HERCULES®

HI-SHEAR VISCOMETER

Model TS-8

USER GUIDE

KALTEC SCIENTIFIC, INC.
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U. S. A.

Hercules Hi-Shear Viscometer
Model TS-8
Instruction Manual

Kaltec Scientific, Inc.
Last Revision: 12/91

Guaranty and Certificate of Quality

All Hercules Hi-Shear Viscometers are guaranteed against defects in materials and workmanship for a period of one year providing:

- The defective unit has been operated within published electrical specifications;
- The unit has not been damaged by misuse, improper operation, or accident;
- The unit has not been modified or altered; and
- The original purchaser pays all costs of transportation of the unit to Kaltec Scientific, Inc.

VISCOMETERS MUST BE RETURNED DIRECTLY TO THE FACTORY, NOT TO THE DISTRIBUTOR OR AGENT FROM WHICH THEY WERE PURCHASED.

Kaltec Scientific, Inc. limits its obligation under this warranty solely to the repair or replacement of any unit returned during the period covered by the warranty. No other obligations or liabilities are implied or expressed. This form serves as a certificate of quality.

Kaltec Scientific, Inc.

Description and Features

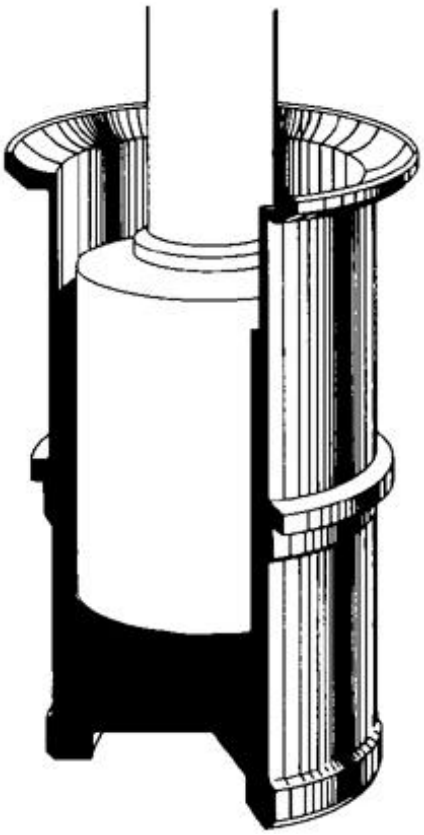
The TS-8 is specifically designed for research and development work. This model is devoted to rendering high accuracy and excellent repeatability to viscometric measurements.

This versatile instrument features a comprehensive control panel and XYT recorder. Its torque transducer provides expanded full-scale accuracy and excellent resolution on low viscosity samples.

The TS-8 has the unique ability to plot viscosity (shear stress) as a function of time, at constant or varying shear rates. Switching the RPM scale to a time base generator performs TIME/FLOW measurements. Periods of recording may be between 22 seconds and 18.3 minutes.

How it Works:

The sample being tested is confined between two coaxial cylinders and the inner cylinder (bob) is rotated. The viscous drag of the sample induces rotational force to the outside cylinder (or cup), which is sensed by a torque sensor that outputs an analog signal directly to the XYT recorder. The TS-8 plots a rheogram of speed vs. torque and is readily calculated into shear rate vs. viscosity or shear rate vs. shear stress.



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Section One

Viscometer Set Up

Unpacking the Viscometer:

Your viscometer and its components were inspected before leaving Kaltec Scientific, Inc., and should be in good working order. Carefully unpack the viscometer by following the instructions listed below.

- Remove the eight (8) screws located at the bottom of the outer box.
- Lift the outer box straight up to clear the viscometer. Two people are recommended to complete this step.
- Invert outer box and remove the parts inside.
- Elevate the base to remove the four (4) bolts fastened to the viscometer.

It is important not to pry the crate apart. The crate and packing materials should be saved in case you ever need to ship your viscometer in for service.

General Assembly:

Except for a few small components, the unit is shipped pre-assembled. These small components include the following: Leveling Mounts (4), Bobs (6), Cup (1), Pinion Levers (2), and Electrical Cords (1).

It is always a good practice for the technician responsible for a laboratory instrument's operation to supervise its unpacking and assembly.

- Carefully remove the unit from its packing and place it on a sturdy table or bench.
- Screw the four rubber leveling mounts into the extended feet of the main casting and adjust the leveling mounts until the unit stands firmly on the table or bench.
- Attach the Pinion Levers by screwing them into the Pinion.
- Connect the unit to the properly rated and grounded electrical outlet (Refer to the metal specification plate affixed to the rear of the unit).
- Connect the data information cable from the viscometer to the input plug on the bottom of the recorder.

