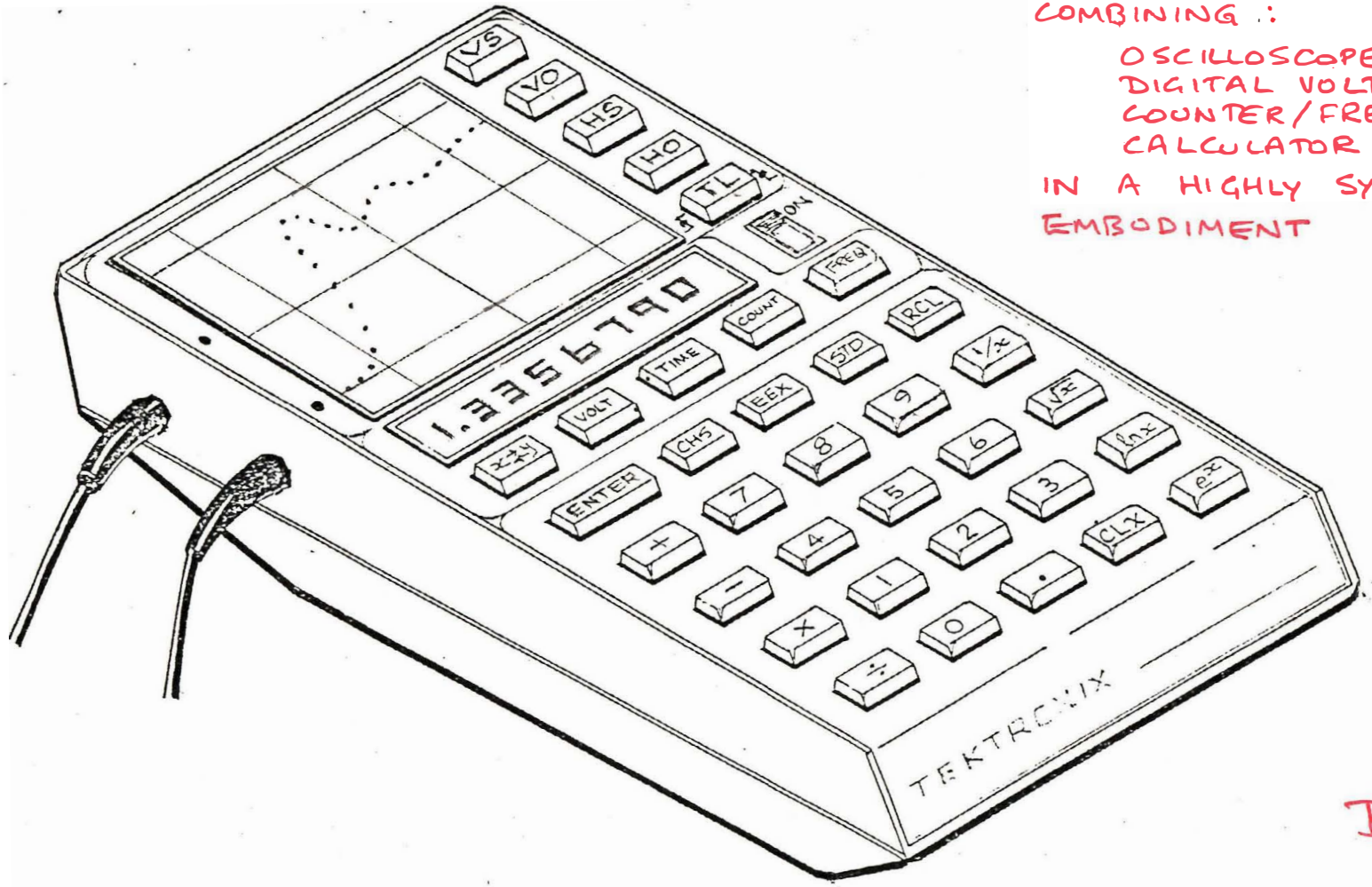
WINDOW BOX

A VERSATILE SERVICE AID
COMBINING :

