OPERATING INSTRUCTIONS
for the
Model CT-6000™
A Digital Circuit-Breaker Analyzer

Manufactured by
Vanguard Instrument Co., Inc.
1824 E. Elma Ct.
Ontario, California 91764

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 Description. Vanguard Instrument's Model CT-6000™ Timer (hereafter, Timer) is a microcomputer-controlled unit that analyzes EHV circuit-breaker (hereafter, breaker) operations. The Timer is easy to use and is designed for reliable operation and rough handling. The Timer is available in three models, which are listed below:

When a breaker-operate coil is powered, the current onset marks the start of contact motion. When the actuator crosses the main-line contact's switch point, the in-series A/B switch opens, breaking the control current and marking the contact's opening or closure. The operate-coil current waveform (in effect, an operating "fingerprint") is a diagnostic tool when it's compared with a breaker's historical norm.

MODEL	CHANNEL INPUTS			
	DRY CONTACTS	VOLTAGE	TRAVEL	CURRENT
CT-6000-3	3^C	2^C	1^C	1^C
CT-6000-6	6^C	2^C	1^A	1^B
CT-6000-12	12^C	2^C	3^C	1^C

A. CT-6000-6 CAN BE ORDERED WITH UP TO 3 TRAVEL TRANSDUCERS
B. CT-6000-6 CAN BE ORDERED WITH 1 OPTIONAL CURRENT-INPUT CHANNEL
C. STANDARD ITEMS

Breaker analysis includes contact timing, stroke (travel), velocity, over travel, bounce back, and wipe. Selectable contact test shots include: Open, Close, Open-Close, and Close-Open.[1] Refer to Table 1 for CT-6000 specifications. The printer produces 4.5-inch-wide paper printouts of breaker test results in graphic and tabulated formats.

2.0 OPTIONS

2.1 Current Profile Monitoring Option.
An open- or close-coil current recording (uses a clamp-on Hall-effect sensor[2] without electrical contact) creates a current profile.[3]

2.2 Three-Transducer Input Option. The CT-6000-3 (3-channel input) is furnished with only one transducer input channel. The CT-6000-6 is also furnished with one Travel Transducer input channel, however, users can order the three-Travel-Transducer input channel option. The Model CT-6000-12 is always furnished with 3 Travel-Transducer input channels.

3.0 OPERATING MODES

The CT-6000 has two operating modes: a stand-alone mode and a computer-controlled mode. In the computer-controlled mode, the CT-6000 is controlled by an IBM-compatible

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1. Contact velocity is calculated for only Close and Open strokes.
2. Refer to Appendix A for current sensor part number.
3. Current monitoring is an optional item on the CT-6000-6 (six-channel unit).

field computer via the RS-232C port. Several advantages are available to users under the computer-control mode, which are as follows:

a. A user can time breakers and view the test results on the computer's screen.

b. Test shots can be stored on the computer's hard drive.

c. Test reports can be recalled in an office to be reanalyzed.

d. Test reports can be printed on an office printer or a plotter.

Please refer to the Analysis Software Operating Instructions for more details.

The stand-alone mode allows the Timer to be used to time circuit breakers. The operator can get test results by using the built-in thermal printer. Graphic results can also be acquired from the built-in printer.

The remainder of this manual deals with the CT-6000 stand-alone mode of operation.

NOTE
The CT-6000-12 in the stand-alone mode only supports contact channels 1–6 (timing results) Travel Transducer channel 1 (stroke, velocity). To get the full benefit of 12 contact channels and 3 Travel Transducers, the computer control mode must be used.

4.0 TEST-RESULT TABULATIONS

4.1 Electrical Measurement Results:
Main contact and Resister timing

NOTE
The CT-6000 is capable of detecting contact insertion resistors ranging from 20 ohms to 5000 ohms. Any input resistance above 10,000 ohms is recognized as an open circuit.

4.2 Mechanical Measurement Results:

a. Total travel
b. Over travel
c. Bounce back
d. Contact wipe
e. Velocity

5.0 TEST-RESULT GRAPHICS

5.1 After testing, graphic waveforms of all contact channels, travel curves, and actuator-coil currents can be printed. With a ZOOM GRAPHICS mode, users can select an enlargement by specifying a time zone.

6.0 CONTROLS AND DISPLAYS

6.1 Before breaker timing, operators should be familiar with all controls and indicators. Figures 1A and 1B show a Timer panel, with arrowed lines pointing to each control and indicator. Line numbers refer to table 2A and 2B, which describes each control and indicator. The keypad and screen are used to operate the Timer.

7.0 CT-6000 Timer Specifications.
Model CT-6000 electrical and mechanical specifications are listed in table 1.

Table 1. CT-6000 Timer Specifications

CONTACT TIMING	Open, Close, Open-Close, & Close-Open (velocity only with Open and Close)
SIZE & WEIGHT	CT-6000-6 and -12: 16 d by 14 w by 11 h (inches); less than 20 pounds Ct-6000-3; 12 d by 16 w by 10 h (inches); less than 15 pounds
OPERATING POWER	3 amperes at 90 to 130 volts, 50/60 Hz
DRY-CONTACT INPUTS	3, 6, or 12 dry-input channels (model dependent)
DRY-CONTACT CHANNEL PROTECTION	100 mA fuses protect all isolated power supplies; contact inputs are grounded until testing and are MOV and zener-diode protected
TRIGGER INPUT	Open/Close: 30 to 300 volts, dc or peak ac
VOLTAGE INPUTS	2 each: range 30 to 300 volts, dc or peak ac
CONTACT RESISTANCE	CLOSED=less than 20 ohms; OPEN=more than 10,000 ohms
INSERTION RESISTANCE	Range: 50 to 5000 ohms
TRAVEL ANALYSIS (OPTION)	1 or 3 travel-input channels. Travel-Transducer required per channel. Linear-range; 0.0-60.0 inches (± 0.01 inch); Rotary-range: 0-360° (± 0.006°)
OPEN/CLOSE CURRENT PROFILE (OPTION)	Non-contacting, Hall-effect sensor, 10- or 100-amp ranges, dc—5 kHz (1 input)
SAMPLING DURATION	1 second–resolution ±125 µ-seconds; 10 seconds–resolution ± 1.25 milliseconds
CIRCUIT-BREAKER SOFTWARE	Analysis software runs on IBM pc computer, Software package provides ANALYSIS graphic display, numerical reports, and database ability at shop or office.
DISPLAY	Back-lighted LCD screen: 4 lines by 20 characters, sunlight viewable
HARD-COPY PRINTOUT	Graphic contact-travel waveforms & tabulated results (4½-inch-wide paper)
SLOW-CLOSE TEST	Measures hand-jacked contact-point distances (hard copy)
PRINTER PAPER	Thermal, 4.5-inch wide (B-G Instruments Co. p/n TP-4)
LOGISTICS SUPPORT	User Training Classes; 72-hour response service available
WARRANTY	One year parts and labor; service also available
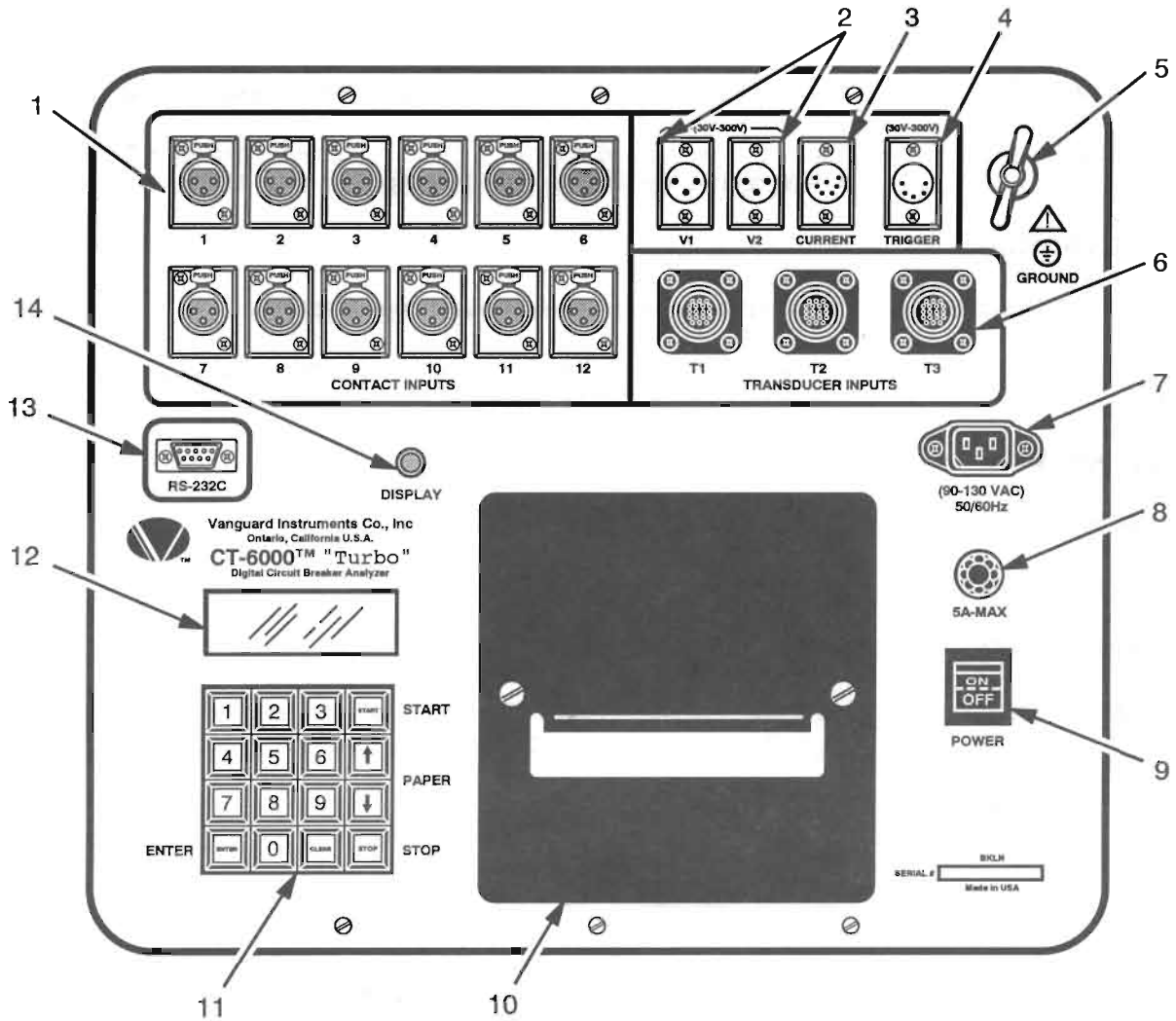
Figure 1A. CT-6000 Timer Control Panel (sheet 1 of 2)

