NEHS0576-01
October 2006

TOOL OPERATING MANUAL

4C9437 Portable Hydraulic Tester
1U8761 Portable Hydraulic Tester (Cancelled)
4C9675 Portable Hydraulic Tester
1U9951 Portable Hydraulic Tester (Cancelled)

SMCS: 0774, 0784

Important Safety Information

Think Safety

Most accidents that involve product operation, maintenance, and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills, and tools to perform these functions properly.

Improper operation, lubrication, maintenance, or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance, or repair on this product until you have read and understood the operation, lubrication, maintenance, and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as “DANGER”, “WARNING”, or “CAUTION”. The Safety Alert “WARNING” label is shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by “NOTICE” labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all-inclusive. If a tool, procedure, work method, or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job.

⚠ WARNING

When replacement parts are required for this product, Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength, and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury, or death.

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Entanglement hazard

Fire hazard

High-pressure fluid hazard

Hot fluid

Hot surface

Protective guards

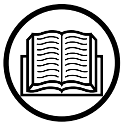
Safety alert symbol

Slipping hazard

Tripping hazard

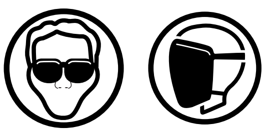
Safety

⚠ WARNING



To avoid personal injury or death, carefully read and understand all instructions before attempting to operate any equipment or tools. Do not operate or work on a machine unless you read and understand the instructions and warnings in this and all other applicable manuals. Contact Dealer Service Tools for replacement manuals. Proper care is your responsibility. Always follow all State and Federal health and safety laws and/or local regulations.

To prevent possible damage to your hearing, always wear ear protection when using this tool and/or working around noise generating tools.



To avoid eye injury, always wear protective glasses or face shield. Make sure no one can be injured by flying objects or debris when using tools or working on a component.

Clean up all leaked or spilled fluids immediately. Oil, fuel, or cleaning fluid leaked or spilled onto any hot surfaces or electrical components can cause a fire, resulting in personal injury or death.

Personal injury can result from slips or falls. DO NOT leave tools or components laying around the work area and clean up all spilled fluids immediately.

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well-ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Check hydraulic oil lines, tubes, and hoses carefully. DO NOT use your bare hand to check for potential leaks. Always use a board or cardboard when checking for a leak. Escaping hydraulic fluid under pressure, even a pinhole size leak, can penetrate body tissue, causing serious injury, and possible death. If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

Personal injury can result from hydraulic oil pressure or hot oil. DO NOT remove a hydraulic tank filler cap unless it is cool enough to touch with your bare hands. Relieve all pressure in a hydraulic system before any caps, lines, fittings, or related items are disconnected or removed.

Contact with hot oil and components can result in severe burns. DO NOT allow any hot oil or components to contact the skin.

DO NOT wear any loose clothing, jewelry, watches, gloves, or anything else that might catch on rotating components.

Personal injury or death can result from a fire. Flammable fluid leaked or spilled onto hot surfaces or electrical components can cause a fire. Clean up all leaked or spilled flammable fluid immediately to prevent a slipping hazard. Sparks or open flames can cause flammable fluid to ignite. DO NOT smoke while working on or near any flammable fluid.

For additional product support questions concerning this tool, contact the Caterpillar Dealer Service Tools Hotline at:

U.S.A.: 1-800-542-8665
Illinois: 1-800-541-8665
Canada: 1-800-523-8665
World: 1-309-675-6277
Fax: 1-309-494-1355
dealerservicetool_hotline@cat.com

Portable Hydraulic Testers
1U8761 4C9437 1U9551 4C9675

Introduction

The Hydraulic Testers are made of a number of instruments combined to safely and accurately measure flow, pressure, temperature and speed. There are four models. The 1U8761 and 4C9437 have a threaded inlet and outlet port. The port connection is a 1-5/16–12 UN O-ring boss. Thread type is stamped on the turbine block adjacent to the inlet and outlet port. The 1U9551 and 4C9675 have a modified SAE-type 1-1/2" flange connection. An O-ring is used as a face seal and the flange held in position by four 1/2" UNC bolts.

Flow

The flow meter consists of an axial turbine mounted in the aluminum base block. The oil flow rotates the turbine and its speed is proportional to the oil velocity. The speed of the turbine is measured by a magnetic sensing head (magnetic reluctance transducer) which transmits a pulse to an electronic circuit. Each pulse is generated by a pass of the turbine blade. The electronic circuit amplifies the pulse and converts it in a number of pulses per second. The DC current is read on ammeter which is calibrated in liters per minute or gallons per minute.

Pressure

Pressure Measurement

The Tester is fitted with 2-1/2 " diameter, 6,000 PSI, 420 bar, dual-scale glycerine-filled pressure gauge. The pressure gauge is connected to a shuttle valve built into the turbine block with a copper capillary tube. The shuttle valve has a connection to both sides of the Tester's loading valve so that it will automatically connect the highest pressure to the pressure gauge; for example, under normal flow conditions, the gauge will measure the pressure in the turbine tube. Under reverse flow conditions, i.e., when the oil goes first through the loading valve and then through the turbine tube, the pressure gauge will measure the oil pressure in front of the loading valve.

Pressure Loading

Resistance to the oil flow can be changed by the pressure loading valve. This valve is not a relief valve but a positive displacement, pressure-balanced shut-off valve. Because of the pressure balancing, it can be operated at pressures up to 6,000 PSI, 420 bar, with flow in either direction. The valve also incorporates two safety discs described below.

Pressure Protection

Built into the loading valve are two safety discs which will prevent the loading valve from being used for creating excessive pressure. The standard safety discs on the 1U8761 and 4C9437 are designed to break at 6300 PSI, on the 1U9551 and 4C9675 at 5500 PSI. Safety discs with lower pressure ratings are available. All of the discs are color-coded for easy identification. These discs are precision made and other pieces of metal should never be substituted.

Temperature

Temperature is measured by a precision thermistor which is built into the magnetic reluctance transducer. The thermistor is very close to the oil flow, being separated and protected from the pressure by a thin stainless steel disc. The electrical output from this thermistor is not linear, but it is linearized by a wheatstone bridge circuit incorporated in the Tester's printed circuit board. Output can be read on the ammeter which has been calibrated in degrees Celsius.

Speed

The Tester can be used for measuring RPM by using the photo-tachometer or mechanically driven tachometer accessory. The tachometer is connected to the Tester at the DIN socket on the left side of the instrument deck. The photo-tachometer is generally used for measuring higher speeds, up to 9000 RPM, and the mechanical tachometer for speeds up to 3000 RPM. The RPM range varies a little for different models. When the photo-tachometer is used, two 'D' size batteries must be fitted to the auxiliary battery holder, located at the back of the Tester case, to provide power for the photo-tachometer light bulb. The mechanically driven tachometer does not require the additional batteries.

Troubleshooting

If the Tester does not work, the most common problem is no flow reading. Usually this is due to a battery fault or jammed turbine.

Problem	Possible Cause	Location of Troubleshooting Procedure
Flow		
No flow reading	Battery fault	Section 1
	Jammed turbine	Section 2
	Magnetic reluctance transducer needs adjusting	Section 4
	Magnetic reluctance transducer is broken	Sections 3 and 9
	Ammeter is broken	Section 5
	Electronic problems	Section 7
Inaccurate flow reading		Section 6
Pressure		
Inaccurate pressure		Sections 10 and 11
No pressure reading		Sections 10 and 11
Loading valve does not control pressure		Section 12
Loading valve difficult to turn		Section 13
Safety discs fail at too low a pressure		Section 12
Temperature		
No temperature reading	Ammeter may be broken	Section 5
	Thermistor failed	Section 8
	Electronic problems	Section 7
Speed		
Inaccurate RPM reading		Section 16
No RPM reading	Ammeter may be broken	Section 5
	Electronic problems	Section 7

Troubleshooting Procedures

1 Checking the Battery (for electronic circuit)

Turn the selector switch to the 'B' test position and see if the needle on the ammeter goes to the right of the 'B' line marked on the scale. If it does not, replace the battery.

To replace the battery, remove the two small pozidrive screws and the battery cover which is immediately below the ammeter on the top deck of the instrument. Install a new 9-Volt transistor radio battery. Use an alkaline battery if possible. A carbon-manganese battery will operate the Tester successfully, but it has a much shorter shelf life and is inclined to leak in the battery holder. Make sure that the press buttons are clean and free from any corrosion. Replace the battery cover and check.