- OSCILLOSCOPE
- DIGITAL VOLTMETER
- COUNTER/FREQ. METER
- CALCULATOR

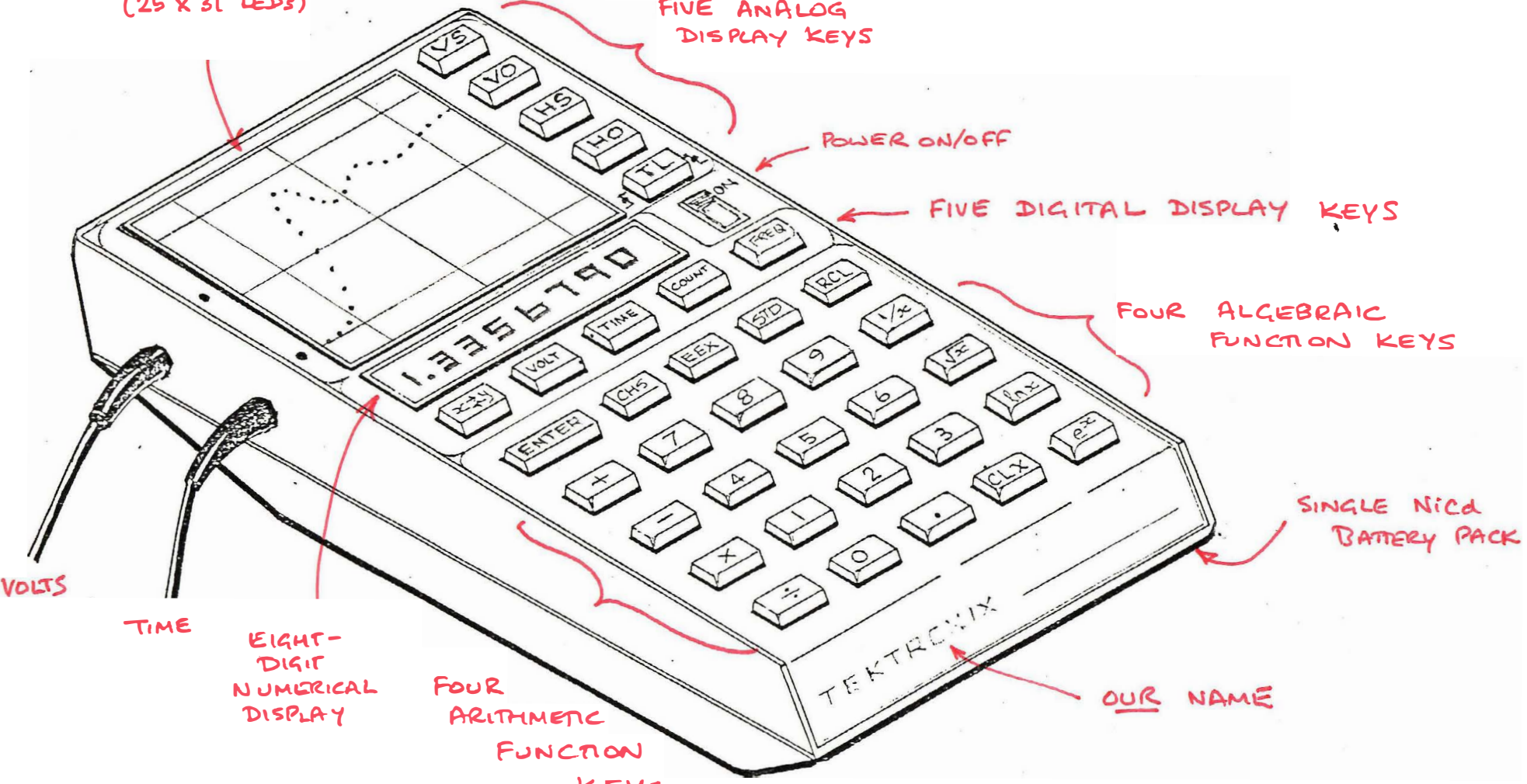
IN A HIGHLY SYNERGISTIC
EMBODIMENT



Barrie Gilbert

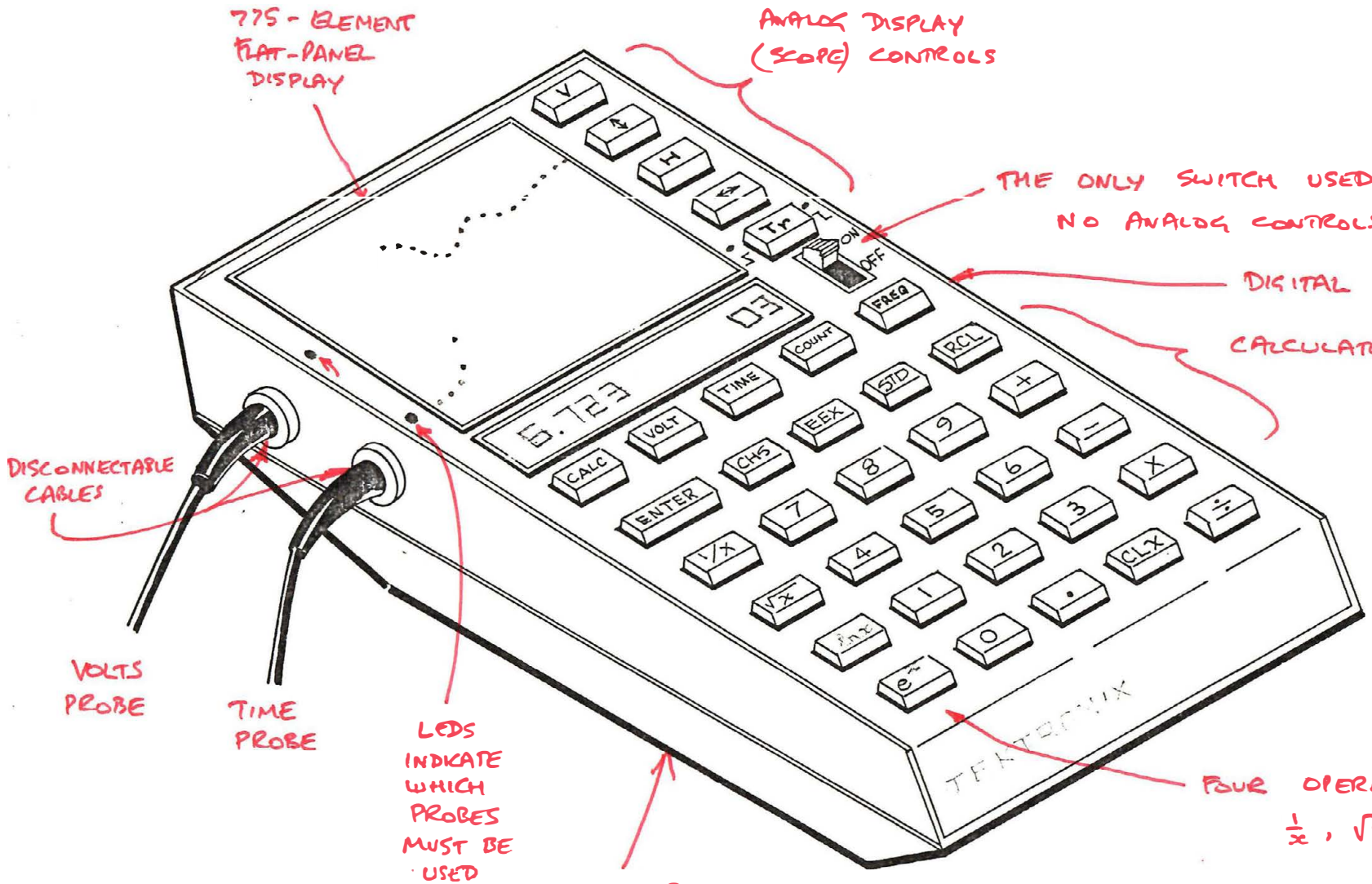
JULY, 1977

GENERAL FEATURES



NOTE: VOLTAGE MEASUREMENTS ARE IN VOLTS, USING INTERNAL BAND-GAP GENERATOR
TIME MEASUREMENTS ARE IN MICROSECONDS

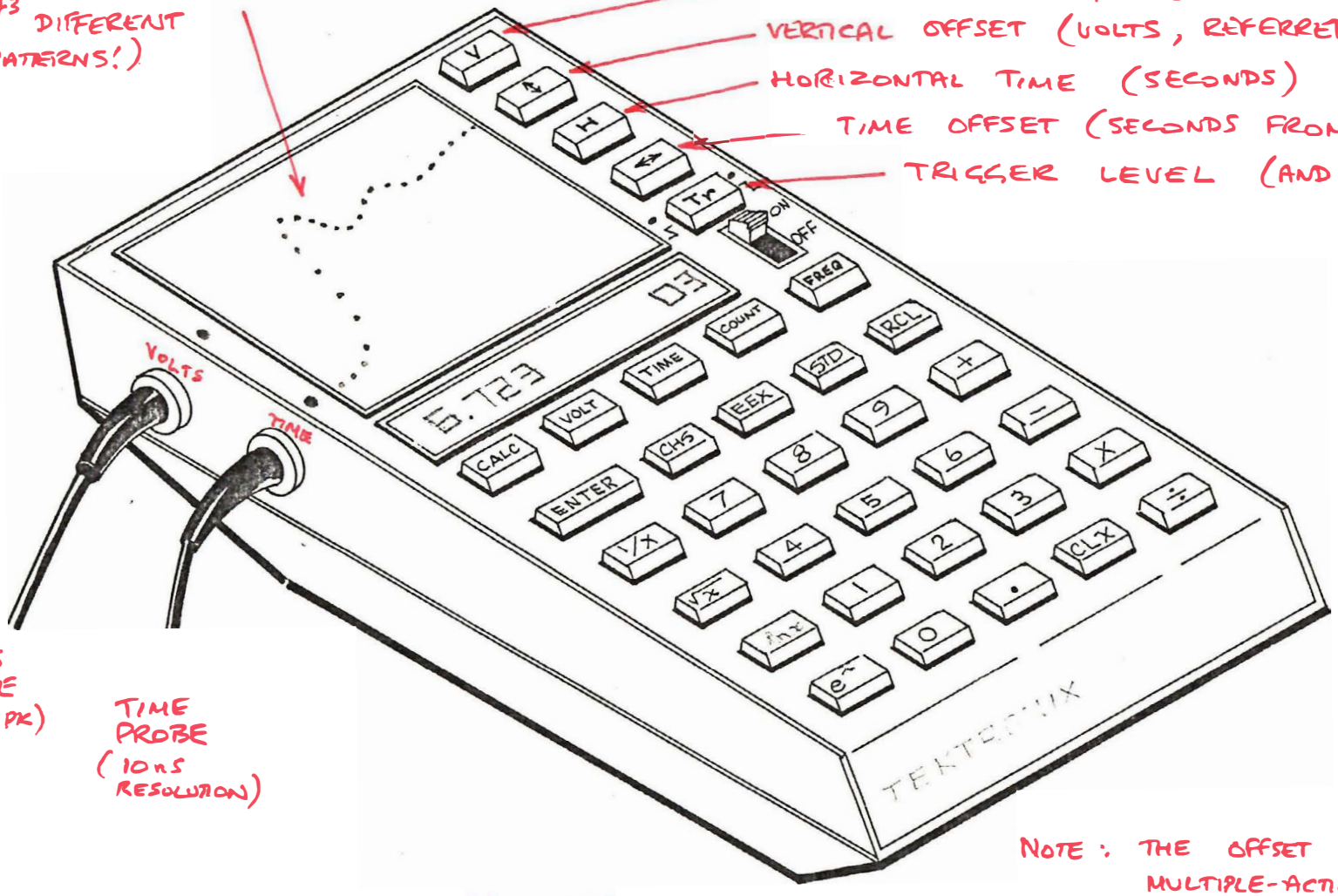
GENERAL FEATURES



25 X 31 LED DISPLAY (10^{43} DIFFERENT PATTERNS!)

USING KEYBOARD (OR ANY DATA CURRENTLY RESIDING IN THE DISPLAY REGISTER, ENTER:

- VERTICAL SENSITIVITY (VOLTS)
- VERTICAL OFFSET (VOLTS, REFERRED TO INPUT)
- HORIZONTAL TIME (SECONDS)
- TIME OFFSET (SECONDS FROM TRIGGER)
- TRIGGER LEVEL (AND ⊓ or ⊔ INDICATOR)



VOLTS PROBE (±500V PK)

TIME PROBE (10ns RESOLUTION)

OSCILLOSCOPE MODE

200MHz BW

10mV FULL-SCREEN

NOTE: THE OFFSET KEYS ARE MULTIPLE-ACTING IF LEFT DEPRESSED. THUS, BY ENTERING A SMALL NUMBER (+ OR −) THEY FUNCTION AS POSITIONING.

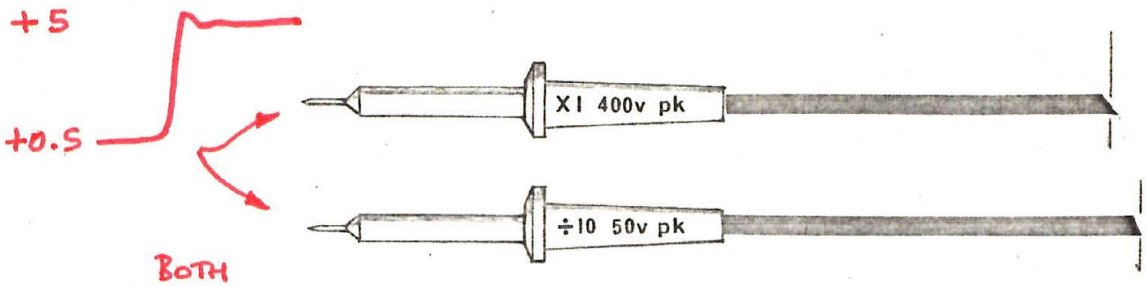
THE TRIGGER LEVEL KEY CHANGES SIGN OF TRIGGER EDGE EACH TIME IT IS DEPRESSED

OSCILLOSCOPE

* 25 x 31 FLAT-PANEL DISPLAY ($>10^{43}$ PICTURES!)
* 20MHz BANDWIDTH, 400V FS TO 100mV FS
* 32-STAGE CCD FOR SINGLE-SHOT WAVEFORM-CAPTURE AND 'VIEW-AHEAD' CAPABILITY
* ALL OPERATING CONDITIONS DIGITALLY-CONTROLLED FROM KEYBOARD
* INHERENT WAVEFORM MEASUREMENT
* WAVEFORM AND STATUS STORAGE
* LOW-CAPACITANCE PROBES

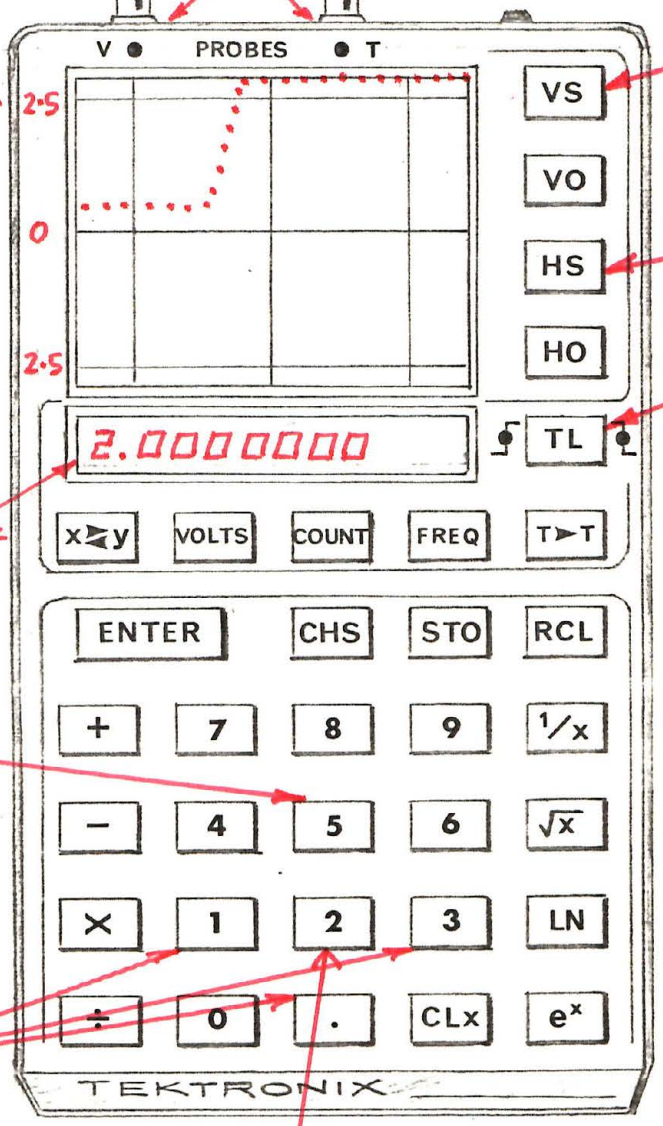
TYPICAL OSCILLOSCOPE

SEQUENCE : 1



BOTH PROBES TO SAME POINT

BOTH LEDS ON



(7) RESULTING DISPLAYS.

NOTE: CENTER-LINE HAS NOT YET BEEN DEFINED, BUT DEFAULT VALUE IS ∅.

WAVEFORM OVER-LOAD (AT TOP) IS APPARENT

(2) STORE VERTICAL SCALE

(6) STORE HORIZ. SCALE

(4) STORE TRIGGER LEVEL

DEPRESSING KEY A SECOND TIME CHANGES TRIGGER SLOPE, INDICATED BY LEDS

(1) SELECT VERTICAL SCALE OF 5V FS

(3) SELECT TRIGGER LEVEL OF 1.6V

(5) SELECT HORIZONTAL SCALE (2μs FS)

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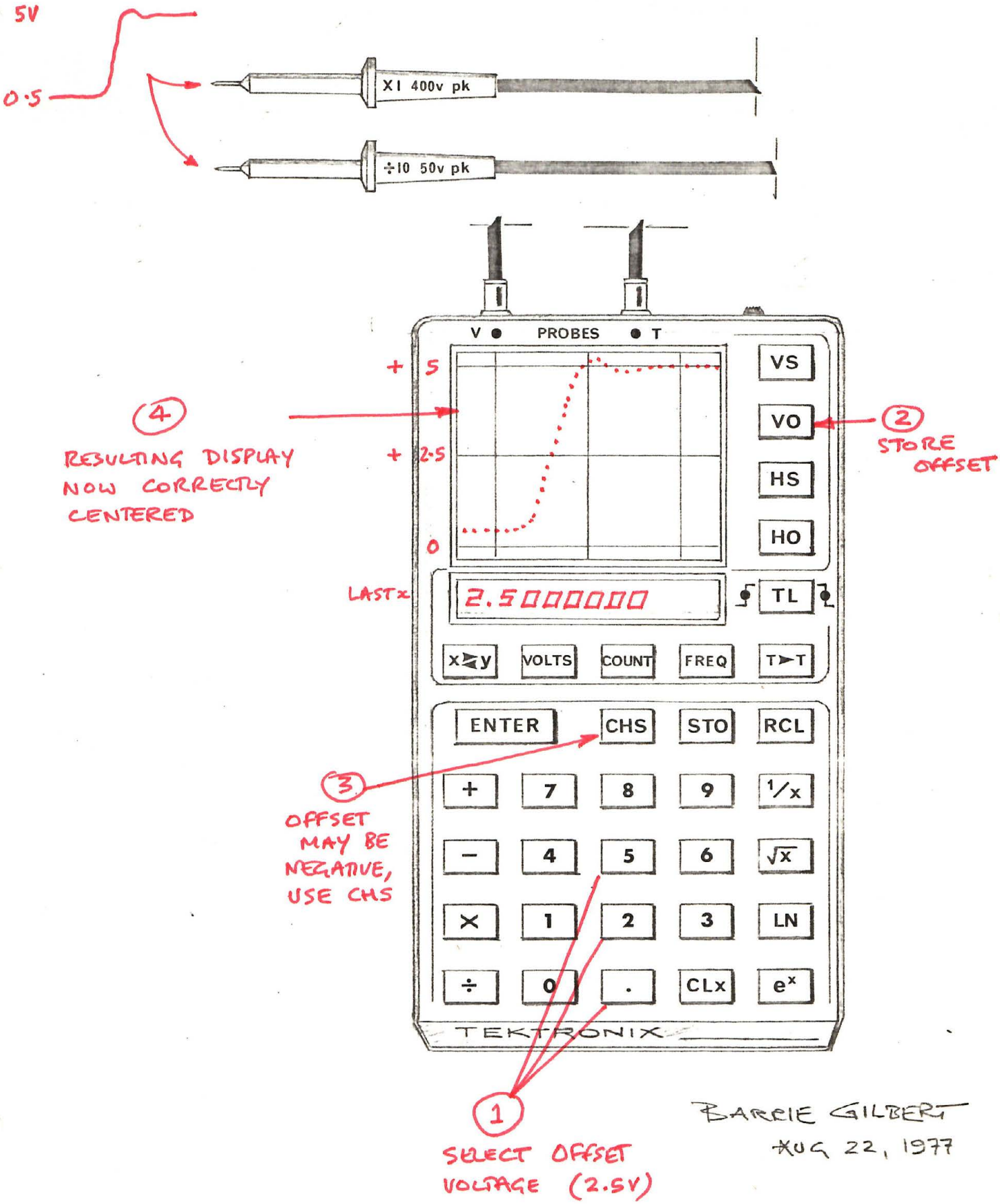
AUG 22, 1977