Table 2A. Functional Description of CT-6000 Timer Controls and Indicators

Fig. 1A INDEX No.	PANEL MARKING	FUNCTIONAL DESCRIPTION
1	CONTACT INPUT (1—12)	Connector, 3-pin: each input is a continuity (dry) sensor for detecting a contact's closing or opening (a timing input to the processor).
2	V1/V2 (30 V–300 V)	Connector, 3-pin: each input is a detector for timing voltage (30–300 V, dc/peak) of open and close coil switching (C1, C2) activation.
3	CURRENT	Connector, 7-pin: current probe input
4	TRIGGER (30 V–300 V)	Connector, 5-pin: input (30 to 300 Vac, dc, or peak) triggers timing functions.
5	GROUND	Stud, 5/16-18 threads, with wing nut; safety ground terminal
6	TRANSDUCER INPUTS (T1–T3)	Connector, 16-pin: each input (T1–T3) is a travel-encoder output (contact motion data)
7	90–120 VAC; 50/60 Hz	Connector, 3-pin: Power-cable socket with 3rd-wire ground (power cable is furnished)
8	5A–MAX (fuse)	Fuse, input power line; rated at 2.5 amperes
9	POWER/ON/OFF	Switch, 2-pole, on-off, rocker; input power
10	unmarked (printer)	Thermal printer; prints 4½-inch-wide paper; processor controlled
11	16-key number pad, CLR, up/down arrows (START, PAPER, STOP, ENTER)	Switches, momentary-contact, pushbuttons: Timer controls; numeric, and alternate (*) functions (clear/back-space key) and arrows
12	unmarked (display screen)	Liquid-Crystal Display (LCD), back-lighted: 4 line by 20 characters per line; displays selections of operating menus and options
13	RS-232C	Connector, D, 9-pin: RS-232C computer interface
14	DISPLAY	Knob, rotary: user turns knob to adjust contrast of LCD screen.
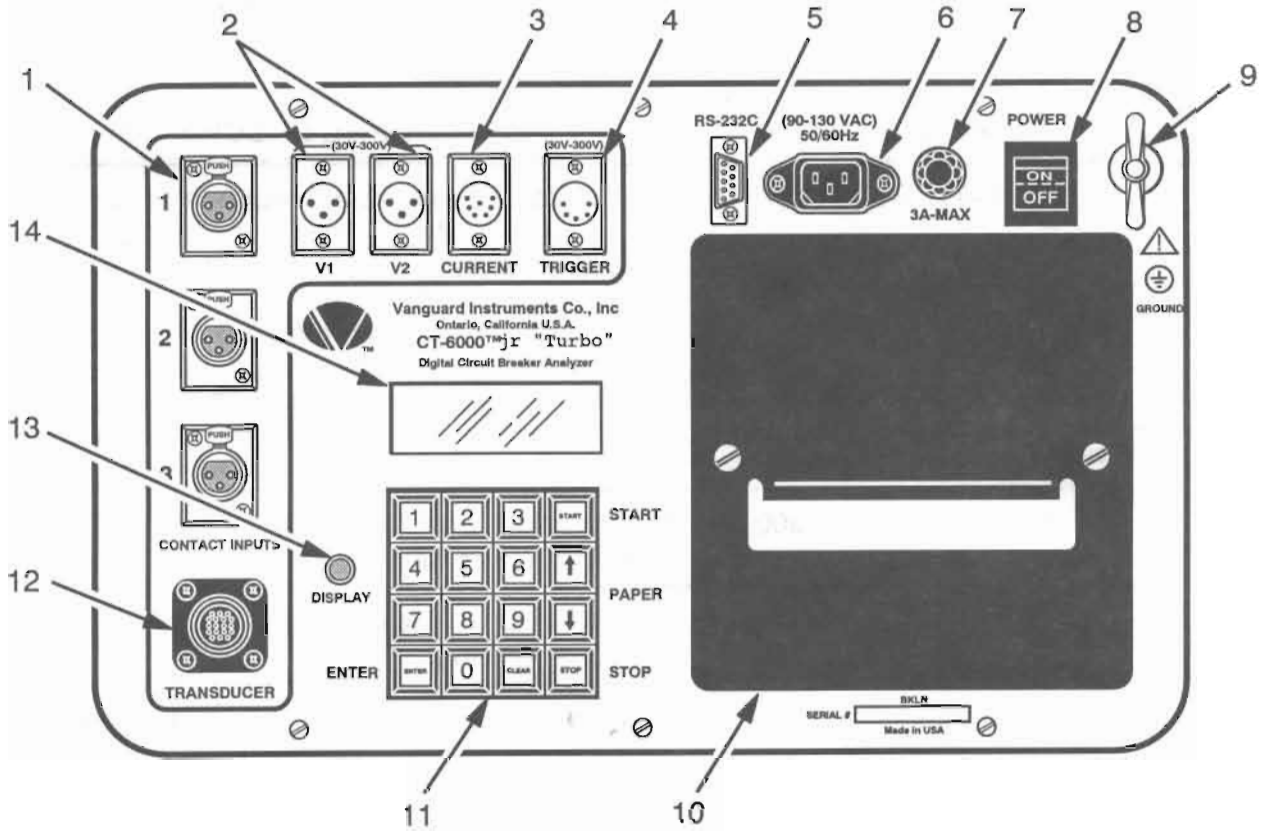
Figure 1B. CT-6000 jr Timer Control Panel

Table 2B. Functional Description of CT-6000 jr Timer Controls and Indicators

FIG. 1B INDEX NO.	PANEL MARKING	FUNCTIONAL DESCRIPTION
1	CONTACT INPUT (1–3)	Connector, 3-pin; each input is a continuity (dry) sensor for detecting contact's closing or opening (a timer input to the processor).
2	V1/V2 (30–300V)	Connector, 3-pin: each input is a detector for timing voltage (30–300 V, dc/peak) of open and close coil switching (C1, C2) activation.
3	CURRENT	Connector, 7-pin: Current probe input
4	TRIGGER (30 V–300 V)	Connector, 5-pin: input (30 to 300 V, dc or peak) triggers timing functions.
5	RS-232C	Connector, 9-pin, type D: Computer interface
6	90–120 VAC; 50/60 Hz	Connector, 3-pin: Timer power-cable socket with 3rd-wire ground (cable furnished)
7	3A–MAX (fuse)	Fuse, input power line, 3 amperes
8	POWER/ON/OFF	Switch, 2-pole, on-off; input power
9	GROUND	Stud, 5/16-18 threads, with wing nut: safety ground-cable terminal
10	unmarked (printer)	Thermal printer; prints 4½-inch-wide paper; processor controlled
11	16-Key number pad, CLR, up/down arrows (START, PAPER, STOP, ENTER)	Switches, momentary-contact, pushbuttons: Timer controls; numeric, and alternate (*) functions (clear/back-space key) and arrows
12	TRANSDUCER	Connector, 16-pin: input is a travel-encoder output (contact-motion data)
13	DISPLAY	Knob, rotary: user turns knob to adjust contrast of LCD screen
14	unmarked (LCD display)	Liquid-Crystal Display (LCD) back-lighted: 4-line by 20 characters per line; displays selections of operating menus and options

8.0 TEST HOOKUP CONNECTIONS

8.1 The Timer must be cable-connected to the breaker before testing. Figure 2A shows a typical hookup (other breaker types may require other hookups). Carefully note the breaker's configuration before making a hookup (i.e., plan tests to ensure there is no hazard). Proceed with the following steps:

a. Connect CT-6000 Timer ground-terminal stud to station ground.

b. If contact-travel data is needed, install Travel Transducer on circuit breaker and connect cable to Timer (see figure 2A).

c. Connect dry-contact cables (see figures 2A & 2B).

d. Connect trigger cables. (See figure 2A for typical positive-trip or negative-trip breaker hookup.) See figure 3 for a dc-trip/ac-close trigger hookup.

WARNING
Always connect a ground cable between the CT-6000 panel ground stud and the station's ground. Failure to heed this warning can result in lethal shock to operating personnel and in static-discharge damage to the Timer.

WARNING
Ensure that Timer is connected to a solid ground by always cleaning the station ground stud before making any safety-ground connection.

NOTE
Figure 2A shows a trigger hookup for a breaker having "positive-trip" wiring (i.e., applying station power supply's positive voltage to trip or close breakers). For "negative-trip" wiring, the trigger hookup is similar, except that negative station voltage is used to trip or close breakers (i.e., trigger common is connected to the station's power-supply positive voltage).

NOTE
For breakers that use dc voltage to operate the open coil and ac to operate the close coil, contact VIC for special trigger leads. This trigger set consists of four leads: 2 leads are for close-trigger and 2 are for open-trigger voltage input. These trigger leads connect across the breaker's open and close operate coils (see figure 3).

e. If Open and Close-coils are to be monitored, connect Voltage inputs (V1, V2) across open/close coils. (Note: Voltage inputs monitor voltages in a range of 30 to 300 volts dc or peak ac.)

f. Connect Power cord (with third-wire safety ground) to Timer power input.

g. Remove grounded static drains from one side of breaker contacts (otherwise, commonly grounded drains will cause test contacts to be short circuited).

h. Energize breaker operating-coil power supply and proceed with operations as described in procedure starting with paragraph 9.0.

Positive Trip Circuit.

Negative Trip Circuit.