Do not leave the switch in the 'B' test position as this can quickly run down the battery. Normal current consumption of the Tester is less than 3 milliamp, but on the battery test position current consumption has been increased to 10 milliamp. Although the battery saving circuit will cut off the supply after approximately one hour, a considerable part of the battery's life can be wasted.

2 Cleaning the Turbine Assembly

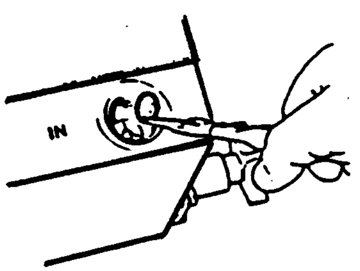


Fig. 1

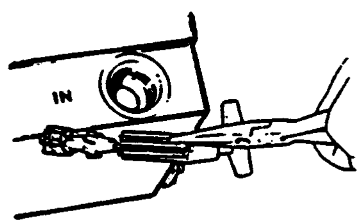


Fig. 2

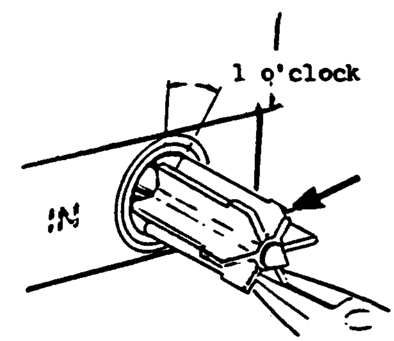


Fig. 3

If the flow meter still does not work after checking the battery, remove the turbine assembly (Fig. 1, 2 and 3).

Take out the circlip with a pair of circlip pliers and, with a pair of soft-nosed pliers, gently grip one of the blades of the turbine flow straightener and pull gently. Do not rotate the assembly. This action can cause one of the flow straightener blades at the rear of the turbine to catch on the magnetic pick-up.

Examine the turbine assembly carefully and see if there are any pieces of O-ring or PTFE tape wrapped round the turbine. Carefully remove any obstruction and wash the whole turbine assembly in an organic solvent such as kerosene, denatured alcohol, etc. Blowing gently along the axes of the flow straightener should make the turbine spin freely without any vibration. Check that the turbine tube is free from debris as it is possible for magnetic particles to stick to the end of the transducer.

In replacing the turbine assembly, note that a corner of one of the blades of the flow straightener has been clipped off at an angle of about 45°. With the Tester horizontal, this blade should be in the one o'clock position inside the turbine tube. The bottom of the recess at the inlet port has been 'staked' to provide two small ridges The blade should be placed between the ridges as this will prevent the complete turbine assembly from being rotated by flow forces.

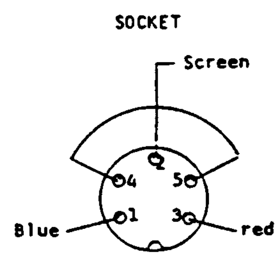
It is important to put the turbine back in the correct rotational position. Rotating the assembly can change the distance between the tip of the turbine blades and the face of the magnetic pick-up. The gap can be too large resulting in a signal that is too weak and the Tester will not give good low flow readings. Alternatively, the turbine blades may come too close to the transducer and accuracy will be affected by magnetic detenting. In extreme cases, they may actually touch the face of the transducer so that the turbine will not spin.

3 Checking the Magnetic Reluctance Transducer

To carry out the necessary tests and adjustments to the transducer, the instrument panel assembly must be removed from the Tester.

Loosen the six pozidrive head screws and lift the panel above the box two or three centimeters. This will allow access to the nut that connects the capillary tube to the bottom of the pressure gauge. You can hold the instrument deck above the box by using two small pieces of wood. Two sticks, approximately 2 cms by 2 cms and about 25 cms long will work.

Disconnect the capillary tube from the pressure gauge. (Use a 5/8" across flats spanner on the nut and a 9/16" across flats spanner on the gauge.) Lift the deck clear. The printed circuit board, which is attached to the underside of the deck, will still be connected to the magnetic reluctance transducer which sticks out from the top surface of the turbine block. Disconnect the wires by removing the insulating tape around the DIN plug and socket and gently pull the two apart.



Pins 2 & 3 transducer coil (flow)
Pins 1 & 2 thermistor (temp.)

Fig. 4

Connect a multimeter to pins 2 and 3 on the transducer socket (Fig. 4). Measure the resistance of the transducer coil which should be approximately 3,000 ohms. If the resistance is very low, the coil has shorted out. If very high, a wire has probably broken. Make sure the DIN socket is properly soldered to the wires from the transducer. The plastic sleeve can be easily slid back if the small metal clip is depressed, allowing access to the soldered connections. It is not practical to repair a broken transducer. A new one should be installed (Section 9). After a new transducer assembly has been screwed into position, it needs to be adjusted (Section 4).

4 Adjusting the Magnetic Reluctance Transducer

Another reason for no flow may be the magnetic reluctance transducer is not adjusted properly. If the ammeter works correctly on the battery check, and the turbine has been checked to ensure that it runs freely, then the problem is in the wiring, electronic circuit or the transducer.

To check the transducer, first make sure that it is correctly adjusted as this is critical to the accuracy of the flow measurement. To ensure correct adjustment, reconnect the DIN plug and socket so that the signal can show on the ammeter. Turn the selector switch to 'flow'. Loosen the outer hexagon sleeve nut of the transducer (use a 1" across flats spanner) and turn counterclockwise about half a turn. Using an air line, blow a small quantity of compressed air into the inlet port of the turbine tube so that the turbine spins freely. (Make sure the loading valve is open. If the valve is closed, the air can go down one side of the turbine tube and back up the other, effectively trying to rotate the turbine in opposite directions, so it does not turn at all.)

Turn the transducer body clockwise (Body has 13/16" across flats hexagon.). As the transducer approaches the turbine blades, a signal should begin to register on the ammeter. Continue turning the transducer until the face of the transducer eventually comes into contact with the tip of the turbine blades. (Do this very carefully otherwise the turbine bearing can be damaged or the spindle bent.) The turbine will immediately stop; there will be no signal to the ammeter; and the needle will quickly go back to zero.

The transducer should be rotated back about 1/8 turn, i.e., 45° counterclockwise to give the correct clearance to the turbine. Holding the turbine body firmly in position, tighten the outer hexagon sleeve. Do not over tighten the hexagon sleeve nut as it is possible to stretch the body of the transducer, resulting in its failure.

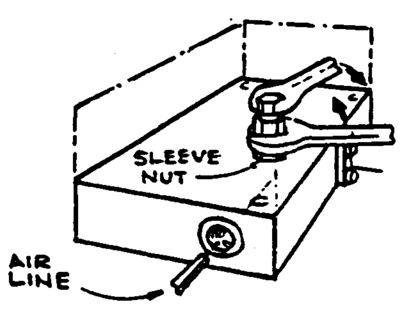


Fig. 5

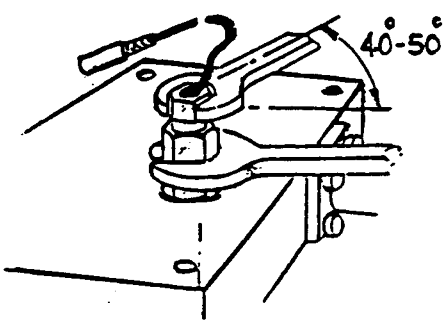


Fig. 6

To check the sensitivity of the transducer, blow a small amount of air through the turbine and measure the minimum steady reading that can be obtained on the ammeter. On both the 'hi' and 'lo' scales, this should not be more than the bottom 4% of the scale; i.e., a 1U9551 or 4C9675 on 'hi' should read down to 20 liters/minute.

If the minimum reading cannot be obtained, slide back the plastic sleeve on the DIN socket or plug, and with the two halves still connected, attach a volt meter to pins 2 and 3. Switch to the 'lo' flow setting and spin the turbine with air so that the ammeter shows maximum flow.

NOTICE

Do this with care because if the turbine is turning too fast, the ammeter will be overloaded and if it is extremely overloaded, or is overloaded too often, the ammeter will be damaged.

The volt meter should indicate at least 1 Volt and it could be considerably more. If you get a 1-Volt-plus reading, try adjusting the transducer closer to the turbine to see if the minimum reading can be obtained. (Disconnect the volt meter before carrying out this test as it can reduce the signal going to the Tester's electronic circuit. How much effect the volt meter would have depends upon its input impedance.) If the 1-Volt reading cannot be obtained or it proves impossible to adjust the transducer to get the required minimum reading, then the transducer should be replaced.