TYPICAL OSCILLOSCOPE SEQUENCE



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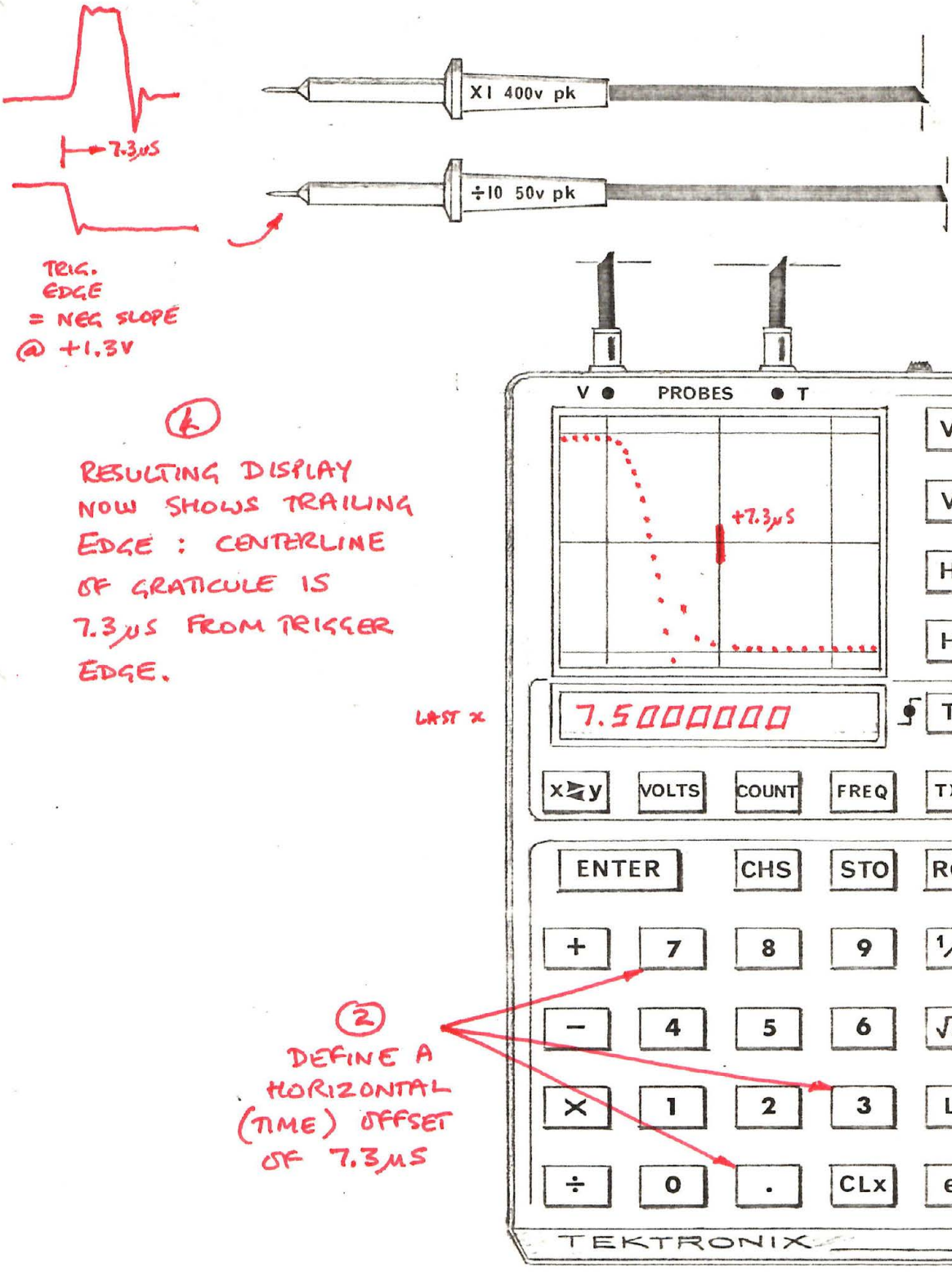
TYPICAL OSCILLOSCOPE SEQUENCE : 3



(k)

RESULTING DISPLAY NOW SHOWS TRAILING EDGE : CENTERLINE OF GRATICULE IS 7.3μS FROM TRIGGER EDGE.

(3) LOAD HORIZ. OFFSET

(1) DEPRESS TO GET OTHER TRIGGER EDGE

(2) DEFINE A HORIZONTAL (TIME) OFFSET OF 7.3μS

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AUG 22, 1977

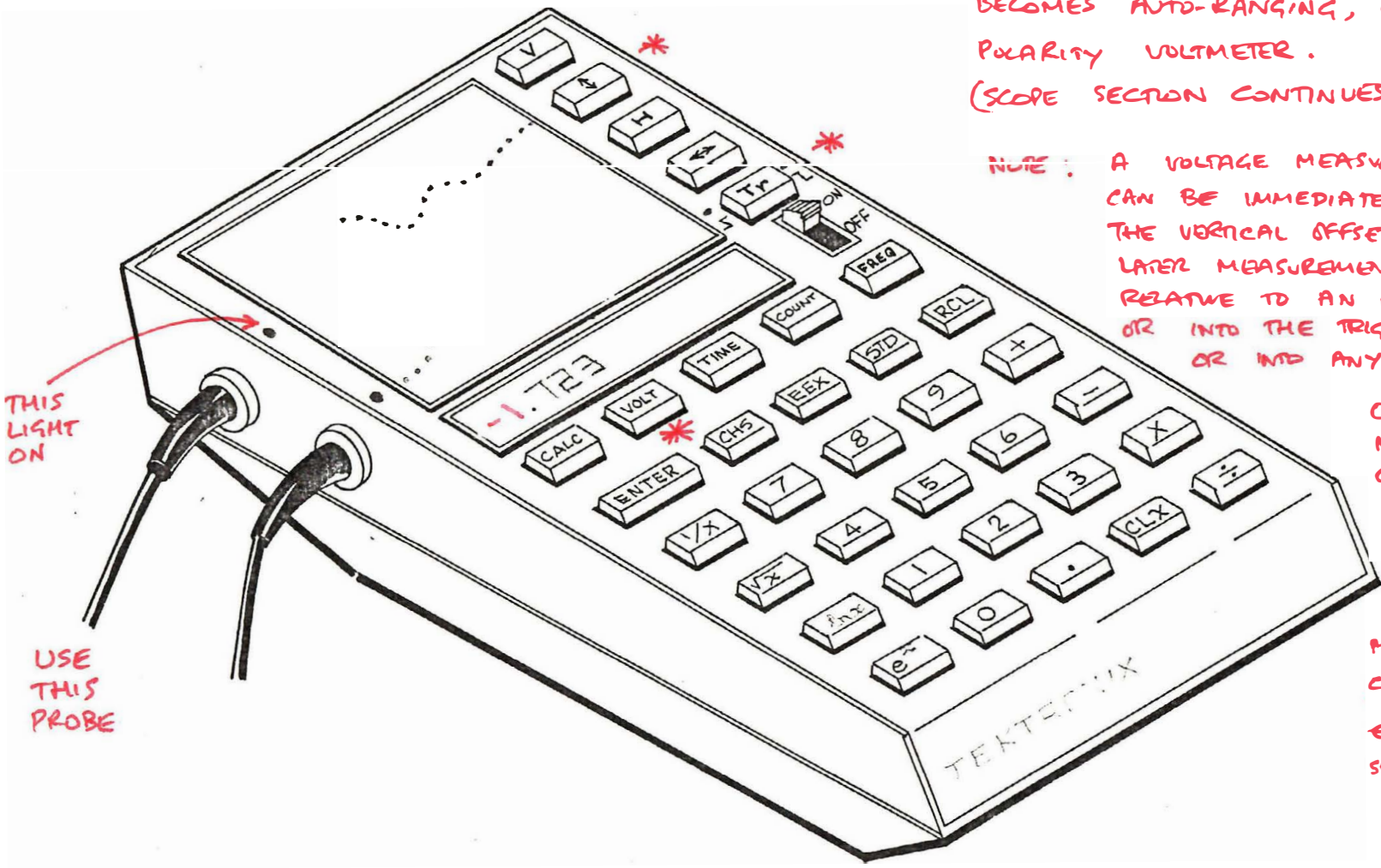
DVM MODE

PRESS 'VOLT' KEY IN DIGITAL DISPLAY ROW BECOMES AUTO-RANGING*, AUTO-ZERO, AUTO POLARITY VOLTMETER.
(SCOPE SECTION CONTINUES TO RUN).

NOTE: A VOLTAGE MEASURED IN THIS WAY CAN BE IMMEDIATELY DUMPED INTO THE VERTICAL OFFSET LATCH (FOR LATER MEASUREMENT OF A WAVEFORM RELATIVE TO AN ARBITRARY LEVEL), OR INTO THE TRIGGER-LEVEL LATCH, OR INTO ANY OTHER REGISTER.

OF COURSE, THE MEASURED QUANTITY CAN THEN BE MANIPULATED DIGITALLY IN ANY WAY DESIRED.

(FOR EXAMPLE MEASURE A V_{BE} AND COMPUTE I_C USING e^x KEY AND A SUITABLE SCALING CONSTANT)



* AN ALTERNATIVE TO AN AUTO-RANGING, 3½ DIGIT DISPLAY IS TO USE A 'VISUAL LOGIC DISPLAY' CONCEPT: A SIX-DIGIT DISPLAY OF THE FORM XXX.XXX. THIS MAKES THE MAGNITUDE OF THE MEASUREMENT VERY READILY APPARENT

DIGITAL VOLTMETER

* SINGLE BASIC RANGE (WITH X1 PROBE) OF ±199.99 V FS (10mV RESOLUTION)

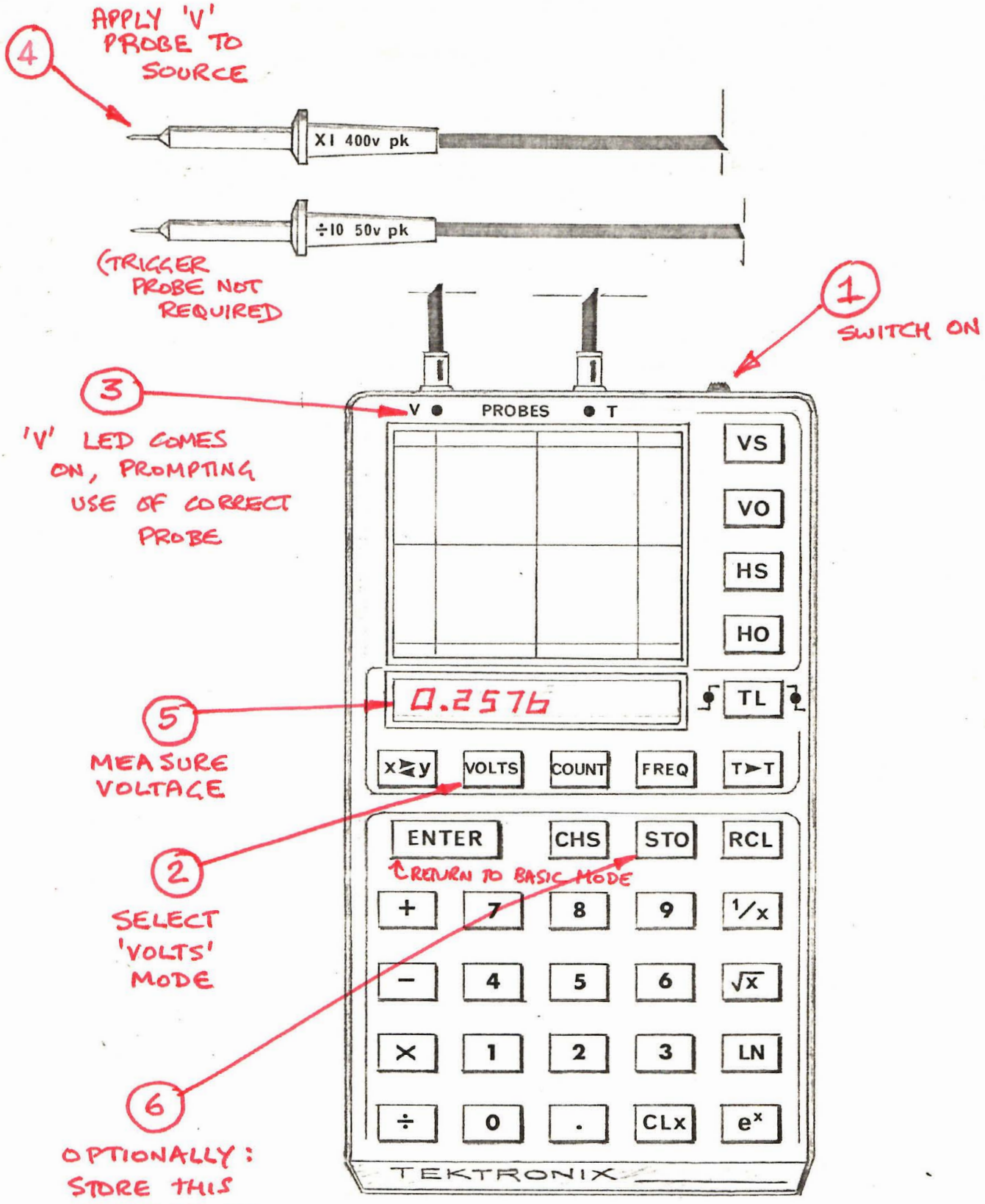
* FIXED DECIMAL POINT REDUCES READING ERROR