Unpacking the XYT Recorder

This instrument has been accurately calibrated before shipping, carefully tested for proper operation and thoroughly inspected for any defects. It passed all inspections and was packed carefully. Unpack it

slowly and check for any damage that might have occurred during shipping. Should you find any, notify the shipping agent or carrier immediately.

Installing the XYT Recorder

The recorder should not be operated near any intensive source of heat or acid fumes. Make sure that the proper line or AC-voltage is used. Unless otherwise specified, your instrument is equipped for operation with 220 V, UK 240 V, USA 110 V, and 50-60 Hz. Subsequent change is possible, but should not be done without checking with a Kaltec engineer.

Key points to keep in mind when using the recorder are:

- The two retaining screws must be removed before operating. **Save these screws and the shipping carton, in case you need to ship the recorder in for service.**
- Always set both toggle switches on X and Y modules in "cal" and "M" position.
- To engage the time base, set toggle to "YT" position on the LYD module. Time base will automatically start when TRACE, SET RPM, or AUTO buttons are depressed.

Section Two

Supplies and Accessories

Viscometer Accessories:

The accessories listed below were shipped with the viscometer.

Cup (P/N 10042): Insert the Cup carefully into the Cup Holder. Align the Cup's key with the Cup Holder's key. Carefully lower the Cup to the bottom. Turn the Cup slightly counterclockwise until the Cup locks into place. **CAUTION: If the Cup is difficult to remove from the Cup Holder, do not force the Cup out. Forcing the Cup will either damage the Cup or the Cup Holder. To remove the Cup, gently tap the Cup with your hand. Lift the Cup straight up.** Refer to **Symptoms and Solutions** in Section 4**.**

Bobs (P/N 10020 - 10031): Screw the Bob clockwise no more than finger tight onto the lower, threaded end of the Drive Spindle. NOTE: Hold the Drive Spindle only by the flats at the top, using the Spindle Wrench provided.

Bob Box (P/N 10035): The Bob Box was specifically designed to hold Bobs A, B, C, D, E, and FF. The box prevents the Bobs from being damaged while not in use.

Fluid Depth Gauge (P/N 10310): The line closest to the letter represents the amount of sample necessary for a particular Bob. To use: Insert the gauge (ball end up) in the Cup. Hold the gauge straight up with the end resting on the bottom of the Cup. Pour the sample into the center of the Cup until it reaches the line on the gauge for the Bob you will be using.

Splash Shield (P/N 12101): The shield is a safety precaution. It also prevents possible splattering of test material. This shield must be in place while spindle is rotating.

Accessories List:

PART NUMBER	DESCRIPTION
10042	Cup
10020	"A" Bob
10022	"B" Bob
10024	"C" Bob
10026	"D" Bob
10028	"E" Bob
10029	"EE" Bob
10031	"FF" Bob
10033	Bob Box
10310	Fluid Depth Gauge
12101	Splash Shield

XYT Recorder Supplies

Your viscometer was originally shipped with a pack of graph paper and two pens.

Paper Kaltec's Graph Paper, part number 10400. The graph will be speed vs. torque and is readily calculated into shear rate vs. viscosity or shear rate vs. shear stress.

Pens Recorder Model LY17100: Red pen, part number 36714; Black pen, part number 36716.

Recorder Model Ly17300: Red pen, part number 36715; Black pen, part number 36717.

Section Three

The Viscometer

Control and Indicators

ABORT: Interrupts any operation, halts rotation of the Bob, and the pen movement of the recorder within one second, but -- unlike **STOP** -- does not reset the **DIGITAL TIMER** or **DIGITAL RPM** displays.

AUTO: Activates a standard, fully reproducible measurement cycle. The Bob will accelerate from zero rpm to a pre-selected maximum in a fixed duration of 20.4 seconds and then will decelerate to zero rpm in the next 20.4 seconds. The recorder is automatically driven up and down with the Bob's direction to generate the Y-axis of the rheogram. The actual maximum rpm achieved will remain until pressing the STOP button resets the display.

DIGITAL TIMER: Displays the time elapsed from the start of a cycle to the point at which it achieves its maximum rpm speed. The **TIMER** retains this readout of elapsed time during deceleration cycle or when **RETURN**, **ABORT**, **HOLD**, or **SET-RPM** functions are activated. Press **STOP** button to reset **TIMER** to zero.

DIGITAL RPM: Indicates maximum Bob rpm speeds attained in **AUTO**, **TRACE**, **SET-RPM**, and **HOLD** functions. During **AUTO** and **TRACE** cycles, the display will follow the acceleration but not the deceleration of the Bob rpm speed. Use the actual RPM value retained in the display when calculating viscosity.

