# TESTER TG2402 Mk. II

(P.O. CODE No. 313825)

## OPERATING MANUAL

TREND COMMUNICATIONS LTD
ST. JOHN'S ESTATE
TYLERS GREEN
HIGH WYCOMBE
BUCKS
ENGLAND

PHONE: PENN (049 481) 3721
GRAMS: TREND HIGH WYCOMBE
TELEX: 83625
A/B: TREND DATA TYGN
PUB NO: TD 430

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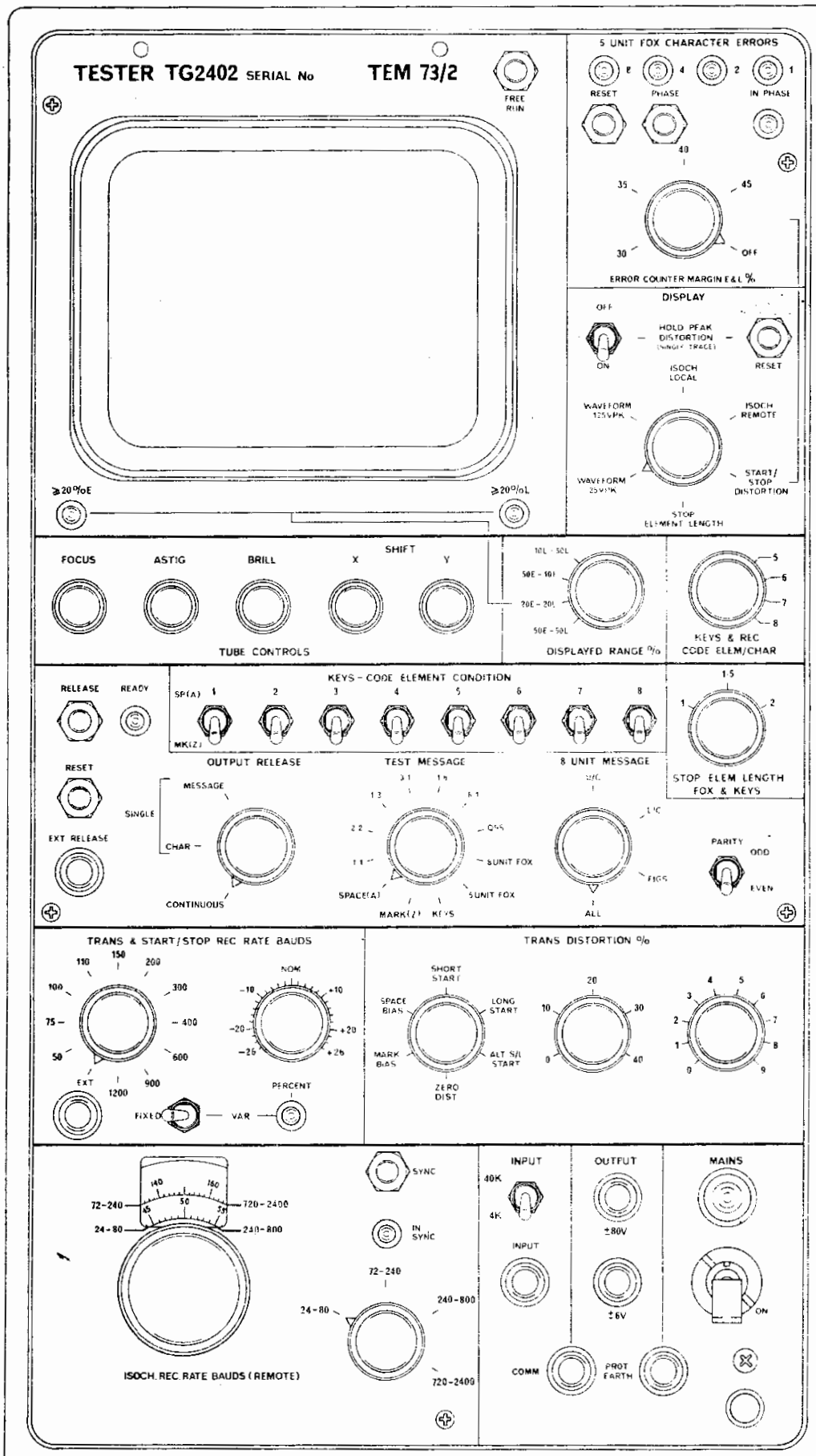

TESTER TG2402 SERIAL No
TEM 73/2
FREE RUN
5 UNIT FOX CHARACTER ERRORS
RESET
PHASE
IN PHASE
ERROR COUNTER MARGIN E & L %
DISPLAY
HOLD PEAK DISTORTION
ISOCH LOCAL
ISOCH REMOTE
START/ STOP DISTORTION
STOP ELEMENT LENGTH
≥20%E
≥20%L
FOCUS
ASTIG
BRILL
SHIFT
X
Y
TUBE CONTROLS
DISPLAYED RANGE %
KEYS & REC CODE ELEM/CHAR
RELEASE
READY
KEYS - CODE ELEMENT CONDITION
OUTPUT RELEASE
TEST MESSAGE
8 UNIT MESSAGE
STOP ELEM LENGTH FOX & KEYS
EXT RELEASE
SINGLE
MESSAGE
CHAR
CONTINUOUS
5 UNIT FOX
FIGS
ALL
PARITY
ODD
EVEN
TRANS & START/STOP REC RATE BAUDS
NOM
EXT
FIXED
VAR
PERCENT
TRANS DISTORTION %
SHORT START
SPACE BIAS
LONG START
MARK BIAS
ALT S/L START
ZERO DIST
ISOCH. REC. RATE BAUDS (REMOTE)
SYNC
IN SYNC
72-240
24-80
240-800
720-2400
INPUT
OUTPUT
MAINS
40K
4K
±80V
±6V
ON
COMM
PROT EARTH

CONTENTS

# 1.0 GENERAL DESCRIPTION

## 1.1 Outline of Use

The Tester TG2402 is a portable, mains operated Telegraph Distortion Measuring Set (TDMS) for use in mcvft terminals, TAS centres, Telex exchanges, teleprinter maintenance centres and workshops and electronic repair centres etc.

The tester contains a receiver and a transmitter complete with internal signalling supplies of ±6v and ±80v.

The receiver can be used for waveform monitoring, measurement of start/stop or isochronous distortion, or for the measurement of stop element length. Speed error can be detected and character errors can be counted when receiving the 5 unit 'fox' test message.

The transmitter produces test signals of various patterns and messages. Predetermined amounts of start element or bias distortion can be introduced.

## 1.2 Outline of Construction

The tester construction is of extruded aluminium side and rear panels with a cast aluminium front panel frame. Both side panels are finished in light aircraft grey acrylic textured paint and are cut from a length of extrusion. This has been designed to provide board guide location for a mother board, and captive screw channelling for mounting some of the larger power supply components.

The rear panel extrusion provides support for three plug in printed circuit boards and has two mounting plates for power transistors with external cooling fins for heat dissipation. It has a black anodised finish.

The front panel frame is made from a precision sand casting and supports a 1/8" aluminium plate upon which the front panel components are mounted. A 22 swg high purity decorative aluminium plate covers both casting and component plate to provide front panel control annotation.

Strengthening between front and rear at the top of the tester is achieved by a handle support bracket, positioned above the centre of gravity of the tester.

Four covers, finished in black acrylic textured paint, encompass the tester. The two side covers are held in position by Dzus fasteners. The bottom cover carries the tester feet and stand. The front cover, used only in non-operational conditions, houses the mains lead and plug and is held in place by three toggle catches.

1.3 Introduction to Mk.II Tester

The Mk.II tester differs from the Mk.I only in minor respects.

The means by which the basic 1% divisions are obtained is slightly different. This is described briefly in Chapter 4 and does not effect the operation of the tester in any way. Two existing features of the tester have been made strappable options. These are described in paras.3.1.4 and 3.1.5.

An additional facility has been provided on the Data Logger socket (pin 15) and certain spare logger socket pins have been terminated. (See Table 2 ).

2.0 T.D.M.S. SPECIFICATION

2.1 Transmitter

2.1.1 Start Stop

2.1.1.1 Signalling Rates

- Continuously variable fram 37.0 to 1512 bauds with an accuracy of 2% and a stability better than 1% over any 30 sec. period.
- Fixed speeds of 50, 75, 100, 110, 150, 200, 300, 400, 600, 900 and 1200 bauds are provided to an accuracy of ±0.1% with o stability better than 0.1% over any 30 sec. period for speed checking.
- External timing input of ±6V square wave at a frequency numerically equal to the required bit rate.

  NB Use of this facility prevents use of the start/stop receiver and distortion generating circuits.

2.1.1.2 Test Messages

- Eight element switching keys capable of generating any character of 5, 6, 7 or 8 code elements.
- "Q.B.F." message using international alphabet number 5, with front panel selection for upper case, lower case, figures, and all three lines in sequence with odd or even parity.
- "Q.B.F." message using international alphobet No.2.

