Errata

Title & Document Type: **3721A Spectrum Display Operating Manual**

Manual Part Number: **03721-95003**

Revision Date: **April 1971**

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, life sciences, and chemical analysis businesses are now part of Agilent Technologies. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A. We have made no changes to this manual copy.

Support for Your Product

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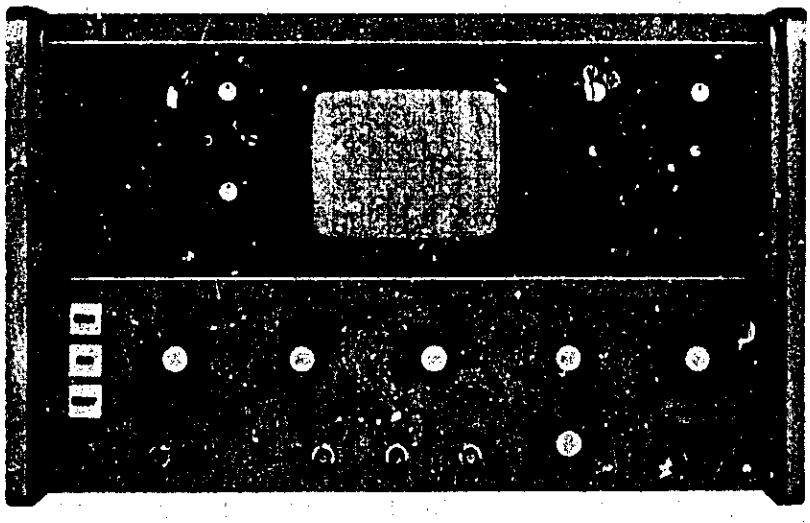
Agilent Technologies

OPERATING MANUAL

CORRELATOR
3721A



HEWLETT hp PACKARD

HP 3721A

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

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OPERATING MANUAL

MODEL 3721A
CORRELATOR

SERIAL PREFIXES

This manual applies to all instruments having a serial prefix U . . . and also to those having serial prefixes 1123U and below. (See Paragraph 1-17 Instrument Identification.) Instruments with serial prefixes above 1123U *may* have a manual change sheet, to which reference should be made.

03721-95003

Printed: APRIL 1971

FOREWORD

For convenience and ease of operation the information for the Model 3721A Correlator has been presented in three publications:

- **OPERATING MANUAL** *hp* Part No 03721-95003
- **SERVICE MANUAL VOLUME 1** *hp* Part No 03721-95004
- **SERVICE MANUAL VOLUME 2** *hp* Part No 03721-95005

HOW TO ORDER

To order any of the above publications, contact your nearest Hewlett-Packard Sales and Service Office (addresses at the back of this manual). Give the *hp* Part No of the publication and the complete number, name and serial number of your instrument.

OPERATING MANUAL CONTENT

Section I	contains a brief description and the specifications of the instrument
Section II	covers unpacking and installation
Section III	gives control, connector and indicator descriptions, general operating information and detailed operating procedures for the four basic measurement modes
Section IV	gives details of the Delay Offset Option Series 01
Section V	gives details of the Correlation – Computer Interface Option 020
Section VI	gives details of the Tape Punch Interface Options 021 and 022
Appendix A	includes a worked example of a configuring procedure using Prepare Control System
Appendix B	shows D.6Ø and F/A.C. computer listings using Option 020