HOLD: For use with **TRACE** operation. Pressing the **HOLD** button during **TRACE** cycle halts the Bob's acceleration and maintains constant rpm speed from that point on. At the same time, the recorder is halted and the **DIGITAL TIMER** is activated. Once **HOLD** is activated Bob speed can only be decelerated.

RETURN: Decelerates the rotation speed of the Bob and reverses the pen's direction. During a **TRACE** or **HOLD** operation, pressing the **RETURN** button decelerates Bob and pen movement to zero at the same rate as that of the previous acceleration. During **SET-RPM** operation, pressing the **RETURN** button decelerates the speed of the Bob (nut not the recorder) to zero within one second. This is the preferred way to stop a Bob during **SET-RPM** operation.

RPM SELECTOR: For use with **TRACE**, **AUTO**, and **SET-RPM** functions. Selects maximum Bob rpm speeds. The "Vx1" setting selects a speed roughly equal to that indicated on **VARIABLE RPM DIAL** -- from 0 to 1000 rpm. The "Vx10" setting selects a speed roughly ten times that shown on **VARIABLE RPM DIAL** -- from 0 to 5500 rpm. The remaining four

settings select speeds corresponding to the pre-set at the **TRIM CONTROLS**.

SET-RPM: Used for precise pre-selection of maximum rpm for a specific measurement cycle as well as to adjust or change the values at the **TRIM CONTROLS**. Bob accelerates to selected maximum rpm within one second and then runs at this speed until stopped. Actual speed may be read at **DIGITAL RPM** indicator and may be adjusted (if variant) during operation at the **VARIABLE RPM DIAL** (with the **RPM SELECTOR** set at "Vx1" or "Vx10"). Either the Bob or the Cup must be removed during this operation. We recommend that both be removed.

STOP: Primarily for terminating a measurement, but may be used to interrupt an operation for any reason. Activation brings the Bob and the recorder pen to rest within one second and resets the **DIGITAL TIMER** and **DIGITAL RPM** displays.

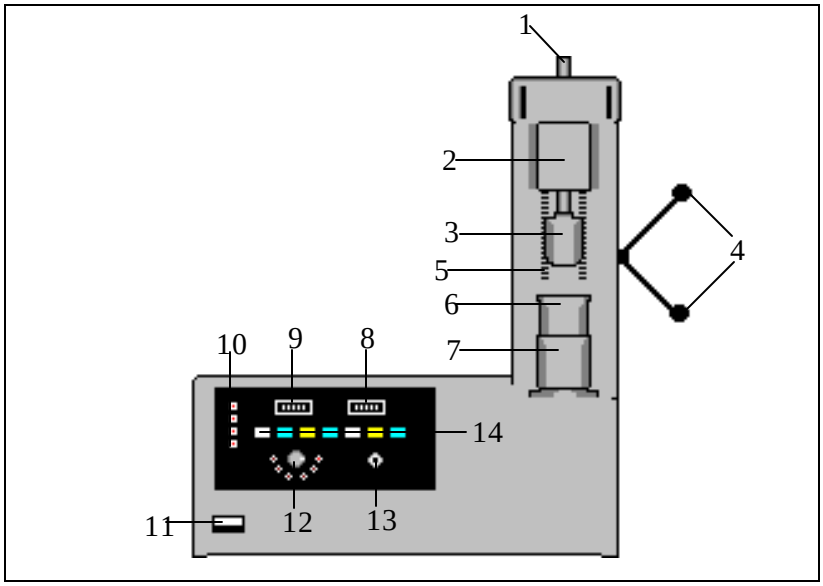
TRACE: Bob accelerates from zero rpm to a selected rpm speed in a fixed 20.4 seconds and then automatically enters **HOLD** mode (unless **HOLD** button is pressed before selected speed is attained), retaining that speed until the **STOP** or **RETURN** button is activated. The moment that selected rpm speed is attained, the **DIGITAL TIMER** activates, and the recorder pen stops.

TRIM CONTROLS: These permit precise calibration or changing of the four preset speeds. See *Calibrating the Viscometer*, page 20, for the operation of these controls.

VARIABLE RPM DIAL: Selects Bob rpm speed when RPM SELECTOR knob is set at "Vx1" or "Vx10." May be used to set maximum Bob rpm speeds for AUTO operation or to set constant Bob rpm speeds for TRACE operation. See *Calibrating the Viscometer*, page 20, for the operation of this control.