NOTICE

The magnetic reluctance traducer contains a small coil with a soft iron core which is attached to a permanent magnet. If, when installing the transducer, the outer sleeve is over tightened, it is possible for the permanent magnet to become detached from the soft iron core of the coil. Even the tiniest gap between these two components will result in a large reduction of the output signal and make the transducer unserviceable.

5 Checking the Ammeter

Flow and RPM are displayed on a 100 microamp moving coil ammeter mounted on top of the instrument panel. The ammeter is sturdily constructed and will take shocks up to 100 g without damage. However, if the Tester is dropped, it can be damaged.

If, after checking that the Tester has a good battery, the needle on the ammeter does not move when the selector knob is turned to the 'B' test position, then the ammeter is probably broken. This can be confirmed by gently shaking the Tester. If the needle does not move or moves in a very sluggish manner, the ammeter should be replaced.

To install a new ammeter, remove the instrument panel of the Tester (Section 3). Loosen the three small hexagon nuts (One of the nuts also supports the P.C.B. bracket.) and disconnect the wires from the two terminals. Install a new ammeter with the correct scale. The pink wire goes to the '+' terminal, the green/black wire to the other. If the wires are connected incorrectly, the meter will try to read backwards. After installing a new ammeter, the Tester must be re-calibrated (Section 6).

6 Recalibrating the Flow Meter

After installing the ammeter, the flow and RPM meter sections of the Tester must be re-calibrated.

On the underside of the instrument panel (usually on the side of the battery compartment) there is a small label with the appropriate meter factors for the instrument. There are a number of Hertz for a given flow rating on both 'high' and 'low' flows, and a similar frequency rating for the tachometer circuit. (If for any reason this information is missing, the frequency figures can be supplied by Caterpillar Service Technology. The serial number stamped on the side of the turbine block is needed.)

To recalibrate the flow and RPM meters, connect the DIN plug, which connects to the transducer, to an appropriate frequency generator. (A standard audio frequency generator is not usually accurate enough. Accuracy should be better than ±0.5 Hertz. Caterpillar can supply an 8T5200 Frequency Generator which includes appropriate connecting leads. Figure 7 shows how to connect the 8T5200 Frequency Generator.)

Apply a frequency to pins 2 and 3 (Fig. 7) by turning the selector switch to the required scale and frequency as shown on the label applied to the circuit. Adjust the ammeter reading with one of the four potentiometers mounted on the edge of the printed circuit board. These potentiometers are shown clearly on drawing FT2312A and Figure 7. Note that the adjustment screws on theses potentiometers are locked in position with a small quantity of silicon rubber. The silicon rubber is easily removed. After adjustment, the screws should be re-locked to prevent any possibility of movement due to vibration. (A silicon rubber used for sealing the edge of bathtubs, etc., is quite suitable. Small tubes of this silicon rubber manufactured by DuPont are widely available.)

If the turbine has been replaced, the Tester must be re-calibrated on a flow calibration stand. Oil at a known flow rate must be passed through the Tester and the potentiometer adjusted so that the ammeter shows the correct reading. Factory calibration is carried out with oil at 46°C, viscosity 28 centistokes.

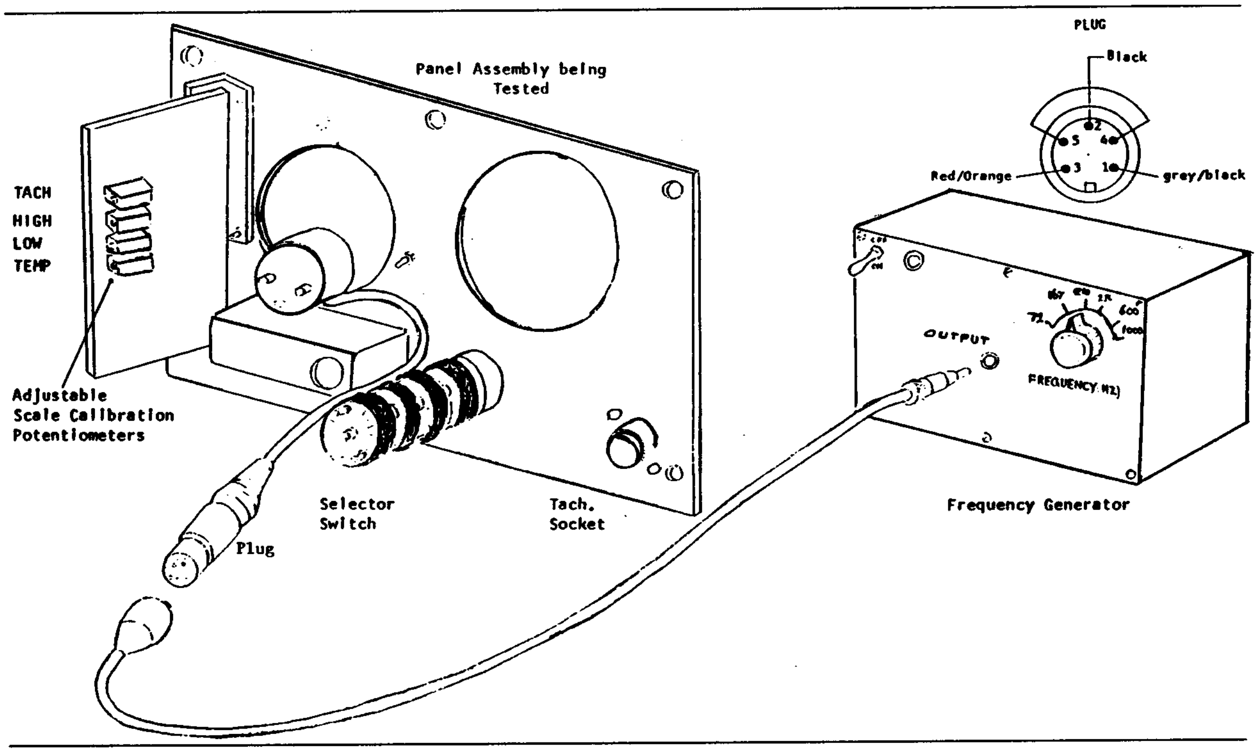


Fig. 7
Tester Calibration of Electronic Circuits

7 The Electronic Circuit

If there is a problem in the electronic circuit, it is usually difficult to find and can be very time consuming. It is easier and normally cheaper to install a new printed circuit board which is supplied complete with wire harness. Figures 8b and 8c show the wiring color code for soldering to the wafers on the selector switch. A complete description of the electronic circuit, however, follows.

Drawing FT1993 (Fig. 8a) shows the basic schematic layout of the electronic circuit that is used in these Caterpillar portable flow meters. The circuit carries out the following functions:

- Stabilized power supply
- Wheatstone bridge circuit for temperature measurement
- Schmitt trigger and mono-stable for pulse counting
- Timer for switching battery off made up of oscillator, counter and switch

Stabilized Power Supply
Components (Fig. 8a): IC4A, D4, R15, R16, R17, R27 and C11

Item D4 is a band-gap reference diode which is used to set up a reference voltage across the operational amplifier IC4A. The voltage at which the amplifier is set is determined by voltage divider made up of resistors R16 and R17. This circuit is set to give a precise 4-Volts output and this voltage will remain stable over a fairly wide range of input voltage, load and temperature conditions, i.e., the circuit automatically takes care of the change in voltage from the battery as its power is consumed. The circuit is very efficient, the total power loss being around 9 milliwatts. R27 is a very high value resistor which ensures that IC4A always turns on. C11 is fitted as a precaution to prevent D4 from oscillating.

Wheatstone Bridge Circuit for Temperature Measurement
Components (Fig. 8a): R18, R20, R21, R22 and R23, RV4 and IC4B

R22 and R21 make up one pair of legs of the bridge and have equal values. R20 and R18, the thermistor which is not shown, make up the other leg of the bridge. R18 is a resistor in series with the thermistor and is used to give better linearity. The thermistor is usually incorporated inside the magnetic reluctance transducer and is close to the oil flow and therefore sensitive to the oil temperature.

The 4-Volt output from the stabilized power supply is too high for the bridge circuit. At this level it can cause self-heating of the thermistor. The voltage is reduced to the appropriate level by IC4B and this operational amplifier is used in conjunction with variable resistor RV4 to calibrate the bridge circuit by adjusting the voltage level to the appropriate value.

The ammeter, calibrated in degrees C, is connected by appropriate switches across the bridge to the junctions of R21/R20 and R22/R18. R23 is a ballast resistor for the meter. The change in resistance of the thermistor with temperature is not linear, and the use of the Wheatstone Bridge Circuit enables a more linear output to be achieved.