Transducer
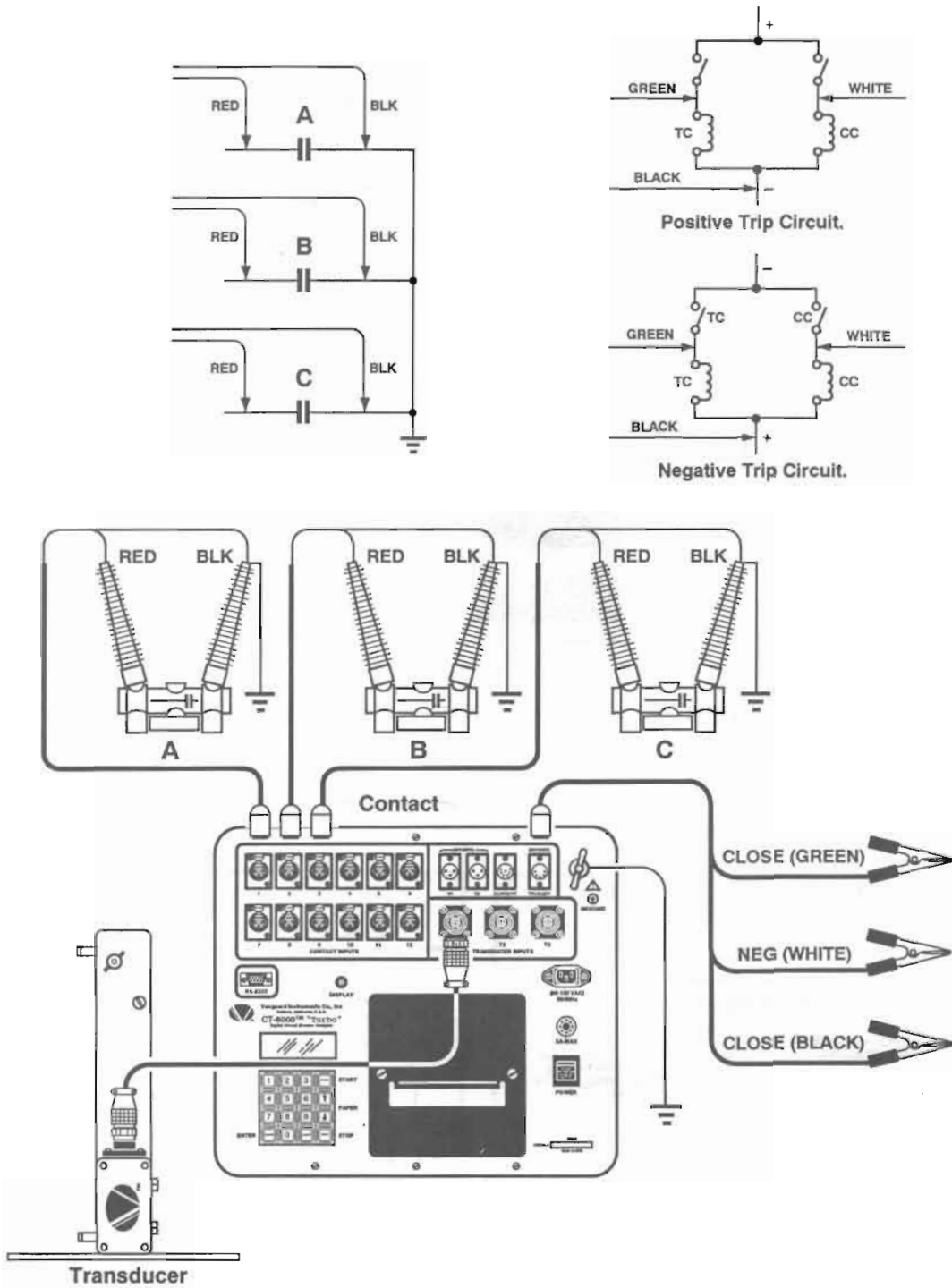
Figure 2A. Typical Timer Hookup
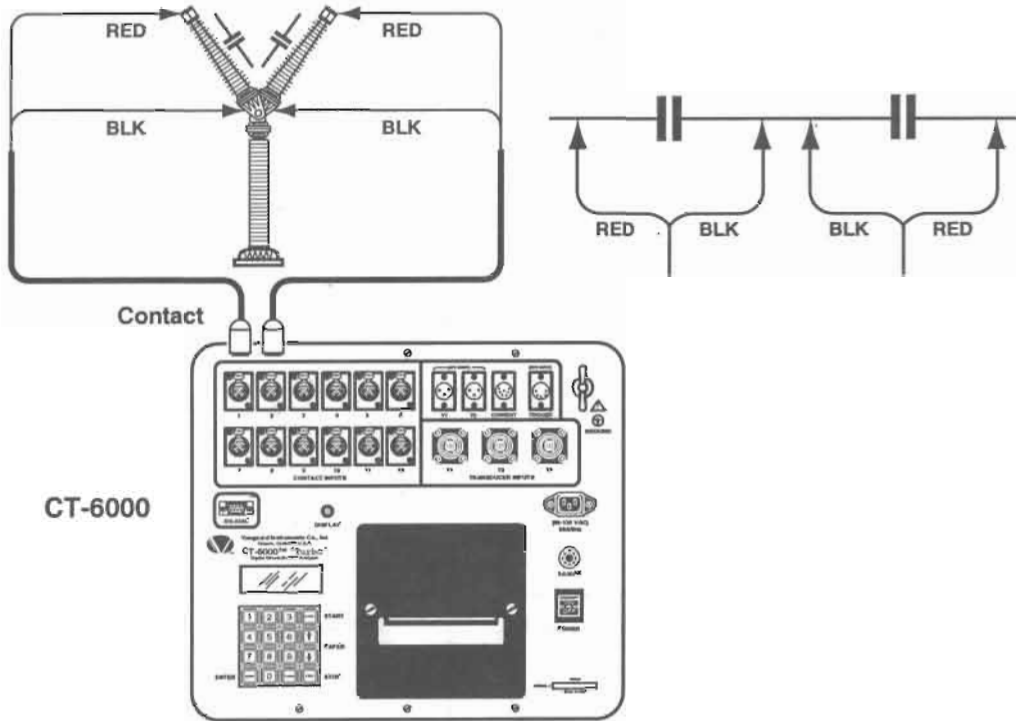
Figure 2B. Typical Series-Contact Hookup
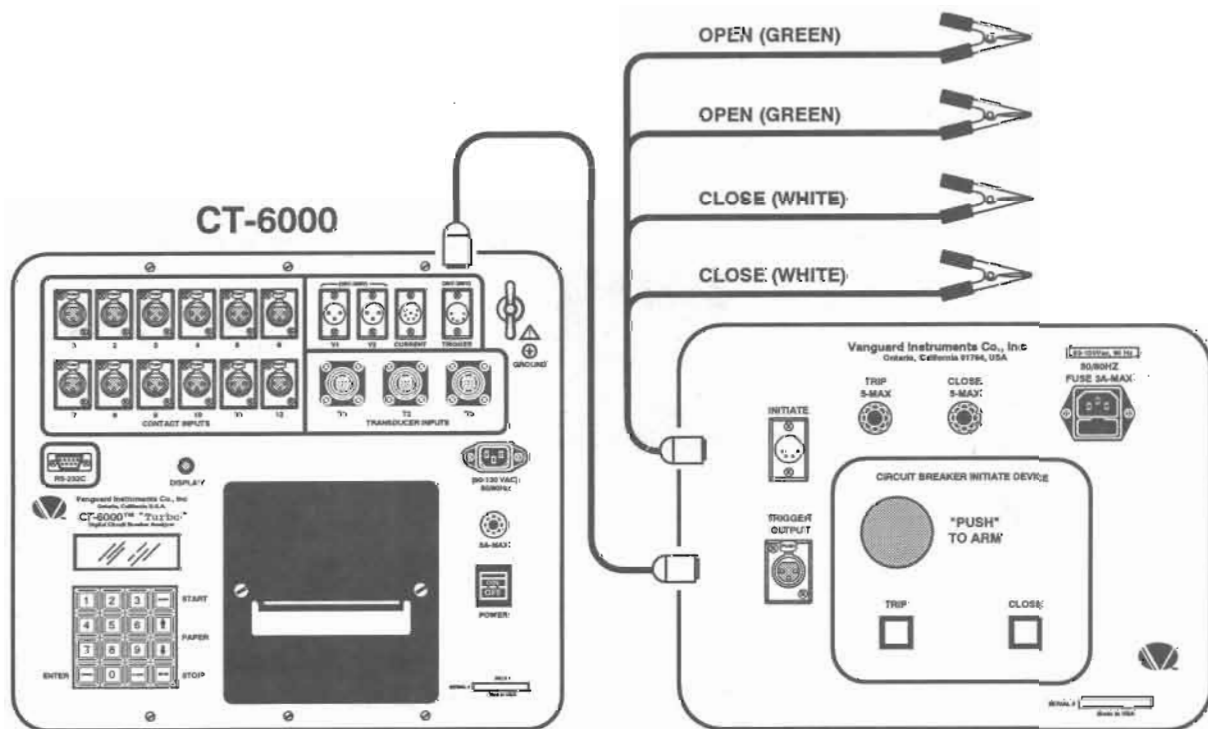
Figure 2C. Typical Timer and Initiate-Device Hookup
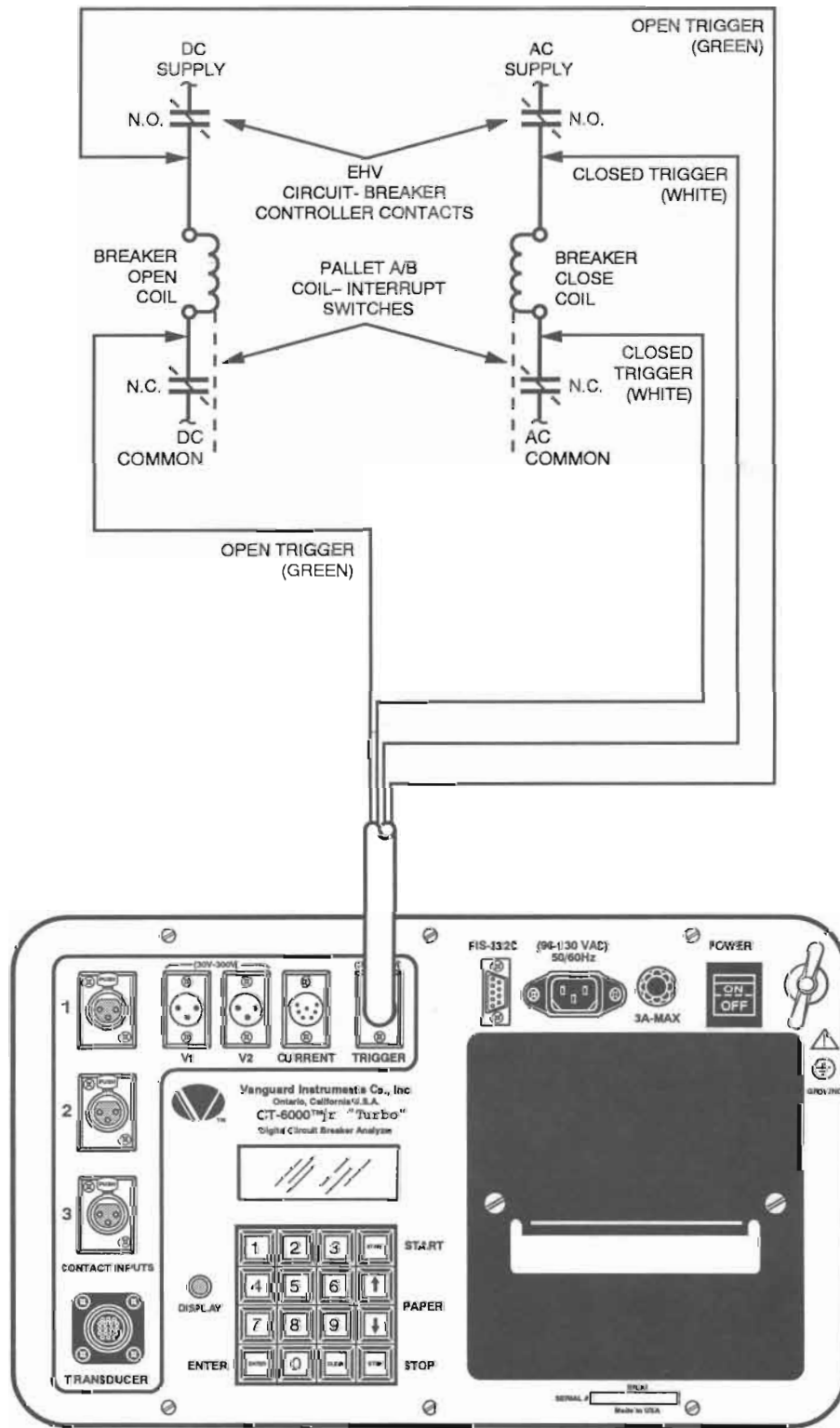
Figure 3. Timer Hookup with DC-Trip and AC-Close Circuits

9.0 OPERATING PROCEDURES

Two operating modes are available with the CT-6000 circuit-breaker Timers:

   a. Stand-Alone mode,

   b. Computer-Controlled mode.

The remainder of this manual is dedicated to operating the CT-6000 Timer in the stand-alone mode. (Note: Instructions for computer-controlled mode are described in a separate CT-6000 IBM-software Operating Instruction manual.

Figure 4 is an operator's reference "road map" that shows all the menu paths used for operating the CT-6000 Timer. The main steps required for timing a circuit breaker are listed in the diagram in the next column:

```
┌─────────────────────────────────┐
│          HOOKUP UNIT            │
│ 1. GROUND UNIT                  │
│ 2. HOOK UP CABLES TO BREAKER    │
│ 3. INSTALL TRANSDUCER           │
└─────────────────────────────────┘
                 │
┌─────────────────────────────────┐
│          APPLY POWER            │
│ 1. TURN TIMER POWER ON          │
│ 2. PERFORM SELF TEST (CABLE,    │
│    TRANSDUCER)                  │
└─────────────────────────────────┘
                 │
┌─────────────────────────────────┐
│          TIME BREAKER           │
│ 1. SELECT TIMER TEST            │
│ 2. OPERATE BREAKER              │
└─────────────────────────────────┘
                 │
┌─────────────────────────────────┐
│          GET RESULTS            │
│ 1. GET TABULATED RESULTS        │
│ 2. GET GRAPHIC RESULTS          │
└─────────────────────────────────┘
                 │
          TEST COMPLETED
```
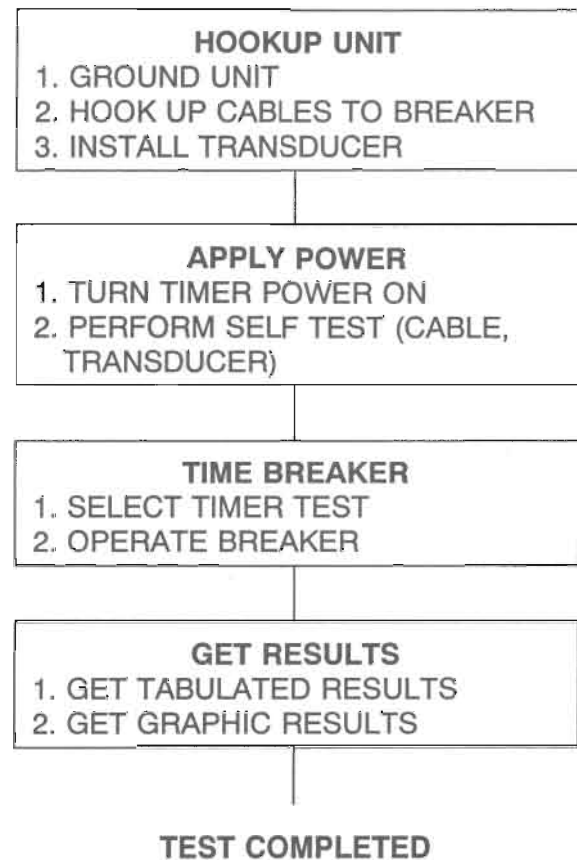
9.1 Timing a Breaker

The Model CT-6000 will time circuit breakers in the following operations:

1. OPEN
2. CLOSE
3. OPEN-CLOSE
4. CLOSE-OPEN

The procedures for timing breakers in OPEN and CLOSE operations are described in paragraphs 9.1.1 and 9.1.2.

INSERTION RESISTOR?
1. NO
2. YES

TIMING WINDOW: ?
1. WINDOW = 1 SEC
2. WINDOW = 10 SEC

1. OPEN (START OPEN TIMING)
2. CLOSE (START CLOSE TIMING)
3. OPEN-CLOSE (START OPEN-CLOSE TIMING)
4. CLOSE-OPEN (START CLOSE-OPEN TIMING)

OPEN TIMING

"START" TO CONTINUE
OR
"STOP" TO ABORT

WAIT FOR OPEN VLTG

OPEN BRKR NOW!
"STOP" TO ABORT

→ MAIN MENU

1. TABULATED RESULTS (PRINTS BREAKER TIMING RESULTS)
2. PLOT FULL CHART (PRINTS GRAPH)
3. PLOT EXPANSION (PRINTS EXPANDED PLOT "FROM" "TO")
4. PLOT 0-200 MS (PRINTS EXPANDED PLOT FROM 0 TO 200 MS)

→ MAIN MENU

ANALYSES POINT #1
1. PERCENTAGE OF STRK
2. DISTANCE OF TRAVEL
3. CONTACT POINT

ANALYSES POINT #2
1. PERCENTAGE OF STRK
2. DISTANCE OF TRAVEL

SELECT OPERATION
1. OPEN TIMING
2. CLOSE TIMING

OPEN THRESHOLD
(RANGE 20-240)
XXX
ENTER TO CNFRM

NO. OF SAMPLES
(RANGE: 01-10)
XX
ENTER TO CNFRM

VOLTAGE THRESHOLD
(RANGE 05-240)
XXX
ENTER TO CNFRM

1. READ TAG (N/A)
2. SAVE SHOT RSLT (N/A)
3. PRINT LAST RSLT (N/A)
4. PRINT TAG CONTENTS (N/A)

→ MAIN MENU

1. ANALYSIS POINTS
2. SET THRESHOLD
3. BREAKER TAG
4. NEXT PAGE

1. COMPUTER INF
2. SLOW-CLOSE TEST
3. MEMORY CARD (N/A)

→ MAIN MENU

1. SET CLOCK
2. PRINT DATA
3. TEST TRANSDUCER
4. CHECK HOOK-UP

MAIN MENU
1. TIME BREAK
2. GET RSLT
3. SET-UP
4. DIAGNOSTIC

Figure 4. Timing Menu Steering Logic

9.1.1 Timing an OPEN Operation:
(Refer to table 3.)

Table 3. Open Operation With NO Insertion Resistor

STEP	OPERATION	ACTION	DISPLAY
1	READY TIMER FOR BREAKER OPERATION	PRESS #1 KEY	INSERTION RESISTOR? 1.NO 2.YES
2	SELECT NO INSERTION RESISTOR	PRESS #1 KEY	TIMING WINDOW 1.WINDOW= 1 SECOND 2.WINDOW= 10 SECONDS
3	SELECT 1-SECOND WINDOW	PRESS #1 KEY	1.OPEN 2.CLOSE 3.OPEN-CLOSE 4.CLOSE-OPEN
4	SELECT OPEN OPERATION	PRESS #1 KEY	OPEN TIMING "START" TO CONTINUE OR "STOP" TO ABORT
5	ARM TIMER FOR OPEN OPERATION	PRESS "START" KEY	WAIT FOR OPEN VOLTAGE OPEN BRKR NOW! "STOP" TO ABORT
6	OPEN BREAKER!	OPEN BREAKER WITH INITIATE BOX OR CONTROL SWITCH	PLEASE WAIT CALCULATION IN PROGRESS
7	ANALYZER IS READY TO OUTPUT RESULT OF PREVIOUS OPEN OPERATION	NONE	1.TIME BRKR 2.GET RSLT 3.SETUP 4.DIAGNOSTIC

9.1.2 Timing a Close Operation
(Refer to table 4.)

Table 4. Close Operation With Insertion Resistor

STEP	OPERATION	ACTION	DISPLAY
1	READY TIMER FOR BREAKER OPERATION	PRESS #1 KEY	INSERTION RESISTOR? 1.NO 2.YES
2	SPECIFY INSERTION RESISTOR	PRESS #2 KEY	TIMING WINDOW 1.WINDOW= 1 SECOND 2.WINDOW= 10 SECONDS
3	SELECT 1-SECOND WINDOW	PRESS #1 KEY	1.OPEN 2.CLOSE 3.OPEN-CLOSE 4.CLOSE-OPEN
4	SELECT CLOSE OPERATION	PRESS #2 KEY	CLOSE TIMING "START" TO CONTINUE OR "STOP" TO ABORT
5	ARM TIMER FOR CLOSE OPERATION	PRESS "START" KEY	WAIT FOR CLOSE VOLTAGE CLOSE BRKR NOW! "STOP" TO ABORT
6	CLOSE BREAKER!	CLOSE BREAKER WITH INITIATE BOX OR CONTROL SWITCH	PLEASE WAIT CALCULATION IN PROGRESS
7	ANALYZER IS READY TO OUTPUT RESULT OF PREVIOUS CLOSE OPERATION	NONE	1.TIME BRKR 2.GET RSLT 3.SETUP 4.DIAGNOSTIC

9.2 GET TIMING RESULTS

Two types of timing results are available to the user: Tabulated Results and Graphic Results.