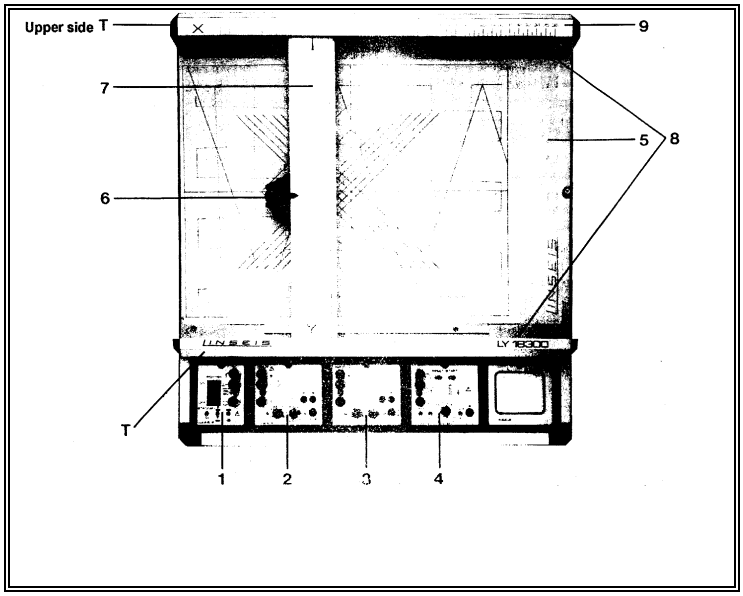
Measuring Zone

The Measuring Zone consists of the Bob, the Cup, the Cup Holder, and the Drive Spindle. It is always important that this area is free of dust. To prevent any dust from getting on to the Bob, the Cup, and the Cup Holder, place the Splash Shield on the Spindle Housing. This is also a safety precaution and keeps the work area cleaner during tests.



(1)	Drive Spindle	(12)	RPM Selector
(2)	Spindle Housing	(13)	Variable RPM Selector
(3)	Bob (Rotor)	(14)	(Left to Right)
(4)	Pinion Levers		* Stop Button
(5)	Dovetail Slide		* Trace Button
(6)	Cup		* Hold Button
(7)	Cup Holder		* Return Button
(8)	Digital RPM Display		* Set-RPM Button
(9)	Digital Timer Display		* Auto Button
(10)	Trim Controls		* Abort Button
(11)	On/Off Button		

The XYT Recorder

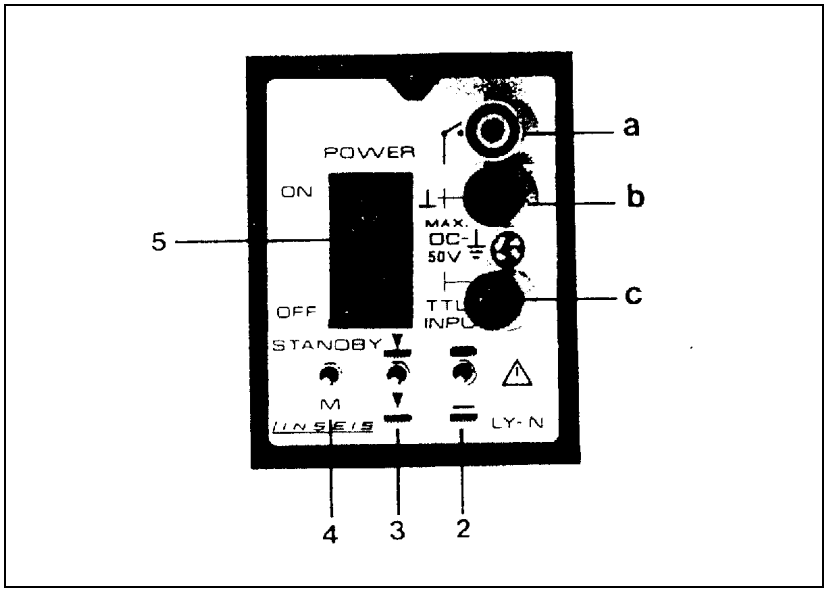


1. Power supply module
2. Input module for the X-axis
3. Input module for the Y-axis
4. Digital time base generator LYD
5. Writing area with paper hold-down mechanism
6. Sled with pen take-up mechanism for the Y-axis
7. Scale for the Y-axis
8. Guides for the X-axis sled
9. Scale for the X-axis

T Transport Screws

Power Supply Module:

The power module contains the main switch and switches for stand-by, pen lift, paper hold-down and jacks for external control of the pen lift.



