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WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

213 DMM OSCILLOSCOPE

WITH OPTIONS

SERVICE

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

Serial Number _____

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LIST OF ILLUSTRATIONS (CONT.)

SPECIFICATIONS

The 213 DMM Oscilloscope is a portable measurement instrument that is designed to be used as either a digital multimeter or an oscilloscope. Function selection is made with a front-panel pushbutton switch. Voltage measurements are made with the integral high-impedance probe, while current and resistance measurements are made through a low-impedance banana jack input on the side panel. Operating power is provided by internal rechargeable batteries or from power-line voltage. An integral battery charger recharges the batteries whenever the instrument is connected to the power line.

The digital multimeter measures ac or dc voltage and current, and resistance. It features true rms responding circuitry when making ac voltage or current measurements. Full scale measurement ranges are 0.1 to 1000 V, 0.1 to 1000 mA, and 1 kΩ to 10 MΩ with a 200% full scale overrange on all ranges except 1000 V. The crt readout is a 3½-digit display containing an automatic polarity indicator, and a decimal point which is positioned by the range selector switch. Overrange is indicated by an unblanked readout display consisting of scrambled character segments.

The oscilloscope function provides a single channel, dc to 1 MHz vertical deflection system with calibrated deflection factors of 5 mV to 100 V/division with a reduced bandwidth of dc to 400 kHz on the 5 mV and 10 mV ranges. Current deflection factors are 5 μA to 100 mA/division from dc to 400 kHz with a reduced bandwidth of dc to 200 kHz on the 5 μA and 10 μA/division ranges. The horizontal deflection system provides calibrated sweep rates from 0.5 s to 2 μs/division, with a variable sweep magnifier that provides uncalibrated sweep rates to at least 5 times faster than the selected rate. The trigger input is either internal or external and provides stable triggering over the full bandwidth of the vertical deflection system. The oscillo-

fied. Warm up time for specified accuracies is 10 minutes. If the instrument is already stabilized at the ambient temperature, warm up time is 10 seconds.

TABLE 1-1
Digital Multimeter Electrical Specifications

Characteristic	Performance Requirement
DC AND RMS VOLTS	
Range	0.1 V to 1000 V
Resolution	100 μV at 0.1 V full scale (reading must be at least 10% of full scale)
Input Resistance	10 MΩ within 1%
Input Capacitance	
0.1 V to 10 V	Approximately 150 pF
100 V to 1000 V	Approximately 100 pF
Input Leakage Current	200 pA max at 30°C or less with 2 mV or less change from open to shorted probe

OPERATING INSTRUCTIONS

SAFETY INFORMATION

This instrument is designed to allow the input common reference to float above ground. Under this condition, the probe common clip, COMMON input jack, mA-Ω input jack, EXT TRIG jack, and the power plug prongs may be at a dangerous potential. See Table 1-4, Common Isolation Protection in the Specifications section.

When operated on batteries, the power line plug should be stored in the rear-panel insulated compartment. Potentials applied to the common connectors (probe common clip or COMMON jack) may cause small amounts of current to flow in the power-line circuitry creating a possible shock hazard on the plug prongs.

The probe common clip and COMMON jack are electrically connected to each other; therefore, any potential applied to one is present on the other creating a possible shock hazard. Also, to prevent dissimilar voltages being applied to the probe common clip and COMMON jack, which could jack, should not be connected simultaneously to a circuit under test.

Personal and equipment safety precautions are used throughout this manual and are identified as follows:

Personal Safety — **WARNING**

Equipment Safety — **CAUTION**

CONTROLS, CONNECTORS, AND INDICATORS

Side Panel

(1) **mA-Ω**—Banana-jack input for current and resistance measurements. In the Ω mode, this jack is negative with respect to the COMMON jack.

(2) **EXT TRIG**—Banana-jack, high-impedance input for external trigger voltage.

(3) **DC BAL**—Screwdriver adjustment to adjust for mini-

(4) **COMMON**—Banana-jack common return path for current and resistance measurements, or as an alternate reference point or common return when using the voltage probe. It is electrically connected to the probe common clip.