9.2.1 Get Tabulated Results

(See figure 5A; refer table 5, below.)

Table 5. Get Tabulated Result

STEP	OPERATION	ACTION	DISPLAY
1	GET TIMING RESULTS	PRESS #2 KEY	1.TABULATED RSLT 2.PLOT FULL CHART 3.PLOT EXPANSION 4.PLOT 0–200MS
2	PRINT TABULATED RESULTS	PRESS #1 KEY	1.TABULATED RSLT 2.PLOT FULL CHART 3.PLOT EXPANSION 4.PLOT 0–200MS

9.2.2 Timing Results of a Close-Open

(See figure 5B.)

9.2.2.1   The Contact and Resistor Times are defined in figures 5C and 5D.

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┌─────────────────────────────────────────────────────────────┐
│                                                               │
│      BREAKER TIMING RESULTS                                   │
│                                                               │
├───────────────────────────────────────────────────────────────┤
│  DATE:05/26/97        TIME:08:15:31                           │
├───────────────────────────────────────────────────────────────┤
│  COMPANY:                                                     │
│  STATION:                                                     │
│  CIRCUIT:                                                     │
│  MFR:                                                         │
│  MODEL:                                                       │
│  S/N:                                                         │
│  OPERATOR:                                                    │
├───────────────────────────────────────────────────────────────┤
│  TEST: OPEN                                                   │
├───────────────────────────────────────────────────────────────┤
│  CONTACT TIME                                                 │
│  CHA     MS       CYCLE     P/F    WIPE                       │
│   1    031.375    01.89            00.48   IN                 │
│   2    035.625    02.14            00.79   IN                 │
│   3    034.875    02.10            00.73   IN                 │
├───────────────────────────────────────────────────────────────┤
│  CONTACT SPREAD <mS>                                         │
│  dT1&2            dT1&3            dT2&3                       │
│  04.250           03.500          00.750                      │
├───────────────────────────────────────────────────────────────┤
│  TRAVEL ANALYSIS                                             │
│  STROKE:         06.99   IN                                   │
│  SPEED:          08.70   F/S                                  │
│  OVR-TRVL:       0.05    IN                                   │
│  BOUNCE BACK:    0.01    IN                                   │
│                                                               │
│  SPEED ANALYSIS:                                             │
│  POINT1=10%                                                   │
│  POINT2=50%                                                   │
└───────────────────────────────────────────────────────────────┘
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VANGUARD INSTRUMENT CO.INC. <39>. HPN <C> 1991. 1992. 1993.1994. 1995
ONTARIO. CA. USA TEL: 909-933-0034 FAX: 909-933-0046
OPERATION: 0012
SERIAL NUMBER: 6288
CLOSED THRESHOLD=020 OPENED THRESHOLD=235 SAMPLE=003 VOLTAGE=020

NOTES:

1. Contact control channel No.1 takes 31.375 mS (milliseconds) from the open coil energizing until contact opens. This time is also converted into cycles (60 Hz) as 1.89 cycles.

2. Breaker stroke is measured by the travel transducer as 6.99 inches.

3. Average velocity calculation is based on analysis point 1 (at 10% of stroke) and point 2 (at 50 % of stroke), which is 8.70 F/S (feet per second).

(See also the footnotes of figure 5B, following pages.)

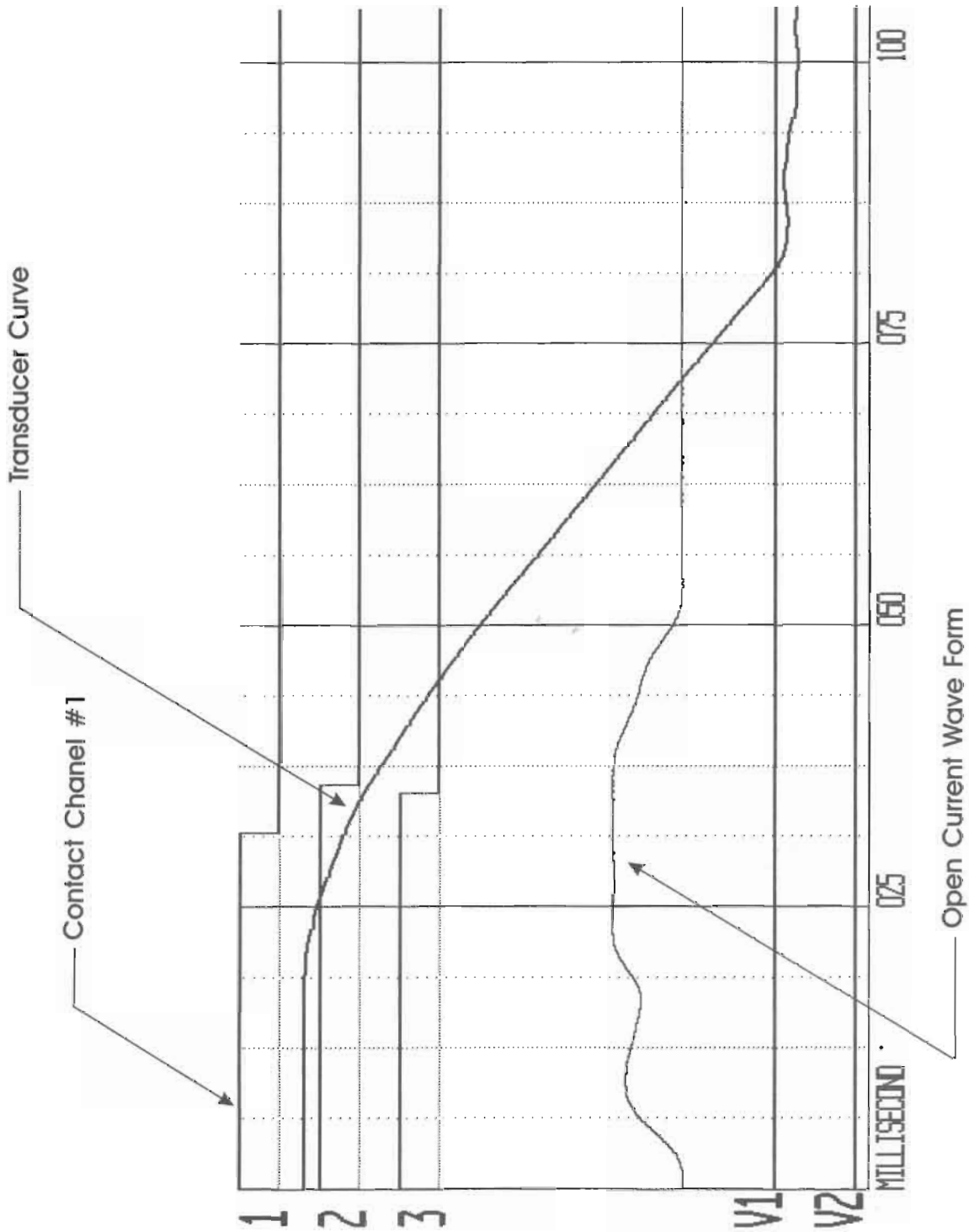**Figure 5A. Example of a Typical Tabulated Result Printout (sheet 1 of 6)**

Figure 5B. Graphic Results of Trip Operation—from figure 5A (sheet 2 of 6)

```
┌─────────────────────────────────────────────────┐
│  BREAKER TIMING RESULTS                          │
├─────────────────────────────────────────────────┤
│  DATE:05/26/97       TIME:08:45:00               │
├─────────────────────────────────────────────────┤
│  COMPANY:                                         │
│  STATION:                                         │
│  CIRCUIT:                                         │
│  MFR:                                             │
│  MODEL:                                           │
│  S/N:                                             │
│  OPERATOR:                                        │
├─────────────────────────────────────────────────┤
│  TEST: CLOSE-OPEN                                 │
├─────────────────────────────────────────────────┤
│  CONTACT LIVE TIME <MS>                           │
│    1   024.00                                     │
│    2   028.37                                     │
│    3   028.87                                     │
├─────────────────────────────────────────────────┤
│  CONTACT TIME                                     │
│  CHA  CLOSE<MS>      CLOSE<CY>                    │
│    1   175.250        10.55                       │
│    2   173.500        10.45                       │
│    3   173.500        10.45                       │
├─────────────────────────────────────────────────┤
│  CONTACT TIME                                     │
│  CHA   OPEN<MS>       OPEN<CY>                    │
│    1   199.250        12.00                       │
│    2   201.875        12.16                       │
│    3   202.375        12.19                       │
└─────────────────────────────────────────────────┘
```
VANGUARD INSTRUMENT CO.INC. (39). HPN (C) 1991. 1992. 1993.1994. 1995
ONTARIO. CA. USA TEL: 909-933-0034 FAX: 909-933-0046
OPERATION: 0016
SERIAL NUMBER: 6288
CLOSED THRESHOLD=020 OPENED THRESHOLD=235 SAMPLE=003 VOLTAGE=020

NOTES:

1. Contact-close time: Time from close coil energizing to point when contacts touch. Contact-close time for channel #1 is 175.250 ms (milliseconds).

2. Contact-open time: Time from close coil energizing until contacts open. Contact-open time for channel #1 is 199.250 ms.

3. Contact-live time: Time measured to contacts touching. Contact live time for channel #1 is:

Contact-open time:	199.250795.625 ms
Contact-close time:	-175.250 ms
Contact live time:	24.00 ms