1. The input jacks a, b, and c are for external pen up/down control.
   Switch 3 must be in the pen up position
   Connect the jacks a and b to lower the pens
   Feed a TTL-signal to the jacks b and c with minus on b to lower the pens

Voltage amplitude	2.4 - 50 V square wave
Cut-off frequency	$\leq$ 6 Hz

2. Switch for the paper hold-down mechanism
   The symbols at the switch represent the paper on the writing area.
   Particularly in dry atmospheres the static charge on the writing area will disappear slowly

3. Switch to raise or lower the pen
   The symbols at the switch represent the position of the pen over the paper.

4. Stand-by switch

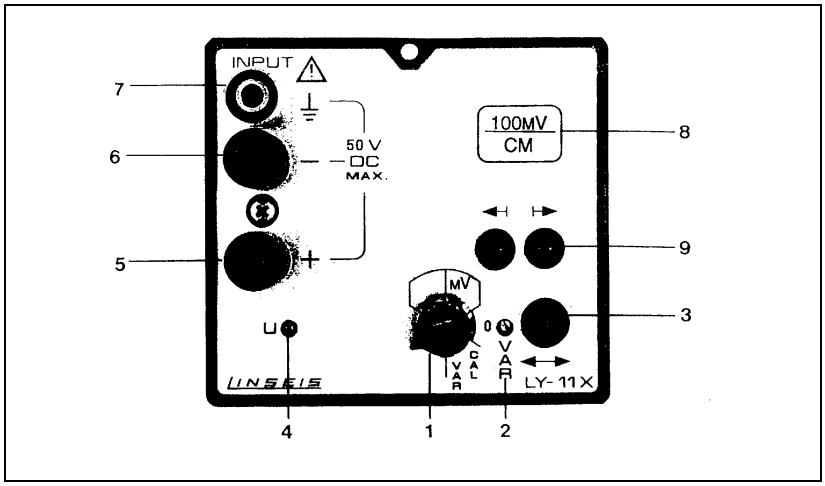
Stand-by	The X-sled moves to the right and the pen to the upper position. The out of range LED is on Incoming signals are ignored. The stand-by is used to change paper, the pen or the adjustment.
M	Measurement

5. Main power switch

X-Input Module:

Single range module preset for 100mV per centimeter

With variable range expansion and zero line shift over the entire writing width.



1. Switch 0-cal-var
   - 0 Input jacks cut-off, electronic disconnected, it is possible to adjust the zero point
   - cal Measurement in the selected range
   - var Measurement in the range adjusted with the var-potentiometer

2. var-potentiometer to increase the sensitivity (Please do NOT adjust)

3. Potentiometer to adjust the zero point anywhere at the writing area

4. Potentiometer to adjust the voltage offset of the mV-preamplifier (Please do NOT adjust)

5. Jack for the positive RPM signal from the viscometer (100 mV/cm; 2.2 V = full scale)

6. Jack for the negative RPM signal from the viscometer (100 mV/cm; 2.2 V = full scale)

7. Jack to connect protective ground / earth

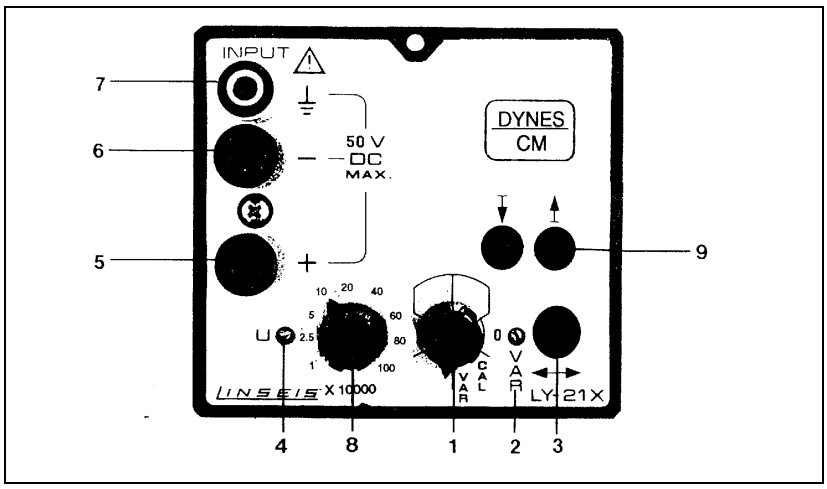
8. Indication of the range, adjusted in our company

9. Over range indication LED
   If the pen moves outside the writing area or the input signal is out of range, an electronic control circuit switches the servomotor off (LED is lighted). A measurement is not possible until the signal decreases inside the writing area. If an input signal shows a sudden increase crossing the recorder area, the control circuit cuts the servomotor off immediately. The sled remains at the latest position adjusted.