* AUTO-ZERO, AUTO POLARITY

* MEASUREMENTS CAN BE STORED OR TRANSFERRED TO SCOPE, OR COUNTER/TIMER — FOR EXAMPLE, TO SET AN OFFSET LEVEL OR TRIGGER LEVEL

* X10 PROBE FOR ±1999.9 V FS
  X0.1 PROBE FOR ±19.999 V FS

TYPICAL DVM SEQUENCE



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AUG 22, 1977

7 PRESS 'ENTER' TO RETURN TO BASIC MODE

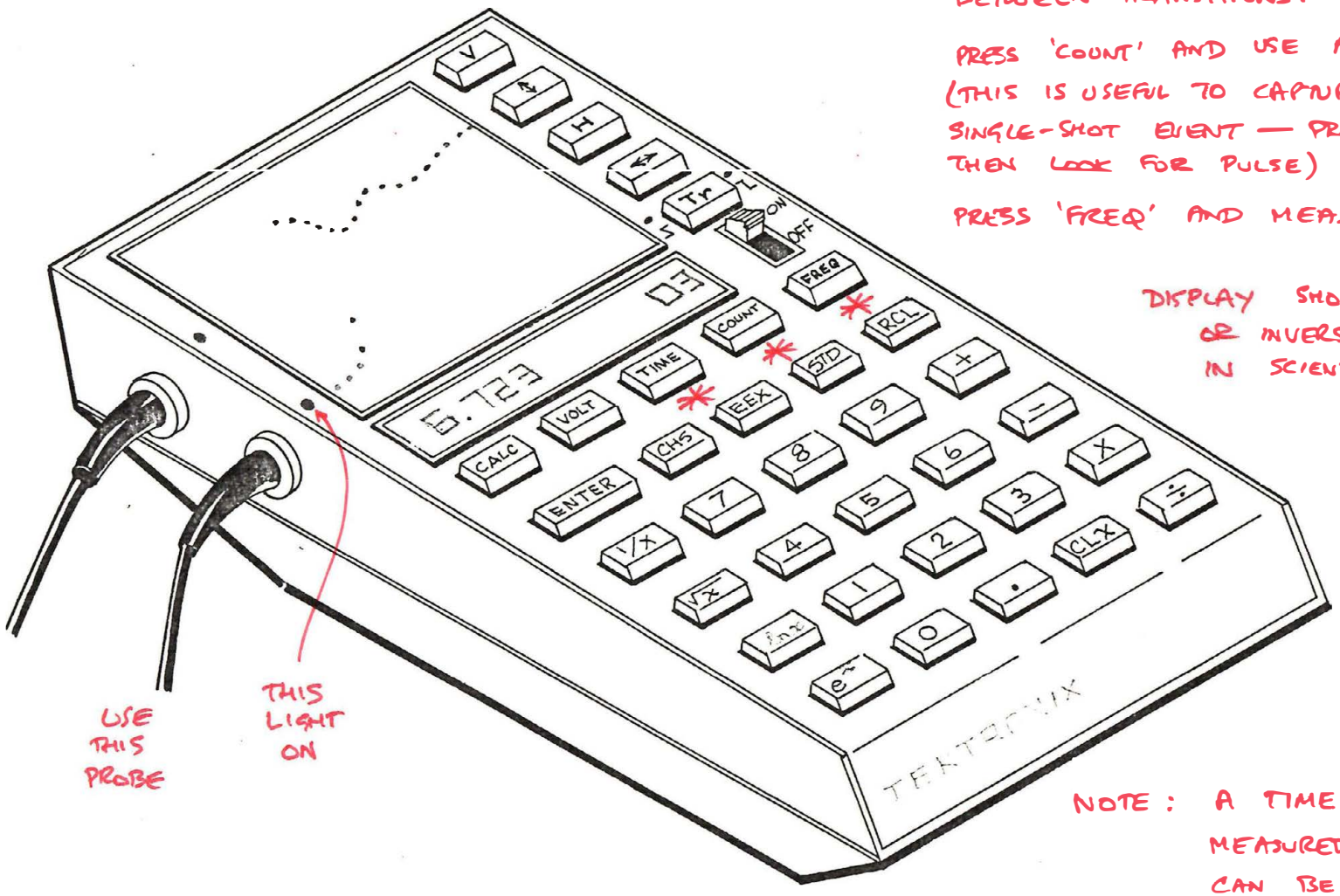
COUNTER MODE

PRESS 'TIME' AND MEASURE PERIOD BETWEEN TRANSITIONS.

PRESS 'COUNT' AND USE AS TOTALIZER. (THIS IS USEFUL TO CAPTURE A NARROW SINGLE-SHOT EVENT — PRESS 'CLx' THEN LOOK FOR PULSE)

PRESS 'FREQ' AND MEASURE FREQUENCY.

DISPLAY SHOWS SECONDS ('TIME' MODE) OR INVERSE SECONDS ('FREQ' MODE) IN SCIENTIFIC NOTATION.



NOTE: A TIME OR FREQUENCY MEASURED IN THIS WAY CAN BE DUMPED INTO ANY OTHER REGISTER.

COUNTER-TIMER

* RESOLUTION OF 10nS FOR CAPTURE OF BRIEF EVENTS IN COUNT MODE

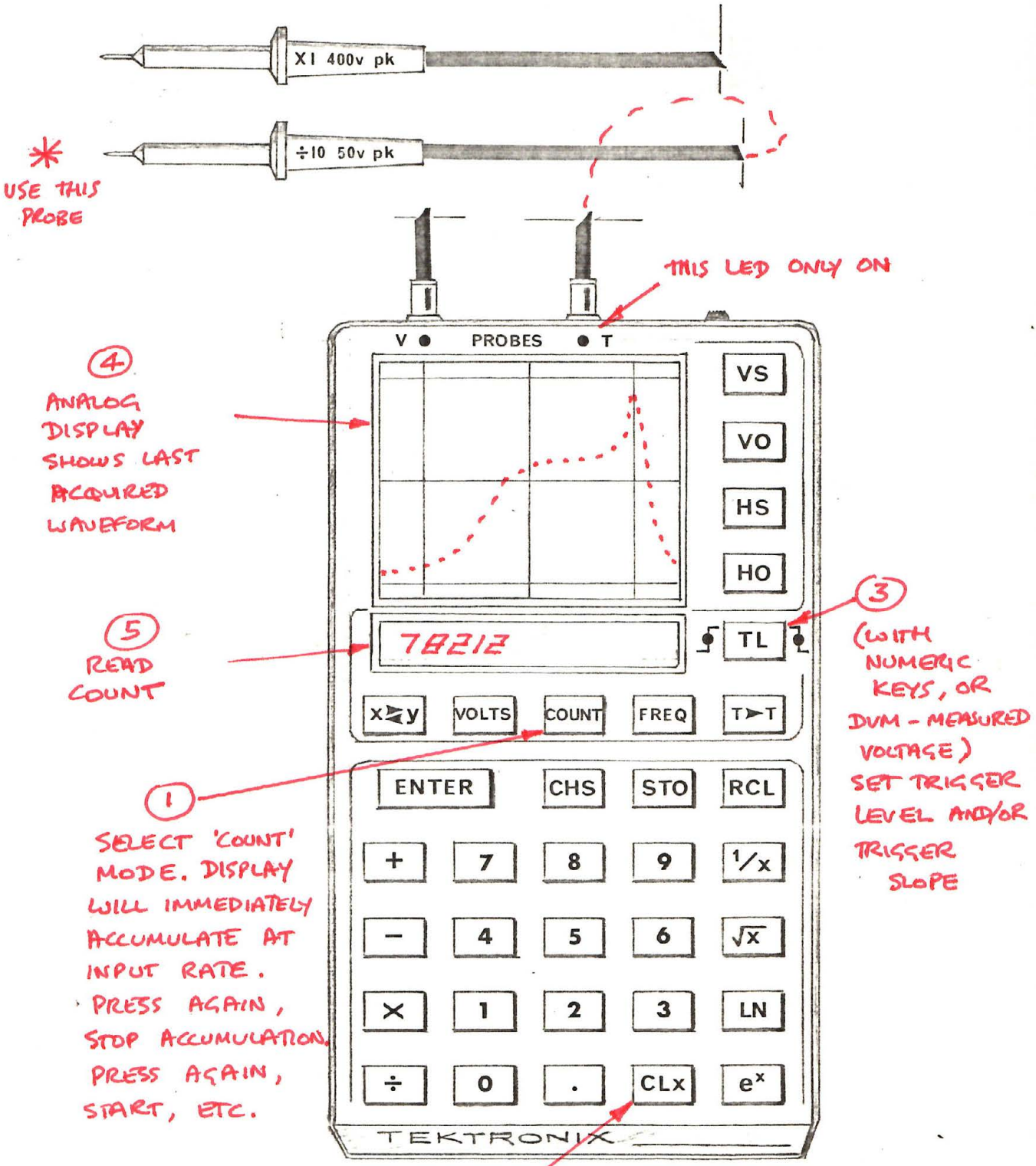
* MAXIMUM COUNT RATE OF 50MHz, FIXED ONE-SECOND GATE, IN 'FREQ' MODE

* DIGITALLY-CONTROLLABLE TRIGGER LEVEL & SLOPE

* TRANSITION TIMING IN 'T>T' MODE

TYPICAL COUNTER / FREQUENCY-METER USE

1 : COUNTING, UNGATED



PRESS 'ENTER' TO RETURN TO BASIC MODE

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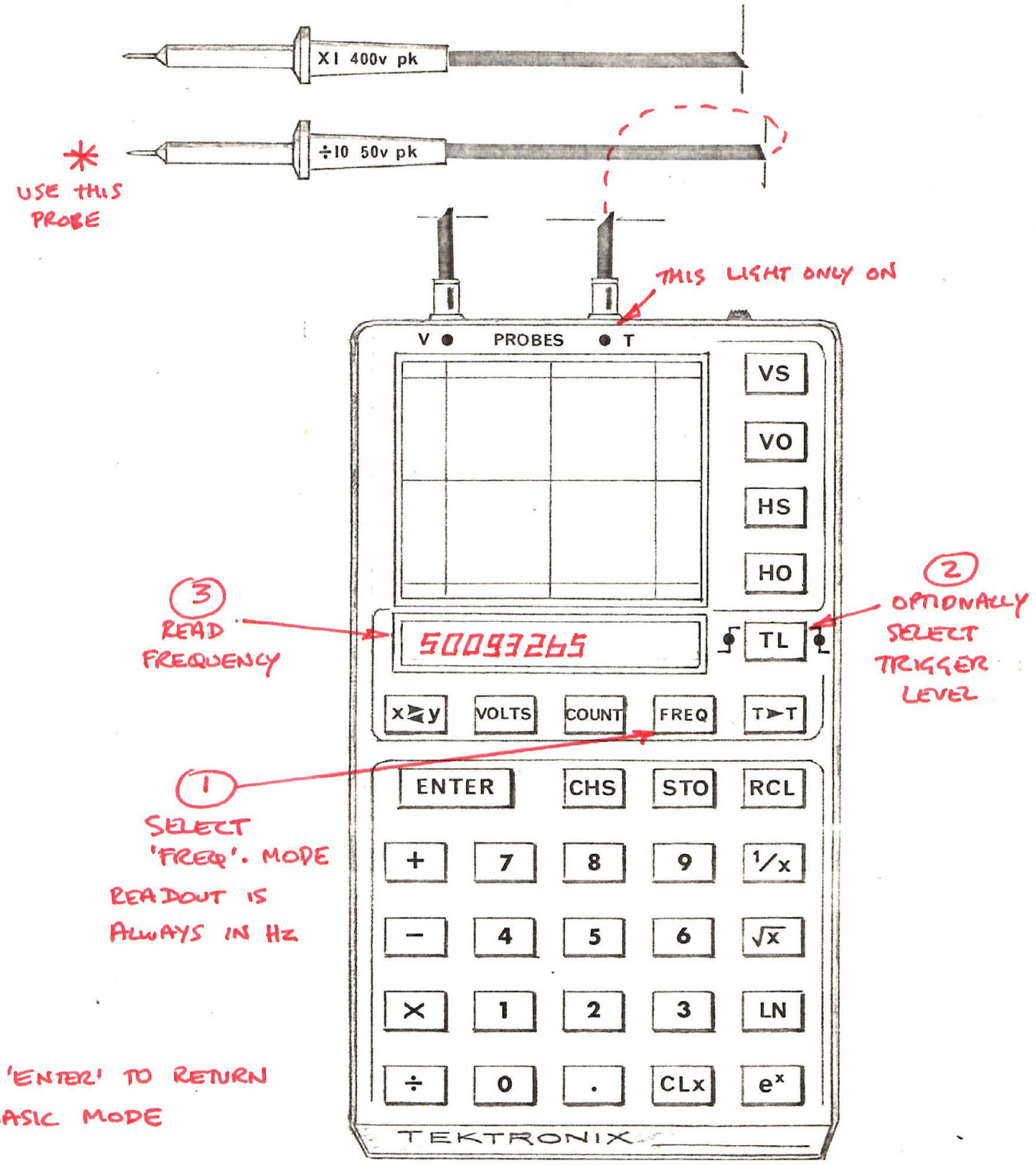
TYPICAL COUNTER/FREQUENCY-METER USE