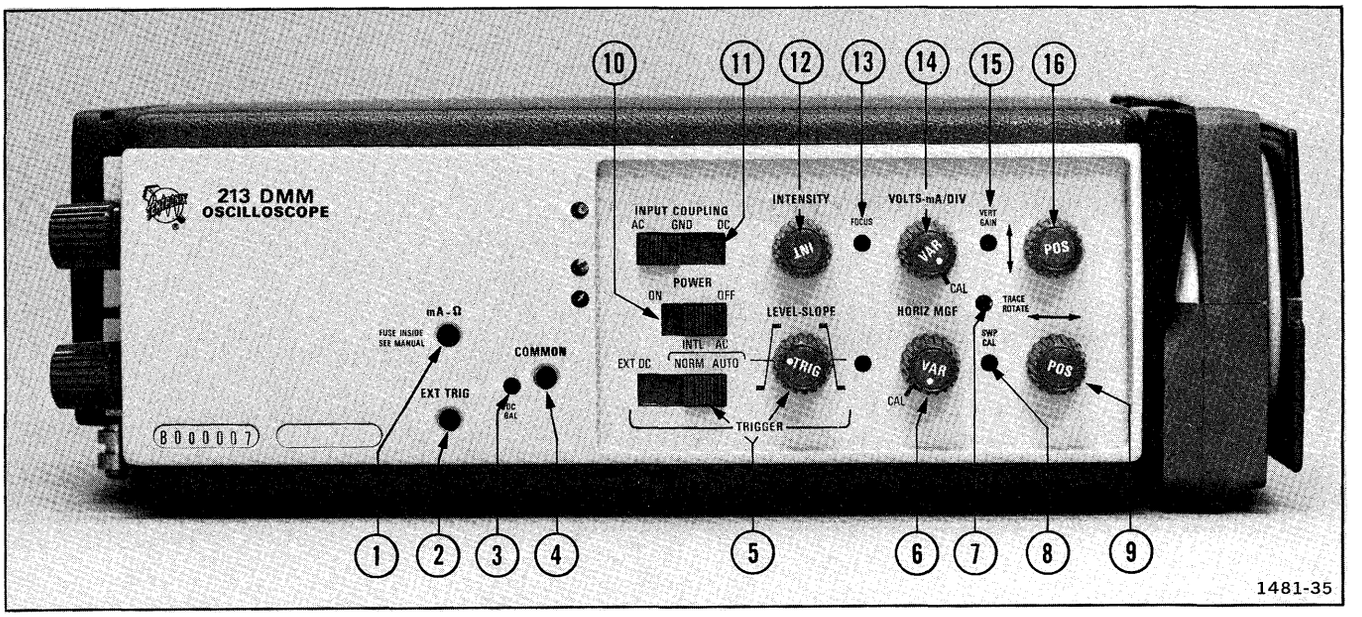


Fig. 2-1. Side panel.

THEORY OF OPERATION

This section of the manual contains a description of the circuitry used in the 213 DMM-Oscilloscope. The description begins with a discussion of the instrument using the Block Diagram pullout page in the Diagrams section. Then, each circuit is described in detail using additional detailed diagrams and the schematics in the Diagrams section. The detailed diagrams contain the same component designations as the schematics; therefore, refer to the schematics for component electrical values and relationships. The schematic being described is identified by its Diagrams section number (e.g. ◇2◇) following the first paragraph title that begins the description of a particular schematic.

DIGITAL LOGIC

Digital logic techniques are used to perform some functions within this instrument. The function and operation of the logic circuits are described using logic symbology and terminology. All logic functions are described using the positive logic convention. Positive logic is a system of notation where the more positive of two levels is called the true, HI, or 1 state and the more negative level is called the false, LO, or 0 state. The HI-LO method of notation is used in the logic descriptions in this manual. The specific voltages which constitute the HI or LO state may vary between individual devices.

detailed diagrams or other techniques to illustrate their functions.

Table 3-1 contains the logic symbol and truth table for the logic device used in this instrument.