The sum of the input voltage and the voltage between the input jacks and ground may not exceed 50 V.

Y-Input Module:

Multi range module with 9 ranges 10,000 dyne-cm up to 1,000,000 dyne-cm, variable range expansion and zero line shift over the entire writing width.



1. Switch 0-cal-var
   - 0 Input jacks cuts-off, electronic disconnected, it is possible to adjust the zero point
   - cal Measurement in the selected range
   - var Measurement in the range adjusted with the var-potentiometer

2. var-potentiometer to increase the sensitivity (Please do NOT adjust)

3. Potentiometer to adjust the zero point anywhere at the writing area

4. Potentiometer to adjust the voltage offset of the mV-preamplifier (Please do NOT adjust)

5. Option jack for the negative torque signal from the viscometer

6. Option jack for the positive torque signal from the viscometer

7. Jack to connect protective ground/earth

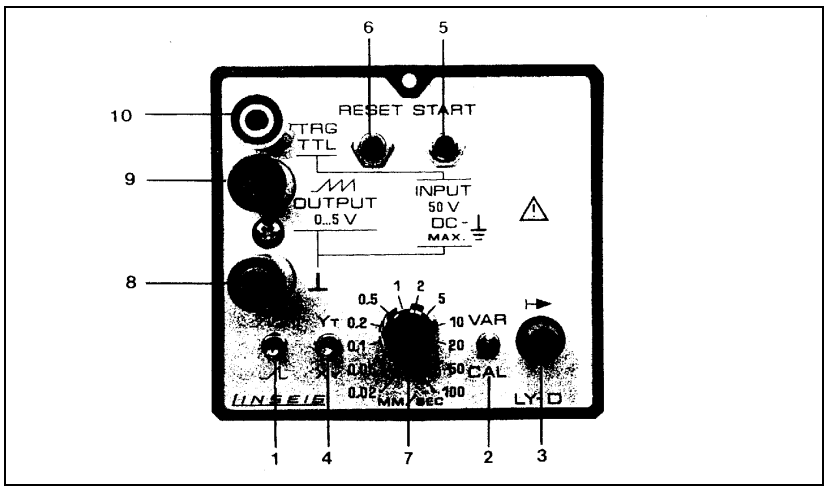
8. Measuring range selector

9. Over range indication LED
   If the pen moves outside the writing area or the input signal is out of range, andelectronic control circuit switches the servo motor off (LED is lighted). A measurement is not possible until the signal decreases inside the writing area. If an input signal shows a sudden increase crossing the recording area, the control circuit cuts the servo motor off immediately. The sled remains at the latest position adjusted.

The sum of the input voltage and the voltage between the input jacks and ground may not exceed 50 V.

LYD Module:

The crystal controlled time base generator permits a y=f(t)-mode to the XY-mode. This increases the application range of the recorder. 12 chart speeds are available.



1. Switch to select single or multi deflection of the time axis
2. Switch to select a constant or a variable deflection amplitude
   VAR Variable deflection amplitude 100 - 350 mm
   CAL Constant deflection amplitude 0 - 370 mm
3. Potentiometer to adjust the variable deflection amplitude when the switch 2 is in the VAR-position
4. Switch to select XY- or y=f(t)-mode
   XY Time base generator off, recording via input modules
   YT Time base generator active, no recording via x-input modules
5. Push-button to start the time axis
   The switch 1 must be in the single deflection position and the pen lowered to the paper when the START-button is pressed.
6. RESET-button
   Push this button to stop the time base deflection and to move the sled to the start position.
7. Switch to select the deflection speed
   0.02 0.05 0.1 0.2 0.5 1 2 5 10 20 50 100 mm/s
8. Common negative pole for the ramp output and the trigger input
9. Positive pole of the ramp output, 0 - 5 Vpp
10. TRG / TTL Trigger input to start the time base with an external pulse of 20ms pulse width and 2.24 - 50 V pulse amplitude
    The power supply module generates 4 operation voltages.
    * +15V Comes from the X-axis
    * +5V Generated by a switching controller
    * +5 V reference Generated with a REF02 out of the + 15 V

Graph Paper Placement:

The recorder is supplied with stops on the front and left side of the recorder bed. The paper should be placed against these two stops while laying flat against the bed. Orientation of the Hercules® graph paper on the recorder bed is placed so the RPM axis is aligned with the X axis of the recorder. When correctly positioned, the zero points of the graph paper and recorder will coincide. The torque axis is driven backwards on the recorder, hence the zero point of the graph paper will be nearest full scale on the Y axis of the recorder.