2 : FREQUENCY



PRESS 'ENTER' TO RETURN TO BASIC MODE

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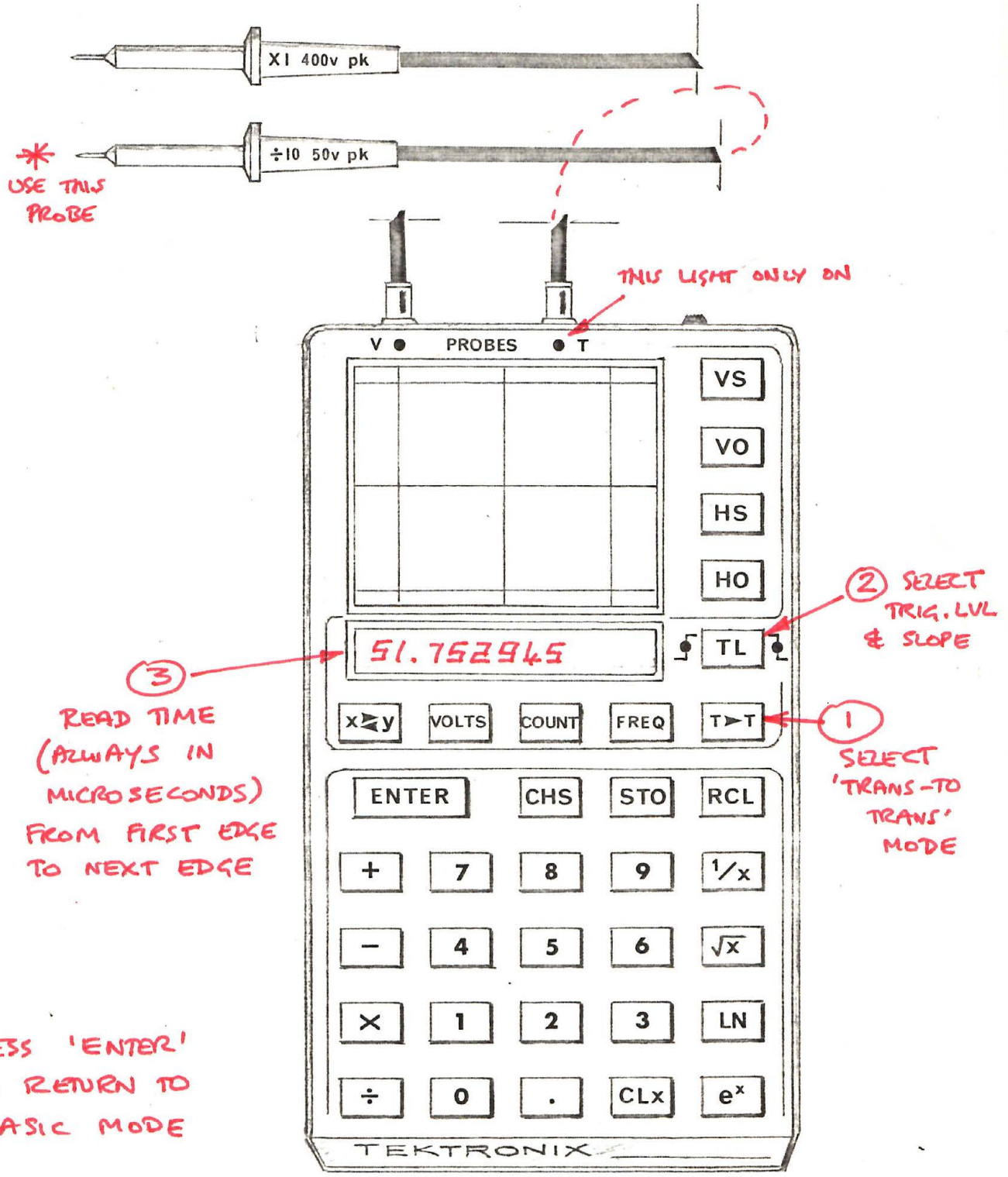
TYPICAL COUNTER/FREQUENCY-METER MODE

3 : TRANSITION-TO-TRANSITION TIME



PRESS 'ENTER' TO RETURN TO BASIC MODE

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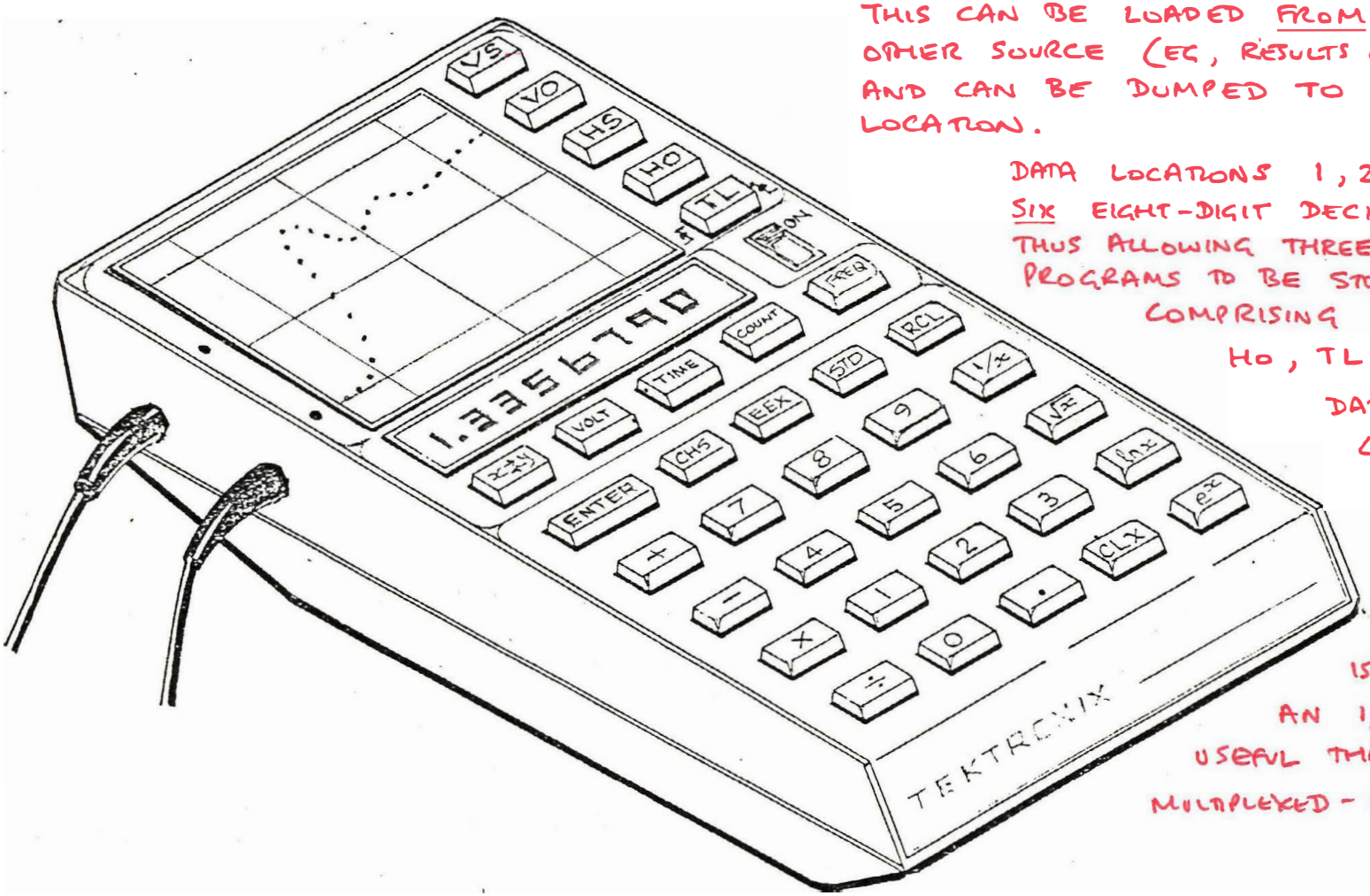
THE COMMON-DATA CONCEPT

THE DIGITAL DISPLAY ALWAYS SHOWS THE CONTENTS OF THE X-REGISTER IN THE STACK. THIS CAN BE LOADED FROM ANY SIGNAL OR OTHER SOURCE (EG, RESULTS OF A CALCULATION), AND CAN BE DUMPED TO ANY STORAGE LOCATION.

DATA LOCATIONS 1, 2 AND 3 STORE SIX EIGHT-DIGIT DECIMAL NUMBERS, THUS ALLOWING THREE OSCILLOSCOPE PROGRAMS TO BE STORED, EACH COMPRISING VS, VO, HS, HO, TL AND x

DATA LOCATIONS 4 THROUGH 9 ARE SINGLE-MEMORY, STORING JUST x

A SUITABLE CALCULATOR CHIP IS AVAILABLE, HAVING AN I/O STRUCTURE MORE USEFUL THAN THE USUAL MULTIPLEXED-LED TYPE.



CALCULATOR MODE

OPERATES IN REVERSE POLISH.

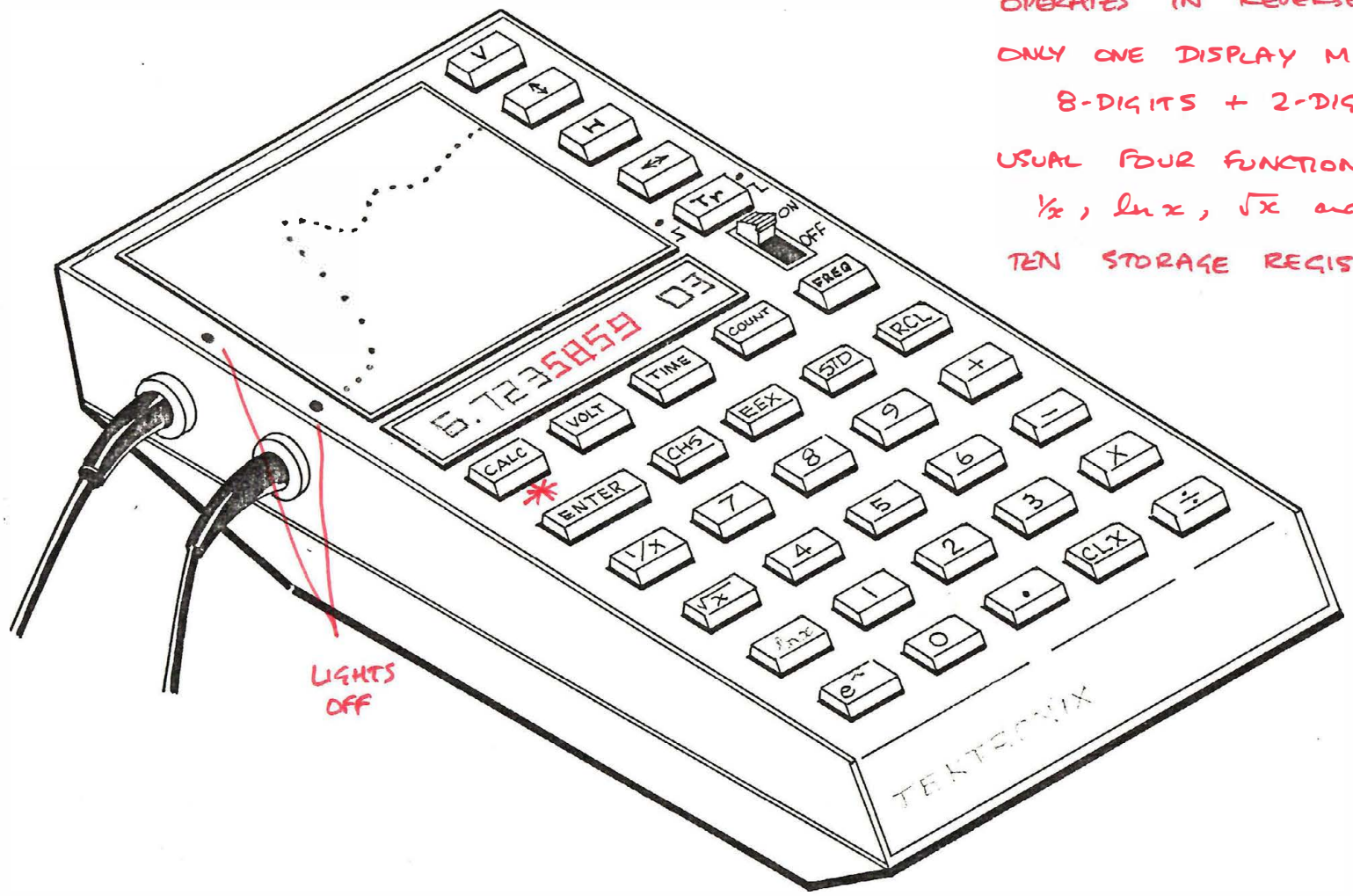
ONLY ONE DISPLAY MODE:

8-DIGITS + 2-DIGIT EXPONENT.