  The 5 UNIT FOX message is as follows:

  LF CR LF CR LTRS THE SP QUICK SP BROWN SP FOX SP JUMPS SP OVER SP THE SP LAZY SP DOG SP FIGS 1234567890

2.1.1.2 Test Messages continued

- The 3 lines of the 8 UNIT FOX message are as follows:

  Line 1 LF CR LF CR THE SP QUICK SP BROWN SP FOX SP JUMPS SP OVER SP THE SP LAZY SP DOG

  Line 2 LF CR LF CR the SP quick SP brown SP fox SP jumps SP over SP the SP lazy SP dog

  Line 3 LF CR LF CR SP ! " £ $ % & ' ( ) * + , - . / 0123456789:;<=> ? @ [ \ ] ^ _ ` { | } ~ DELETE

  Each line of the "QBF" messages is preceded by LF, CR, LF, CR characters, plus an optional 200 ms period of stop polarity. The first pair of LF, CR characters are not subject to the distortion of para. 2.1.1.4.

2.1.1.3 Output Release

- Single character, single message or continuous operation may be selected and released by a start button or external release signal of between +6 and +80 volts.

2.1.1.4 Distortion

- Short start, long start, alternate short/long start, or bias distortion may be imposed on the above messages in 1% steps up to 49%.

2.1.1.5 Stop Element

- Stop element length may be set to 1, 1½ or 2 elements.

2.1.1.6 Low Level Output

- ±6V for 3000 to 7000 ohm loads.

2.1.1.7 High Level Output

- ±80V ±6% when working into a 6K ohm load.
- 100mA maximum short circuit current limit.
- 500mV maximum ripple when working into a 5K ohm load.
- 96V maximum output under any condition.
- 4V maximum deviation between +ve and -ve supplies.

2.1.2 Isochronous

2.1.2.1 Signalling Rates

- As quoted in paragraph 2.1.1.1.

2.1.2.2 Signalling Levels

- As quoted in paragraph 2.1.1.6 and 2.1.1.7.

2.1.2 Isochronous continued

2.1.2.3 Test Signal Patterns
- Binary Z (Negative polarity, Mark Condition)
- Binary A (Positive polarity, Space Condition)
- Signals with binary Z to A ratio 1:1
- Signals with binary Z to A ratio 2:2
- Signals with binary Z to A ratio 1:3
- Signals with binary Z to A ratio 3:1
- Signals with binary Z to A ratio 1:6
- Signals with binary Z to A ratio 6:1
- "Q9S" test message CCITT Rec R51
- The Q9S message is as follows:

  LTRS S CR LF Q FIGS SP 9

2.1.2.4 Distortion
- The above test signals may be subjected to bias distortion of either polarity from 0 to 49% in 1% steps.

2.1.2.5 Output Release
- As quoted in paragraph 2.1.1.3 for the "Q9S" test message.

2.2 Receiver

2.2.1 Start Stop

2.2.1.1 Input Signalling Rates
- As quoted in paragraph 2.1.1.1.

2.2.1.2 Input Signals
- 5, 6, 7 or 8 code elements per character.

2.2.1.3 Display Facilities
- Input waveform, maximum amplitude 125Vpk.
- Input waveform, maximum amplitude 25Vpk.
- Elements separated start stop distortion display with optional single trace hold peak facility.
- Stop element length display.
- x Scan expand on all displays.
- Indication of transition polarity.

2.2.1 Start Stop continued

| | | |
|---|---|---|
| 2.2.1.4 | Input | - Input threshold ±3.5V.<br>- Maximum input 125V peak.<br>- Input Resistance 4K ohms or 40K ohms. |
| 2.2.1.5 | Character Error Counter | - Maximum of 15 character errors in the 5 unit Q.B.F. message.<br>- Distortion margin variable between 30% and 45% in 5% steps to an accuracy of ±1%.<br>- Automatic phasing after push button operation. |
| 2.2.1.6 | Accuracy of Measurement | - ±0.25% for transition distortion up to 50% early or late.<br>- Input speed error detected with an accuracy better than 0.75% when compared with the fixed speeds of paragraph 2.1.1.1. |

2.2.2 Isochronous

| | | |
|---|---|---|
| 2.2.2.1 | Input Signalling Rates | - For 'local' working the speeds are as quoted in paragraph 2.1.1.1.<br>- For 'remote' working the speed is continuously variable from 24 to 2400 bauds in four bands, with an accuracy of 1% and a stability better than 1% over any 30 sec. period. |
| 2.2.2.2 | Display Facilities | - Input waveform, maximum amplitude 125V peak.<br>- Input waveform, maximum amplitude 25V peak.<br>- Single trace distortion measuring display for isochronous 'local' working with optional hold peak facility.<br>- Single trace distortion measuring display for isochronous 'remote' working with optional hold peak facility.<br>- x Scan expand on all displays.<br>- Indication of transition polarity. |
| 2.2.2.3 | Input | - As quoted in paragraph 2.2.1.4. |

2.2.2 Isochronous continued

| | | |
|---|---|---|
| 2.2.2.4 | Accuracy of Measurement | - ±0.5% for isochronous and bias distortion up to 100% (±0.25% for individual distortion up to 50%). |
| 2.2.2.5 | Synchronisation | - Synchronism may be achieved to any of the test patterns in paragraph 2.1.2.3 which may be distorted but must have a speed stability of 0.1% over any 30 sec. period. Synchronism will be maintained over signal breaks of up to 500ms. |

TABLE 1

TERMINAL BLOCK CONNECTIONS

| | |
|---|---|
| 1. | Protective Earth |
| 2. | Common Return |
| 3. | ±6V Output |
| 4. | ±80V Output |
| 5. | Input |

Ref. para. 3.1.2.

TABLE 2

DATA LOGGER CONNECTIONS

| Pin No. | Signal | Tester In/Out | Specification |
|---|---|---|---|
| 1 | - | - | - |
| 2 | - | - | - |
| 3 | Received Data | OUT | +5V for 'Space', 0V for 'Mark' |
| 4 | Character Error Pulse | OUT | See Note 1 |
| 5 | +5V | OUT | See Note 3 |
| 6 | +5V | OUT | See Note 3 |
| 7 | Common Return | - | 0V |
| 8 | +5V | OUT | See Note 3 |
| 9 | - | - | - |
| 10 | Character Pulse | OUT | See Note 2 |
| 11 | - | - | - |
| 12 | - | - | - |
| 13 | - | - | - |
| 14 | - | - | - |
| 15 | Receiver Phase Indication | OUT | +5V IN PHASE, 0V normal |
| 16 | - | - | - |
| 17 | Receiver Signal Element Timing | OUT | See Diag.1and Note 7 |
| 18 | "B.C.D. $\frac{1}{2}$" | OUT | See Diag.1 and Note 6 |
| 19 | +5V | OUT | See Note 3 |
| 20 | Re-phase Receiver Control | IN | 0V for REPHASE, O/C normal |
| 21 | - | - | - |
| 22 | - | - | - |
| 23 | 0V | - | See Note 3 |
| 24 | - | - | - |
| 25 | Reset Peak Distortion Store | IN | +5V or +6V RESET, 0V or -6V COUNT |
| 26 | B.C.D. 1 | OUT | ) |
| 27 | B.C.D. 2 | OUT | ) |
| 28 | B.C.D. 4 | OUT | ) |
| 29 | B.C.D. 8 | OUT | )See Diag.1 and Note 6 |
| 30 | B.C.D. 10 | OUT | ) |
| 31 | B.C.D. 20 | OUT | ) |
| 32 | B.C.D. 40 | OUT | ) |
| 33 | - | - | - |
| 34 | Distortion Read Out Timing | OUT | See Diag.1 and Note 4 |
| 35 | 0V | - | See Note 3 |
| 36 | Error Counter Stop/Run | IN | +5V or +6V STOP, 0V or -6V RUN. Note 5 |
| 37 | 0V | - | See Note 3 |

Note 1 The pulse on pin 4 is a negative going pulse between +5V and 0V, cammencing an detection of an error and ending at the end of the character with that error. The output from pin 4 is not terminoted by the loss of phase indication or by the maximum count being reached or by the signal on pin 36.

Note 2 The pulse on pin 10 is a positive going pulse between 0V and +5V commencing at the beginning of a valid incoming start element and ending half an element after the last code element of the same character. When receiving isochronous signals, pin 10 remains at +5V.

Note 3 These pins provide terminations for idle data logger inputs. Those shown as +5V are connected to +5V via 1000 ohm resistors.

Note 4 The pulse on pin 34 is a negative going pulse between +5V and 0V with a duration of 0.25% of a bit beginning with the start of the $\frac{1}{2}$% interval following each transition detected. Diag.1 shows the position of this pulse for a transition occurring between $\frac{1}{2}$% early and 1% early.