Schmitt Trigger and Mono-stable for Pulse Counting
Schmitt Trigger components (Fig. 8a): IC4C, R10, R11, R12, R13, R14 and C4
Mono-stable components (Fig. 8a): IC5, C1, C2, D3, R7, R6, R3, R4, R5, RV1, RV2, RV3

Flow measurement is carried out by monitoring the speed of an axial turbine which is rotated by the oil flow. The turbine speed has a nearly linear relationship with the oil velocity. As the cross-sectional area of the oil is constant over a wide range of velocities, the turbine speed can be directly related to rate of flow. The turbine speed is monitored by a magnetic reluctance transducer which gives an output approximately in the shape of a sine wave each time a turbine blade passes its face. The frequency of this sine wave is therefore directly related to the turbine speed.

The sine wave is fed into the Schmitt trigger circuit. The sine wave input turns the amplifier IC4C on and off for both positive and negative parts of the sine wave, creating a fairly clean, square wave output. The output is differentiated into a spike by the capacitor C3 and the balancing resistors R8 and R9. The spike is used to trigger the mono-stable.

IC5 gives a regular pulse output whose height (voltage) is determined by the stabilized power supply and whose length (time) is controlled by capacitor C1 and the resistors R3, R4, R5 and RV1, RV2 and RV3.

As can be seen, the resistors are used in pairs for 3 switchable circuits which allows the mono-stable output to be calibrated for different settings depending upon the way RV1, RV2, RV3 are adjusted. Each pulse coming from the mono-stable for a given setting will have a constant amount of energy and the number of pulses will be directly proportional to input frequency and therefore to the turbine speed. These pulses are fed directly to an ammeter which is connected between the negative rail and the junction of resistors R6 and R7. The pulses are integrated by the meter movement and the meter deflection is directly proportional to the turbine speed and therefore flow rate.

Timer for Switching Battery Off
The timer is made up of an oscillator, counter and switch.

- Oscillator

Components (Fig. 8a): IC1A and IC1B, C9, C10, R23 and R24

The first part of the timer is made up of an oscillator. The output of the oscillator is fed to the counter IC2.

- Counter

Components (Fig. 8a): IC2, IC1C, IC1D, C8 and R25.

IC2 is a 14-bit binary counter which is set to zero when the circuit is first turned on. The output from the oscillator is counted by IC2 and when it reaches 8192 counts (2^{13}), IC1C and IC1D are reversed to give an output to the switch which disables the oscillator.

- Switch

Component (Fig. 8a): IC3

IC3 is a quad bilateral gate which is connected in parallel to provide the necessary current-carrying capacity. An output from the counter circuit brings all these gates high and interrupts the battery voltage to the circuit.

NOTE

Components C6, C2 and C7 are used for decoupling purposes. R1 and R2 are used as a voltage divider and load when checking battery voltage. D1 protects the circuit in case the battery is connected incorrectly.

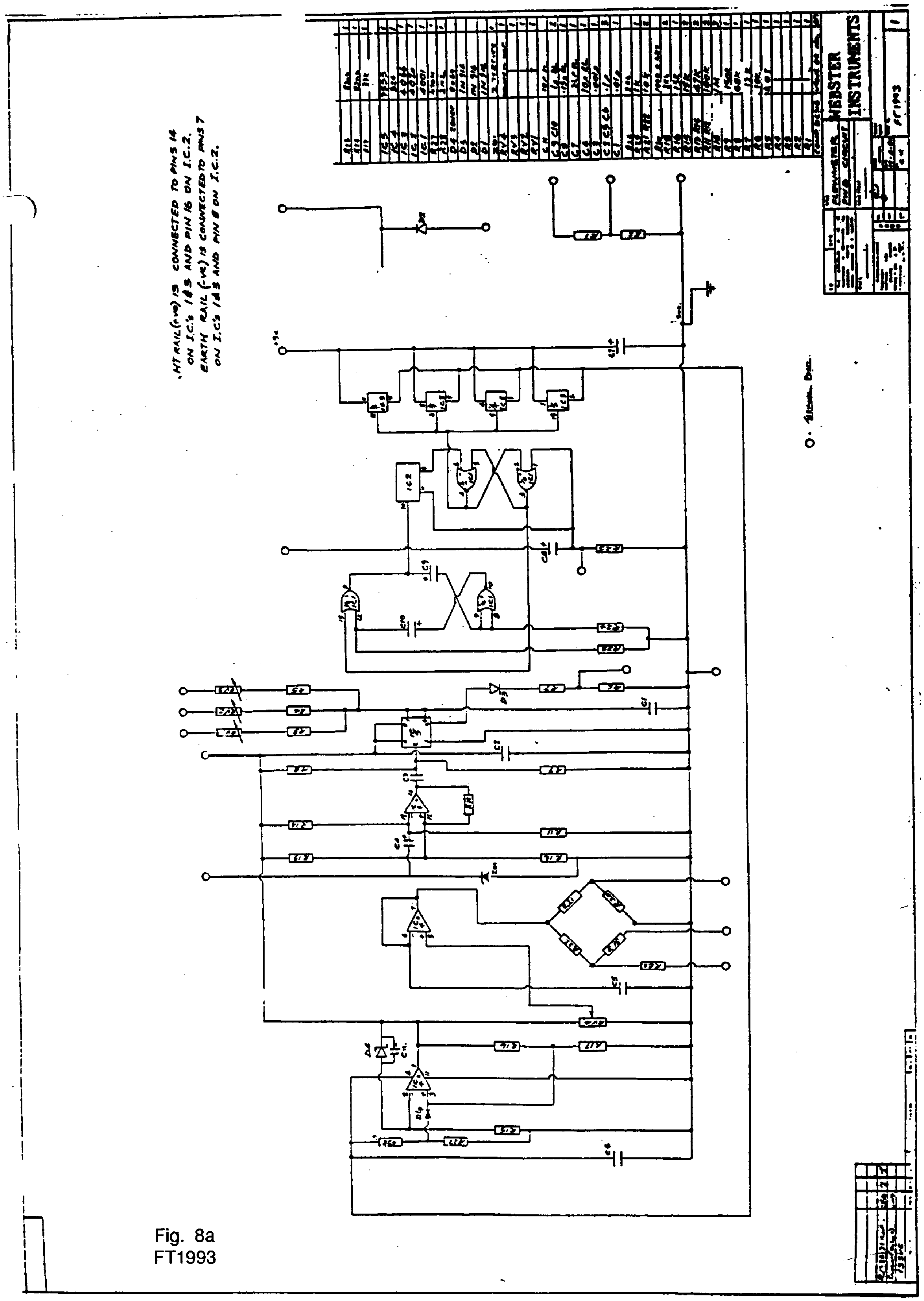
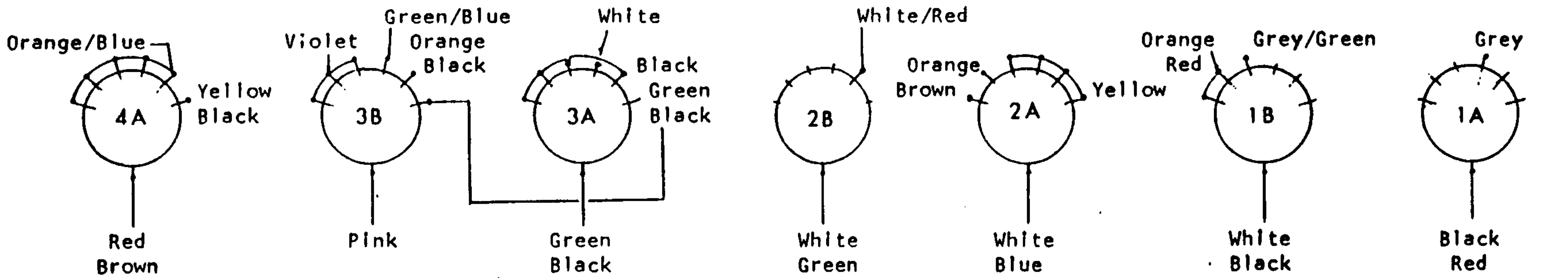
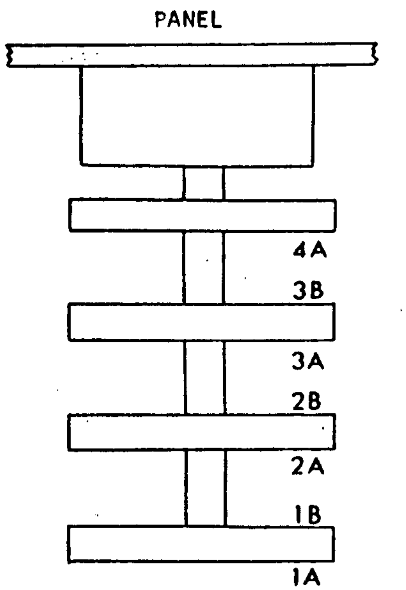