USUAL FOUR FUNCTIONS PLUS

$\frac{1}{x}$, $\ln x$, $\sqrt{x}$ and e^x

TEN STORAGE REGISTERS



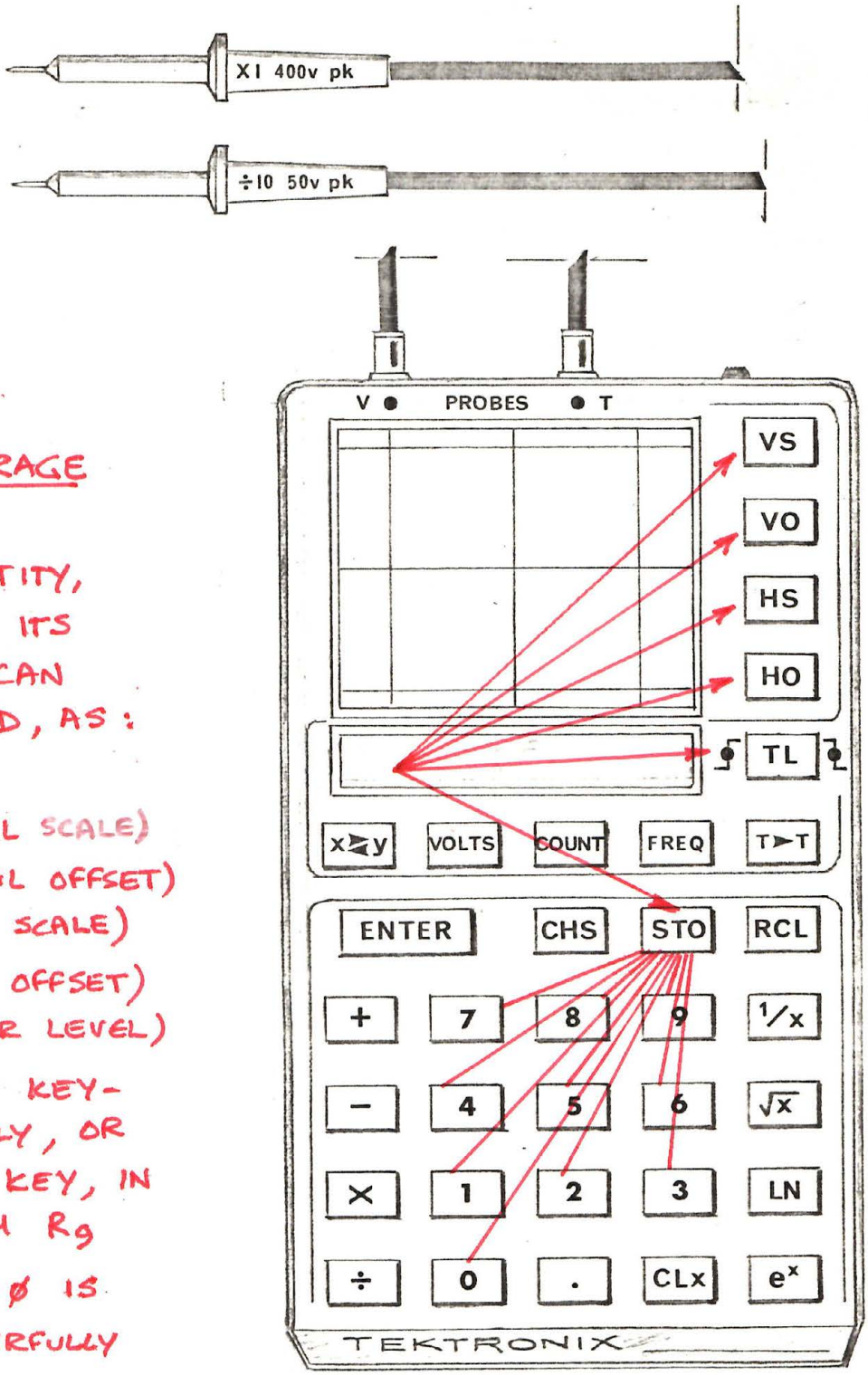
WHY INCLUDE A CALCULATOR??

* CALCULATOR CHIPS ARE CHEAP, HAVE ALREADY SOLVED MANY PROBLEMS SUCH AS KEYBOARD SENSING (BUSS-ORIENTED RPN CHIPS AVAILABLE FROM NATIONAL)

* CALCULATOR IS USED TO OPERATE CERTAIN INTERNAL SYSTEMS (eg. VERTICAL AMPLIFIER HAS A SQUARE-LAW GAIN CHARACTERISTIC TO REDUCE 4000:1 RANGE TO 64:1 RANGE AT CONTROL NODE)

* CALCULATOR IS USEFUL! FOR EXAMPLE, THE PERIOD OF A WAVEFORM CAN BE FOUND USING $1/x$.

* FAMILIARITY WITH CALCULATORS WILL EASE MARKET ACCEPTANCE — IMMEDIATELY SEEN AS SOMETHING WHICH CAN BE READILY CONTROLLED



DATA STORAGE

ANY QUANTITY, WHATEVER ITS SOURCE, CAN BE STORED, AS:

VS (VERTICAL SCALE)
VO (VERTICAL OFFSET)
HS (HORIZ. SCALE)
HO (HORIZ. OFFSET)
TL (TRIGGER LEVEL)

USING ONE KEY-STROKE ONLY, OR VIA 'STO' KEY, IN R_0 THROUGH R_9

[NOTE: STO 0 IS MORE POWERFULLY USED FOR WAVE-FORM STORAGE]

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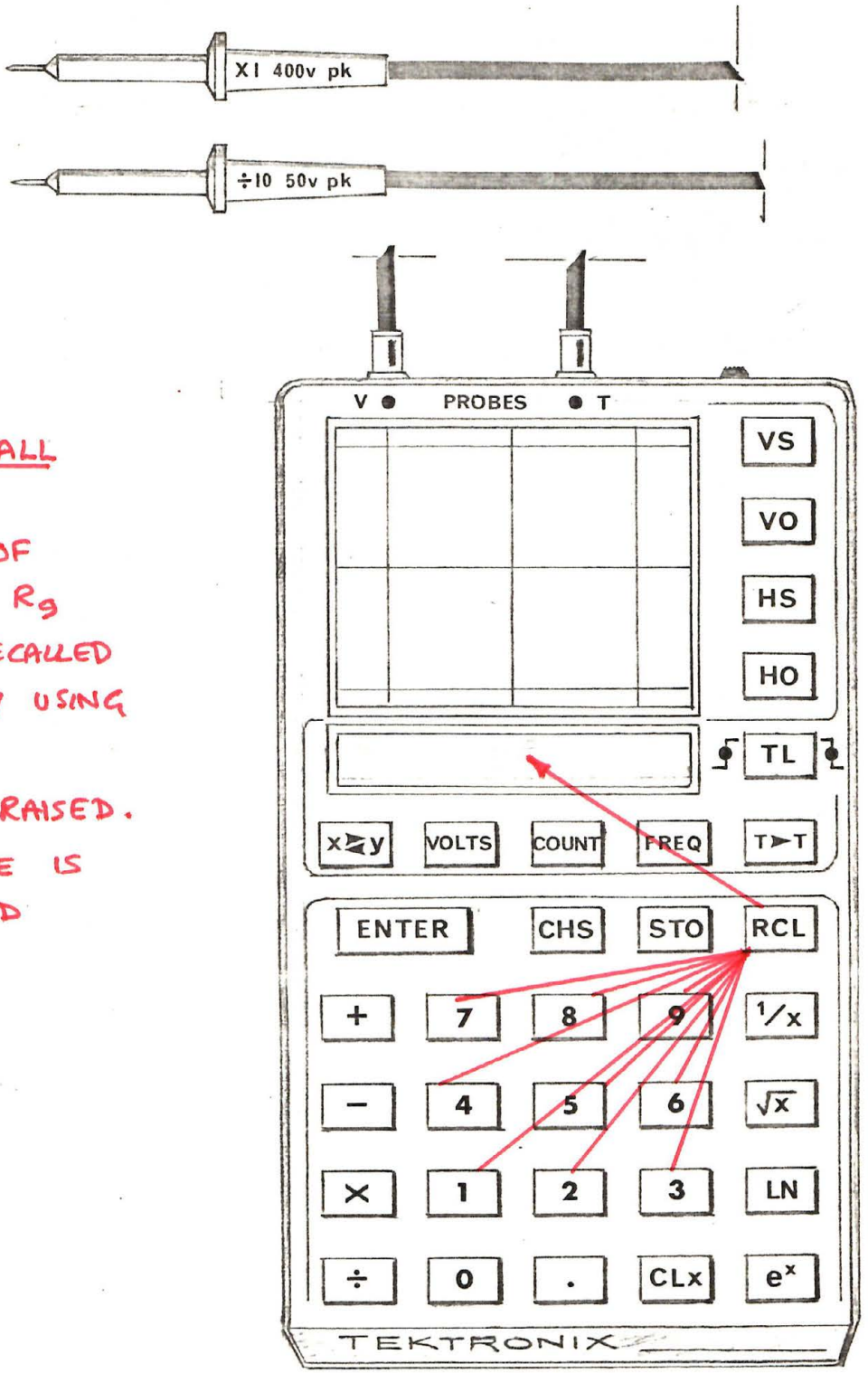
DATA RECALL

CONTENTS OF R_1 THROUGH R_9 CAN BE RECALLED TO DISPLAY USING RCL n.

STACK IS RAISED.

SCOPE MODE IS UNCHANGED



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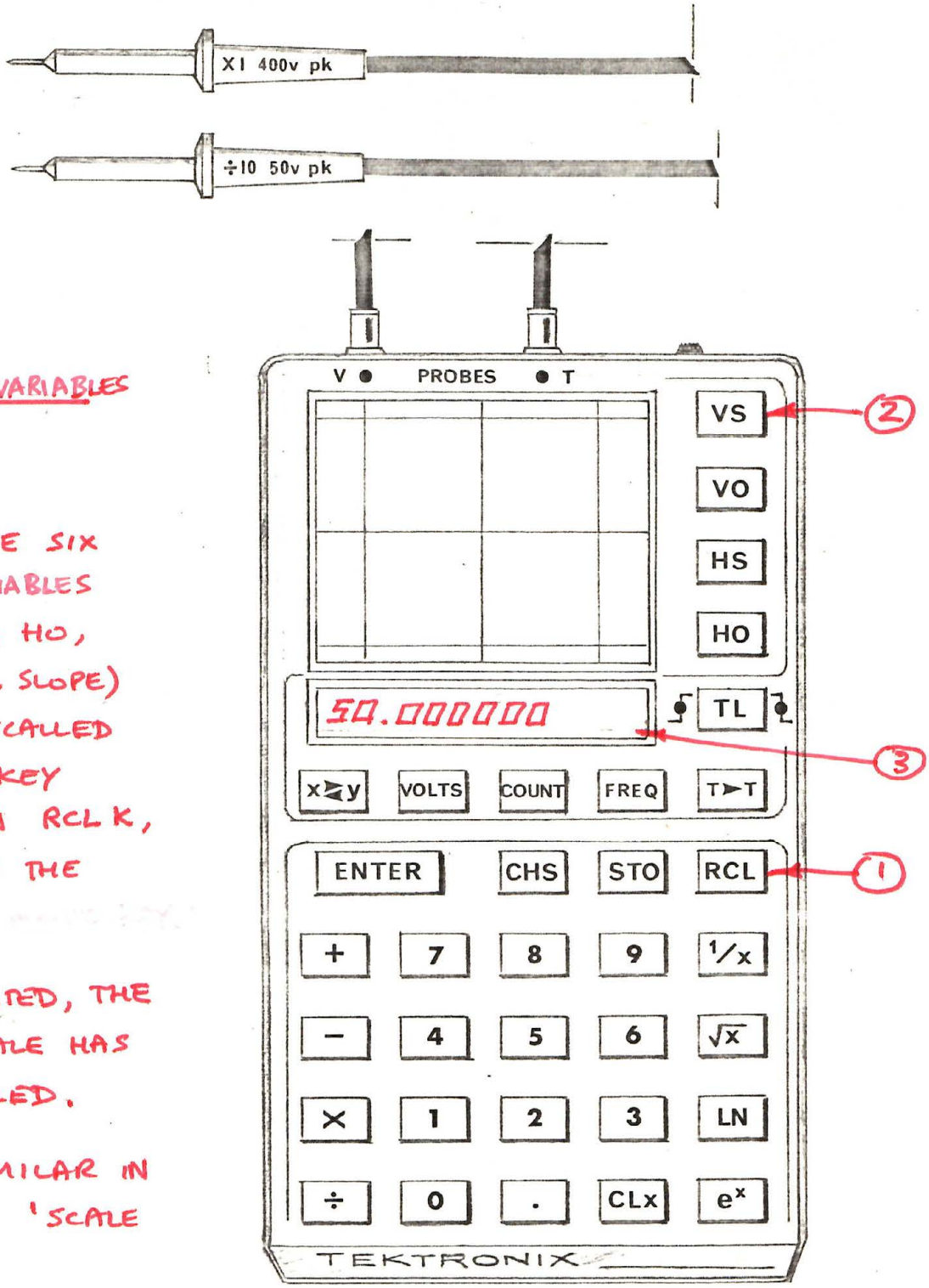

OPERATING VARIABLES RECALL

EACH OF THE SIX ANALOG VARIABLES (VS, VO, HS, HO, TL AND TRIG. SLOPE) CAN BE RECALLED USING THE KEY COMBINATION RCL K, WHERE K IS THE APPROPRIATE

AS ILLUSTRATED, THE VERTICAL SCALE HAS BEEN RECALLED.