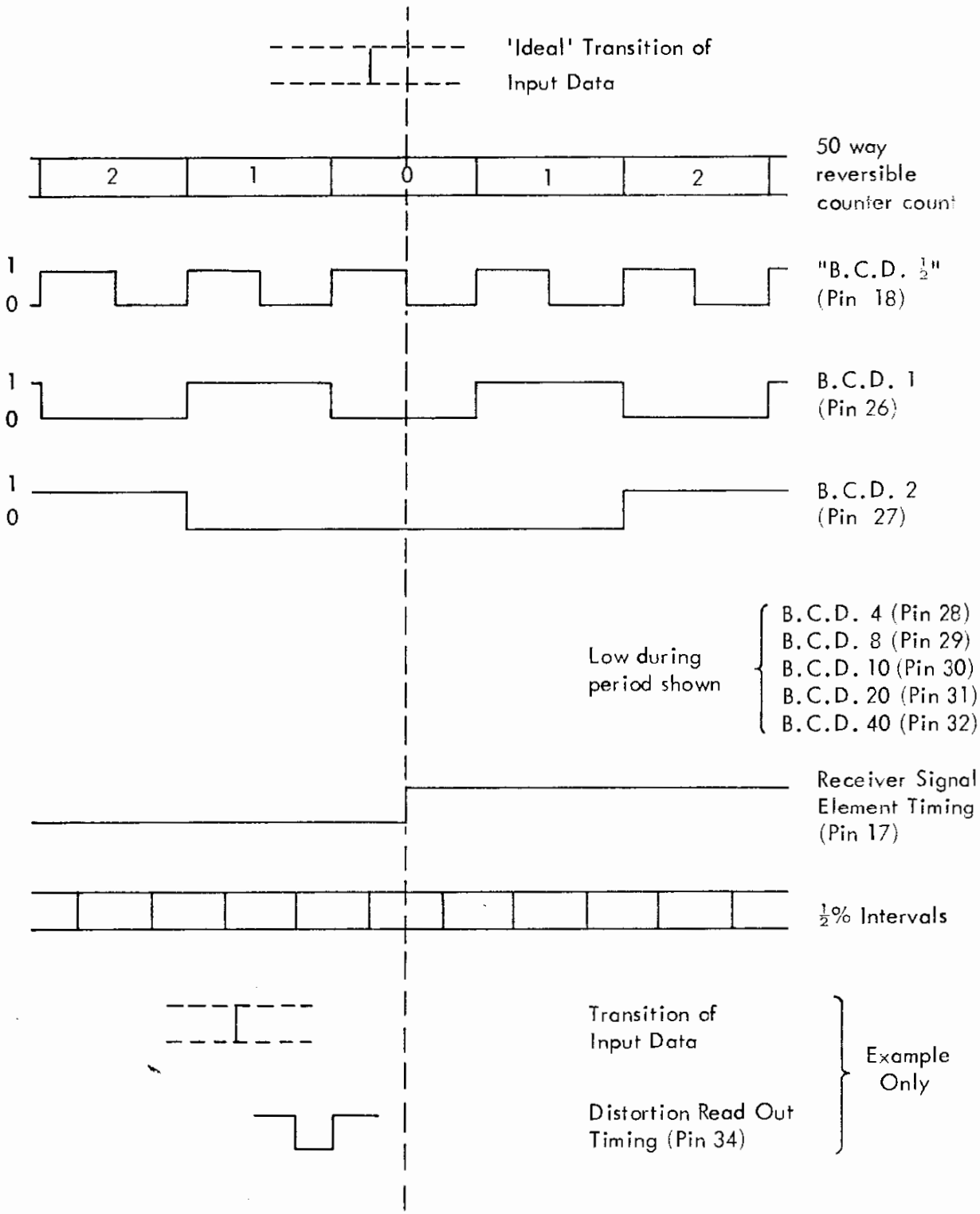
Note 5 When the error counter is allowed to run, it continues from the total at which it was stopped. The pulses on pin 4 are not effected by the signal on pin 36.

Note 6 The signals on pins 26 to 32 are the Binary Coded Decimal outputs from the 50 way reversible counter. A binary '1' is represented by +5V and a binary '0' by 0V. The timing and sequence of the counter count with reference to the 'ideol' transition time is as shown in Diag.1. The signal on pin 18 defines the $\frac{1}{2}$% steps necessary for the meosurement accuracy required.

Note 7 The signal on pin 17 has a '1' to '0' ratio of 1:1 with each positive going edge (from 0V to +5V) coincident with the centre of Count 0 (See Diag.1). The idle condition is '0'.

DIAG. 1

OUTPUT WAVEFORMS TO DATA LOGGER



2.3 Power Supplies

2.3.1 Mains Input - 190-250v rms 50/60Hz without tap change.

2.3.2 Power Consumption - 55VA

2.3.3 Fuse - Mains input:- 1A anti surge P.O. Fuse No.72/1.

- +5 Volt supply:- 5A P.O. Fuse No. 73/5.

2.4 Dimension

2.4.1 Size - Width 8-11/16" (221mm)

- Height 16" (406mm)

- Depth 14-9/16" (370mm) Excluding front cover

2.4.2 Weight - 36.5lb (16.5 kg) approximately

2.4.3 External Finish - Rear Panel Black anodised

- All Covers Black acrylic paint

- Sides Light aircraft grey acrylic paint

2.5 Operational Condition

2.5.1 Temperature Range - 0°C to 40°C

2.6 Signalling Level Conventions

| Telegraph | | | | | Logic | | |
|---|---|---|---|---|---|---|---|
| Start | + | Space | O | A | 0 | 0v | Low |
| Stop | - | Mark | ● | Z | 1 | +5v (nom.) | High |

# 3.0 T.D.M.S. OPERATING INSTRUCTIONS

## 3.1 INSTALLATION

3.1.1 After removing the lid by undoing three catches, unwind the mains cable. Check thot the fuses are of the correct rating. (1 A onti-surge, P.O. 72/1 for moins, 5A P.O. 73/5 for the +5v line). The mains fuse is wired into the "LINE" (brown) lead of the mains cable, which must be connected correctly. The NEUTRAL le od of the mains cable is coloured blue. The EARTH (green/ yell ow) le ad of the mains cable must be connected to the supply mains earth. The tester may be used in any convenient position without loss of accuracy, provided air can circulate past the rear of the instrument.

3.1.2 If the instrument is to be used in a test desk, connections to Tag Block 4, beneath the left-hond side cover, should be made before the instrument is placed in the desk (see Table 1 ).

3.1.3 To prevent the tester triggering to interference pulses, a short start rejection facility can be opplied to each start/stop character received (and to the first start polarity element of an isochronous messoge). See Fig.1.

When the input goes positive (start polarity), the tester detects negative pulses occurring during the period equivalent to the first 30% of a full length start element. If a negative pulse of a length exceeding the preset limit occurs, the tester resets and immediately recommences the process.

The length of the negative pulse which will cause rejection can be preset to o period equivalent to either 10% or 5% of a full length start element. Alternotively, the tester may be set to accept any positive pulse as a valid start element (no short start rejection).

During manufacture, the instrument is strapped to reject 5% negative pulses. If required, this may be altered as follows:

> For rejection of 10% negative pulses, neither LK1 nor LK2 on board 2 should be inserted. For rejection of 5% negative pulses LK1 should be inserted. For no short-start rejection, LK2 should be inserted.

3.1.4 When displaying start-stop distortion with the HOLD PEAK DISTORTION control OFF, the six horizontal lines of the display for 5 unit characters are normally given a greater vertical separation than for 6, 7 or 8 unit characters. During manufacture, the instrument is strapped to give this wider separation. However, if the tester is to be used mainly with low speed signals, the narrower separation can be used for the 5 unit display in order to reduce the subjective effects of flicker. This may be done by cutting the TRACE SEPARATION link on board 3.