Section Four

Viscometer Maintenance

Lubricating the Viscometer:

Bi-Monthly. Clean and lubricate the four areas of the Dovetail Slide that contact the Spindle Housing and the top half of the Drive Spindle that slides through the Drive Pulley. Use a heavy lithium grease for best results. Kaltec recommends that you apply the grease while in both the raised and lowered position of the spindle housing.

Never. DO NOT lubricate bearings (except for the components mentioned above). All other bearings are permanently sealed and do not require lubrication. Especially DO NOT lubricate Cup Holder bearings; they are designed for "dry" operation, and any lubrication whatsoever will adversely affect measurement accuracy.

Preventive Maintenance:

Your Hercules® TS-8 Hi-Shear Viscometer has been ruggedly designed and has been operated for 50 hours before shipment. Like all fine instruments, however, it is vulnerable to misuse or neglect. Observing the following rules and tips will ensure many years of trouble-free and effective use.

- Be especially careful when handling the Cup Holder, and try to protect it from any undue pressures or shocks. Abuse may result in the Cup Holder shaft becoming bent or damage to the torque sensor.
- Never force the Cup in to or out of the Cup Holder. If insertion or removal of the cup ever becomes more difficult than usual, check under the cam slot for a recently formed burr. Such a burr should be filed and polished away to prevent interference with the Cup's normal outer dimension.
- Keep unit clean. Sample spills and other contaminants can permanently damage some components, especially the Cup Holder bearings.
- Never lubricate the Cup Holder bearings.
- Clean and lubricate Dovetail Slide and upper Drive Spindle regularly. See **Lubricating the Viscometer**.
- Only qualified technicians should service major problems such as Bob and Cup misalignment, bent shafts, or electronic malfunction. When in doubt, contact Kaltec's Service Department.

Calibrating the Viscometer:

Your Hercules® Hi-Shear Viscometer has been fully calibrated at the factory prior to shipment. All controls should yield the selected maximum rpm within ±1%. Do not be alarmed, however, if there is a variance greater than 1% between a selected rpm speed and that shown on the **DIGITAL RPM** display. The readout of the **DIGITAL RPM** display reflects actual speed, and the **RPM SELECTOR** and **VARIABLE RPM** dials will always select *repeatable* rpm speeds. Simply conduct all measurement cycles and calibrations in accordance with the rpm speeds indicated on the **DIGITAL RPM** display.

Trim Control Calibration: The four preset maximum rpm settings may be changed or adjusted at any time. To adjust, first remove the Bob from the Drive Spindle and the Cup from the Cup Holder. Set **RPM SELECTOR** to desired speed, and press **SET-RPM** button. When maximum speed is indicated on **DIGITAL RPM** display, insert a small screwdriver into appropriate **TRIM CONTROL** opening and turn clockwise to increase and counter clockwise to decrease rpm speed. When adjustment is complete, press **STOP**. Whenever you want that rpm speed again, simply set the **RPM SELECTOR** accordingly.

Variable RPM Calibration: To calibrate and pre-select maximum rpm speeds other than the four preset speeds, set **RPM SELECTOR** to "Vx1" or "Vx10" settings (See **RPM SELECTOR**, page 9), press **SET-RPM** button, and adjust at the **VARIABLE RPM DIAL** until desired value is shown at **DIGITAL RPM** display. The "Vx1" setting results in an rpm speed roughly equal to that displayed on **VARIABLE RPM DIAL**; the "Vx10" setting results in an rpm speed roughly ten times that displayed on **VARIABLE RPM DIAL**. Press **STOP** to terminate operation and to reset displays.

Confirm calibration by performing the test rheograms sent with the instrument. Make certain the Bob, Cup, and the sample have been conditioned to 25° C.

Cleaning the Viscometer:

Unplug the viscometer from the AC power outlet before cleaning. The viscometer should be cleaned after every test. If the sample has spilled on the viscometer, make sure it is cleaned up before it dries. The sample could damage the Cup Holder bearings or other small components.

When washing, use a damp sponge. Do not allow water to run inside the viscometer, this could damage the electronic components and cause a shock hazard. NEVER pour water or cleaning solution directly on to the viscometer. This could cause more damage to the viscometer. ONLY clean the outer surface of the viscometer.

Determining if the Viscometer Needs Service:

Your viscometer is designed to give you years of reliable service. If you are having a problem with your viscometer, use the **Symptoms and Solutions** table will help determine if your viscometer needs servicing.

If the problem occurs with the data on the graph, return to **Calibrating the Viscometer** and run a calibration test. Compare this graph with the one you received with the viscometer. If the problem does not occur while using the Kaltec's Test Fluid, the problem may be a phenomenon of your sample. ***Measurement of Fluid Rheology and Interpretation of Rheograms*** should assist in determining possible causes. If you are still having problems, call Kaltec's Service Department at 810-349-8100 for prompt assistance.