BLOCK DIAGRAM DESCRIPTION

The following discussion is provided to aid in understanding the overall concept of the 213 DMM Oscilloscope before the individual circuits are discussed in detail. Refer to the Block Diagram pullout page in the Diagrams section.

Signals to be displayed on the crt are applied to either the voltage probe or the mA-Ω input jack. Both inputs are shared by the DMM and oscilloscope functions.

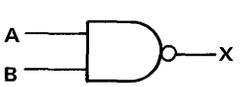
The signals are then coupled and attenuated (voltage inputs) or converted to voltages (current and resistance) and amplified by the Input Buffer Amplifier. From this amplifier the signal goes to either the DMM or Oscilloscope function.

In the DMM function, a two-pole, low-pass active filter provides ac rejection and is switch selected when measuring dc.

The Gm Converter rectifies bipolar ac signals into a unipolar current to drive the RMS Converter, or A/D Converter. The RMS Converter changes the rectified signals into a unipolar current of equivalent rms value to drive the A/D Converter.

The A/D Converter changes the unipolar current into a binary coded decimal (BCD) output to drive the Character Generator. The Character Generator accepts the BCD input and converts it to X, Y, and Z signals to drive the Output Amplifiers and Z-Axis Amplifier which cause crt deflection and blanking to create the readout display.

TABLE 3-1
NAND Gate Logic Chart

			Input		Output
NAND gate U250A, B, C, & D		A device with two or more inputs and one output. The output of the NAND gate is LO if and only if all of the inputs are at the HI state.	A	B	$\overline{X}$
			LO	LO	HI
			LO	HI	HI
			HI	LO	HI
			HI	HI	LO

MAINTENANCE

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance, or troubleshooting of the 213. It also includes repackaging information.

TEKTRONIX FIELD SERVICE

Tektronix, Inc. maintains repair and recalibration facilities at its local Field Service Centers and the Factory Service Center. For further information or assistance, contact your local Tektronix Field Office or representative.

PREVENTIVE MAINTENANCE

Preventive maintenance consists of recalibration, cleaning, visual inspection, and lubrication. Preventive maintenance, performed on a regular basis, can prevent instrument breakdown and will improve the reliability of this instrument. The severity of the environment to which the instrument is subjected will determine the frequency of maintenance. A

Recalibration

To insure accurate measurements, check the calibration of this instrument after each 1000 hours of operation or every 6 months if used infrequently. In addition, replacement of components may necessitate recalibration of the affected circuits. The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed or corrected by recalibration.

Cleaning

The 213 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path which may result in instrument failure. The cabinet provides protection against dust in the interior of the instrument and operation without them necessitates more frequent cleaning.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. In particular, avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents. Recommended cleaning agents are isopropyl alcohol (Isopropanol) or ethyl alcohol (Fotocol or Ethanol).

EXTERIOR. Loose dust accumulated on the outside of the instrument can be removed with a soft cloth or small brush. The brush is particularly useful for dislodging dirt on and around the controls. Dirt that remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

INTERIOR. Dust in the interior of the instrument should be removed occasionally to prevent undesirable electrical conduction. Clean the interior with a dry, low-velocity stream of air. If this method doesn't remove all the loose dust, or if hard dirt is present, the boards will have to be disassembled for further cleaning. A soft bristle brush or a cotton tipped applicator is useful for cleaning in narrow spaces or for cleaning the more delicate components.

voltage multiplier, and the thick film input attenuator resistors should receive special attention. Excessive dirt or dust in these areas may cause high-voltage arcing, or signal-path shunting, which would result in improper instrument operation.

CATHODE-RAY TUBE (CRT). Clean the plastic light filter and the crt face with a soft, lint-free cloth dampened with denatured alcohol.

Visual Inspection

The 213 should be inspected occasionally for such defects as broken connections, improperly seated semiconductors, damaged or improperly installed circuit boards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

Lubrication

Generally, there are no components in the 213 that will require lubrication during the life of the instrument.