Figure 5C. Example of a Typical Tabulated Result Printout (sheet 3 of 6)
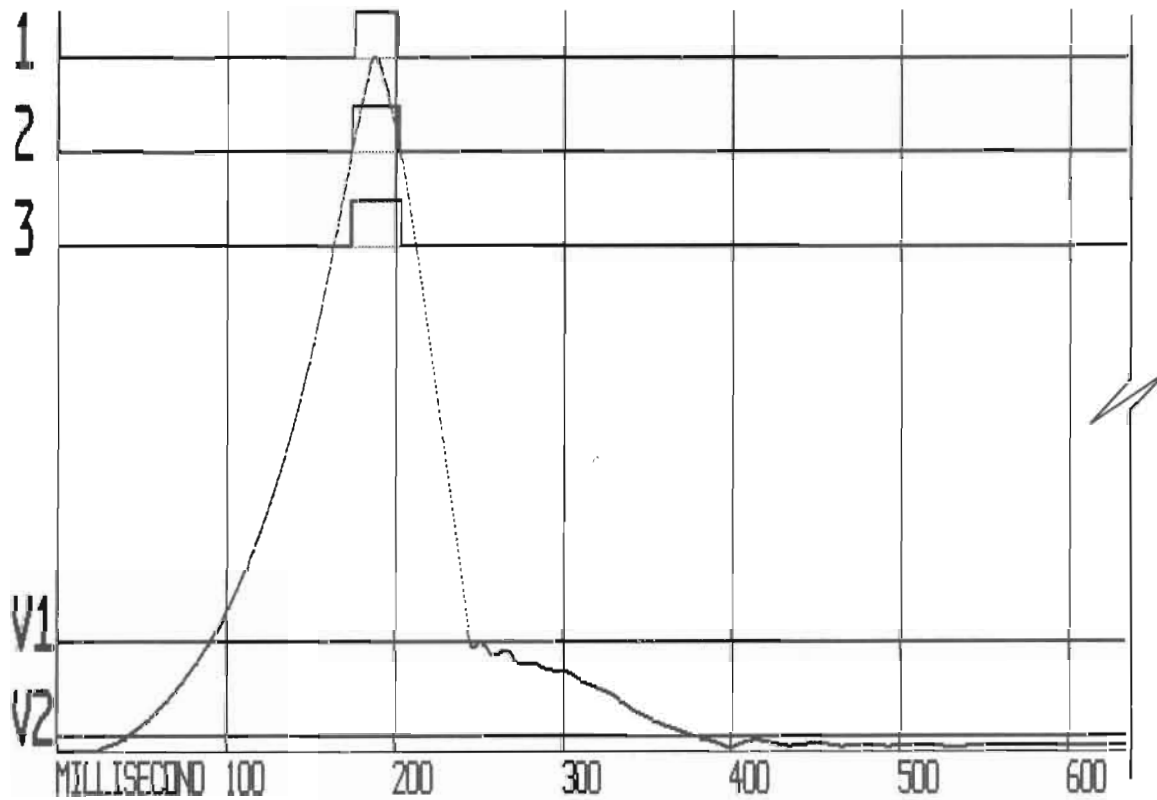
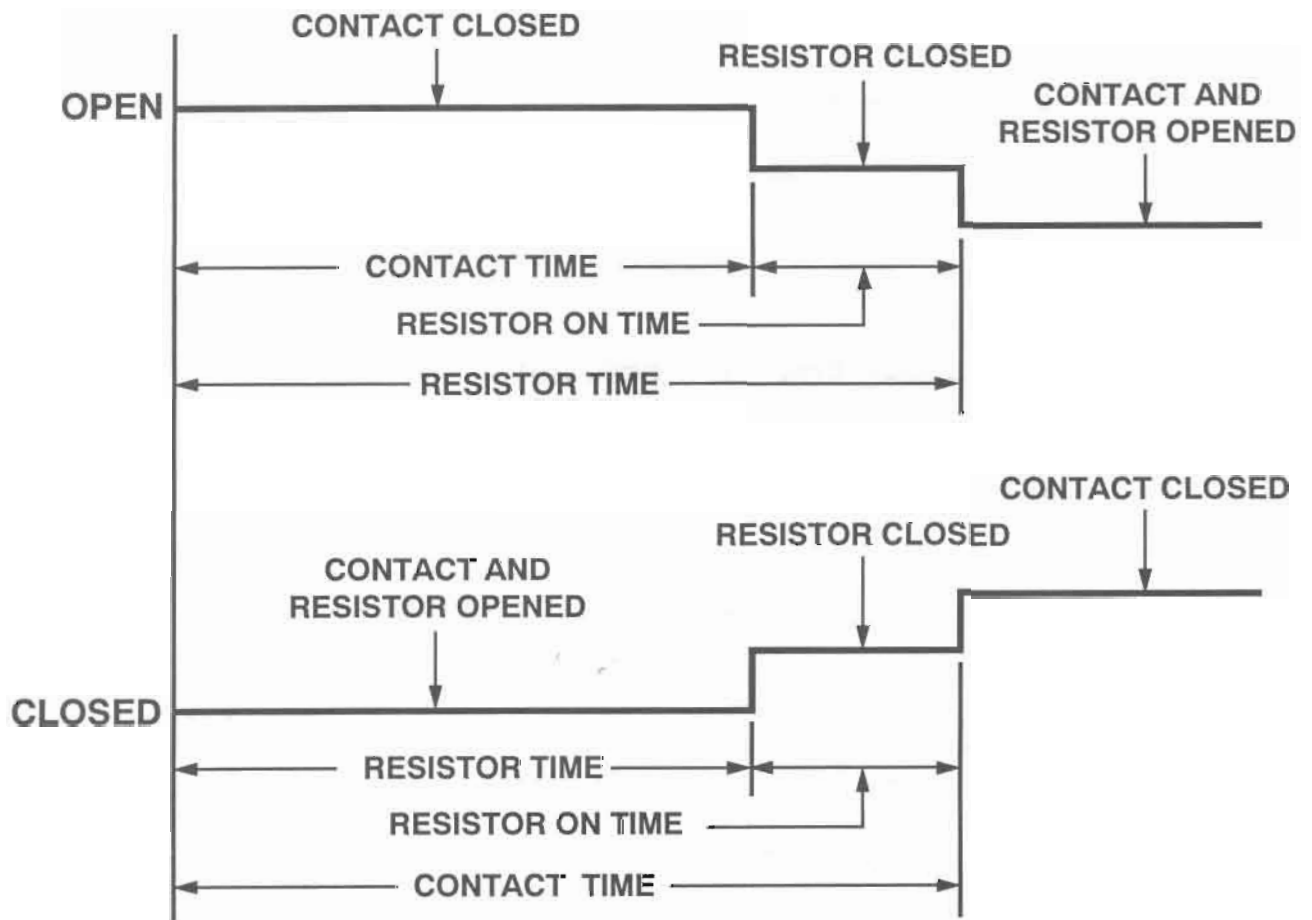**Figure 5D. Graphic Results of Close-Open Operation–from prior page (sheet 4 of 6)**

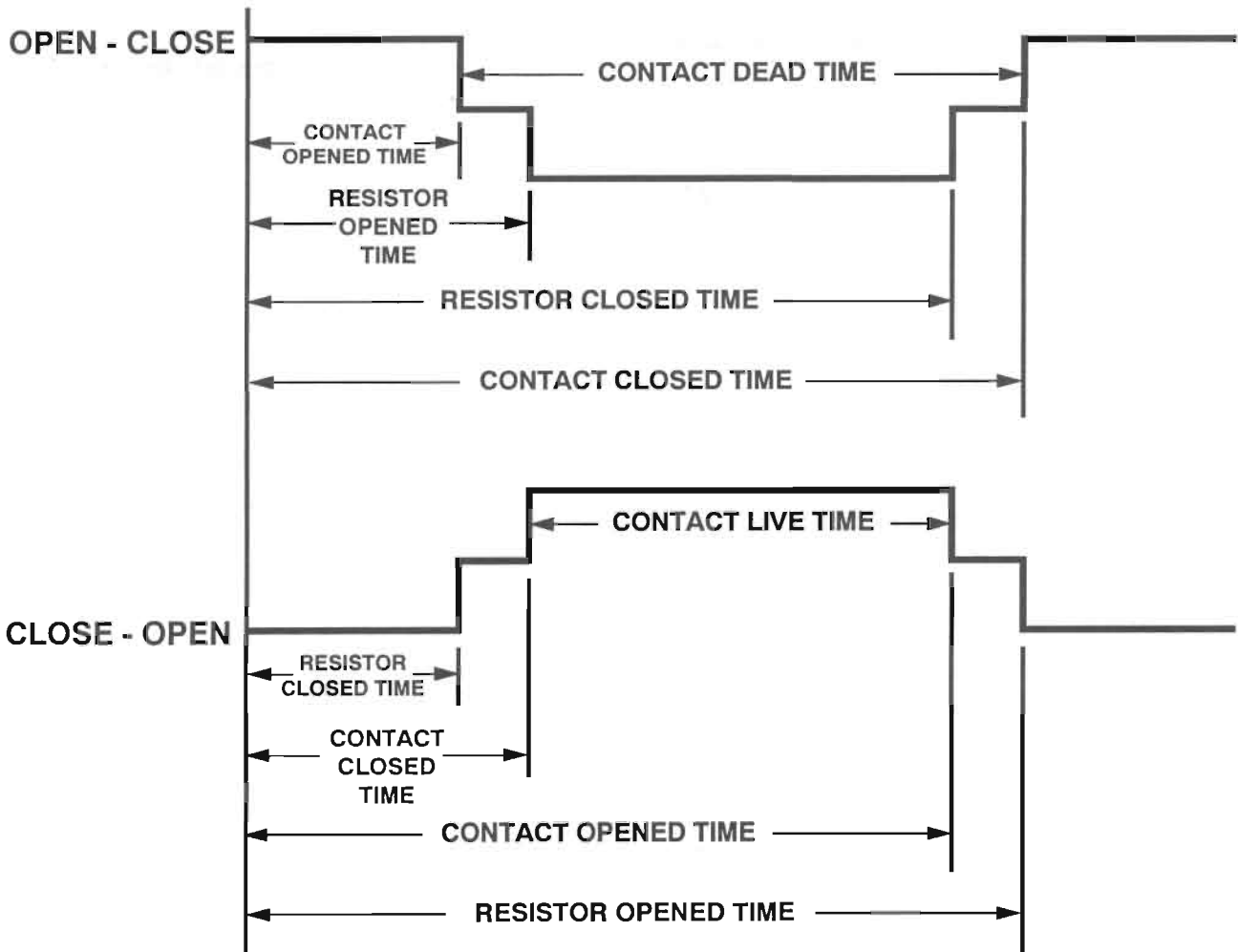Figure 5E. Typical Graphic Output of Open and Close Operations (sheet 5 of 6)

Figure 5F. Typical Graphic of Open-Close & Close-Open Operations (sheet 6 of 6)

9.2.3 Get Full Plot of Results
(See figure 6.)
The full chart plot shows a strip chart of a timing diagram of contact and travel traces from 0.0 milliseconds to 999 milliseconds.

Note: The operator can stop a strip chart printout at any time by pressing the STOP key. Pressing the PAPER key or the up-arrow (↑) key will advance the paper by several lines.

Table 6. Get Full Chart Plot of Results

STEP	OPERATION	ACTION	DISPLAY
1	GET TIMING RESULTS	PRESS #2 KEY	1.TABULATED RSLT 2.PLOT FULL CHART 3.PLOT EXPANSION 4.PLOT 0–200MS
2[2]	PLOT FULL CHART	PRESS #2 KEY	PLOT CURRENT TRACE? 1.YES 2.NO
3[1]	PLOT CURRENT TRACE	PRESS #2 KEY	CURRENT WAVEFORM? 1.NORMAL 2.INVERTED
4[1]	CURRENT TRACE POLARITY	PRESS #1 KEY (NORMAL) OR #2 KEY (INVERTED)	PLEASE WAIT PLOTTING GRAPH

NOTES:

1. If current profile monitoring option isn't available, steps 3 & 4 won't appear on menu (i.e., directly plots).

2. Pressing the STOP key always terminates the graphical output.

9.2.4 Get Plot Expansion of Results
(See figure 6; refer to table 7.)

Table 7. Get Plot Expansion of Results

STEP	OPERATION	ACTION	DISPLAY
1	SELECT GET RSLT	PRESS #2 KEY	1.TABULATED RSLT 2.PLOT FULL CHART 3.PLOT EXPANSION 4.PLOT 0–200MS
2	SELECT PLOT EXPANSION	PRESS #3 KEY	EXPANSION FROM:[1]
3	EXPAND FROM 0 MS	PRESS #4 KEY	EXPANSION FROM: OOO MS "ENTER" TO CNFRM
4	CONFIRM 000 MS	PRESS ENTER KEY	EXPANSION TO:[1]
5	EXPAND TO ZOOM	PRESS #3 KEY	EXPANSION TO:[1] 300 MS "ENTER TO CONFRM"
6	CONFIRM ZOOM	PRESS ENTER KEY	PLOT CURRENT TRACE? 1.YES 2.NO
7	SELECT CURRENT TRACE PLOT	PRESS #2 KEY (YES)	PLEASE WAIT PLOTTING GRAPH

NOTES:

1. To and from time entries, using numerical key pad, are always a single digit that represents 100-millisecond increments, thus: 0=zero millisecond (=start of movement)
   1=100 milliseconds
   2=200 milliseconds
   3=300 milliseconds

   .

   .

   .