THIS IS SIMILAR IN FUNCTION TO 'SCALE READOUT'.

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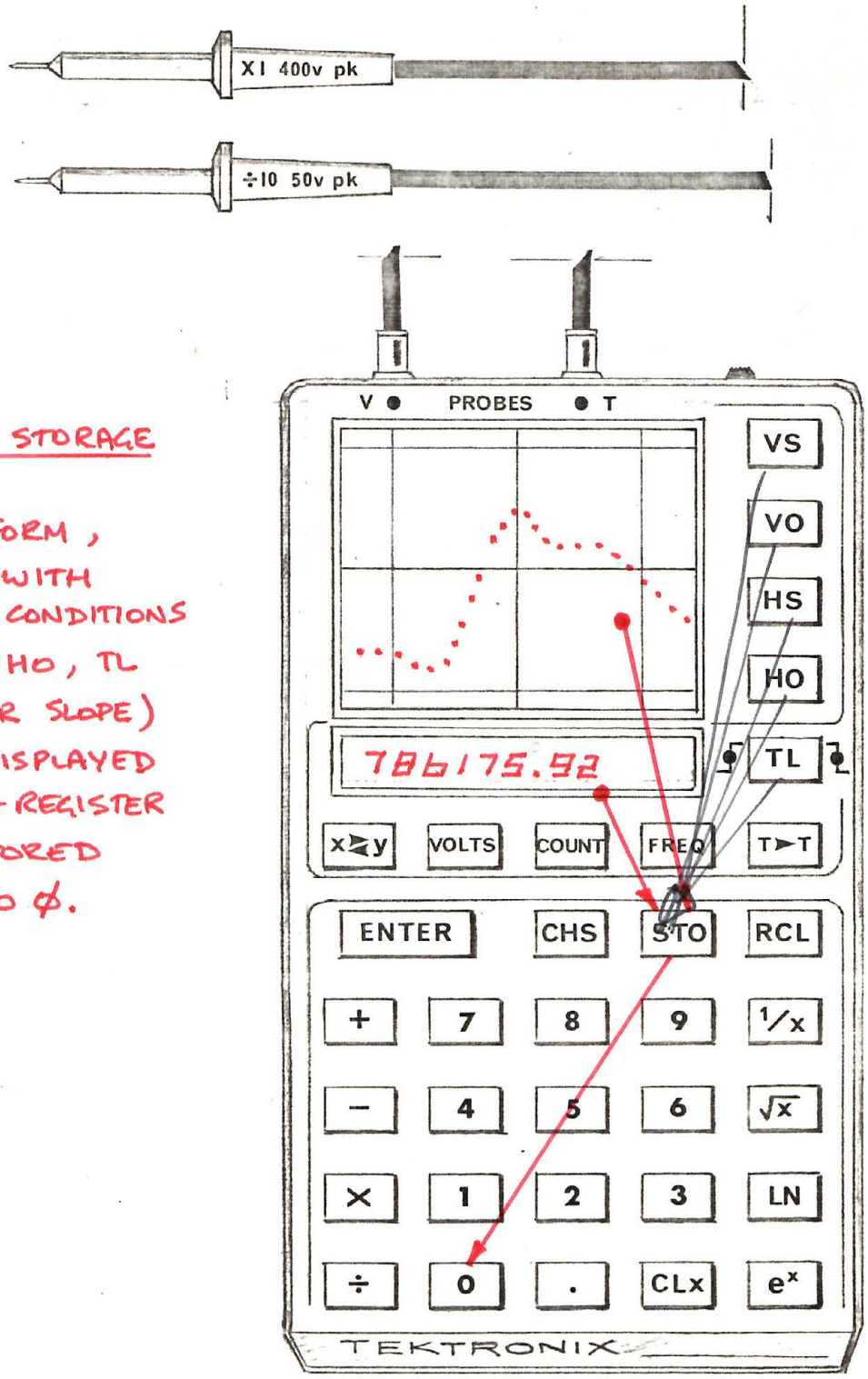
AUG 22, 1977

WAVEFORM STORAGE

ANY WAVEFORM, TOGETHER WITH OPERATING CONDITIONS (VS, VO, HS, HO, TL AND TRIGGER SLOPE) AND THE DISPLAYED DATA IN X-REGISTER CAN BE STORED USING STO ∅.



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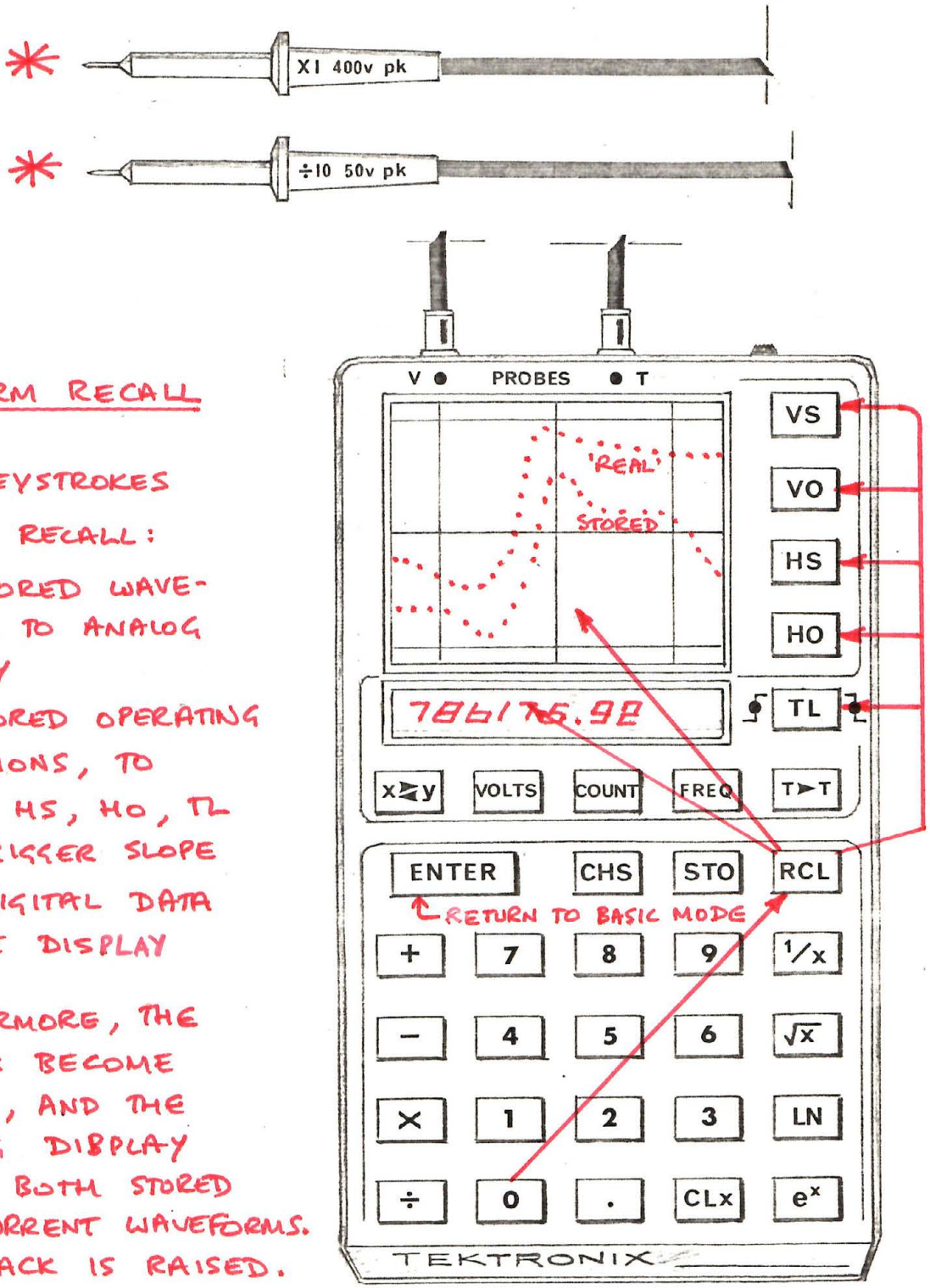

WAVEFORM RECALL

THE KEYSTROKES STO ∅ RECALL:

a) THE STORED WAVEFORM, TO ANALOG DISPLAY

b) THE STORED OPERATING CONDITIONS, TO VS, VO, HS, HO, TL AND TRIGGER SLOPE

c) THE DIGITAL DATA TO THE DISPLAY

FURTHERMORE, THE PROBES BECOME ACTIVE, AND THE ANALOG DISPLAY SHOWS BOTH STORED AND CURRENT WAVEFORMS. THE STACK IS RAISED.

OPERATION OF THE 'ENTER' KEY CAUSES EXIT FROM THIS MODE

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AUG 22, 1977

REQUIRED TECHNOLOGY

* USES OFF-THE-SHELF CALCULATOR/μP, MEMORIES AND DIGITAL DISPLAY

* USES SPECIAL SH3 AMPLIFIER FOR 4000:1 GAIN-CONTROL

* LCD OR LED MATRIX DISPLAY

* SHORT CCD LINE IS REALIZABLE, IDEAL APPLICATION OF CCD TECHNOLOGY.

* EXTENSIVE USE OF TEK-MADE ICs, SOME LASER-TRIMMED

* INTEGRATED KEYBOARD/DISPLAY SUBSTRATE. (ONLY TWO CIRCUIT BOARDS).

POSSIBLE MARKETS

* SERVICING OF A VERY WIDE RANGE OF ELECTRONIC PRODUCTS : ANALOG, DIGITAL, MECHANICAL, COMMUNICATIONS

* NEW HOBBYIST MARKET ?

* KEY TO 'UNLOCKING' NON-SCOPE USERS, THROUGH FAMILIARITY WITH CALCULATORS.

* ANTICIPATED SELLING PRICE : $500

BASIC MODES.

1) CALCULATOR. After pressing CALC key, the numeric display shows the x-register of a four-variable stack. Operation is RPN, chosen because of its suitability for the remaining functions of the instrument. All keys below the CALC key operate in the usual way. Registers 1 thro 4 are available and storage arithmetic is possible (STO+n, etc). Natural logarithm, exponential and square-root are provided as basic pre-programmed functions.

2) VOLTMETER After pressing VOLTS key, the numeric display shows the dc voltage measured on the left-hand probe. Full auto-ranging and auto-zero is employed, from

MAIN FEATURES

1) OSCILLOSCOPE

* Uses low resolution flat panel display (LED or LCD) of 25 X 31 elements
* Provides 20MHz bandwidth at any sensitivity from 400V FS TO 100mV FS
* Uses 32-stage CCD for single-shot waveform capture and "view-ahead-of-trigger" capability
* All operating conditions (vertical sensitivity, vertical offset, time scale, time delay, trigger level and trigger slope) are controlled digitally
* One set of operating conditions and one waveform can be stored; following a recall operation the new and old waveforms are presented simultaneously, facilitating comparison.

low-capacitance

* Two, passive probes, one always used for voltage measurements, the other always used for timing inputs.

2) VOLTMETER

auto-polarity, auto-zeroed

* A single, six-digit display window (±199,999V) provides constant 1mV resolution and aids instant appraisal of magnitude.

FORECASTED IC INVOLVEMENT IN 'WINDOW-BOX'

This is a summary. Full details cannot be provided until system development is more mature. However, a description of the currently-perceived system architecture is being prepared. Numbers correspond to those on tentative schematic.

1. Programmable pre-amplifier. Approx 45 transistors. Requires SHF III with laser trimming.
2. Differential 40-stage CCD. Tek CCD process
3. 5-bit A-D converter. Will use a commercial 8-bit SAR-ADC in chip form.
4. Waveform RAM. Requires <512 bits. Commercial CMOS may be available. However, special organization, plus possibility for integrating this into either the Control System or the Pseudo-random Display System, might make it part of these TEK-made circuits.
5. Trigger Recognizer. Standard process circuit
6. Timebase system. Very complex requirements needing LSI SHF III implementation.
7. Control System. This can be either an MSI standard-process circuit, or extended to include the waveform RAM, in which case it would use CMOS.

8-10 Pseudo-random Transformation Logic. An LSI system, interface-limited so as to probably need 3 CMOS circuits, possibly only two.