PERFORMANCE CHECK

This section contains a procedure for checking instrument performance without removing the cabinet or making internal adjustments (external operators adjustments are made as needed). Only the performance essential to measurement accuracy and correct operation are checked. The procedure is also useful as an aid in troubleshooting and preventive maintenance. To aid in locating a step in the Performance Check procedure, an index is provided preceding the procedure.

EQUIPMENT REQUIRED

The equipment required to accomplish the performance check procedure is listed in Table 6-1. The comments in the Equipment Required portion of Section 6 and the footnotes for Table 6-1 also apply to the performance check procedure.

EQUIPMENT PREPARATION

Refer to Equipment Preparation in Section 6, except do not remove the equipment cabinet.

Control settings precede each major function to be performance checked. Titles for controls are fully capitalized in

CHECK PROCEDURE

CALIBRATION

PRELIMINARY INFORMATION

Calibration Interval

To assure instrument accuracy, check the calibration of the 213 every 1000 hours of operation, or every 6 months if used infrequently. Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section.

Tektronix Field Service

Tektronix, Inc. provides complete instrument repair and recalibration at local Field Service Centers and the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

Using This Procedure

This section provides several features to facilitate calibra-

CONTROL SETTINGS. Control settings precede each major function to be calibrated. Titles for external controls are fully capitalized in the procedure (e.g. INTENSITY) and internal adjustments are initial capitalized only (e.g. Ohms Cal).

COMPLETE CALIBRATION PROCEDURE. Completion of each step in the complete Calibration procedure ensures that this instrument is correctly adjusted and performing within all given tolerances.

PARTIAL CALIBRATION. A partial calibration is often desirable after replacing components, or to touch up the adjustment of a portion of the instrument between major recalibrations. To calibrate only part of the instrument, set the controls as given under Control settings at the beginning of the major instrument section for that particular portion. To prevent unnecessary recalibration of other parts of the instrument, readjust only if the tolerance given in the CHECK— part of the step is not met.

EQUIPMENT REQUIRED

The test equipment and accessories given in Table 6-1, or its equivalent, are required for complete calibration of the 213. Specifications given for the test equipment are the minimum necessary for adequate calibration. Therefore, the specifications of any test equipment used must meet or exceed the listed specifications. All test equipment is assumed to be correctly calibrated and operating within the listed specifications. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed.

Special Calibration Fixtures

Special Tektronix calibration fixtures are used in this procedure only where they facilitate instrument calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your Tektronix Field Office or representative.

All of the listed test equipment, or its equivalent, is required to completely check and adjust this instrument. The Calibration procedure is based on the first item of equipment given as an example in the Equipment Required list. If the exact item is not available, first check the Specifications column carefully to see if any other equipment is available which might suffice. Then check the Purpose column to see what this item of test equipment is used for. If used for a check or adjustment that is of little or no importance to your measurement requirements, the item and corresponding step(s) can be deleted.

Complete checking or calibration may not always be necessary or desirable. The user may be satisfied with checking only selected characteristics, thereby reducing the amount of test equipment actually required. The equipment required for the actual calibration adjustments in the procedure are identified in Table 6-1 with a footnote (1).

INSTRUMENT OPTIONS

Your instrument may be equipped with the following option, if it was ordered from the factory with the option installed. If not, the option can be installed at a later date by contacting the closest Tektronix Field Office or representative.

OPTION 1

This option allows the instrument to charge the batteries or operate from a power line source of 180 to 250 V ac (48 to 62 Hz) or 180 to 250 V dc. Refer to the parts list and Diagram 5 in this manual for information concerning C416 which is used with Option 1 but not with the standard 213. Refer to Accessories page at the back of the manual for the power cord cable assembly included with Option 1 for adapting to appropriate power plugs. Part number for the A5 board used with Option 1 is listed here.

A5	670-2226-21	CIRCUIT BOARD ASSEMBLY: POWER SUPPLY (OPTION 1)

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF).
Values less than one are in microfarads (μF).

Resistors = Ohms (Ω).