   8=800 milliseconds
   9=900 milliseconds

2. Graphic expansion is in 100-millisecond expansion only.

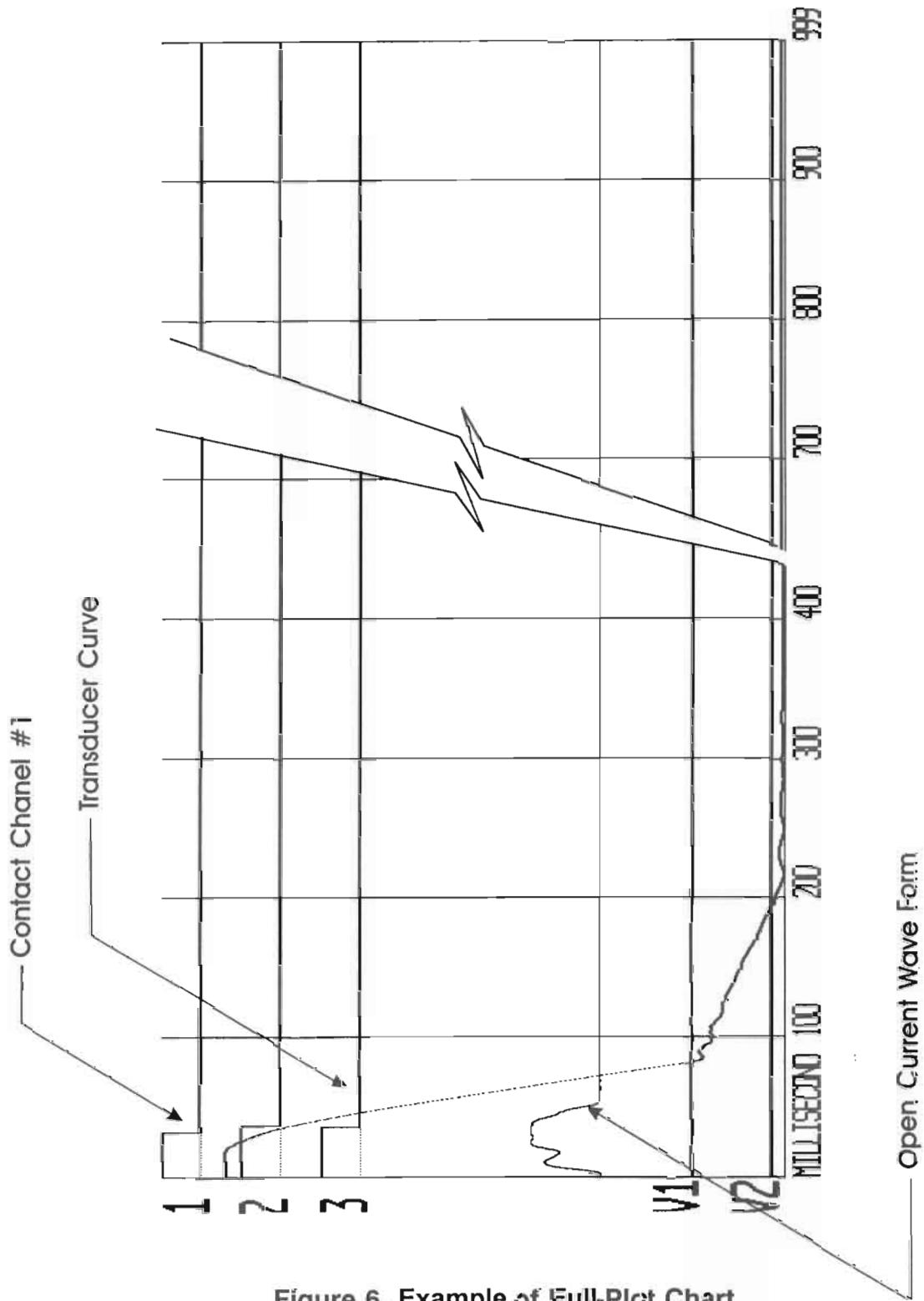3. Pressing the STOP key will always terminate the graphical output.
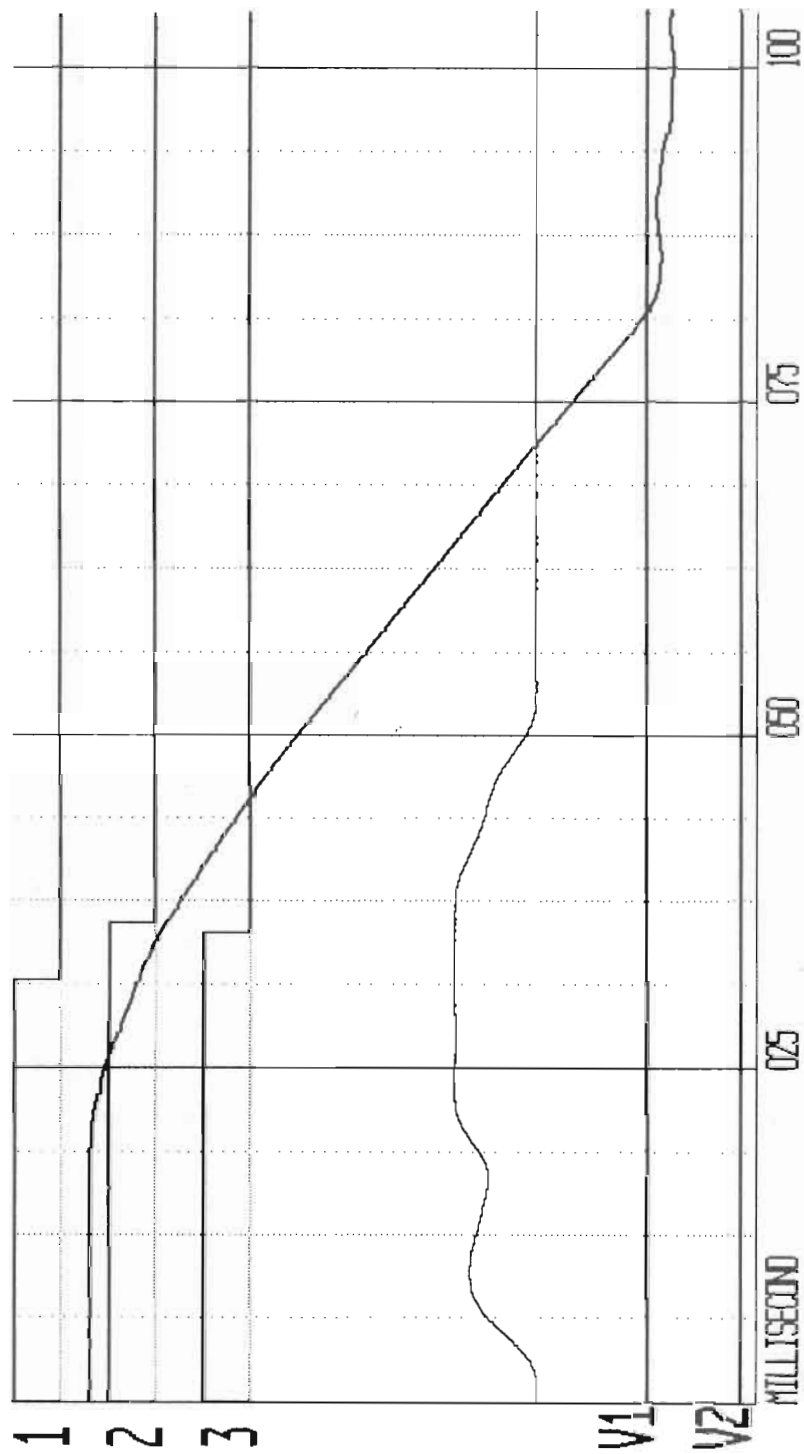
Figure 6. Example of Full-Plot Chart

Figure 7. Example of Expansion Plot

9.2.5 Get Plot Expansion of Results from 0.0 to 200 ms. To simplify the expansion selection, the menu has a preselected plot from 0.0 to 200 milliseconds.

usually found in the close operation. In this operation, over-travel is the distance a contact moves beyond its final position.

Table 8. Get Plot-Expansion Result From 0 to 200 Milliseconds

STEP	OPERATION	ACTION	DISPLAY
1	SELECT GET RESULT	PRESS # 2 KEY	1. TABULATED RESULTS 2. PLOT FULL CHART 3. PLOT EXPANSION 4. PLOT 0-200 MS
2	SELECT PLOT EXPANSION	PRESS #4 KEY	PLOT CURRENT TRACE 1. NO 2. YES
3	SELECT CURRENT PLOT	PRESS #2 KEY	CURRENT WAVE FORM? 1. NORMAL 2. INVERTED
4	SELECT WAVE FORM	PRESS #1 KEY	PLEASE WAIT PLOTTING GRAPH

9.3 Breaker Travel Analysis

The CT-6000 travel analysis includes breaker stroke, over-travel, bounce-back, and contact-wipe distances, and contact velocity calculation.

9.3.1 Breaker Stroke
The CT-6000 uses a digital transducer to measure a breaker's contact stroke, over travel, and bounce back. The digital transducer output is 200 counts per linear inch of travel; the resolution is accurate to 1/200 inch. The output resolution is ±0.01 inch on the test result report.

Unlike slide-wire transducers, the CT-6000 transducer needs no calibration or setup. A user verifies transducer function by selecting diagnostic test of the transducer (para. 7.10).

9.3.2 Breaker Over-travel Distance
Over-travel is a distance the contact moves beyond the resting position. Over-travel is

9.3.3 Breaker Bounce-Back Distance. Bounce back is the distance the breaker's contact moves before the resting position after over travel. Again, bounce back is typically found in the close operation.

9.3.4 Contact Wipe. Contact wipe is the distance measured from the close position to the contacts touching (or parting). In the close operation, contact wipe is measured from the contacts touching position to the final closed position.

In the open operation, contact wipe is measured from the close position to contact break (or parting) position.

NOTE
Contact wipe is measured during operation. This measurement may not be as accurate as measurement done using the slow close mode. It is recommended the user use the slow close test (paragraph 9.6) to verify wipe measurement if required.

9.3.5 Breaker Velocity

The CT-6000, when used with a travel transducer, calculates the breaker contact velocity through the arc zone. Users must program the calculation points (analysis points) on the travel curve for the unit to calculate contact velocity. Analysis points selection and setup are discussed in the following paragraphs:

9.3.6 Analysis Point Selections.

Analysis points are used to calculate average contact speed through the contact's arc zone. The analysis points are usually specified by the breaker manufacturers. The analysis points are fully programmable in the Timer by the user. The Timer will store up to two setups for calculating velocity (one each for open and close). These setups are stored in the Timer's internal memory for up to five years (using battery power when the ac is off).

9.3.7 Analysis Point No.1.

Three selections are available to the user for setting analysis point No. 1:

1. PERCENTAGE OF STRK
2. DISTANCE OF TRAVEL
3. CONTACT POINT #1

a. Percentage of Stroke:
Percentage of stroke is distance based upon percentage of total breaker stroke distance. *This distance is always measured from the starting point at the fully closed position of the breaker contacts.*

b. Distance of Stroke:
Distance of travel range is selectable from 00.0 inch to 99.99 inches. *Again, this distance is referenced from the contact's closed position.* The user must enter *four digits* to define the distance from the fully closed position of the breaker. As an example, when an analysis point of 1.25

inches is the entry, the operator must enter "0125" with the key pad.

c. Contact Point:
Contact point is the distance from the contact's closed position to the point where they (channel 1) are in transition from close-to-open (or open-to-close position).

9.3.8 Analysis Point No. 2.

Only two selections for analysis point 2 are available to the user:

1. PERCENTAGE OF STRK
2. DISTANCE OF TRAVEL

The selection of analysis point No. 2 is the same as for analysis point No. 1.

> REMINDER
> Average velocity through the arc zone is calculated by using the following formula:
> $$V_{ave} = \text{Distance} \div \text{Time}$$
>
> Since this function is linear, analysis points 1 and 2 can be transposed.

As an example:
Velocity calculation for a breaker operation based upon 00.50 inch (point No. 1) to 03.00 inch (point No. 2) is the same as 03.00 (point No. 1) to 00.50 (point No.2).

> NOTE
> The current breaker contact velocity will be recalculated based on data stored in memory (RAM) after any new analysis point(s) is selected. The user does NOT need to operate the breaker again to acquire new contact velocity data after changing the analysis points (a new velocity is calculated from travel data stored in memory from the last operation).

Table 9. Set-Up Analysis Points

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET-UP	PRESS #3 KEY	1. ANALYSIS POINTS 2. SET THRESHOLD 3. BREAKER TAG 4. NEXT PAGE
2	SELECT ANALYSIS POINTS	PRESS #1 KEY	SELECT OPERATION 1. OPEN TIMING 2. CLOSE TIMING
3	SELECT OPEN OR CLOSE STROKE	OPEN: PRESS #1 KEY CLOSE: PRESS #2 KEY	ANALYSIS POINT #1 1. PERCENT OF STRK 2. DISTANCE OF TRAVEL 3. CONTACT POINT
4	SELECT AP #1 (START OF AVG VELOCITY CALC)	% TRAVEL: PRESS #1 KEY DISTANCE: PRESS #2 KEY CNTCT PT: PRESS #3 KEY	*(DISPLAYS CURRENT PARAMETERS)*
5	ENTER AP PARAMETERS	USE KEY PAD TO SELECT PARAMETERS	ANALYSIS POINT #2 1. PERCENTAGE OF STRK 2. DISTANCE OF TRAVEL
6	SELECT AP #2 (END OF AVG VELOCITY CALC)	% TRAVEL: PRESS #1 KEY DISTANCE: PRESS #2 KEY	*(DISPLAYS CURRENT PARAMETERS)*
7	ENTER AP PARAMETERS	USE KEY PAD TO SELECT PARAMETERS	*(RETURNS TO HOME MENU)*

NOTES:

1. The operator is required to enter both the analysis point parameters when entering this menu.

2. Pressing the clear (CLR) key permits the operator to re-enter new parameters if an error is made in the key-pad entries.

3. Percentage of stroke requires a two-digit input. Percentage ranges from 01 to 99.

4. Distance in inches requires a four-digit input from the operator. For example, a distance of 1 inch is entered as 01.00. The decimal point is automatically inserted by the Timer.

9.4 Set Open Threshold & Data Sample
(Refer to table 10.)

The CT-6000 uses a 20-volt dc isolated power supply to measure a breaker's contact condition (open or close). The CT-6000 takes 8000 readings of the breaker contact during an operation, using either a 1-second window or 10-second window.

There are 2 settings involved in the breaker contact-time calculation: Open threshold and number of samples.

9.4.1 Open Threshold.
The Open Threshold allows the CT-6000 to determine when the breaker contacts are opened or closed. An ideal open-contact reading from the Analog-to-Digital Converter provides a decimal reading of 255. A noisy (static noise) open-contact reading may produce a reading of 245 or less. If the operator sets the open threshold at 220, the timer will recognize any reading above 220 as an open circuit.