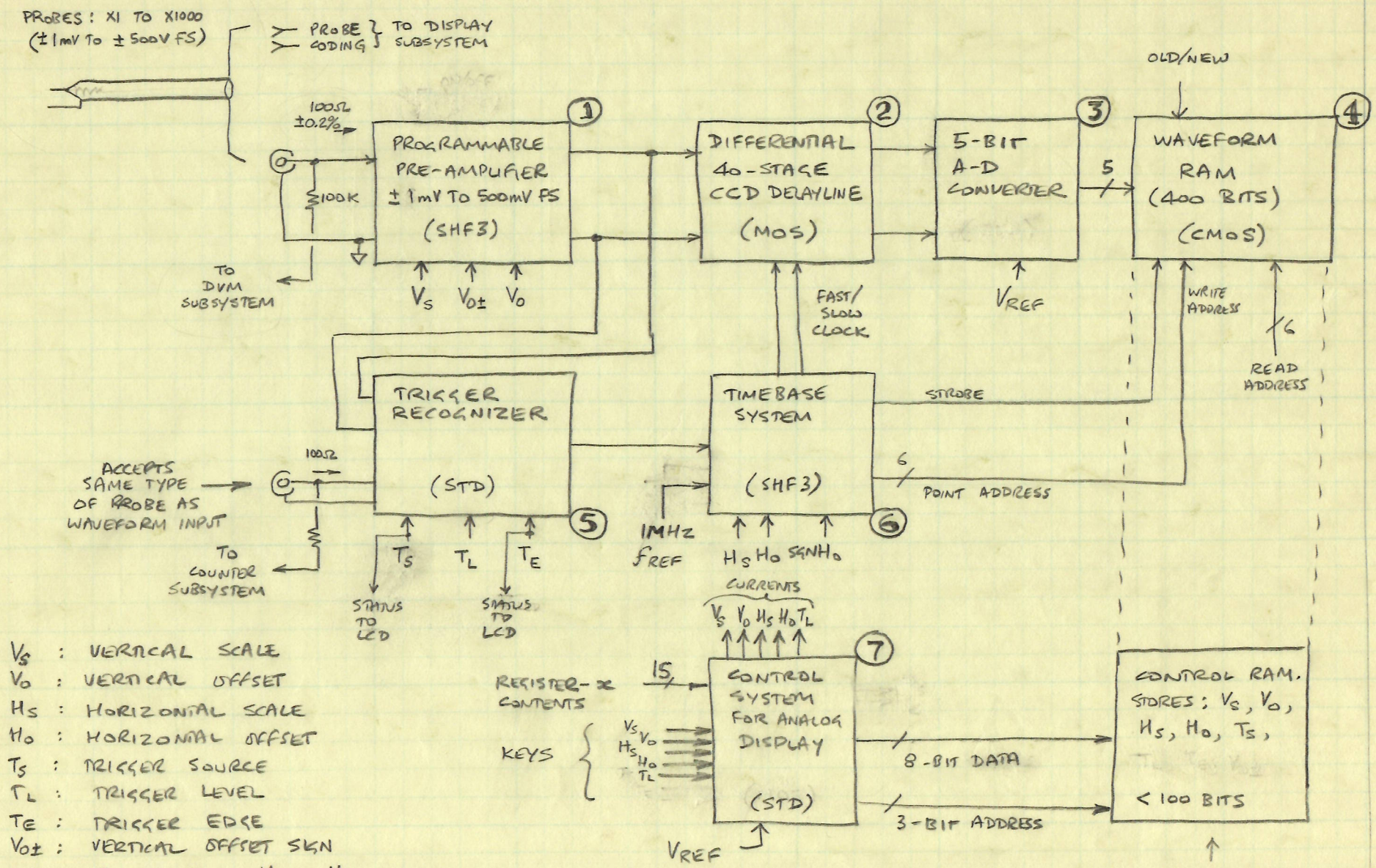
11. Calculator. Every endeavor would be made to use a commercial part here. Possible contenders are National's MM57103 or their MM5781/2 Controller-Oriented Processor, the latter being a two-chip set.

12. Keyboard/Display Scanner. This provides special interfacing needed for full set of keys and dual-source digital-display data. It also includes decimal-point-adjusting logic. Tek-made CMOS

13. DVM/Counter Subsystem and Time Reference. This is a CMOS circuit containing the DVM analog front-end, BCD counters with latches for count accumulation, mode logic and all remaining clocking functions. Preferably CMOS, but might be I^2L.

14. Power Converter. This accepts the basic 3.5V input from the NiCd Battery-pack and delivers +8.75V MOS circuits, -2.5V to SHF III circuits in waveform acquisition system and a precise +1.25V for DVM system. Uses standard process with laser trimming.

15. 30MHz Pre-scaler. Used in counter/frequency-meter modes. SHF III

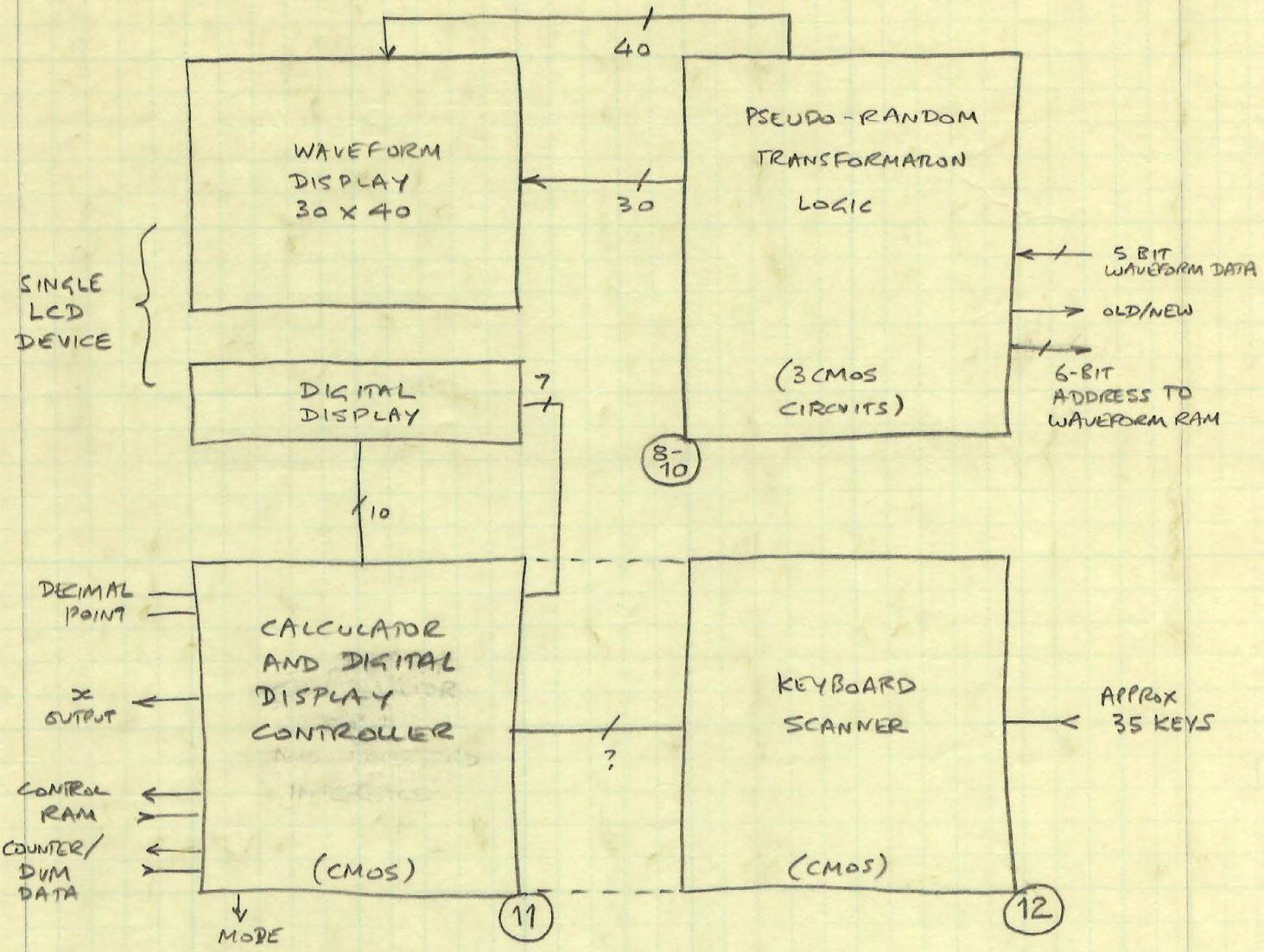


V_S : VERTICAL SCALE
V_O : VERTICAL OFFSET
H_S : HORIZONTAL SCALE
H_O : HORIZONTAL OFFSET
T_S : TRIGGER SOURCE
T_L : TRIGGER LEVEL
T_E : TRIGGER EDGE
$V_{O\pm}$: VERTICAL OFFSET SGN

WAKE-UP STATUS : $V_S = H_S =$ MAX
$V_O = H_O = T_L =$ ZERO
$T_S =$ INTERNAL
$T_E = V_{O\pm} =$ POSITIVE

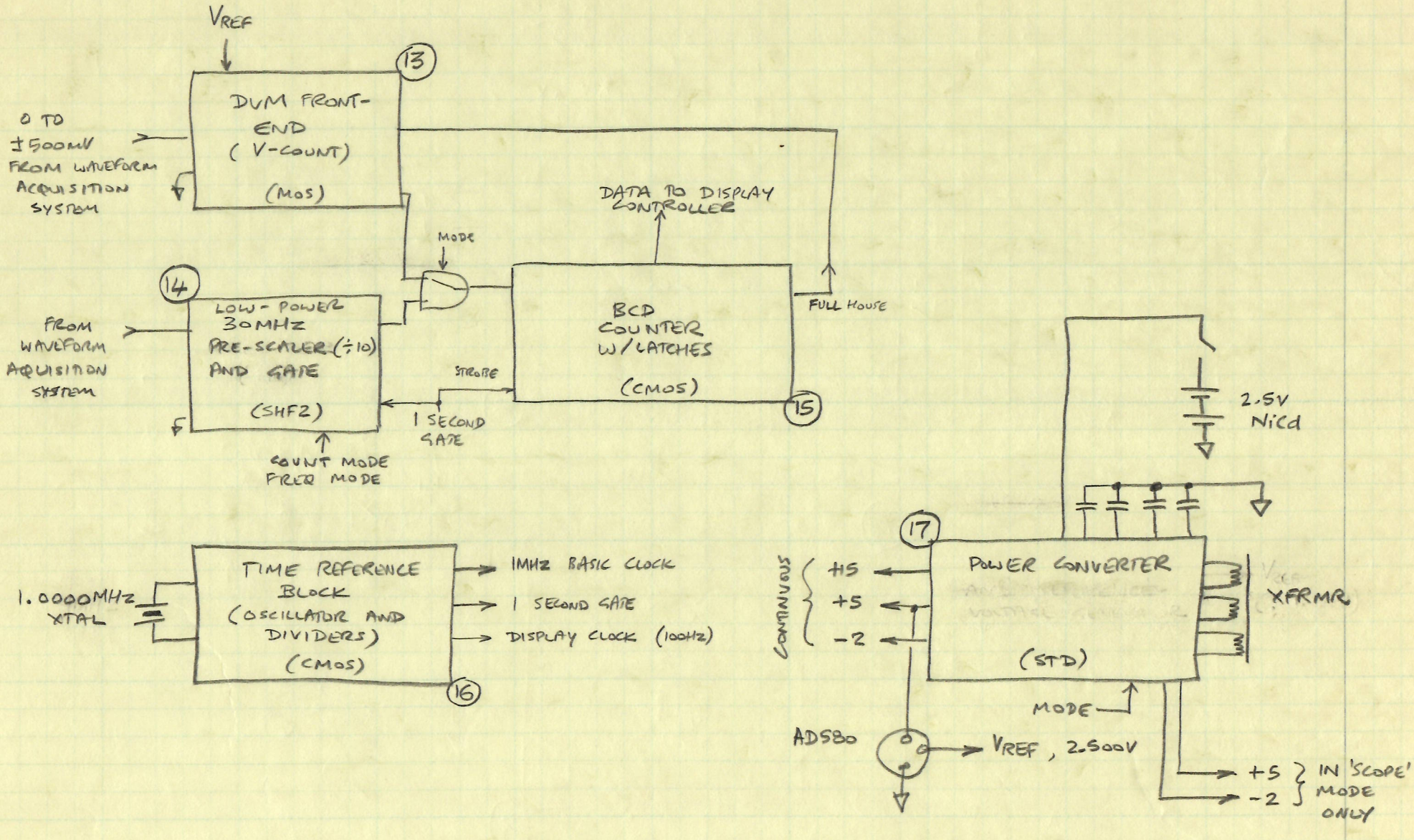
WINDOW BOX :

WAVEFORM ACQUISITION SYSTEM



WINDOW-BOX :

DISPLAY CONTROLLER, KEYBOARD AND CALCULATOR (ALL DIGITAL)



WINDOW-BOX: DVM/COUNTER AND BASIC REFERENCES.