Returning for Service:

If your viscometer requires servicing, contact Kaltec Scientific for complete service information.

If you need to ship your viscometer in, pack it in its original crate. If needed, a shipping crate may be obtained from Kaltec. In-transit damage is not covered by the warranty. We suggest that you always insure shipments.

You can help assure effective servicing of your viscometer by following these guidelines:

- Follow the instructions in this manual to make certain the malfunction is in your viscometer. If possible, identify the defective function.
- If you determine that repair is required, please include the following items when you return your viscometer for service:
  - All Bobs, Cups, and Cup Holders
  - Electrical Cords (1)
  - Leveling Mounts (4)
  - Pinion Levers (2)
  - XYT Recorder
- Include the following paper work:
  - A brief description of symptoms, the model, and the serial number.
  - A graph from a typical test using Kaltec Test Fluid.
  - A graph from a test using your sample.
- Include name, address, and a phone number where you may be reached during the day.
- Incoming shipments must be prepaid. If shipments are sent in "Collect," a service charge of $10.00 plus the amount of the freight bill will be added your bill. When shipping the instrument in, you must pay for all freight. Kaltec will ship the viscometer back to you "Prepaid" and then add it to the invoice.

- Ship to: **Kaltec Scientific, Inc.**
  22425 Heslip Drive
  Novi, Michigan 48375-4138 U. S. A.

- On your Bill of Lading list the instrument as follows:

  Crated Machinery
  NMFC Item #133300, Sub 2
  Class 85

For international shipments, the schedule B number for the instrument is:

9026.80.0 Check Digit 4

- After Kaltec has received and inspected your instrument, a representative from Kaltec will call with the cost of repairs. A Purchase Order number will be required for repairs to be made.

Symptoms and Solutions:

SYMPTOM	LIKELY CAUSE	SOLUTION
Cup resists attachment and detachment from Cup Holder.	Dried sample material in and around up Holder. A burr has formed on Cup's cam-lock groove. Cup is bent.	Clean thoroughly with steel wool. File burr off. Replace with new cup immediately.
Spindle Housing tracks poorly.	Sample material on Slide. A burr has formed on Slide.	Clean thoroughly with stiff brush. Use fine sandpaper or emery cloth to remove burr and lubricate.
Bob does not rotate when unit is activated at AUTO, TRACE, or SET-RPM.	DC fuse (located in back of unit) has blown.	Replace with AGC 20 fuse only.
Power switch indicator or displays do not light up when power is turned on (and unit is properly plugged in).	AC fuse is blown.	Contact Kaltec's Service Department before replacing.

Section Five

Technical Data

TS-8 Technical Data:

Maximum Shear (sec^{-1})	1 to 1.1 x 10^5
Torque Range (dynes/cm)	1.0 x 10^4 to 1.5 x 10^7
Shear Stress Range (dynes/cm^2)	80 to 6.0 x 10^5
Viscosity Range (centipoise)	1.5 x 10^6 (at 18 sec^{-1})
RPM Selection (Preset Maximum) Variable Maximum	550, 1100, 2200, 4400, 50 to 5500
Torque Range Selections (dynes/cm) x 10^3	10, 25, 50, 100, 200, 400, 600, 800, 1000

TS-8 Physical Data:

Weight (lbs., net/gross)	170/245
Space Requirements (HxWxD, inches)	33 x 37 x 20

XYT Recorder Technical Data:

Chart Format			DIN A4
Available Writing Area			212 x 290 mm
Dimensions (mm, W x H x T)			380 x 154 x 410
Cut-off frequency -3 db	X-axis		1.5 Hz/200 mm
	Y-axis		3.0 Hz/200 mm
Chart hold system			Electrostatic
Stand-by position			Upper right corner
Pen up/down cut-off frequency			$\leq$ 10 Hz
Fuses	Primary	220/240 V	0.315 A slow blow
		110 V	0.6 A slow blow
	Secondary		2 x 2 A slow blow
			2 x 1.25 A slow blow
			2 x 0.5 A slow blow
Power Supply			110/220/240 V 50/60 Hz
Protection class			I according to DIN 0411

Time Base Generator:

Principle	Crystal controlled counter, A/D-converter
Deflection speed	0.05, 0.10, 0.20, 0.50, 1, 2, 5, 10, 20, 50, 100 mm/s
Ramp output	0 – 936 mV
Trigger mode	Manual, automatic or external via 20ms pulses with 2.4 – 60V