NOTE

The Timer always defaults the open threshold setting to 235 when the unit is first turned on. Up and Down arrow keys allow the user to change "Opened threshold" setting. Pressing the "Enter" key advances to next setting.

9.4.2 Number of Samples.
Another setting that affects the contact timing results is the "Number of Sample."

The user selects number of samples to filter out the contact bounce during a contact time calculation. A setting of 3 require the timer software to look for 3 consecutive readings of the contact data to be the same (after a contact status change) before deciding it is a contact transition.

An Example: The Timer software is looking for a contact open time and detecting a contact #1 transition from close to open at 31.375ms (see figure 5A). For this reading to be valid, the next 3 consecutive readings have to be the same (an open condition) before this reading can be use.

If there is a noise spike (where the reading looks like an opened condition) from 0 to 31.375 ms and the noise duration is less than 3 "readings long," the software will ignore the transition.

A setting of 5 will not change the above open time, but the software will look for 5 consecutive readings (open readings) before using the 31.375 ms value. Since there is no contact bounce after 31.375 ms, there is no change in the value.

NOTE

A setting of 1 or 2 allows the user to catch the first contact bounce and use it as the value. A setting of 5 or more will use the second or third contact bounce as the value. The timer will default the setting to 3 when unit is first turned on. Up and Down arrow keys allows the user to change this setting. Pressing the "Enter" key advances to next menu.

9.4.3 Voltage Threshold.
Voltage threshold allows users to change the voltage detection condition on voltage channels 1 and 2. The CT-6000 defaults to a setting of 020 or a minimum input of 40 Vdc is considered an "ON" condition on the V1 & V2 graphic output.

Very seldom is the user required to change this setting. The setting could be lowered to detect a lower dc voltage or raised to eliminate some voltage spike.

Up and Down arrow keys allows the user to change this setting. Pressing the "Enter" key advances to next menu.

Table 10. Set-Up Set Threshold

ITEM	OPERATION	ACTION	DISPLAY
1	SELECT SET-UP	PRESS #3 KEY	1. ANALYSIS POINTS 2. SET THRESHOLD 3. BREAKER TAG 4. NEXT PAGE
2	SELECT SET THRESHOLD	PRESS #2 KEY	OPEN THRESHOLD (RANGE: 25–240) XXX ENTER TO CNFRM
3	SELECT OPEN THRESHOLD LEVEL	PRESS ↑ & ↓ KEYS TO VARY LEVEL, THEN PRESS ENTER TO SET (goes to next screen)	NO. OF SAMPLES (RANGE: 01–10) XX2 ENTER TO CNFRM
3	SELECT NUMBER OF DATA SAMPLES	PRESS ↑ & ↓ KEYS TO VARY LEVEL, THEN PRESS ENTER TO SET (goes to next screen)	VOLTAGE THRESHOLD (RANGE: 05–240) XXX ENTER TO CNFRM
4	SELECT VOLTAGE THRESHOLD	PRESS ↑ & ↓ KEYS TO VARY LEVEL, THEN PRESS ENTER TO SET (goes to next screen)	PLEASE WAIT CALCULATION IN PROGRESS

NOTES:

1. Default threshold values always display, but threshold values can be changed by using up/down arrow keys to increase (↑) & decrease (↓) levels. When wanted level displays, press ENTER to confirm (load value).

2. Default setting will work under most timing conditions. It's recommended the user only change these setting under extreme static conditions when a default setting cannot provide the desired results.

9.5 PUTTING The CT-6000 UNDER COMPUTER CONTROL

Table 11. Computer Control

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET-UP	PRESS #3 KEY	1. ANALYSIS POINTS 2. SET THRESHOLD 3. BREAKER TAG 4. NEXT PAGE
2	SELECT NEXT PAGE	PRESS #4 KEY	1. COMPUTER ITF 2. SLOW CLOSE TEST 3. MEMORY CARD
3	SELECT COMPUTER INTERFACE	PRESS #1 KEY	COMPUTER CONTROL[1] "STOP" TO ABORT

NOTES:

1. An interconnect cable must be run between Timer's RS-232C port and a compatible computer (an IBM-pc).

2. Refer to the Breaker timing software manual for the software to run on the IBM-compatible computer.

3. The CT-6000's RS-232 connector pinout are listed at the right:

4. The operator is required to put the CT-6000 under computer control before executing the IBM program.

PIN No.	SIGNAL. NAME
2	Tx
3	Rx
5	GRND

9.6 SLOW-CLOSE TEST

The Slow-Close (Contact Travel) test allows operators to check the breaker contact travel difference between the three phases. The travel distance of each phase is measured from the fully opened position of the breaker contact until the contact closes (i.e., contacts are touching). The contact wipe of each phase is also provided on the printout. The contact wipe is the distance (in inches) from the contact's point of first touching to the final closed position of the breaker. A typical contact travel test result is shown in figure 8.

```
+----------------------------------------------+
|         BREAKER  TIMING  RESULTS             |
+----------------------------------------------+
| DATE: 05/04/92              TIME: 10:06:10   |
+----------------------------------------------+
| COMPANY:                                     |
| STATION:                                     |
| CIRCUIT:                                     |
| MFR:                                         |
| MODEL:                                       |
| S/N:                                         |
| OPERATOR:                                    |
+----------------------------------------------+
| CONTACT: TOUCH                               |
|  1= 07.73IN                                  |
|  2= 07.79IN                                  |
|  3= 07.87IN                                  |
+----------------------------------------------+
| CONTACT WIPE:                                |
|  1= 00.58IN                                  |
|  2= 00.53IN                                  |
|  3= 00.44IN                                  |
+----------------------------------------------+
```

NOTE:
This test is performed by using only contact channels 1, 2, and 3.

Figure 8. Example Contact-Test Printout

Table 12. Slow-Close Test

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP	PRESS #3 KEY	1. ANALYSIS POINTS 2. SET THRESHOLD 3. BREAKER TAG 4. NEXT PAGE
2	SELECT NEXT PAGE	PRESS #4 KEY	1. COMPUTER ITF 2. SLOW CLOSE TEST 3. MEMORY CARD
3	SELECT CONTACT TRAVEL	PRESS #2 KEY	BRKR SLOW CLOSE TEST RMV CT GND (1 SIDE) "ENTER" TO CNFRM
4	VERIFY THAT ONE SIDE OF BREAKER CONTACT IS DISCONNECTED FROM GROUND	PRESS "ENTER"	CONTACT 1: OPEN CONTACT 2: OPEN CONTACT 3: OPEN "START" TO ZERO COUNTER
5	ZERO TRAVEL COUNTER	PRESS "START"	CONTACT 1: OPEN CONTACT 2: OPEN CONTACT 3: OPEN
6	MANUALLY JACK BREAKER TO CLOSE CONTACTS	MANUALLY CLOSE BREAKER	[TIMER DISPLAYS CONTACT OPEN OR CLOSE ON SCREEN AND PRINTS OUT CONTACT DISTANCE FROM FULLY OPEN TO CLOSE.]
7	PUT BREAKER IN FULLY CLOSED POSITION TO FIND CONTACT WIPE	MANUALLY JACK BREAKER TO CLOSED POSITION	LIFT BRKR TO CLS POS THEN PRESS "ENTER" TO FIND CONTACT WIPE
8	FIND CONTACT WIPE RESULT	PRESS "ENTER" KEY	(TIMER DISPLAYS CONTACT WIPE.)
9	GET HARD COPY OF CONTACT WIPE RESULT	PRESS "STOP" KEY	[DISPLAY RETURNS TO HOME MENU.]

NOTES:

1. Follow the normal timer test hook up except no trigger lead is required.

2. A Travel transducer is required for this test.

3. Only contact channels 1, 2, and 3 are setup for this test.

9.7 SET TIMER CLOCK.

Table 13. Set Timer Clock

STEP	OPERATION	ACTION	DISPLAY
1	SELECT DIAGNOSTIC	PRESS #4 KEY	1. SET CLOCK 2. PRINT DATA 3. TEST TRANSDUCER 4. CHECK HOOK-UP
2	SELECT SET CLOCK	PRESS #1 KEY	TIME: HH:MM:00[1] 09:32:00 (CURRENT TIME) DATE: DD:MM:YY 11/27/91 (CURRENT DATE)
3	ENTER HOUR AND MINUTE	USE NUMBER KEY PAD	TIME: HH:MM:00 09:32:00 HH:MM:00
4	ENTER DAY, MONTH, AND YEAR	USE NUMBER KEY PAD	DATE: DD:MM:YY 11/27/91 ____
5	DONE SETTING CLOCK	USE "ENTER" KEY	*(RETURN TO HOME MENU.)*

Note:

1. Clock seconds are not preset into the counter; when hour and minute are keyed in, followed by pressing "ENTER," clock timer always begins counter at 00 seconds, then increments at 1-second intervals.

2. The user is **required** to set all time and date inputs under this selection.

9.8 PRINT DATA

Table 14. Print Data

STEP	OPERATION	ACTION	DISPLAY
1	SELECT DIAGNOSTIC	PRESS #4 KEY	1. SET CLOCK 2. PRINT DATA 3. TEST TRANSDUCER 4. CHECK HOOK-UP
2	SELECT PRINT DATA	PRESS #2 KEY	STARTING ADDRESS?
3	SELECT STARTING ADDRESS	USE NUMBER KEY[2]	1. EVERY POINT 2. EVERY 5 POINTS
4	PRINT DATA EVERY 5 SAMPLES	PRESS #2	"STOP" TO ABORT

Note:

1. Print data command allows the operator to look at data in memory collected by the Timer. This diagnostic tool is very helpful to determine the Open thresholds for the timer.

2. Each key number represents a starting address; e.g., press "0" to select starting address 0000, press "1" key to select address 1000, key 2 to start at address 2000, etc.

9.9 TEST TRANSDUCER

Table 15. Test Transducer

STEP	OPERATION	ACTION	DISPLAY
1	SELECT DIAGNOSTIC	PRESS #4 KEY	1. SET CLOCK 2. PRINT DATA 3. TEST TRANSDUCER 4. CHECK HOOKUP
2	SELECT TEST TRANSDUCER	PRESS #3 KEY	TRANSDUCER TEST: 1=00.00 IN 2=00.00 IN 3=00.00 IN
3	FIND TRANSDUCER DISPLACEMENT	MANUALLY MOVE TRANSDUCER SLIDER	TRANSDUCER TEST 1 = XX.XX IN 2 = XX.XX IN 3 = XX.XX IN

Note:

1. The transducer test lets the operator bench test the Timer's Travel Transducer. The Timer's display shows the Transducer's linear displacements in inches.

2. Pressing the "STOP" key will terminate this test.

9.10 CHECK HOOKUP

Table 16. Check Hook-Up

STEP	OPERATION	ACTION	DISPLAY
1	SELECT DIAGNOSTIC	PRESS #4 KEY	1. SET CLOCK 2. PRINT DATA 3. TEST TRANSDUCER 4. CHECK HOOK-UP
2	SELECT CHECK HOOK-UP	PRESS #4 KEY	MAKE SURE BREAKER IS IN CLOSED POSITION, THEN PRESS "START"
3	CONFIRM TEST	PRESS START PUSHBUTTON	MAIN MENU DISPLAYS PRINTER PRINTS OUT[1] A RESULT

Note:

The Check Hook-up lets the operator verify the contact cable hook-up to the breaker (or to the test contact cables). To test the contact cable, short circuit each contact cable (i.e., connect red clips to black clips) and go through this test (described in table 20). The Timer prints out the test result after this test. A functional contact cable, when short-circuited (red and black clips mutually clipped together) will be indicated as "CLS" on the printout.

10.0 TROUBLESHOOTING

This section provides possible solutions to problems that may be encountered when using the Timer. The fault symptoms are listed as headings above tables of possible causes and remedies in this section.

NOTE

Timers will not operate breakers under test. Breakers must be operated with a VIC Breaker Initiate device or by the local over-ride switches on the breaker control box.

Table 17. Symptom: Timer did not receive trigger signal after circuit breaker operation

SYMPTOM	PROBABLE CAUSE	REMEDIAL ACTION
TIMER IS STILL IN "ARM" MODE (BEEPING SOUND CONTINUES) AFTER BREAKER HAS ALREADY OPERATED.	1. NO TRIGGER VOLTAGE IS DETECTED BY THE TIMER.	1A. CHECK TRIGGER INPUT POINT. 1B. CHECK TRIGGER CABLE and LEADS.
	2. TIMER TRIGGER INPUT IS NOT WORKING.	2. VERIFY TRIGGER INPUT CIRCUIT BY APPLYING A VOLTAGE TO THE PROPER TRIGGER INPUT. INPUT VOLTAGE CAN BE 30 TO 300 V AC/DC. IF TRIGGER VOLTAGE IS DETECTED, TIMER WILL CAPTURE DATA & PERFORM CALCULATION.

Table 18. Symptom: Timer will not arm.

SYMPTOM	PROBABLE CAUSE	REMEDIAL ACTION
Timer displays "DETECT OPEN OR CLOSE VOLTAGE."	1. Trigger "NEG" lead is hooked up to "POS" terminal.	Check trigger cable hookup.