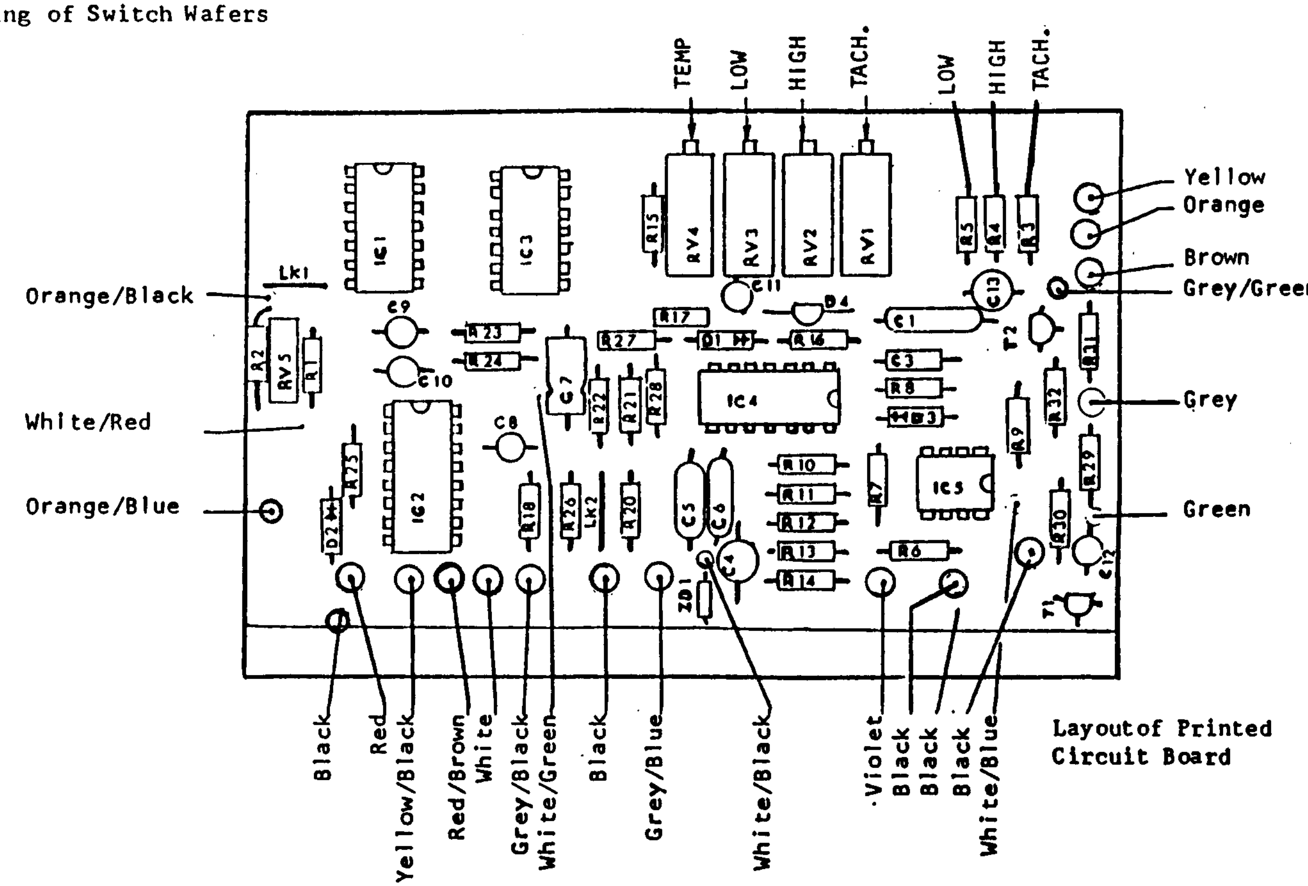
Fig. 8a
FT1993



Wiring of Switch Wafers



Selector Switch
showing Wafer Positions



Layoutof Printed
Circuit Board

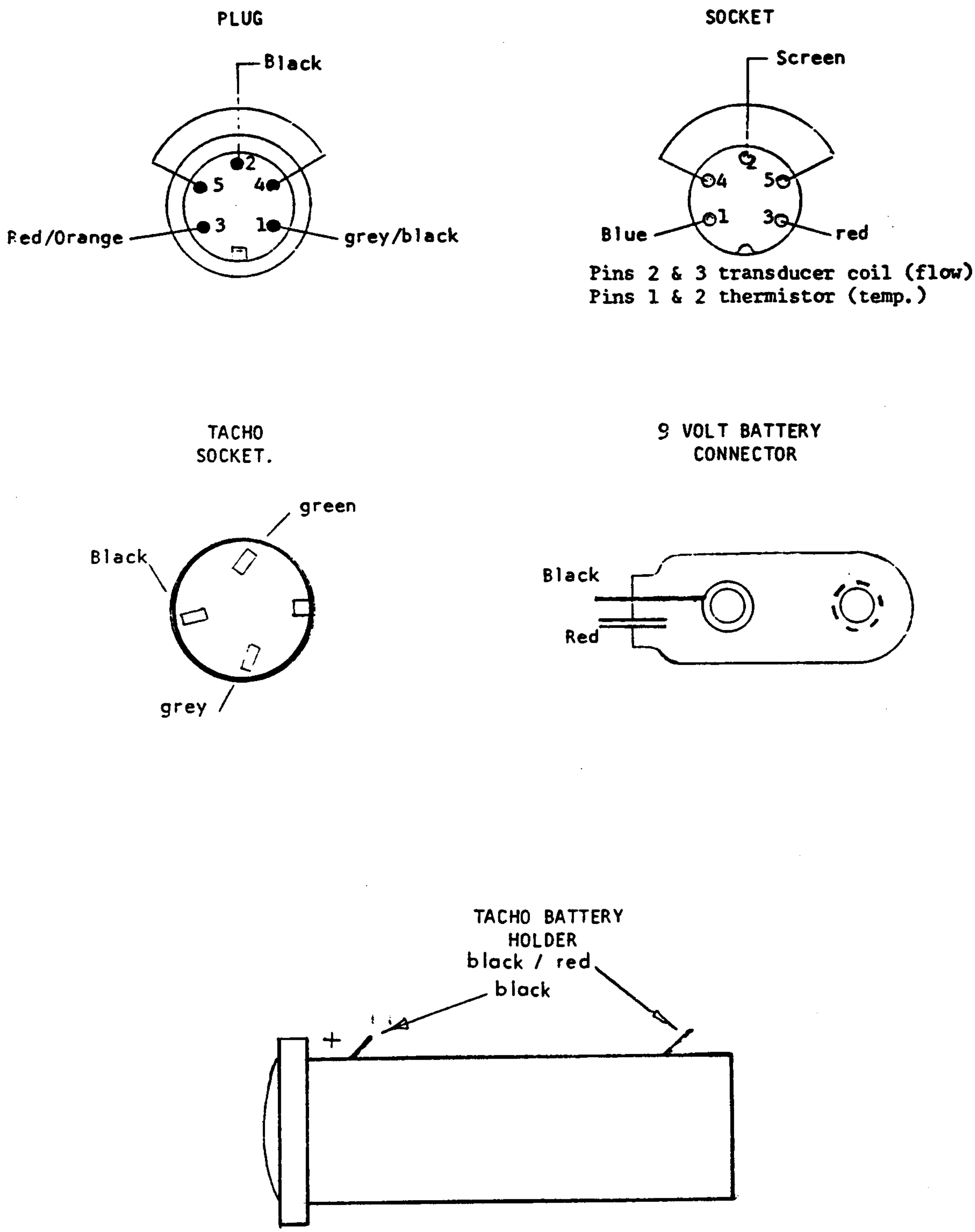


Fig. 8c
Wiring Details - Transducer

8 Temperature

If the unit reads flow, but fails to show the temperature when the switch is turned to the appropriate position, there is usually an electrical problem. A fault may have developed in the wiring; a wire may have come loose from the selector switch; one of the wires coming out of the transducer in which the temperature measuring thermistor is buried has broken; or there is a problem in the electronic circuit which may mean replacing the electronic circuit.

To ensure the temperature circuit is correctly adjusted and the thermistor is in good order, perform the following tests.