FIG. 1 SHORT START REJECTION

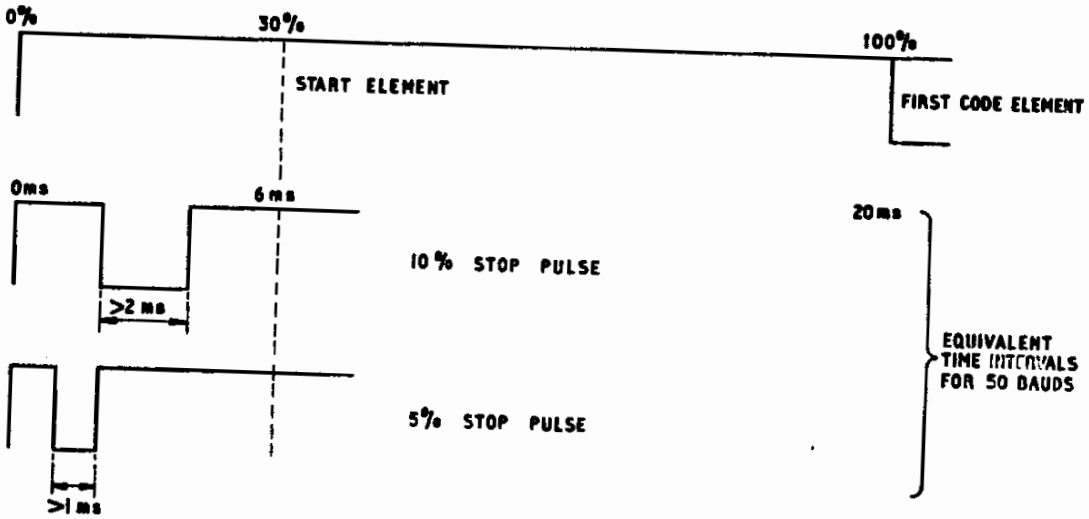
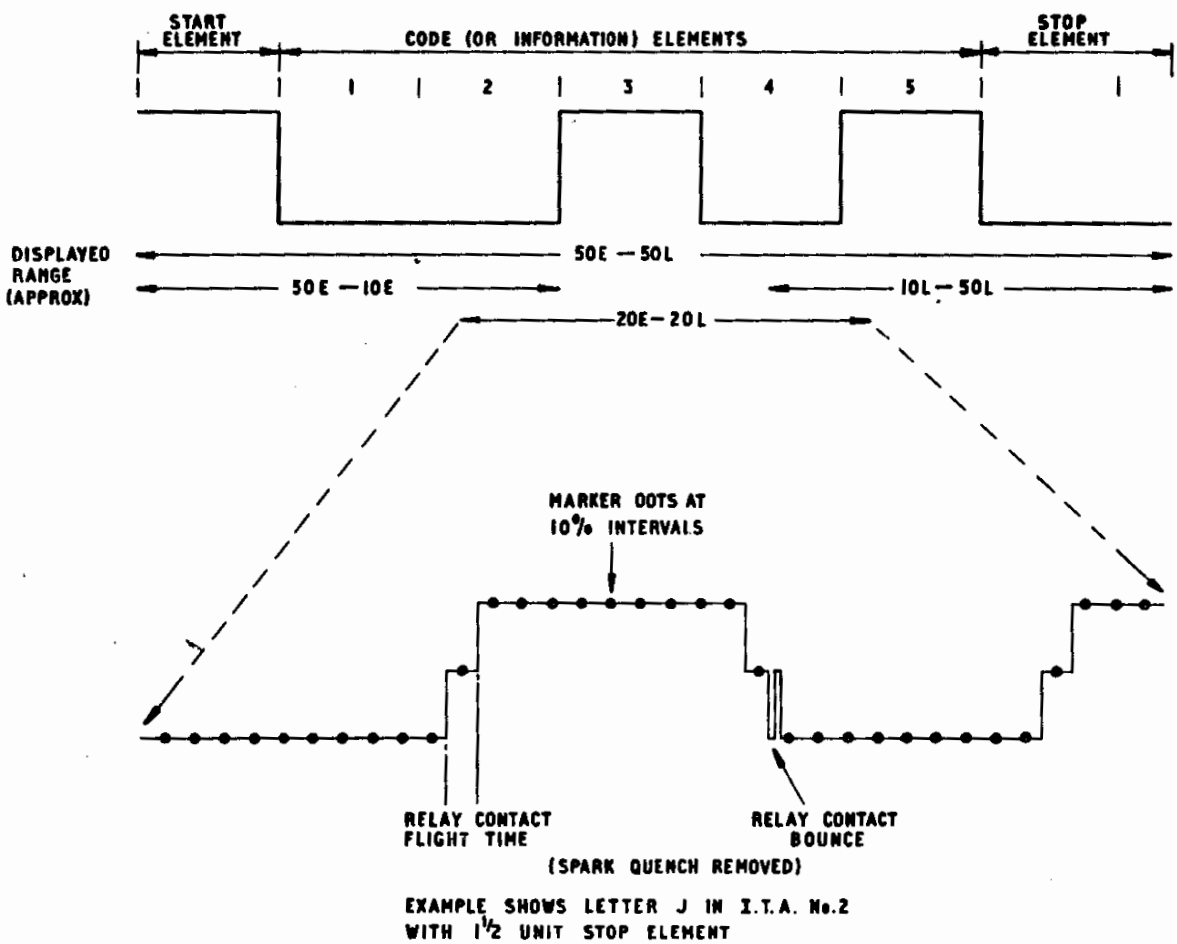



FIG. 2 WAVEFORM DISPLAY




EXAMPLE SHOWS LETTER J IN I.T.A. No.2
WITH 1½ UNIT STOP ELEMENT

## 3.1 INSTALLATION continued

3.1.5 As stoted in para.2.1.1.2 each line of the 'QBF' messages may be preceded by a 200ms period of mark polarity. This is to allow time for the carriage to return on high speed teleprinters etc.

During manufacture the instrument is strapped to include the 200ms mark period. However, if the QBF messages are required to be used as isochronous signals, the mark period may be removed by inserting the NO 200 ms BREAK link on board 1.

## 3.2 TRANSMITTER OPERATION

3.2.1 Connect the tester to a suitable A.C. mains supply and check that the mains neon indicator glows. Switch the MAINS switch to ON.

3.2.2 Set the TRANS & START/STOP REC RATE controls to the required speed, using the VAR control if necessary (see table below for typical settings of VAR control).

| | TRANS & START/STOP REC RATE | |
|---|---|---|
| Required speed (bauds) | Fixed | Var. |
| 45½ | 50 | - 9% |
| 61½ | 50 | + 23% |
| 82 2/7 | 75 | + 9% |
| 96 | 100 | - 4% |
| 123 3/7 | 100 | + 23% |
| 134½ | 110 | + 22% |
| 192 | 200 | - 4% |

3.2.3 Set the OUTPUT RELEASE control to CONTINUOUS, and the TEST MESSAGE control to the desired message. If the 8 UNIT FOX message (I.T.A. No.5) is required, set the 8 UNIT MESSAGE control to the appropriate position. (Upper case, Lower case, Figures or ALL) and the PARITY switch to ODD or EVEN, as required. For either FOX message or KEYS set the STOP ELEMENT LENGTH, FOX AND KEYS control to the desired length. If the TEST MESSAGE control is set to KEYS, the length of character must be selected on the KEYS & REC CODE ELEM/CHAR control, and the desired character set up on the KEYS-CODE ELEMENT CONDITION controls. A start element will automatically be added.

3.2.4 Set the TRANS DISTORTION % controls to the required magnitude of the appropriate type of distortion. N.B. Start element distortion has no effect on the 1:1, 2:2, 1:3, 3:1, 1:6 or 6:1 patterns. It does slightly affect the character rate as the stop element length is unaltered.

3.2.5 Take the signal output from either the ±80v terminal (telegraph) or the ±6v terminal as appropriate, and connect the "telegroph earth" or "signal common" wire to the "COMM" terminal.

3.2.6 If a continuous data output is not required, set the OUTPUT RELEASE control to SINGLE MESSAGE or SINGLE CHARACTER. The output will remain in the "Mark" (stop-polority) condition until a release signal is applied, either by depressing the RELEASE button, or from an external source via the EXT RELEASE terminal. (A signal greater than +3v is required, which must be free of contact bounce after the end of the released character.)

3.2.7 After a release signal has been applied, the tester will transmit a message or character, as appropriate. If the TEST MESSAGE control is set to 1:1, 2:2, 1:3, 3:1, 1:6 or 6:1, the transmission will continue until a reset signal is applied (by depressing the RESET button). If the TEST MESSAGE control is set to KEYS, a single character will be transmitted on both SINGLE MESSAGE and SINGLE CHARACTER positions of the OUTPUT RELEASE control. At the end of each charocter or message, the output remains in the "Mark" (stop polarity) condition.

3.2.8 If, during the transmission, the RESET button is depressed, the output will reset to the "Mark" (stop polarity) condition. If the OUTPUT RELEASE control is set to CONTINUOUS, the transmission will restort when the RESET button is released. If the OUTPUT RELEASE control is set to either of the other positions, a release signal will be required to restart the transmission.

3.2.9 If, during the transmission, the OUTPUT RELEASE control setting is changed, the transmission will be controlled by the new setting.

## 3.3 RECEIVER OPERATION

3.3.1 Connect the tester to a suitable A.C. mains supply and check that the mains neon indicator glows. Switch the MAINS switch to ON, and wait for a few minutes while the CRT heater warms up.

3.3.2 Set the INPUT control to 40k for "monitor" type measurements (when the tester is used to monitor data traffic on a through circuit), or to 4k for "terminated" type measurements (when the tester is used to terminate a data line or other signal source).

3.3.3 Connect the input signal (of between ±6v and ±80v nominal) to the INPUT terminal, and the "telegraph earth" or "signal common" to the COMM terminal.

3.3.4 WAVEFORM DISPLAY (FIG.2)

3.3.4.1 Set the DISPLAY control to WAVEFORM, 125V PK or 25V PK as required. Set the DISPLAYED RANGE control to 50E-50L. Set the TRANS & START/STOP REC RATE control to the nominal speed of the incoming data, using the VAR control if necessary.

3.3.4.2 Each sweep of the display is triggered by the leading edge of a "Space" (Start polarity) element, the number of elements displayed being controlled by the KEYS & REC CODE ELEM/CHAR control.

3.3.4.3 For start/stop characters, set the KEYS & REC CODE ELEM/CHAR control to the appropriate setting (e.g. 5 for I.T.A. No.2). The display will then show a complete character.