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EXAMPLE OF CONFIGURING A BCS USING PREPARE CONTROL SYSTEM

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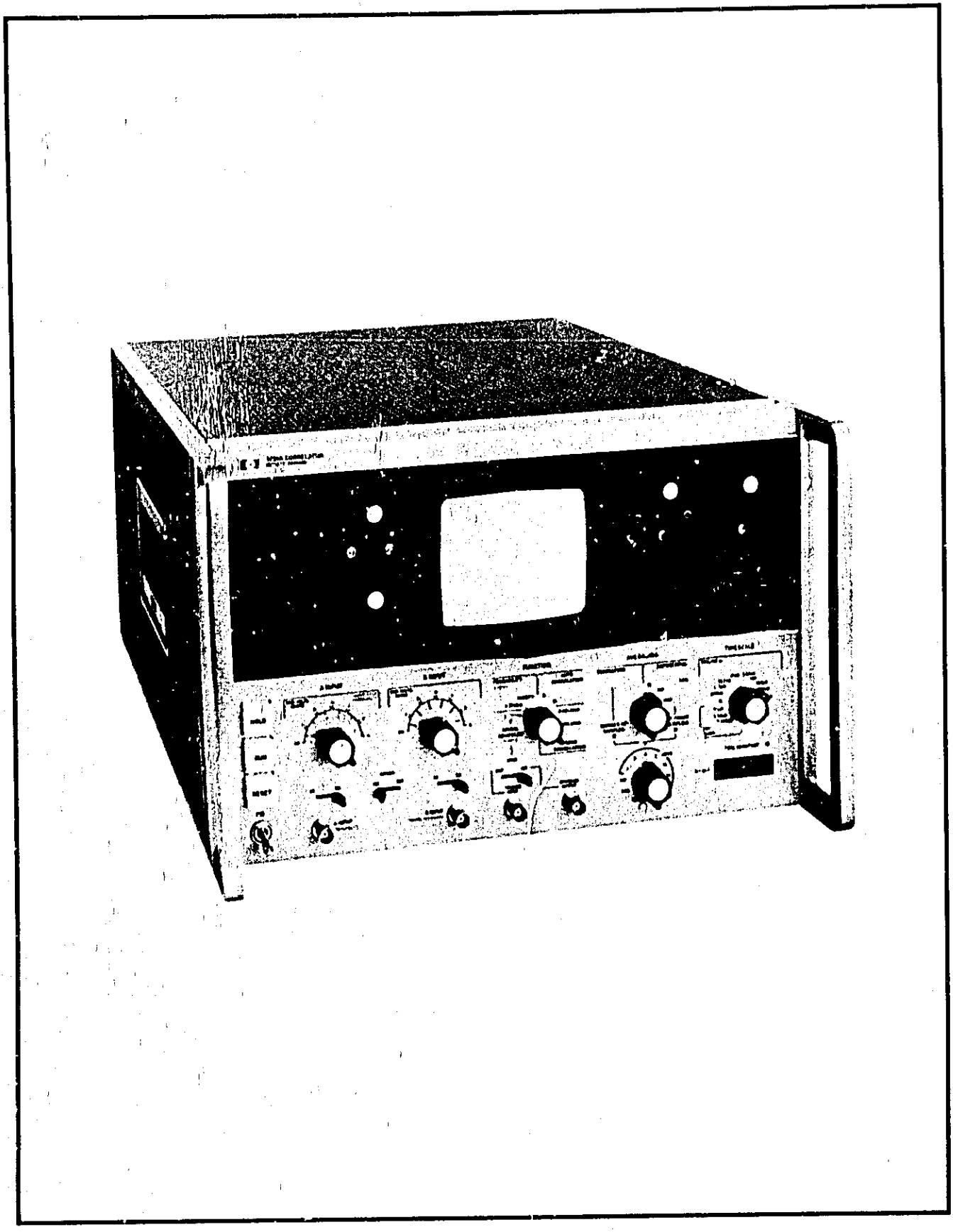


Figure 1-1 Model 3721A Correlator

SECTION I
INTRODUCTION

1-1 DESCRIPTION

1-2 The Hewlett-Packard Model 3721A Correlator is a compact, digital instrument capable of computing and displaying, in real time, autocorrelation, crosscorrelation and probability functions. It has the added facility for recovery of repeated events buried in noise frequently referred to as 'signal averaging'. To avoid by any confusion with *arithmetic averaging*, an essential part of any statistical measurement, this process will be referred to as Signal Recovery when applied to the Correlator.

1-3 In this manual, the instrument will be referred to as the 3721A or Correlator.

1-4 FEATURES

1-5 The 3721A features:

a. Simultaneous computation and display of 100 points of the function selected. The computed function may be displayed indefinitely without deterioration.

b. Time interval between points on the display selectable from 1μ/mm to 1s/mm: in correlation this represents a delay span from 100μs to 100s. By using an external clock the interval can be extended to any delay increment greater than 1μs.

c. A choice of two methods of averaging: SUMMATION AVERAGING – the digital equivalent of pure integration or EXPONENTIAL AVERAGING – the digital equivalent of analog exponential (RC) smoothing. The averaging time constant can be varied from 36ms to over 150 days.

d. Quick-look analysis feature giving rapid indication of the final value of the function – in exponential averaging modes.

e. Outputs for transferring displayed data to external X-Y recorder and oscilloscope.

f. Compatibility with *hp* Model 3722A Noise Generator – making a powerful combination for dynamic response measurements.

g. Data Interface Option Series providing direct interfacing of the 3721A with a computer or tape punch.

h. Delay Offset Option Series enabling the instrument to be used with greater resolution, up to a maximum of 1 point in 1150.