Disconnect the DIN plug and socket between the transducer and the printed circuit board. On the plug half, connect a 10,000 ohm, half-percent-accuracy resistor across pins 1 and 2 (Fig. 8c) on the wire that connects to the printed circuit board. Turn the selector switch to 'temperature' and the ammeter should read 50.5°C. If the reading is incorrect, make adjustments by turning the potentiometer on the edge of the printed circuit board (Fig. 7 and 8).

To check the thermistor, connect an accurate avometer or multimeter to pins 1 and 2 on the socket, i.e., the half that is connected to the transducer. Measure the resistance. The resistance for the appropriate temperature should be as shown in the table below. For accurate results, the Tester should have been in a stable temperature for at least 24 hours. If an incorrect reading is obtained or there is no reading, the thermistor must be replaced. This can be done only by replacing the complete transducer (Section 9). It is not practical to repair or replace the thermistor inside the transducer.

Table 10° to 30°C

Temp. °C	Resistance (ohms)	Temp. °C	Resistance (ohms)
10	62,354	21	36,242
11	59,268	22	34,556
12	56,352	23	32,956
13	53,594	24	31,439
14	50,986	25	30,000
15	48,519	26	28,634
16	46,184	27	27,338
17	43,974	28	26,107
18	41,882	29	24,937
19	39,900	30	23,827
20	38,022		

9 Installing a New Transducer

Remove the instrument panel assembly (Section 3). Loosen the hexagon sleeve nut (turn counterclockwise) with a 1" across flats spanner. Remove the transducer and sleeve by turning the transducer body counterclockwise with a 13/16" across flats spanner.

Before installing the new transducer, make sure the internal O-ring is inserted inside the hexagon sleeve nut. Replace the copper washer between the top of the turbine block and the hexagon sleeve nut. The transducer must be adjusted to its correct position (Section 4). Do not over tighten the hexagon sleeve nut as this might stretch the transducer body and separate the magnet from the core of the coil and make the transducer inoperative. After the transducer has been locked into its correct position, the turbine block should be pressure tested to make sure no oil can leak past the transducer into the instrument box (Section 11).

10 Checking the Pressure Gauge

If the pressure gauge does not indicate pressure or is suspected of registering the incorrect pressure, it should be removed from the Tester and checked on a comparator or dead weight machine, or with the 5P8558 Calibration Group.

To remove the pressure gauge, remove the instrument panel (Section 3). With a screwdriver, loosen the two long clamp screws and rotate the clamp until the square hole in the clamp is in line with the square boss of the pressure gauge.

11 Pressure Test

The pressure gauge, which has a 1/4"-19 BSPF thread, should be connected to a comparator or dead weight tester and checked at 10%, 50% and 90% of the scale. All the readings should be within ±1.6% of the full scale reading.

If the pressure gauge is properly calibrated, check the capillary tube that connects the pressure gauge to the turbine block for contamination. Wash the capillary tube with denatured alcohol or a similar solvent and then blow through with an air line to make sure it is clear. Also check the shuttle valve for contamination. To do this, remove the two recessed hexagon plugs, one on the loading valve end of the turbine block, the other on the back of the turbine block near the outlet port. These two plugs are item 29 on assembly drawing FT2218A. Remove any contamination and wash through with denatured alcohol.

When replacing the capillary tube or pressure gauge, it is preferable to replace the small copper washer that forms the seal (item 1.1, part no. FT0804).

12 Changing the Safety Discs

If the loading valve fails to change the pressure when oil is being pumped through the Tester, the safety discs are probably broken and need to be replaced. The easiest way to do this is to remove the complete loading valve assembly from the turbine block.

Remove the four screws that hold the flange to the side of the turbine block (Fig. 9 and 10); gently pull out the complete assembly. In a vice gently grip the 30 mm diameter of the valve poppet (the cylindrical part with the two slots cut into it). Unscrew the hexagon-head safety disc holder (5/8" on 1U9551 and 4C9675, 11/16" on 1U8761 and 4C9437). Underneath, there should be two safety discs separated by a disc spacer.

Remove the damaged discs and install two new discs with the correct pressure rating. The safety discs are supplied flat and should be gently pre-formed in the hand to an approximately truncated cone shape by needing them round the disc spacer. Drop the first one in position; place the disc spacer on top; put the second safety disc in position; and screw the safety disc holder, which also has an internal conical shape, in position on top. Do not over tighten. The maximum torque required is 55 N·m (40 lbs. ft.). Over tightening the safety disc holder can cause the safety discs to fail at a lower pressure. Do not substitute other pieces of metal as these safety discs are very carefully controlled during manufacture to ensure that they will burst at the correct pressure.

Note that two discs must be used. When flow is reversed through the Tester, pressure is applied to the opposite face of the disc. One disc will very quickly fatigue and fail at much lower than its normal burst pressure. (When pressure is applied to the safety disc, it deforms away from the pressure and if pressure is then applied to the opposite side, the small bulge buckles back in the opposite direction. This work hardens the material and results in abrupt and quick fatigue failure. When two discs are used, they bulge in towards one another with an air gap between them.)

When replacing the loading valve assembly in the aluminum turbine block, note that there is a pin protruding inside the cavity. The pin must line up with one of the slots cut into the loading valve poppet to prevent the loading valve poppet from rotating. Make sure the O-ring (item 3.8) that fits under the flange of the loading valve and at the edge of the cavity in the turbine block is in good condition. Replace if necessary.

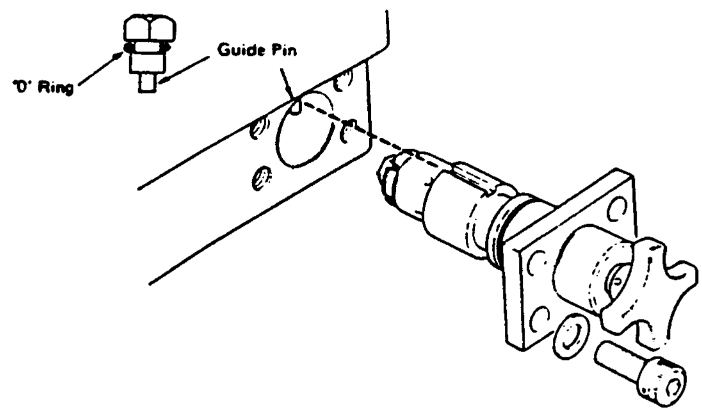


Fig. 9

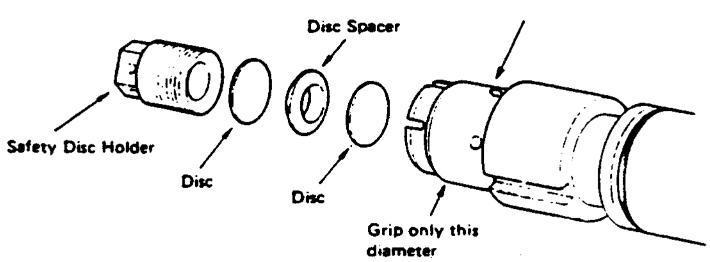


Fig. 10

13 Loading Valve

The loading valve is a pressure-balanced shutoff design. Drawing FT2318A (Fig. 11) shows a cross section of the valve. The valve poppet (item 21) can be moved into the outlet port of the turbine block to restrict or completely block the flow. The poppet is prevented from rotating by the plug (item 37) and is moved backwards and forwards by the spindle (item 3.6).

The spindle has a left hand thread for normal opening and closing. When the spindle is rotated clockwise, the valve closes. The spindle has a small collar and is held in its axial position by two small thrust bearings, one on either side of the collar. Pressure balancing is achieved by equalizing the pressure on both ends of the valve poppet. The small angled hole which comes through to the bottom of the left hand threaded hole allows the necessary transfer of fluid. The fluid gets to the end of the poppet via a slot cut into the spindle thread. The poppet also contains the safety discs which are described in Section 12.

If the loading valve is difficult to turn when the Tester is being used, and at higher pressures the handle becomes almost impossible to turn, this indicates a problem with the pressure balancing. The most likely cause is a blocked pressure balancing hole through the poppet. It should be cleaned by pushing a small piece of wire through to clear the obstruction, washing with denatured alcohol and blowing through with compressed air from an air line.