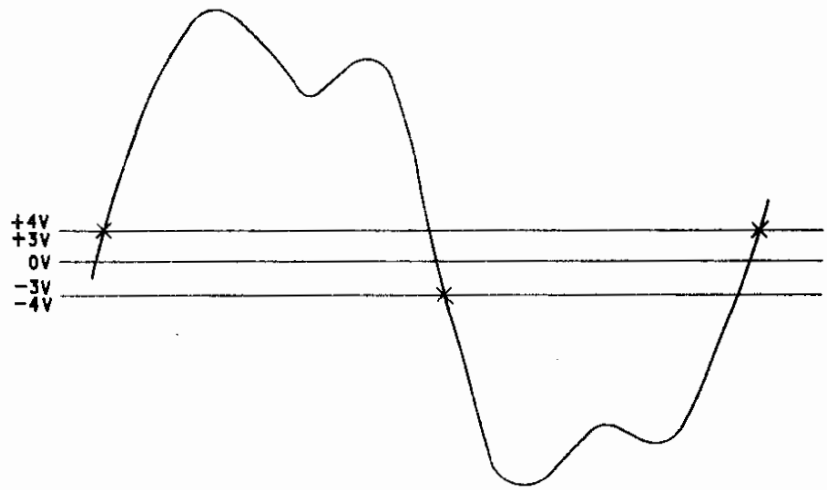
3.3.4.4 For isochronous signals, any convenient setting of the KEYS & REC CODE ELEM/CHAR control may be used.

3.3.4.5 Adjust the CRT controls (FOCUS, ASTIG, BRILL) to obtain the best display and adjust the X and Y SHIFT controls to bring the display into a convenient position.

3.3.4.6 The vertical amplitude of the display is a measure of the signal voltage swing. If the DISPLAY control is set to WAVEFORM 125V PK, an 80-0-80v signal will produce a display amplitude of approximately 2" PK-PK. If the DISPLAY control is set to WAVEFORM 25V PK, a 6-0-6v signal will produce a display amplitude of approximately $\frac{3}{4}$" PK-PK.

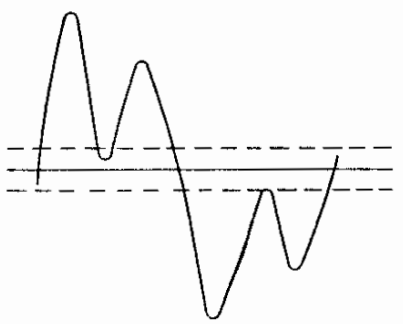
3.3.4.7 The DISPLAYED RANGE control may be used to expand the first, middle, or last 40% of the display. With the display expanded, the BRILL control setting may be adjusted to display marker dots at 1/10 element intervals, (e.g. 2ms @ 50 bauds) beginning as the input signal exceeds the input threshold of $3\frac{1}{2}$v on the leading edge of the first displayed element. These markers enable measurements of contact bounce and flight time to be made.

FIG.3 INPUT THRESHOLD




RECONSTITUTED DATA

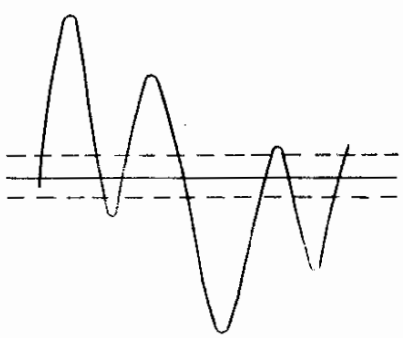
THE THRESHOLD IS 3½V WITH A TOLERANCE OF ±½V
THE DIFFERENCE BETWEEN THE POSITIVE AND NEGATIVE THRESHOLD IS ≠½V



INPUT SIGNAL

"BOUNCE" OR "RINGING" NOT SHOWN ON DISTORTION DISPLAY

RECONSTITUTED DATA



INPUT SIGNAL

"BOUNCE" OR "RINGING" SHOWN ON DISTORTION DISPLAY

RECONSTITUTED DATA

3.3.5 DISTORTION DISPLAY (FIG.4)

The Distortion Display consists of 10% and 1% marker dots. With the correct setting of the BRILL control, the 10% dots appear brighter than the 1% dots. The ideal transition instant (0%) is indicated by the absence of a marker dot. Positive transitions are indicated by dots above the line of markers, and negative transitions by dots below the line. The DISPLAYED RANGE control enables either a full 100% or a selected 40% display to be presented.

3.3.6 TO MEASURE START/STOP DISTORTION

3.3.6.1 C.C.I.T.T. Definition 33.08. The degree of start/stop distortion is the ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and theoretical intervals separating any significant instant of modulation (or restitution), from the significant instant of the start element immediately preceding it.

3.3.6.2 Set the DISPLAY control to START/STOP DISTORTION. Set the DISPLAY, HOLD PEAK DISTORTION control to OFF. Set the DISPLAYED RANGE control to 50E-50L. Set the KEYS & REC CODE ELEM/CHAR control to the appropriate position (e.g. 5 for I.T.A. No.2).

3.3.6.3 Adjust the CRT controls (FOCUS, ASTIG, BRILL) for the best display and adjust the X and Y SHIFT controls to centralise the display.

3.3.6.4 For synchronous start/stop distortion measurements (measurement excluding speed error), set the FIXED/VAR control to VAR, and adjust the TRANS & START/STOP REC RATE, VAR control until the mean line of transition markers is vertical.

3.3.6.5 For asynchronous start/stop distortion measurements (including speed error) set the FIXED/VAR control to FIXED, and the TRANS & START/STOP REC RATE control to the nominal speed of the incoming data.

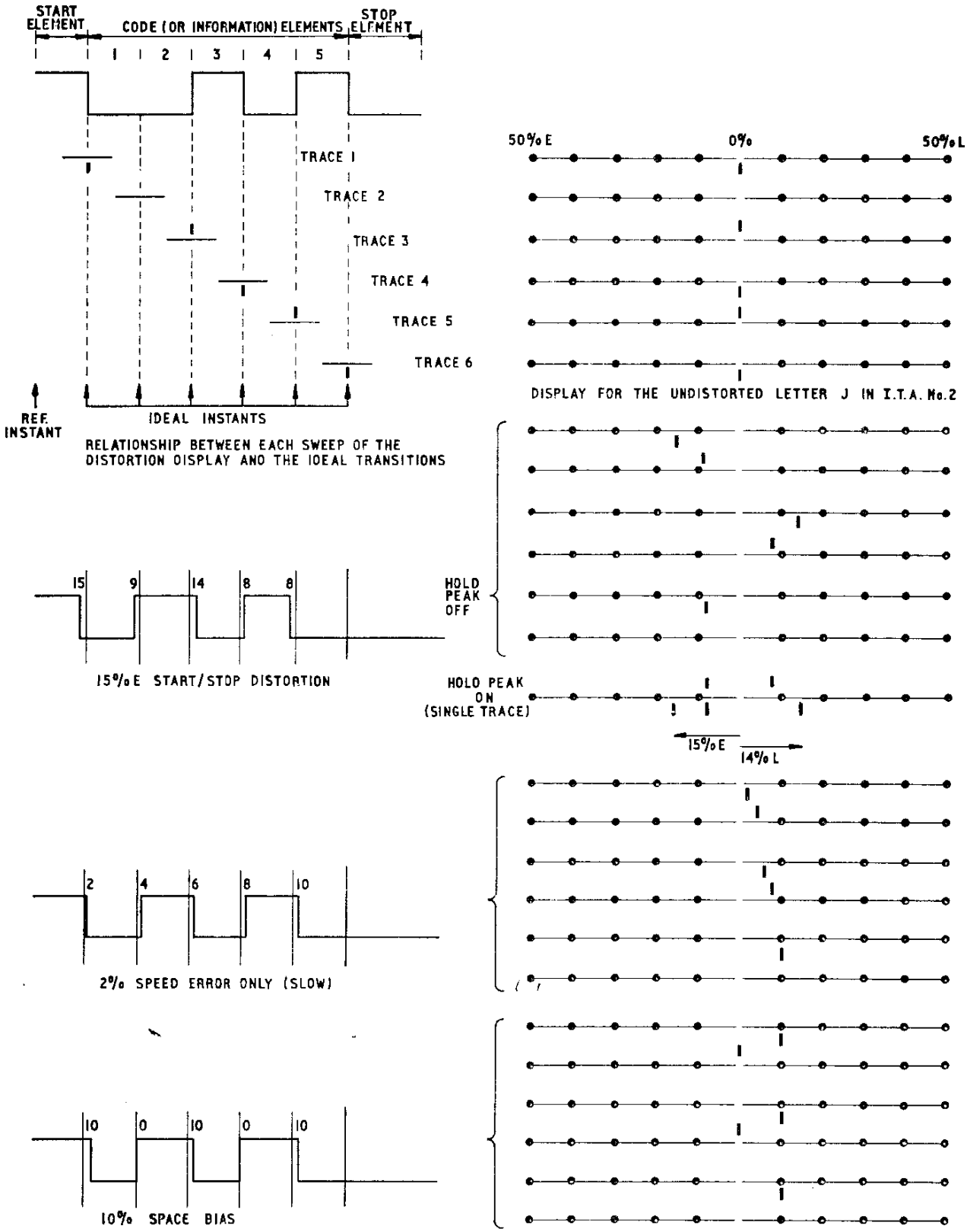
3.3.6.6 Operate the HOLD PEAK DISTORTION, RESET button.

