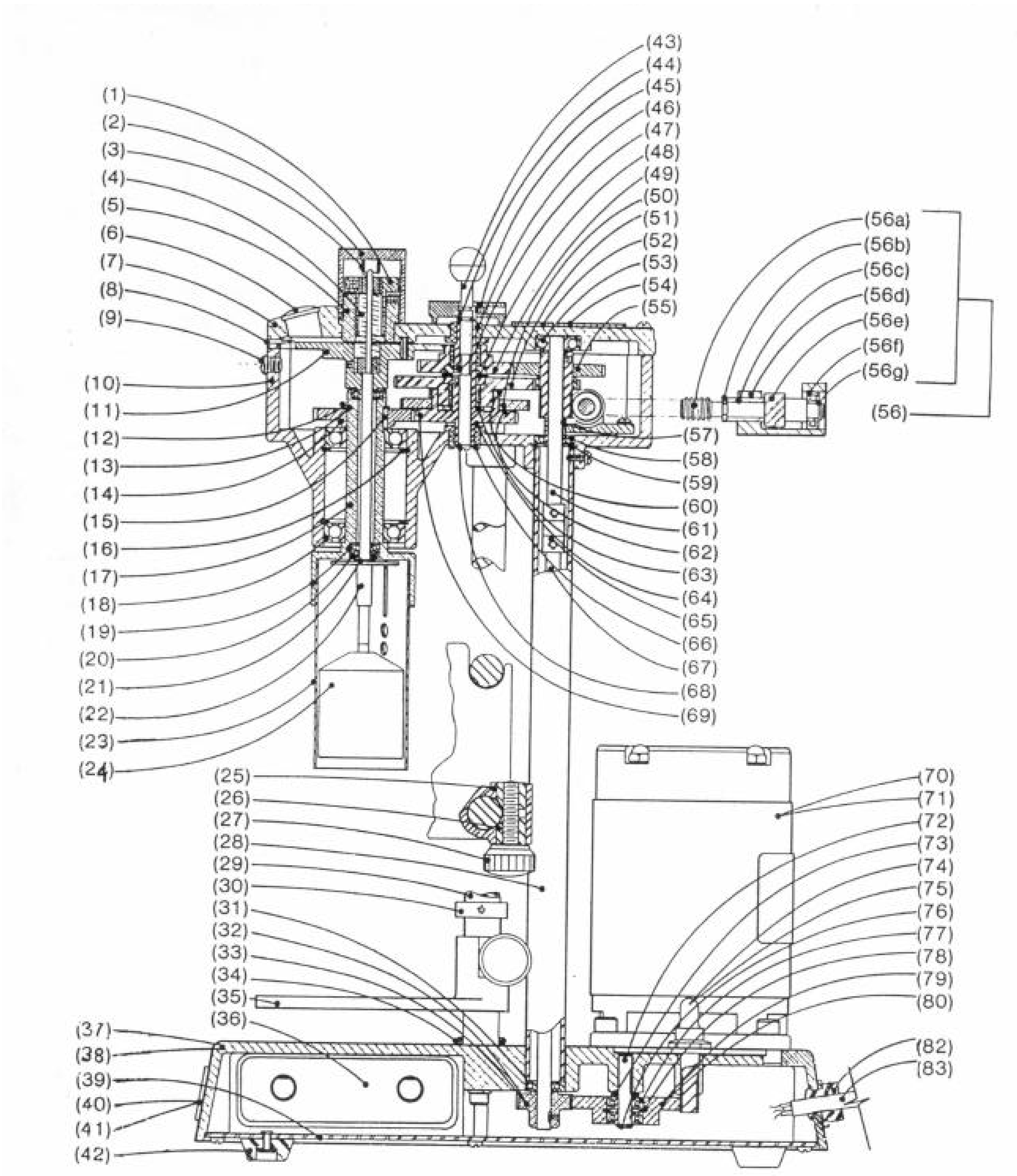


Fig. 6
35A & 35SA

SECTION 11
PARTS LIST

1	30985	Zeroing Sleeve
2	30973	Dust Cap
3	30986	Clamp Sleeve (2)
4	30752	Spring Ass'y. F-1
5	30924	Spring Bushing
6	30975	Lens
7	30793	Housing Cover Ass'y.
8	30862	Pointer
9	30999	Plug Screw
10	31637	Gear Housing
11	30723	Bob Shaft & Dial Ass'y.
12	30027	Retainer
13	31899	Shim
14	30920	Main Shaft Gear
15	30804	Main Shaft Key
16	31546	Retainer (2)
17	31775	Main Shaft
18	30729	Bearing (2)
19	30732	Bearing (2)
20	30912	Bearing Shield
21	L4982	Retainer
22	30887	Splash Guard
23	30847	Rotor R-1
24	30844	Bob B-1
25	30988	Clamp Nut
26	30989	Clamp Spacer
27	30977	Clamp Screw
28	30054	Drive Shaft Tube
29	30991	Support Rod (2)
30	30984	Stop Collar
31	30713	Bearing
32	30935	Drive Shaft Gear (35A)
33	30934	Drive Shaft Gear (35SA)
34	L4511	O-Ring
35	30726	Stage
36	32426	Capacitor
37	30741	Base (35A)
38	30170	Base (35SA)
39	30743	Cover Plate
40	30797	Name Plate (35A)
41	30796	Name Plate (35SA)
42	L7213	Rubber Feet (4)
43	30822	Shift Rod Ass'y.
44	30987	Detent Spring
45	30983	Gel Knob
46	30734	Bushing
47	31271	Balls (6)
48	31400	Washer
49	30913	Upper Change Gear
50	31771	Worm Gear
51	30917	Lower Change Gear
52	31794	Temp. Warning Tag
53	30922	Bearing
54	30795	Speed Selection Tag
55	30928	Cluster Gear
56	30717	Jack Shaft Ass'y.
56a	30716	Worm
56b	30715	Washer
56c	30712	Bushing
56d	30711	Frame
56e	30813	Shaft & Gear
56f	30713	Bearing
56g	31398	Retainer
57	30701	Spacer
58	30713	Bearing
59	30026	Retainer
60	30939	Clutch Spring
61	30905	Upper Drive Shaft
62	31912	Thrust Washer
63	31275	Shim
64	31419	Washer
65	30053	Flex Coupling
66	30734	Bushing
67	30925	Lower Drive Shaft
68	30779	Stop Screw
69	30830	Center Shaft Gear Ass'y.
70	30724	Motor (35A)
71	30725	Motor (35SA)
72	30976	Idler Shaft
73	30776	Washer
74	32919	Switch
75	31288	Switch Boot
76	31398	Retainer
77	30713	Bearing (2)
78	30026	Retainer
79	31918	Idler Gear (35A)
80	31919	Idler Gear (35SA)
82	E3114	Strain Relief
83	A7003	Power Cord

Not Shown

30693	Tag High-Off-Low
30929	Sample Cup

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