1-6 FUNCTIONS COMPUTED

1-7 Correlation. The 3721A computes and displays the following correlation functions:

Autocorrelation of either Channel A or B input.

Crosscorrelation between Channel A and B; A delayed with respect to B.

Crosscorrelation between Channel A and B; B delayed with respect to A.

1-8 The instrument performs simultaneous computation and display of the correlation function for 100 values of delay. The vertical calibration (V^2/cm) is automatically displayed on an illuminated panel.

1-9 Signal Recovery. The 3721A improves the signal-to-noise ratio of repeated events, provided each event is marked by a synchronising pulse. After each synchronising pulse, a series of 100 samples of channel B input is taken and averaged with the corresponding samples from previous series. The vertical calibration (V/cm) is automatically displayed on the illuminated panel.

1-10 Probability. The 3721A computes and displays the following probability functions:

The amplitude probability density function (pdf).

The integral of the pdf, the cumulative amplitude probability distribution function (cdf).

1-11 Both are performed on Channel A signal input only. The signal's amplitude is displayed horizontally, with zero volts in the centre, and vertical deflection represents the probability (either density or integral).

1-12 OPTIONS AVAILABLE

1-13 The 3721A has two Options Series:

Option Series 01 – Delay Offset
Option Series 02 – Data Interface

1-14 Delay Offset. Enables the user to introduce

a selected amount of precomputational delay into the delayed channel, to view the significant part of the computed function with greater resolution: operational in correlation modes only. There are four alternatives available, giving maximum precomputational delays of 150, 250, 450 or 1050Δt, selectable in blocks of 50Δt throughout the range.

1-15 **Data Interface.** This series consists of three options:

Option 020 — Computer Interface which enables the displayed data to be taken out, in digital form, to any of the Hewlett-Packard range of Digital Computers.

Option 021 — Tape Punch Interface which enables the displayed data to be taken to a *hp* 2753A Tape Punch.

Option 022 — as Option 021 but interfacing with a *hp* 8100A Tape Punch.

1-16 Operating instructions for the options are given in Sections IV, V & VI.

1-17 INSTRUMENT IDENTIFICATION

1-18 An identification plate on the rear panel of the Correlator carries the serial number. It will take one of two forms:

a. On earlier instruments, a two-section, eight digit number of the form U . . . — . . . . ., where the U and the first three digits indicate the serial prefix, and the last five are unique to a particular instrument.

b. On later instruments, a two-section, nine digit number of the form . . . . U . . . . . where the first four digits and the U are the serial prefix, and the last five are unique.

Table 1-1 Specifications

INPUT CHARACTERISTICS

Two separate input channels, A and B, with identical amplifiers.

Input amplifier bandwidth. DC to 250kHz nominal. Lower cut-off frequency selectable, dc or 1Hz (10% down at 3Hz).

Input range. Signals accepted from 40mV to 4V rms, over 6 ranges.

Analog-to-digital conversion. Fine quantizer: 7 bits. Coarse quantizer (feeds delayed channel): 3 bits. Coarse quantizer linearized by internally-generated wideband noise (dither).

Overload. Maximum permissible voltage at input: dc coupled 120V peak; ac coupled 400V = dc + peak ac.

Input impedance. Nominally 1MΩ, shunted by 100pF to ground.

CORRELATION MODE

Computes the following functions:

- Autocorrelation of A input
- Autocorrelation of B input
- Crosscorrelation of A and B inputs, A delayed
- Crosscorrelation of A and B inputs, B delayed

Simultaneous computation and display of 100 values of auto or crosscorrelation functi Display sensitivity indicated directly in V^2/cm on illuminated panel. Non-destructive read-out; computed function can be displayed for an unlimited period without deterioration. (Non-permanent storage; data cleared on switch-off.)

Timescale. (TIME/MM = delay increment Δt) 1μs to 1 second (total delay span 100μs to 100 seconds) in 1, 3.33, 10 sequence with internal clock. Other delay increments with external clock; minimum increment 1μs (1MHz), no upper limit.

Delay offset. Option Series 01 provides delay offset (precomputational delay) facility. Enables display resolution to be increased to magnify area of interest (Auto and Crosscorrelation measurements only).