3.3.6.7 Each line of the display corresponds to the period 50% early of an ideal transition point to 50% late of the ideal transition point. The top line corresponds to the first transition (between the start element and the first code element) and the bottom line corresponds to the last transition (between the last code element and the stop element).

3.3.6.8 To hold the peak distortion measured, set the DISPLAY, HOLD PEAK DISTORTION, control to ON. The display will then be a single line with additional markers indicating the peak distortion received (early left and late right). The polarity of these transitions is also indicated.

3.3.6.9 The DISPLAYED RANGE control may be used to examine more closely a selected portion of the display. If the control is set to 20E-20L, and a transition with distortion of 20% or greater is received, one or other of the 20% lamps will light, depending on whether the received transition is early or late.

FIG.4 START/STOP DISTORTION DISPLAY (10% CAL. DOTS ONLY SHOWN FOR CLARITY)



3.3.7 TO MEASURE STOP ELEMENT LENGTH (FIG.5)

3.3.7.1 Set the DISPLAY control to STOP ELEMENT LENGTH, and the DISPLAYED RANGE control to 50E-50L. Set the KEYS & REC CODE ELEM/CHAR control to the appropriate setting.

3.3.7.2 Set the TRANS & START/STOP REC RATE control as for synchronous or asynchronous start/stop distortion measurement (paras. 3.3.6.4, 3.3.6.5).

3.3.7.3 The ideal instant for the beginning of the stop element will be the 0% (blanked marker dot) point in the centre of the top line of the display. The leading edge of the next start polarity element will end the display. The stop element length is given by the total display length between these two points, e.g. for a $1\frac{1}{2}$ unit stop element, two complete lines of dots will be shown (assuming there to be no speed error) giving a length of 150% = $1\frac{1}{2}$ units from the centre of the first line.

3.3.8 TO COUNT CHARACTER ERRORS (FIG.6)

3.3.8.1 Ensure that the test signal source is a Tester TG 2402 with the TEST MESSAGE control set to 5 UNIT FOX.

3.3.8.2 Set up the Receiver as for the measurement of Start/Stop Distortion (paras. 3.3.6.1 to 3.3.6.5).

3.3.8.3 Set the ERROR COUNTER MARGIN control to the required receive margin. The incoming data is compared with an internally generated perfect signal. If the two are not of the same polarity at the instants defining the margin, an error is registered. Thus an error registers when the distortion of the incoming signal is greater than the margin set by more than $\frac{1}{4}$%.

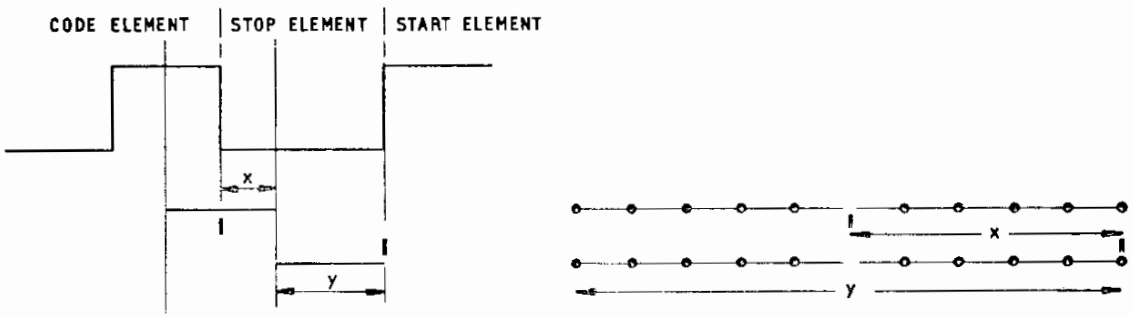
3.3.8.4 Operate the PHASE button and wait for the IN PHASE lamp to light. This may take several seconds at low speeds, as the IN PHASE lamp is lit at the end of the message.

3.3.8.5 Operate the RESET button to clear the Error Counter.

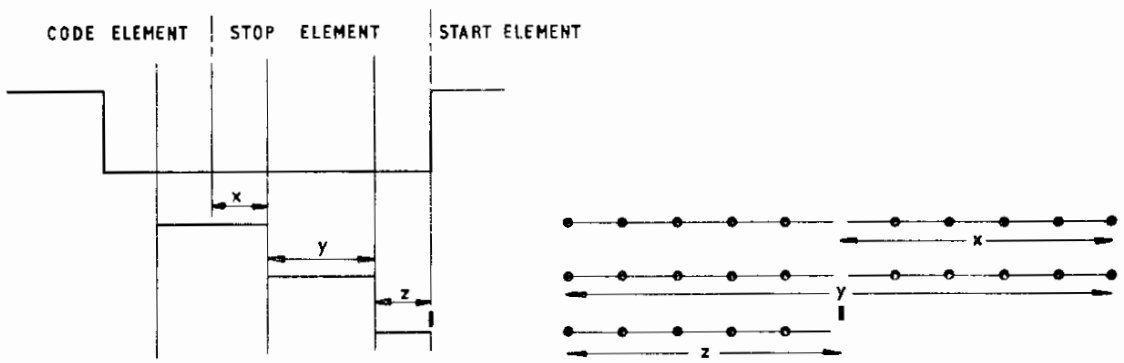
3.3.8.6 The Tester will count errors up to a maximum of 15. If any four consecutive characters have elements in error, the IN PHASE lamp will be extinguished, and no more errors will be counted.

N.B. A character error is defined as one or more elements in error in a character.

FIG. 5

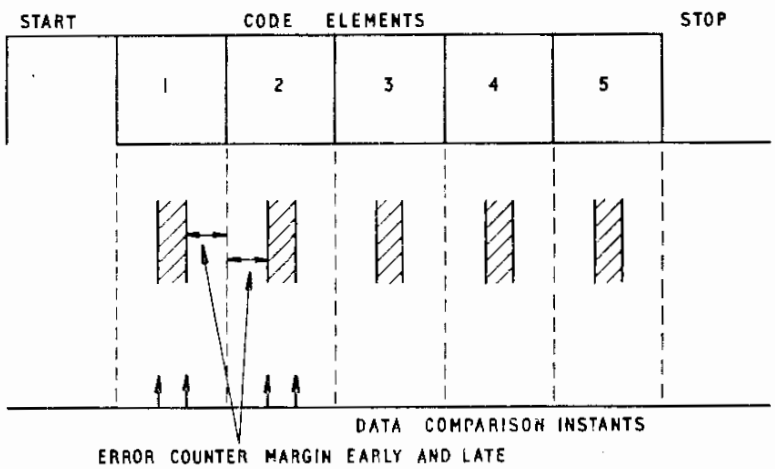



EXAMPLE WITH LAST CODE ELEMENT SPACE POLARITY (UNDISTORTED)
STOP ELEMENT LENGTH = x + y = 150% OR 1½ UNITS




EXAMPLE WITH LAST CODE ELEMENT MARK POLARITY
STOP ELEMENT LENGTH = x + y + z = 200% OR 2 UNITS

FIG. 6 ERROR COUNTER MARGIN




THE RECEIVED SIGNAL MUST BE OF THE CORRECT POLARITY AT THE INSTANTS BOUNDING THE SHADED PERIOD TO BE REGISTERED CORRECTLY

3.3.9 TO MEASURE ISOCHRONOUS DISTORTION (FIG.7)
(INPUT SIGNAL ORIGINATING FROM RE MOTE SOURCE)

3.3.9.1 C.C.I.T.T. Definition 33.07. The degree of isochronous distortion is the ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and theoretical instants separating any two significant instants of modulation, (or restitution), these instants being not necessarily consecutive.

3.3.9.2 Set the DISPLAY control to ISOCH REMOTE, the DISPLAYED RANGE control to 50E-50L and the HOLD PEAK DISTORTION control to OFF.

3.3.9.3 Set the ISOCH REC RATE controls to the nominal speed of the incoming data.

3.3.9.4 Hold the SYNC button depressed, and adjust the ISOCH REC RATE controls for a nearly stationary display.

3.3.9.5 Release the SYNC button, and the IN SYNC lamp should light. If it fails to do so, repeat operations 3.3.9.3. to 3.3.9.5.

3.3.9.6 The ideal transition instont of the receiver display (blanked marker dot) will now be synchronised with the mean position of the incoming transitions.

3.3.9.7 Set the HOLD PEAK DISTORTION control to ON, and operate the HOLD PEAK DISTORTION, RESET button.

3.3.9.8 Read the percentage Isochronous Distortion as the distance between the peak early (left) and the peak late (right) transitions. Peak individual distortion is also indicated.