Table 19. Symptom: Contact timing result = 00 ms or no activity on graph

SYMPTOM	POSSIBLE CAUSE	REMEDIAL ACTION
TABULATED RESULT PRINT OUT = O MS	1. SAFETY GROUND ON BOTH SIDES OF BREAKER CONTACTS ARE STILL ATTACHED TO SUBSTATION GROUND.	1. REMOVE GROUND FROM ONE SIDE OF BREAKER CONTACTS.
	2. CONTACT ISOLATED POWER SUPPLY IS NOT WORKING.	2. VERIFY TIMER CONTACT CHANNEL POWER SUPPLY BY PUTTING TIMER IN ARM MODE. A DC VOLTAGE = 20.0 V ± 0.5 V SHOULD BE AT THE CONTACT CABLE (BETWEEN RED & BLACK CLIPS) OR BETWEEN PINS 2 AND 3 OF CONTACT CONNECTOR.

Table 20. Symptom: Erroneous contact or resistor time

SYMPTOM	POSSIBLE CAUSE	ACTION
ERRONEOUS CONTACT TIME	1. NUMBER OF SAMPLE IS SET TOO LOW	1. CHANGE NUMBER OF SAMPLES (SUGGEST A VALUE OF 5).
ERRONEOUS CONTACT RESISTOR TIME	1. NUMBER OF SAMPLE IS SET TOO LOW	1. CHANGE NUMBER OF SAMPLES
	2. OPEN THRESHOLD IS SET TOO LOW OR HIGH.	2. CHANGE OPEN THRESHOLD (SUGGEST A VALUE OF 240)

Note:
1. An Insertion resistor value more than 10 kilo-ohms is detected as an opened contact.
2. Some resistor contacts are very noisy (excessive chatter). When contacts are noisy, a sample value number of 1 or 2 may be used to produce a more accurate resistor time.

Table 21. Symptom: Erroneous stroke results

SYMPTOM	POSSIBLE CAUSE	ACTION
STROKE VALUE IS CLOSED, BUT NOT EXACTLY AS SPECIFIED BY THE BREAKER MANUFACTURER	1. VIBRATION PICKED UP BY TRANSDUCER DURING OPERATION.[1] 2. WIPING ACTION BY TIMING ROD IS INTRODUCING ERROR ON STROKE READING.[2]	1. SUGGEST SECURING TRANSDUCER TO A NONE-MOVING PART OF THE BREAKER. 2. MOUNT TRANSDUCER MOVING BLOCK TO THE UPPER PORTION OF THE TRAVEL OR SHORTEN THE TIMING ROD TO ELIMINATE WIPING ACTION.
BREAKER STROKE READING IS TOO SHORT OR TOO LONG	STEEL CABLE NOT PROPERLY SECURED TO SLIDER OF TRANSDUCER	1. SECURE CABLE TO SLIDER. 2. PERFORM TRANSDUCER SELF TEST

NOTES:

1. This problem has been observed on vacuum breakers (e.g., Westinghouse & Square D). Since the stroke of the vacuum breaker is about 0.5 inch typically, any vibration picked up by the transducer will generate an erroneous stroke reading. Use a special transducer for these types of breakers.

2. When mounting the transducer horizontally, the extra long timing rod may introduce the wiping action at the end of the contact operation.

APPENDIX A
CURRENT SENSOR

The CT-6000 current input channel is designed to work with the following Hall-Effect clamp-on current measuring sensors:

F.W Bell pn CG-100A

Hewlett-Packard pn 34302A

All CT-6000 models with current input options are furnished with a cable that allows each user to attach their own current probe to the Timer. The cable is terminated with a 7-pin female Switchcraft connector. Connection to the current probe is done with banana-type plugs.

APPENDIX B
TIMING AN ITE BREAKER
(Type 14.4KS500-20B)
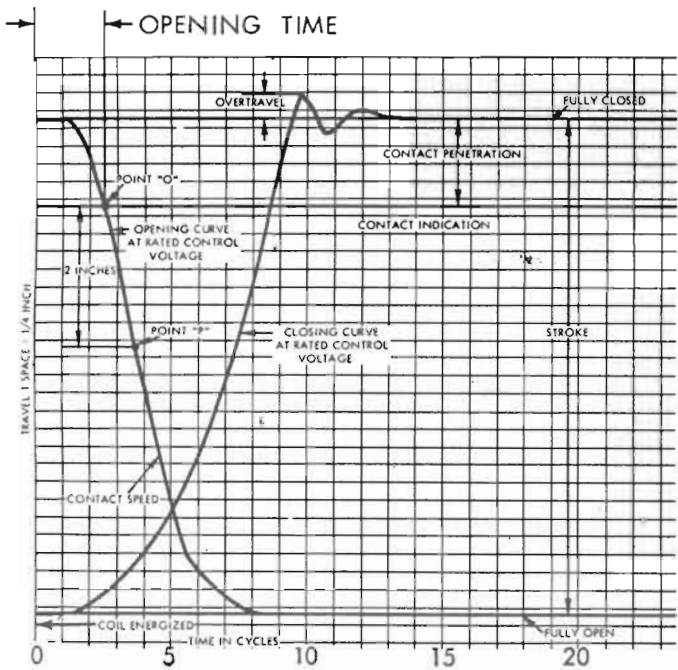
FIGURE 12
Typical No Load Travel Curves
For Opening And Closing
Operations At Rated
Control Voltage
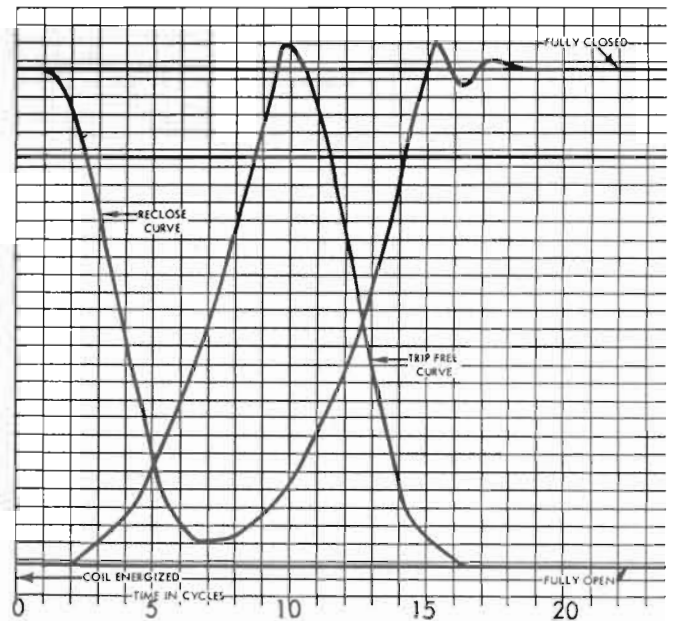
FIGURE 12A
Typical No Load Travel Curves
For Reclosing And Trip-Free
Operations At Rated Control
Voltage

NO LOAD OPERATING DATA	
Opening Speed	8.0 to 9.0 ft/sec.
Opening Time	2.5 +0 - .5 cycles
Closing Time	15 cycles maximum
Reclosing Time	20 cycles maximum
Closing Spring Recharging Time	5 seconds approx.
Stroke	7 ± 1/4 inch
Overtravel (Closing)	1/2" Maximum
Contact Penetration	1 1/4 ± 1/16"

APPENDIX B (continued)
Timing

```
┌─────────────────────────────────────────────┐
│                                             │
│   BREAKER TIMING RESULTS                    │
│  ─────────────────────────────────────────  │
│   DATE: 05/26/97        TIME: 10:45:24      │
│  ─────────────────────────────────────────  │
│   COMPANY:                                  │
│   STATION:                                  │
│   CIRCUIT:                                  │
│   MFR:                                      │
│   MODEL:                                    │
│   S/N:                                      │
│   OPERATOR:                                 │
│  ─────────────────────────────────────────  │
│   TEST:  OPEN                               │
│  ─────────────────────────────────────────  │
│   CONTACT TIME                              │
│   CHA     MS       CYCLE   P/F   WIPE       │
│    1    030.750    01.85         00.48  IN  │
│    2    035.250    02.12         00.80  IN  │
│    3    034.625    02.08         00.75  IN  │
│  ─────────────────────────────────────────  │
│   CONTACT SPREAD <mS>                       │
│   dT1&2         dT1&3        dT2&3          │
│   04.500        03.875       00.625         │
│  ─────────────────────────────────────────  │
│   TRAVEL ANALYSIS                           │
│   STROKE:        07.03  IN                  │
│   SPEED:         09.07  F/S                 │
│   OVR-TRVL:      0.03   IN                  │
│   BOUNCE BACK:   0.00   IN                  │
│                                             │
│   SPEED ANALYSIS:                           │
│   POINT1=01.25IN                            │
│   POINT2=03.25IN                            │
└─────────────────────────────────────────────┘
```
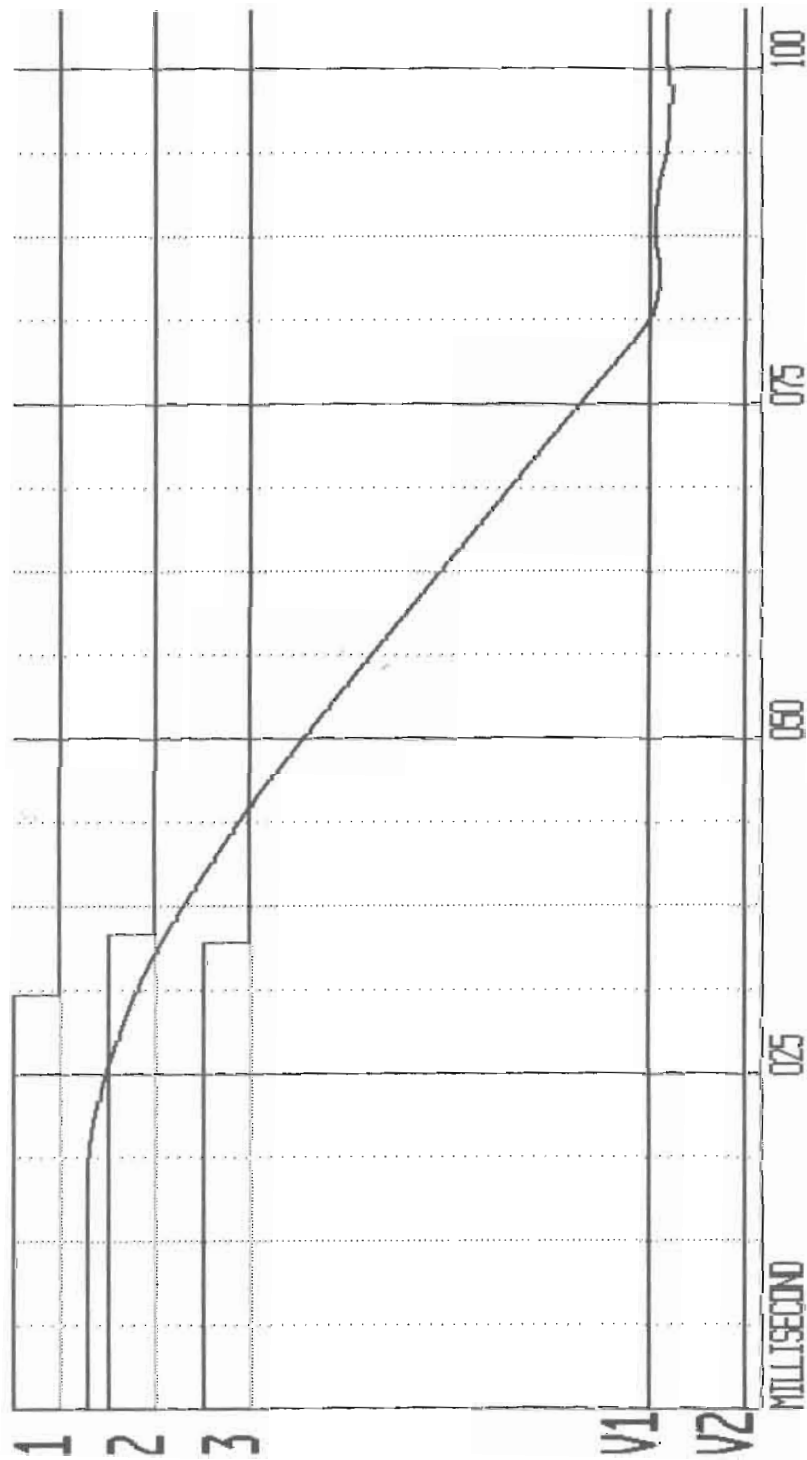
VANGUARD INSTRUMENT CO.INC. (39). HPN (C) 1991. 1992. 1993.1994. 1995
ONTARIO. CA. USA TEL: 909-933-0034 FAX: 909-933-0046
OPERATION: 0017
SERIAL NUMBER: 6200
CLOSED THRESHOLD=020 OPENED THRESHOLD=235 SAMPLE=003 VOLTAGE=020

NOTE:
1. AP1 point is set at 1.25."
2. AP2 point is set 2" below AP1 (i.e., set at 3.25").

APPENDIX B (continued)

Timing

APPENDIX C
GLOSSARY OF DEFINITIONS

RECLOSE– Breaker operations where contacts open, then immediately close.

TRIP FREE– Breaker operations where contacts close, then immediately open.