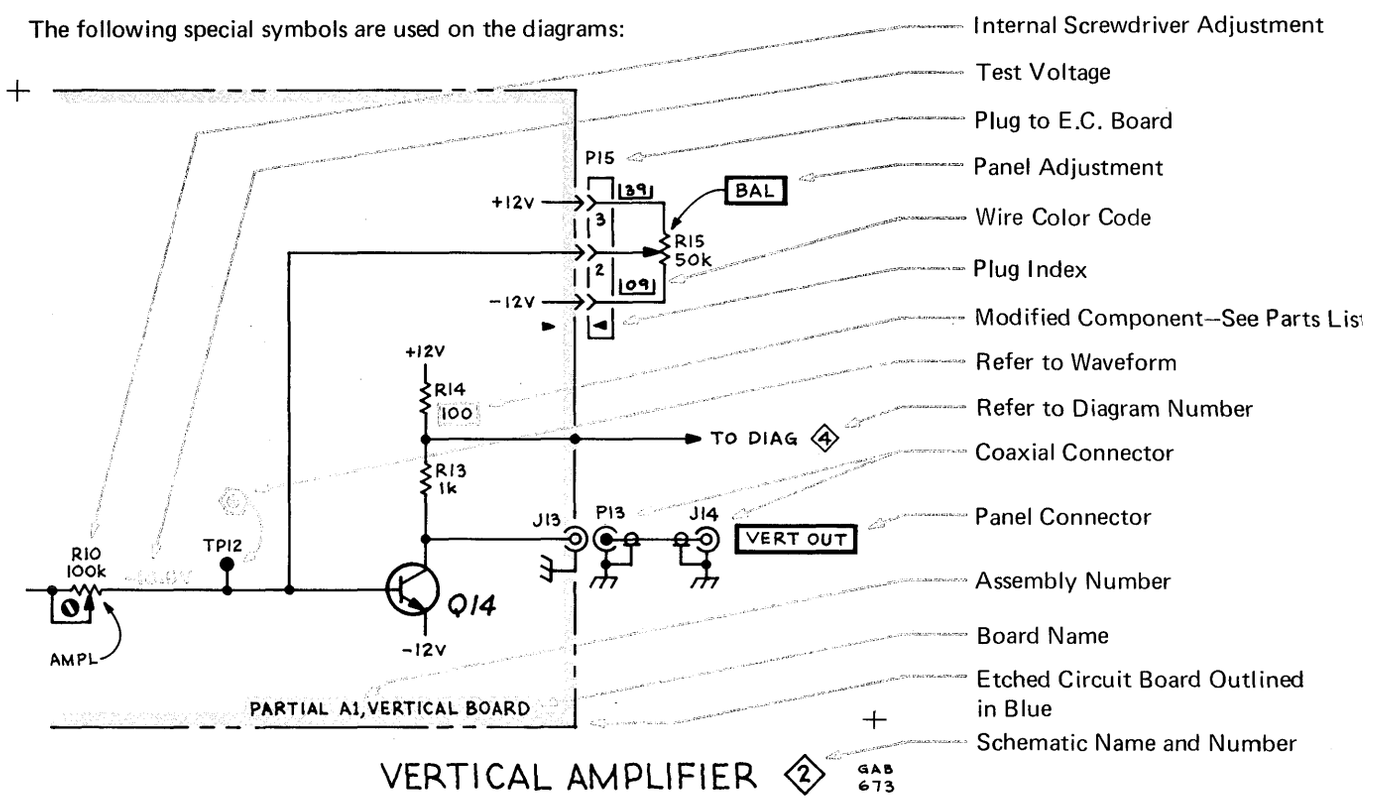
Symbols used on the diagrams are based on ANSI Standard Y32.2-1970.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable (circuit board, etc.)	H	Heat dissipating device (heat sink, heat radiator, etc.)	RT	Thermistor
AT	Attenuator, fixed or variable	HR	Heater	S	Switch
B	Motor	HY	Hybrid circuit	T	Transformer
BT	Battery	J	Connector, stationary portion	TC	Thermocouple
C	Capacitor, fixed or variable	K	Relay	TP	Test point
CB	Circuit breaker	L	Inductor, fixed or variable	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
CR	Diode, signal or rectifier	LR	Inductor/resistor combination	V	Electron tube
DL	Delay line	M	Meter	VR	Voltage regulator (zener diode, etc.)
DS	Indicating device (lamp)	P	Connector, movable portion	Y	Crystal
F	Spark Gap	Q	Transistor or silicon-controlled	Z	Phase shifter