3.3.9.9 If desired, the display may be expanded, as described in para. 3.3.6.9.

3.3.10 TO MEASURE ISOCHRONOUS DISTORTION (INPUT SIGNAL ORIGINATING FROM THE SAME TESTER AS IS BEING USED FOR THE DISTORTION MEASUREMENT)

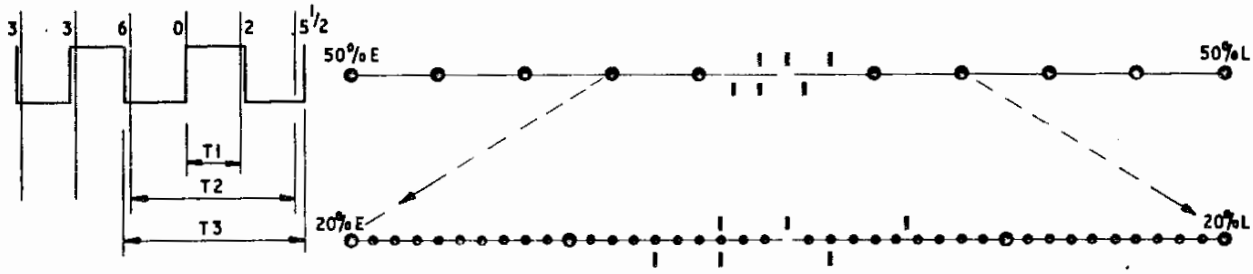
3.3.10.1 Carry out the Synchronising operation as described in paras. 3.3.9.2. to 3.3.9.5

3.3.10.2 When the receiver has been synchronised, turn the DISPLAY control to ISOCH LOCAL. The receiver now takes its timing from the same oscillator as the transmitter, and no further automatic frequency corrections are applied.

3.3.10.3 Continue to measure distortion as described in paras. 3.3.9.7 to 3.3.9.9.

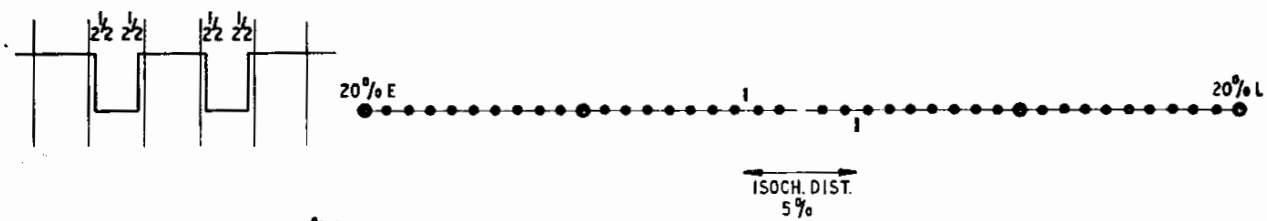
3.3.10.4 The use of the ISOCH LOCAL method is recommended, where possible, as more accurate results can be obtained. This is because the receiver timing is unaffected by the incoming data, as it is in a constant relationship with the transmitter timing. This is not the case in the ISOCH REMOTE method, where the synchroniser is always tending to follow the incoming data.

FIG.7 ISOCHRONOUS DISTORTION




IN EXAMPLE ISOCH. DIST. $= \frac{(T3-T2)\times 100}{T1}$ %

N.B. PEAK INDIVIDUAL DISTORTION ALSO GIVEN 6% E ; 5½ % L




EXAMPLE OF SPACE BIAS (5%)

3.3.11 MEASUREMENT OF BLOCK DISTORTION (DISTORTION IN A SINGLE BLOCK OF DATA, OF ANY LENGTH)

3.3.11.1 With no incoming data, set the DISPLAY control to START/STOP DISTORTION. The tester will automatically reset to the rest position.

3.3.11.2 Set the DISPLAY control to ISOCH LOCAL. The leading edge of the first start polarity element will trigger the display, and the block distortion may be measured, as in paras. 3.3.9.7 to 3.3.9.9.

3.3.12 A test for Group Delay is also possible by switching between test messages 1:1 and 2:2 with the DISPLAY CONTROL set to ISOCH LOCAL. A change in distortion reading gives an indication of the presence of Group Delay Distortion.

# 4.0 GENERAL CIRCUIT DESCRIPTION

## 4.1 Transmitter

To be able to impose distortion on the Data Output in 1% increments, it is necessary first to obtain a 100 x element-rate clock. This clock (HST) is obtained by division-of-8 on the 800 x element rate clock (HSC), the latter being common to both transmit and receive parts of the equipment. HST drives a 100-way Element-Length Counter. This drives the Element-Rate bistable to provide an element-rate timing signal.

The Distortion Control circuit causes distortion to be imposed on an element by lengthening or shortening the count of the 100-way Counter to vary the length of that element by the required amount. Similarly, the Stop Element Control circuit can increase the stop element length of a character to $1\frac{1}{2}$ or 2 units by increasing the length of the count to 150 or 200 respectively.

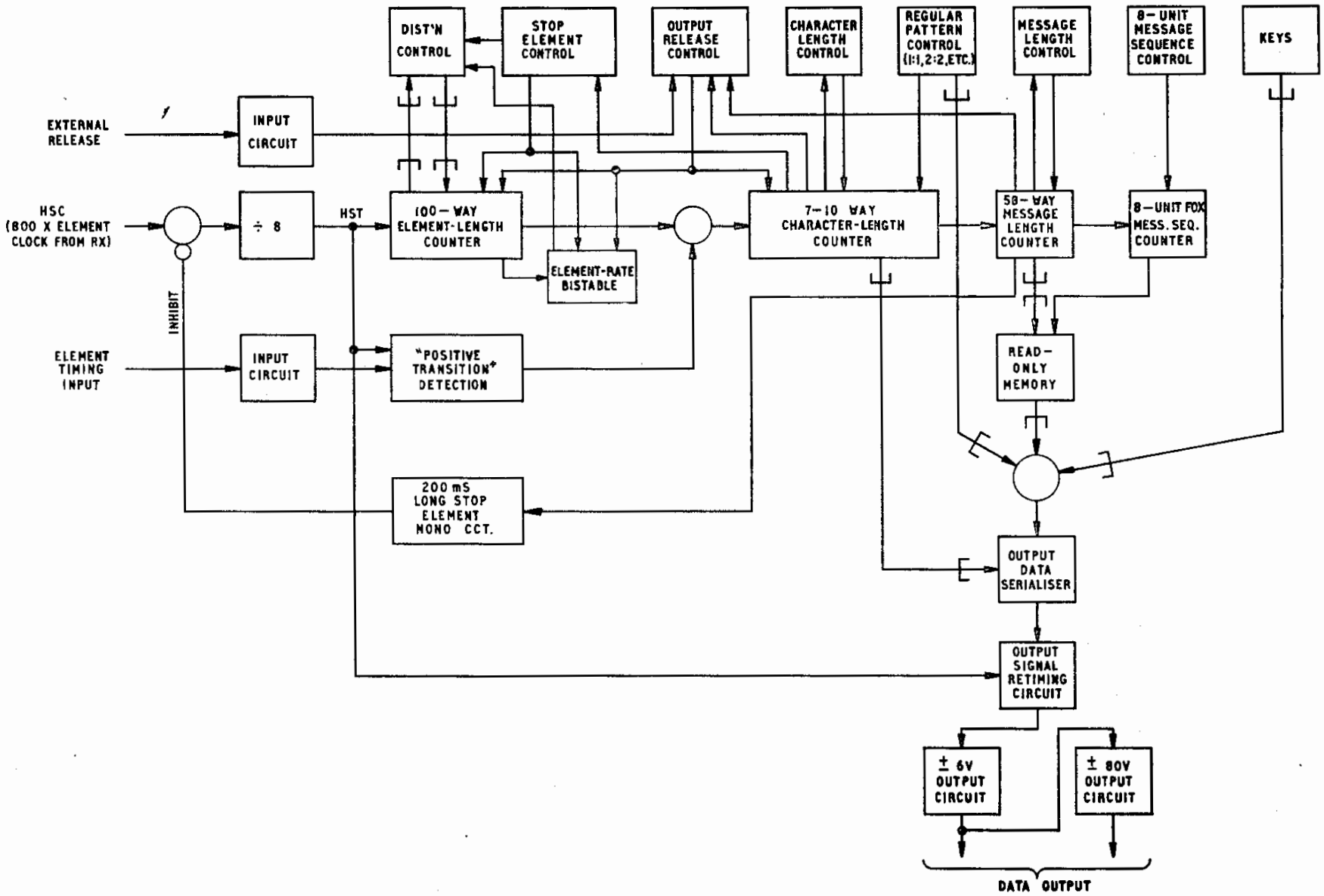
The element-rate signal obtained from the 100-way Counter is used to drive the Character-Length Counter, which can have a count of 7, 8, 9 or 10, depending on the length of character required. It is controlled by the Character Length Control or Regular Pattern Control. ("Regular Patterns", i.e. 1:1, 2:2, 1:3, etc., are formed as special "characters"). The Character-Length Counter output steps the Message-Length Counter. This is used to address the Read-Only Memory (R.O.M.), which contains the Q9S and 5- and 8-unit Fox messages. The length of count depends on the message selected for transmission.