Another reason could be a leaking seal (item 18) at one end of the poppet. This seal is a special low-friction type and a standard O-ring should not be substituted. If the spindle seal (item 3.9) is leaking, then the whole bonnet assembly has to be taken apart for it to be replaced. Remove the loading valve assembly from the turbine block and unscrew the poppet (item 21). Take off the knob (item 3.1) by first knocking out the spiral pin (item 3.10) with a 1/8" dia. pin punch. Undo the retaining ring inside the bonnet with a tubular pin spanner. Remove the first thrust bearing and two thrust washers. Pull out the spindle and remove the second thrust bearing and its two thrust washers. Remove the bearing ring (item 3.5) and pull out the seal (item 3.9). A new seal should be inserted and the procedure described above reversed. Do not over tighten the retaining ring (item 3.12); the spindle should have about 9.25 mm (.010") axial float.

14 Checking the Turbine Assembly

To check that the turbine assembly is in good condition, remove the turbine assembly (Section 2). Blow gently along the straightener blades; the turbine should spin freely. If the turbine bearing is worn, the vibration can be clearly felt with the fingers. If the bearing is faulty, the whole turbine assembly should be replaced. It is possible to change the turbine bearings, but it is often difficult to remove the turbine without damaging the spindle or the flow straightener and the turbine often has to be rebalanced.

15 Assembling the Instrument Box

When assembling the instrument box (item 5) to the turbine block, a new cork gasket (item 25) should be used. Apply Loctite screw lock, or similar material, to the screws. Do not over tighten the screws or the gasket may be crushed and extruded between the block and the side of the box.

16 Tacometer

The photo-tachometer and mechanical tachometer use the same pulse counting circuit as the turbine. The photo-tachometer scale on the ammeter is based on the generation of one pulse per revolution of the photo-tachometer. If two separate pieces of reflector tape are used on the revolving shaft, the photo-tachometer will get 2 pulses per revolution and the reading on the ammeter must be divided by 2.

For the photo-tachometer to function correctly, two 'D' size batteries must be inserted in the battery holder in the side of the case. The positive (+) terminal goes to the battery holder cover. The 'D' cells provide power for the bulb in the photo-tachometer head and also for the photo-tach amplifier. (The signal from the light-dependent resistor built into the photo-tachometer head is very small.) In bright light conditions, the photo-tachometer may appear to work without the 'D' cells, but the reading on the ammeter may or may not be correct. Without power to the amplifier, the pulse counting circuit may double count the very weak signal.

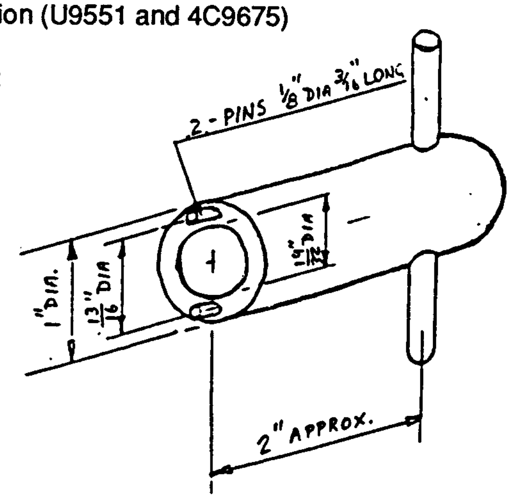
The mechanical tachometer gives a good electrical output of three pulses per revolution and no battery is required.

The tachometer circuit can be calibrated in the same way as the flow circuit (Section 6). In place of a frequency generator, the photo-tachometer head can be pointed at a fluorescent light. If the mains frequency is 50 Hertz, the ammeter should read 6,000 RPM and for 60 Hertz, 7,200 RPM.

Service Tools

In addition to the usual small tools, the following are required:

- To remove instrument panel:
  - No. 2 Pozidrive screwdriver
  - 9/16" across flats open ended spanner
  - 5/8" across flats open ended spanner
- To remove transducer:
  - 1" across flats open ended spanner
  - 13/16" across flats open ended spanner
- To remove instrument case from turbine block:
  - 5/16" Allen key made into a 'T' wrench
  - 9/16" hexagon socket spanner
- To remove loading valve knob:
  - 1/18" diameter pin punch.
- To remove loading valve anti-rotation plug:
  - 1/2" hex. socket spanner (1U8761 and 4C9437)
  - 9/16" socket spanner (1U9551 and 4C9675)
- To remove loading valve assembly:
  - 5/16" Allen key (1U8761 and 4C9437)
  - 3/4" hex. socket with ratchet handle and short extension (U9551 and 4C9675)
- To remove retaining ring holding bearing on loading valve:
  - Special pin spanner, see sketch



- To remove turbine assembly:
  - Thin nosed circlip pliers
  - Soft nosed pliers
- To remove safety discs:
  - 11/16" hex. socket spanner (1U8761 and 4C9437)
  - 5/8" hex. socket spanner (1U9551 and 4C9675)
- To remove handle from case:
  - 1/2" across flats open ended spanner
- For electrical work:
  - 5mm, 6mm 7mm across flats box or socket spanner, small "electrician's" screw driver
  - Temperature controlled soldering iron,
  - 8T5200 Frequency Generator or audio frequency generator with accuracy of ±.5 Hertz up to 1200 Hertz
- To remove plugs to shuttle valve:
  - 1/4" hex. Allen key

Service Parts

NOTE: The FT "part numbers" are not Caterpillar-designed fabricated tool drawings. They are the manufacturer's drawing numbers.

Replacement Safety Discs (item 10)

Part No.	Nominal Pressure	Color	Quantity
For 1U8761 and 4C9437			
FT338-1	1000PSI	white	Two (of the appropriate pressure rating) required per tester
FT338-2	2000PSI	brown	
FT338-3	3000PSI	yellow	
FT338-4	4000PSI	green	
FT338-5	5000PSI	blue	
FT338-6	6000PSI	red	
For 1U9551 and 4C9675			
FT545-5	5000PSI	blue	
FT545-6	6000PSI	red	

Service Parts

Item No.	Part No.	Description	Quantity
Instrument Panel			
	FT2655-1	9 Volt basic front panel assy. Specify tester model number and serial number. Note: This assembly is used on testers after Serial No. 5575 and may be fitted to testers from No. 4797 as a retrofit to update from 4 Volt to 9 Volt. Consult factory for parts required to retrofit earlier testers.	1
6.3.17	FT1333	DIN plug (5 way)	1
6.3.14	4C9625	Gauge 1/4 BSP GLY. Back Con. 2-1/2" 63mm, 6000PSI	1
6.8	FT2079	Washer 6 BA	3
6.9	FT1709	Locknut 6BA Steel for PCB	3
6.10	FT1773	Screw 6BA 3/8 long for PCB	3
6.3.21	FT1962	Connector Tach Battery	2
	FT1963	Plastic Connection Cover for FT 1962	2

Item No.	Part No.	Description	Quantity
Instrument Panel (cont'd)			
6.1	FT1988	PCB Assembly complete with cable harness for use with 100°C temperature scale	1
6.1	FT5164	PCB Assembly complete with cable harness for use with 120°C temperature scale	1
6.7	FT2082	Battery PP3	1
6.3.19	FT2410-1	Battery Cover	1
6.3.20	FT2423	Battery Connector (9 Volt)	1
36	FT2511	Cover Screw (pozi head)	2
6.3.6	FT2611	Switch 6 Way 7 Pole Break before Make	1
6.3.1	FT2654	HT. Mark 3 Front Panel	1
6.3.15	FT386	Knob	1
	FT434	Pop Rivet for DIN socket	2
6.3.7	FT680	DIN Socket (Tacho.)	1
6.4		Meter with Scale and Cover (Specify Scale number)	1
6.1.1	FT967	PCB Board Support	1
	FT2800	Switch Sleeve Cover (to protect wafers)	1
Pressure Gauge Tube Assembly			
1	FT1347	Pressure Gauge Tube Assembly	1
1.1	FT804	Copper Washer	2
Transducer Assembly			
4	4C9623	Transducer Assembly (Flow/Temp.)	1
8	4C9626	Copper Sealing Ring	1
6.3.17	FT1332	DIN Socket (5 pin) FE22	1
	FT2577-016	O-Ring BS016 Vinton	1
	FT0330	Transducer Sealing Nut	1