The following special symbols are used on the diagrams:



REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

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Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

SPECIAL NOTES AND SYMBOLS

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```
1 2 3 4 5                    Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
- - - * - - -
   Detail Part of Assembly and/or Component
   Attaching parts for Detail Part
   - - - * - - -
      Parts of Detail Part
      Attaching parts for Parts of Detail Part
      - - - * - - -
```

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

"	INCH
#	NUMBER SIZE
ACTR	ACTUATOR
ADPTR	ADAPTER
ALIGN	ALIGNMENT
AL	ALUMINUM
ASSEM	ASSEMBLED
ASSY	ASSEMBLY
ATTEN	ATTENUATOR
AWG	AMERICAN WIRE GAGE
BD	BOARD
BRKT	BRACKET
BRS	BRASS
BRZ	BRONZE
BSHG	BUSHING
CAB	CABINET
CAP	CAPACITOR
CER	CERAMIC
CHAS	CHASSIS
CKT	CIRCUIT
COMP	COMPOSITION
CONN	CONNECTOR
COV	COVER
CPLG	COUPLING
CRT	CATHODE RAY TUBE
DEG	DEGREE
DWR	DRAWER
ELCTRN	ELECTRON
ELEC	ELECTRICAL
ELCTLT	ELECTROLYTIC
ELEM	ELEMENT
EPL	ELECTRICAL PARTS LIST
EQPT	EQUIPMENT
EXT	EXTERNAL
FIL	FILLISTER HEAD
FLEX	FLEXIBLE
FLH	FLAT HEAD
FLTR	FILTER
FR	FRAME or FRONT
FSTNR	FASTENER
FT	FOOT
FXD	FIXED
GSKT	GASKET
HDL	HANDLE
HEX	HEXAGON
HEX HD	HEXAGONAL HEAD
HEX SOC	HEXAGONAL SOCKET
HLCPS	HELICAL COMPRESSION
HLEXT	HELICAL EXTENSION
HV	HIGH VOLTAGE
IC	INTEGRATED CIRCUIT
ID	INSIDE DIAMETER
IDENT	IDENTIFICATION
IMPLR	IMPELLER
IN	INCH
INCAND	INCANDESCENT
INSUL	INSULATOR
INTL	INTERNAL
LPHLDR	LAMPHOLDER
MACH	MACHINE
MECH	MECHANICAL
MTG	MOUNTING
NIP	NIPPLE
NON WIRE	NOT WIRE WOUND
OBD	ORDER BY DESCRIPTION
OD	OUTSIDE DIAMETER
OVH	OVAL HEAD
PH BRZ	PHOSPHOR BRONZE
PL	PLAIN or PLATE
PLSTC	PLASTIC
PN	PART NUMBER
PNH	PAN HEAD
PWR	POWER
RCPT	RECEPTACLE
RES	RESISTOR
RGD	RIGID
RLF	RELIEF
RTNR	RETAINER
SCH	SOCKET HEAD
SCOPE	OSCILLOSCOPE
SCR	SCREW
SE	SINGLE END
SECT	SECTION
SEMICOND	SEMICONDUCTOR
SHLD	SHIELD
SHLDR	SHOULDERED
SKT	SOCKET
SL	SLIDE
SLFLKG	SELF-LOCKING
SLVG	SLEEVING
SPR	SPRING
SQ	SQUARE
SST	STAINLESS STEEL
STL	STEEL
SW	SWITCH
T	TUBE
TERM	TERMINAL
THD	THREAD
THK	THICK
TNSN	TENSION
TPG	TAPPING
TRH	TRUSS HEAD
V	VOLTAGE
VAR	VARIABLE
W/	WITH
WSHR	WASHER
XFMR	TRANSFORMER
XSTR	TRANSISTOR

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.