The 8-Unit Fox Message-Sequence Counter, driven from the Message-Length Counter, is used to control the sequence of transmission of the 3 lines of the 8-Unit Fox message when the 8 UNIT MESSAGE switch is set to ALL.

Messages and patterns can be released continuously, character-by-character or message-by-message as determined by the Output Release Control.

The message sources present their characters in parallel form, to the Output Data Serialiser. Here the information elements are scanned and start and stop elements added under the control of the Character-Length Counter, the resultant serial signal being retimed to produce a spike-free output signal. This signal drives the ±6v and ±80v Output Circuits.

With the two Fox messages, a 200ms period of Stop polarity is inserted after every double "Line Feed, Carriage Return" sequence. This is achieved by inhibiting HSC (at the input to the first ÷ 8 stage) for a period of 200ms at the end of the sequence, thus inhibiting HST for the same period.




AHB-T316

TRANSMITTER BLOCK DIAGRAM

FIG. 8A

## 4.2 Receiver

The receiver can derive its timing from one of three sources. These are a 2.88 MHz crystal oscillator, an oscillator which can be varied continuously by ±26% of its nominal frequency of 2.88 MHz and another oscillator, variable from 0.576 to 1.92 MHz, which can be synchronised to incoming data when isochronous working is required.

One of the two 2.88 MHz oscillators, as selected by the FIXED/VAR switch on the front panel, is used if the receiver DISPLAY switch is set to any position other than ISOCH REMOTE. The Speed Divider is controlled by the TRANS & START/STOP REC RATE BAUDS speed switch so that the divider output is at a frequency of 800 x the element-rate selected.

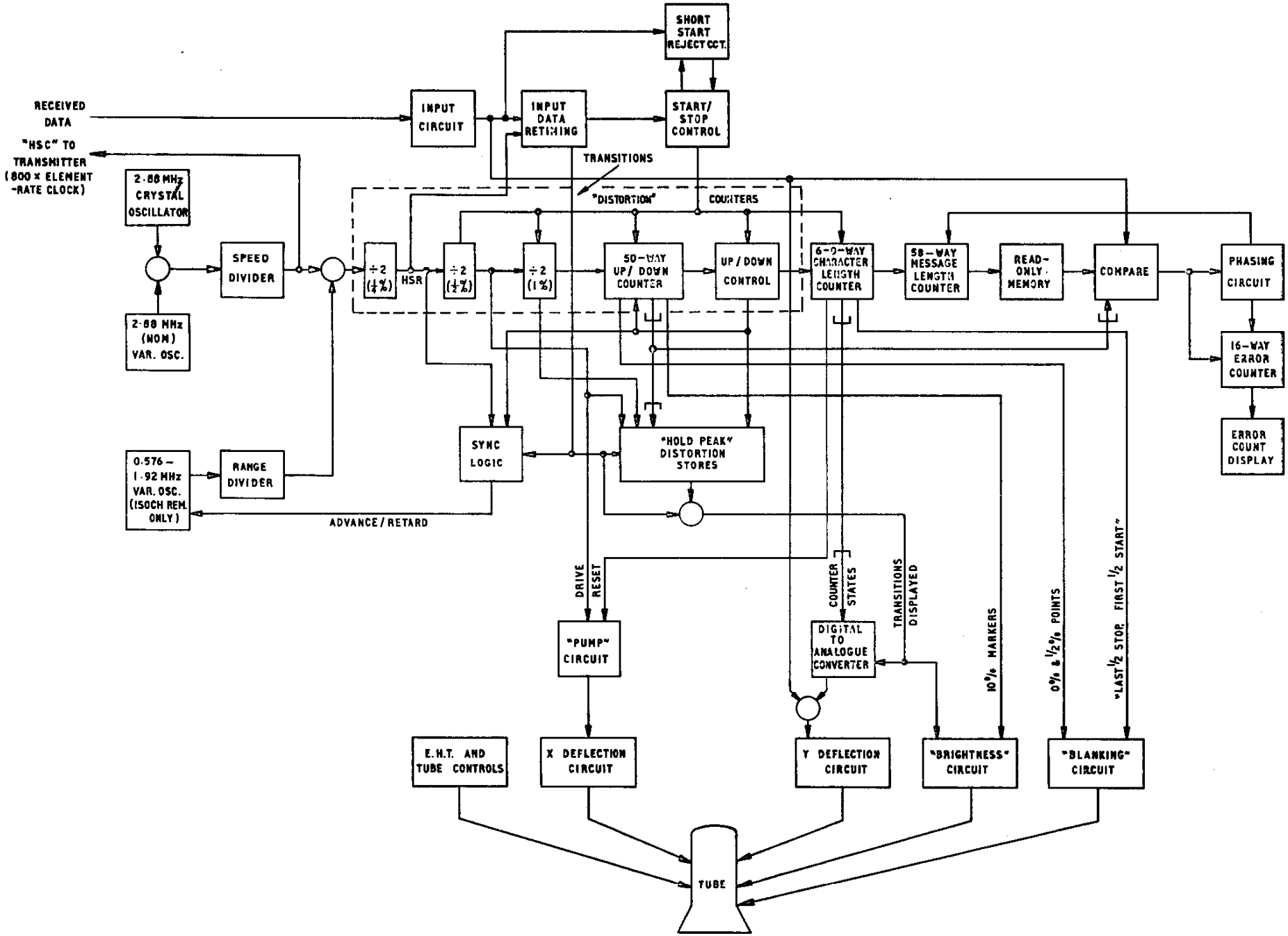
When ISOCH REMOTE is selected by the DISPLAY switch, the 0.576 - 1.92 MHz oscillator is used in the receiver. The Range Divider is switched by the ISOCH REC RATE BAUDS range switch as appropriate so that the divider output is at a frequency of 800 x the element rate selected by the tuning dial and range switch.

The 800 x element-rate clock selected is fed to a ÷ 2 stage to produce the basic 400 x element-rate clock (HSR) used in the receiver measuring circuits; this clock is required to enable distortion measurements to be made to an accuracy of $\pm\frac{1}{4}$%.

The 400 x element-rate clock is now fed to a ÷ 2 stage, which forms the "half-percent" divisions of the element and drives another ÷ 2 stage to form the "one-percent" divisions. The output from this stage drives o 50-way Up/Down (or reversible) counter, the Up/Down Control of which gives a totol division of 100 to give an element-rate timing signal. For the ISOCH REMOTE position of the DISPLAY switch when the 0.576 - 1.92 MHz oscillator is being used, the element-rate signal is used to determine the point of "ideal" transitions of received data. This is compared in the Sync. Logic with the actual transitions detected in incoming data and frequency correction proportional to the phase difference between the "ideal" ond actual transitions is applied to the oscillator.

The element-rate signal drives the Character Length Counter, the count-length of which depends on the number of elements per start/stop character as selected by the CODE ELEM/CHAR switch.

Control is exercised over the Up/Down and Character Length Counters for Start/Stop working, such that when o Start element is detected at the retimed data input, the counters are allowed to run for the duration of the character. Short start rejection is included at this point to ensure that if a supposed start signal turns out to be only a noise spike, then the counters will be reset until the next Start transition is detected.




AHB – 7326/1

RECEIVER BLOCK DIAGRAM

FIG 8B

The Character Length Counter stages are fed to a Digital-to-Analogue converter circuit, which controls the Y-deflection circuit of the C.R.T. to give the 6-9 traces relevant to Start/Stop working. The X-deflection of each trace is obtained using a "Pump" circuit which is itself driven from the output of the "half-percent" divider; this moves the trace across the tube face in "half-percent" increments.

Every other "half-percent" increment of the distortion display is "blanked out" giving a display of "one-percent" dots. Also the first and every subsequent tenth "dot" is brightened, to mark the "10%" dots, except for the middle dot at the 0% point which is blanked-out to show the centre of the trace, i.e. the "ideal transition" point. The appropriate signals are fed to the "Brightness" and "Blanking" Circuits to accomplish this.

The detection of transitions on input data, accomplished in the Input Retiming circuit, is used to modify the Y-deflection and at the same time increase the trace brightness to give the required indication on the tube display.

The "Hold Peak" Distortion Store is used to hold those states of the Up/Down counter which correspond to the early and late transitions of input data that occur farthest away from the "ideal transition" point. The output from this store is used to feed in "held peak transitions", alongside the actual transitions detected in the Input Retiming circuit, to the tube display Y-Deflection and Brightness circuits.

The 58-way Message-Length counter is driven from the Character Length counter output and is used to address a Read-Only Memory (ROM), which has stored on it the 5-unit FOX message. By comparing the ROM output with received Start/Stop data the receiver can first of all be phased with the received message and then made to detect character errors in the message. A character is considered to be in error if one or more of its elements are in error. The Error Counter Margin is determined by signals from the 50-way Up/Down Counter fed to the Compare circuit.