Item No.	Part No.	Description	Quantity
Loading Valves for 1U8761 and 4C9437			
3	4C9627	Loading Valve complete	1
3.11.1.	F80078-3	Bearing Thrustplate	4
3.11	F80153	Bearing Race	2
3.13	FT1257	Disc Spacer	1
9	FT1257	Disc Holder	1
3.1	FT1880	Knob	1
3.4	FT1882	Seal	1
3.6	FT2594	Spindle	1
3.3	FT2596	Bonnet	1
3.5	FT2597	Bearing Ring	1
3.12	FT2598	Retaining Ring	1
21	FT2599	Poppet Valve	1
18	FT2635	Seal	1
10	4C4083	Burst Disc 6000 PSI (420 bar)	2
3.10	FT511	Spiral Pin	1
Loading Valves for 1U9551 and 4C9675			
3	4C9628	Loading Valve complete	1
3.11.1	F80078-3	Bearing Thrustplate	2
3.11	F80153	Bearing Race	1
21	FT1805	Balanced Poppet Valve	1
3.3	FT1807/1879	Bonnet and Flange	1
3.6	FT1808	Spindle	1
3.13	FT1809	Ring	1
9.	FT1811	Retainer (Disc)	1
3.12	FT1844	Ring	1
3.1	FT1880	Knob	1

Item No.	Part No.	Description	Quantity
Loading Valves for 1U9551 and 4C9675 (cont'd)			
3.5	FT1881	Ring	1
3.4.	FT1882	Seal	1
18	FT1883	Seal	1
3.12	FT2434	Bearing	1
3.12.1	FT2435	Bearing (Thrust plate)	2
3.10	FT511	Spiral Pin	1
10	FT545-5	Safety Disc 5000PSI 350 bar	2
Turbine Assembly for 1U8761 and 4C9437			
2	FT2788	Turbine Assembly	1
2.5	FT2792	Spindle	1
2.10	FT2789	Anti Turbulence Disc	2
2.9	FT2793	Straightener Spacer	1
2.6	FT2794	End Straightener	1
2.4	FT2795	Turbine Bearing	1
2.7	FT440	Circlip 3/8" Int.	2
2.1	FT930	Front Straightener	1
2.3/2.8	FT931	Nose Cone	2
Turbine Assembly 1U9551 and 4C9675			
2	FT2830	Turbine Assembly 1U9551 and 4C9675	1
2.5	FT2814	Turbine Spindle	1
2.10	FT2816	Anti Turbulence Disc	2
2.11	FT2817	Straightener Spacer	1
2.9	FT2818	Straightener Spacer	1
2.8	FT5067	Rear Cone	1
2.6	FT5068	Rear Straightener	1

Item No.	Part No.	Description	Quantity
Turbine Assembly 1U9551 and 4C9675 (cont'd)			
2.7	FT647	Circlip	2
2.2	FT648	Turbine Bearing	1
2.4	FT709	Turbine	1
2.3	FT739	Front Cone	1
2.1	FT756	Front Straightener	1
General Spare Parts			
26	F29531-98	Bolt Socket Head (Case to Block)	2
26.1	F29530-50	Bold Hex Head (Case to Block)	2
3.8	F29774-028	O-Ring Viton for 1U8761 and 4C9437	1
	F29771-128	O-Ring for 1U9551 and 4C9675	1
	FT1090	Tacho. Battery Holder	1
35	FT1148	Warning Label for 1U8761 and 4C9437	1
	FT1146	Warning Label for 1U9551 and 4C9675	1
36	FT1328-4	Panel Screws	6
	FT1365	Pop Rivet (Tacho. Battery Holder)	4
5	FT1559	Tester Case with Lid	1
	FT1924	Support Tacho Battery Holder	1
	FT2829	Screw 6BA x 5/8 long (for FT1924)	1
	FT1709	Locknut (for FT1924)	1
	FT2079	Washer	1
38	FT2577-011	O-Ring Viton for 1U8761 and 4C9437	1
	FT2579-906	O-Ring for 1U9551 and 4C9675	1
39	FT2583-250	1/4" NPT Plug	2
41	FT2720	Shuttle Valve Seat	1
40	FT2796	Ball for Shuttle Valve	1
30	FT2808	Instruction Label	1
31	FT307	Tester HANDLE	1
24	FT321	Rubber Tape	one meter
23	FT323	Rubber Feet	4

Item No.	Part No.	Description	Quantity
General Spare Parts (cont'd)			
25	FT326	Cork Gasket Between the Case and Block	1
	FT503	Nameplate	1
20	F29531-40	3/8 UNC x 1" Mounting Bolt for 1U8761 and 4C9437 Loading Valve	4
20	FT29530-53	1/2 UNC x 1.5" Hex, Mounting Bolt for 1U9551 and 4C9675	4
20.1	FT1120	1/2" Washer for 1U9551 and 4C9675 Loading Valve	4
Turbine Blocks			
	FT2595	Turbine Block with 1-11 BSPF Thread for 1U8761 and 4C9437	1
	FT2870	Turbine Block with 1-5/16"--12 UN Thread (O-Ring Boss) for 1U8761 and 4C9437	1
	FT2631	Turbine Block for 1U9551 and 4C9675	1

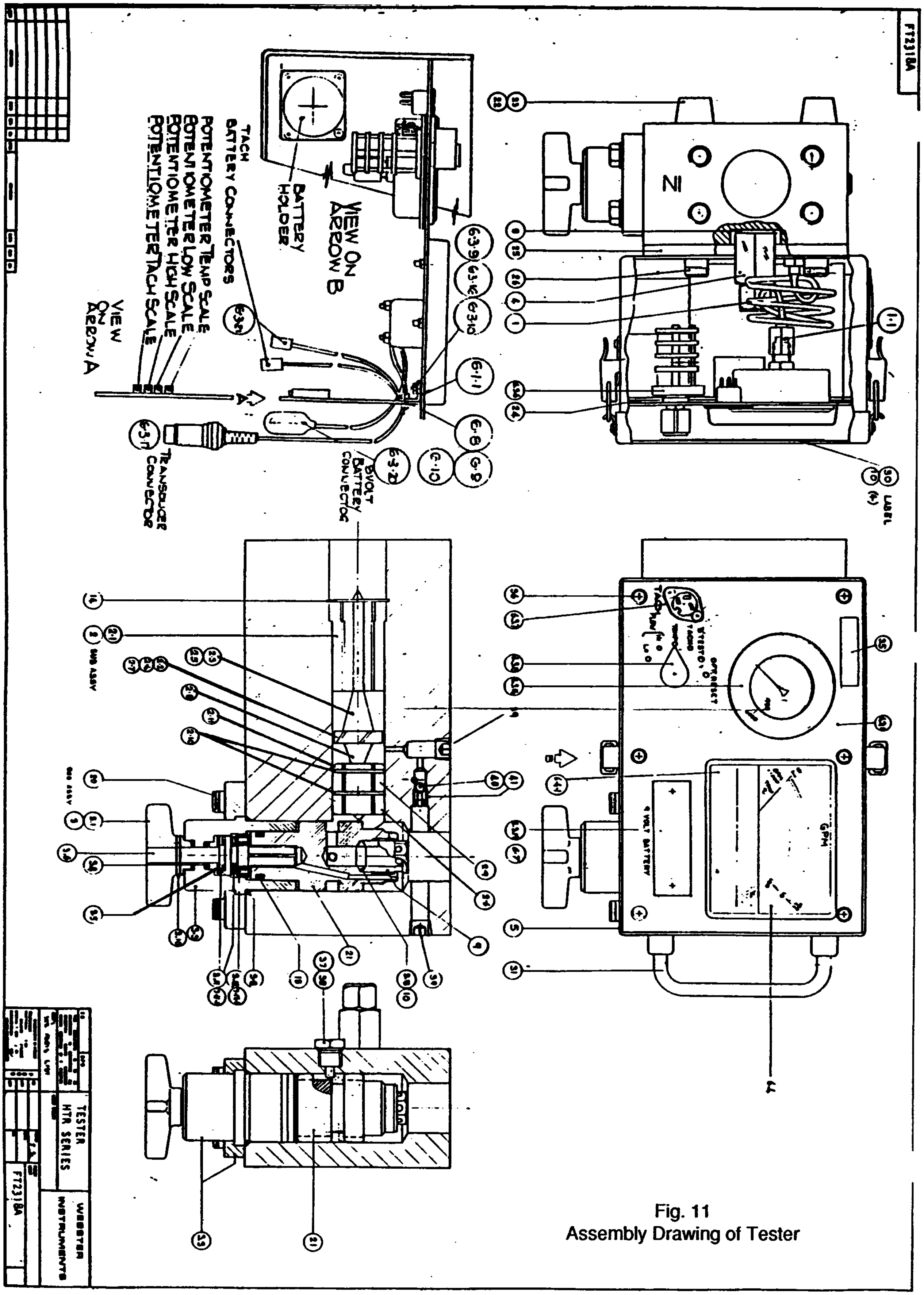


Fig. 11
Assembly Drawing of Tester

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