Display sensitivity. 5×10^{-6} to $5V^2/cm$. Vertical calibration automatically displayed by illuminated panel.

Vertical resolution. Depends on display sensitivity. Minimum resolution is 25 levels/cm. Interpolation facility connects points on display.

Averaging. Two modes are provided: Summation (true integration) or Exponential (digital 'RC' averaging).

Summation mode. Computation automatically stopped after N process cycles, at which time each point on the display represents the average of N products. N is selectable from 128 to 128 x 1024 (2^7 to 2^{17} in binary steps). Display calibration automatically normalized for all values of N.

Exponential mode. Digital equivalent of RC averaging, with time constant selectable from 36ms to over 10^7 seconds. Approximate time constant indicated by illuminated panel. Display correctly calibrated at all times during the averaging process.

Table 1-1 Specifications (continued)

SIGNAL RECOVERY MODE (Channel B only)

Improves signal-to-noise ratio of repeated events, when each event is marked by a synchronizing pulse. After each synchronizing pulse, a series of 100 samples of channel B input is taken, and corresponding samples from each series are averaged. The 100 averaged samples are displayed simultaneously. Display sensitivity is indicated directly in V/cm on illuminated panel.

Synchronization. An averaging sweep is initiated either by a trigger pulse from an external source (EXT) or, in internally triggered mode (INT), by a pulse derived from the internal clock. In the INT mode, the start of each sweep is marked by an output pulse (STIMULUS OUTPUT) used to synchronize some external event.

Trigger input. AC coupled. Averaging sweep initiated by negative-going edge: minimum swing 5V, maximum 20V. Maximum fall-time 4μs, minimum dwell at lower level 0.5μs. Maximum dc voltage 200V.

Stimulus output*. Negative-going pulse at start of averaging sweep, +12V to 0, duration >0.5μs; interval between stimulus output pulses = 100 x TIME/MM + up to 270μs.

Timescale. (TIME/MM = delay increment Δt) 1μs to 1 second (total display width 100μs to 100 seconds) in 1, 3.33, 10 sequence with internal clock. Other intervals (hence other display widths) with external clock; minimum interval 1μs (1MHz), no upper limit.

Display sensitivity. 50μV/cm to 1V/cm. Calibration automatically displayed by illuminated panel.

Vertical resolution. Depends on display sensitivity. Minimum resolution is 25 levels/cm. Interpolation facility connects points on display.

Averaging. Two modes are provided: Summation (true integration) or Exponential (digital 'RC' averaging):

Summation mode. Process automatically stopped after N averaging sweeps, at which time each point on the display represents the average of N samples of the input, taken at a particular time displacement from the synchronizing pulse. N is selectable from 128 to 128 x 1024 (2^7 to 2^{17} in binary steps).

Exponential mode. Digital equivalent of RC averaging, with time constant selectable from 36ms to over 10^7 seconds. Approximate time constant indicated by illuminated panel.

Signal enhancement. Improvement in signal-to-noise ratio equals square root of number of averaging sweeps.

Number of averaging sweeps. = N in summation mode; N x gain factor 1, 10 or 100 in exponential mode.

*Signals specified on Page 1-8

Table 1-1 Specifications (continued)

PROBABILITY MODE (Channel A only)

Displays either amplitude probability density function (pdf) or integral of the pdf of channel A input. Signal amplitude represented by horizontal displacement on display, with zero volts at centre; vertical displacement represents amplitude probability.

Display sensitivity. Horizontal sensitivity 0.05 to 2V/cm in 5, 10, 20 sequence.

Horizontal resolution. 100 discrete levels in 10cm wide display = 10 levels/cm.

Vertical resolution. 256 discrete levels in 8cm high display = 32 levels/cm.

Vertical calibration

Summation averaging. Process automatically stopped when any one point of the display has occurred approximately N times: N being selectable from 128 to 131 072 (2^7 to 2^{17} in binary steps). With the DISPLAY GAIN switch set to MIN, this corresponds to 8cm vertical deflection. The total number of occurrences of the signal at all amplitudes may be obtained from a counter connected to the rear-panel PROCESS CLOCK output.

Exponential averaging. Continuous updating of display, with time constant as given for Correlation and Signal Recovery modes. The Correlator is not vertically calibrated in exponential mode.

Sampling rate. 1Hz to 3kHz in 1, 3, 10 sequence with internal clock. Other sampling rates with external clock; maximum frequency 3kHz, no lower frequency limit.

INTERFACING

X-Y recorder. Separate analog outputs corresponding to horizontal and vertical coordinates of the CRT display.

X drive. -5 to +5V staircase, ±10%, 270ms dwell per step. Alternative 1.35 second dwell per step selected by internal switch.

Y drive. 1V/cm vertical deflection on CRT display, range -4 to +4V, ±10%.

Pen control. 2 modes controlled by toggle switch on rear panel.

a. CONT. Pen lowered for entire sweep.

b. POINT Pen plots series of 100 points per sweep.

Pen lift signal. 0V pen down; voltage from recorder must not exceed +40V in pen-up condition. Maximum sink current 150mA.

Recorder calibration. In the ZERO position of the DISPLAY/ZERO/CAL switch, a signal at the X and Y outputs is available to allow the recorder to be set to zero. Similarly, in the CAL position, a signal is available to allow calibration to the bottom left of the chart. Pressing the RECORD pushbutton starts a single sweep output to the X-Y recorder.

*Signals specified on Page 1-8

Table 1-1 Specifications (continued)

INTERFACING (continued)

Oscilloscope. Separate analog outputs corresponding to the horizontal and vertical coordinates of the CRT display.

Horizontal drive output. 2V staircase, ±10%, 136μs dwell per step. Can be used to trigger oscilloscope timebase or used directly as timebase drive.

Vertical drive output. 1.5V ±10% for 8cm deflection on 3721A CRT.

Trace sweep. Display horizontal direction may be reversed by toggle switch on rear panel; reverses 3721A display and *all* output data.

Z modulation. Normally 0 rising to +5V for blanking.

Noise Generator 3722A. Can be used to control the Correlator. The gate signal from the 3722A is used to set the Correlator into RUN state; on termination of the gate signal, Correlator will go into HOLD state.

Gate signal 3722A.* +1.5V when gate open sets Correlator into RUN state; on rising to +12.0V (gate closed), sets Correlator into HOLD state.

Clock*.

Internal clock. All timing signals derived from crystal-controlled oscillator: stability 40ppm over specified ambient temperature range: accuracy ±0.05%. Internal clock output: train of negative-going pulses, +12V to 0, >0.5μs wide, period as indicated by TIMESCALE switch.

External clock. Minimum interval 1μs. Negative-going level change, minimum transition +5.5 to +2.8V, initiates clock pulse. Minimum dwell at lower level 0.5μs. Maximum permissible levels +12.5 to -8V.

Process clock. 135μs wide positive-going pulse. Normally 0, rises to +12V at start of each process cycle returns to 0 after 135μs.

Digital computer. Option 020 provides interface kit for reading out displayed data to a *hp* Digital Computer.

Tape punch. Option 021 provides interface kit (buffer card and connecting cable) for transferring displayed data to a *hp* 2753A Tape Punch. Option 022 interfaces the Correlator with a *hp* 8100A Tape Punch.

Remote control and indication*.

Control. Remote control inputs for RUN, HOLD and RESET functions are connected to DATA INTERFACE socket on rear panel. Command represented by negative-going level change, minimum transition +5.5 to +2.8V. Minimum dwell at lower level 0.5μs. Maximum permissible levels +12.5 to -8V. Remote control of functions can be effected by grounding appropriate pin.

Indication. Remote indication of Correlator RUN, HOLD or RESET states is available at the DATA INTERFACE socket on rear panel. A condition will be indicated as TRUE when signal is at 0V.

*Signals specified on Page 1-8

Table 1-1 Specifications (continued)

GENERAL

Display. Mono-accelerator tube, 3kV accelerating potential; aluminized P31 phosphor; etched safety glass face-plate reduces glare. 8 x 10cm parallax-free graticule marked in cm squares, 2mm sub-divisions on major axes.

Power requirement. 115 or 230V ±10%, 48 to 440Hz, 250VA.

Connectors. All signal connectors female BNC 50Ω, except Data Interface – 50-way female connector.

Temperature range.
Ambient operating. 0° to +50°C (32° to 122°F).
Shipment and storage. -40° to +75°C (-40° to 167°F).

Weight.
Net. 48lb (22kg).
Shipping. 65lb (30kg).

Accessories furnished.
Detachable Power Cord, Rack Mounting Kit, Circuit Extender Boards (2 supplied), 50-way Connector, Coaxial Cable Extender, Trimming Tool, Time Constant Calculator, Operating and Service Manuals.

Dimensions.

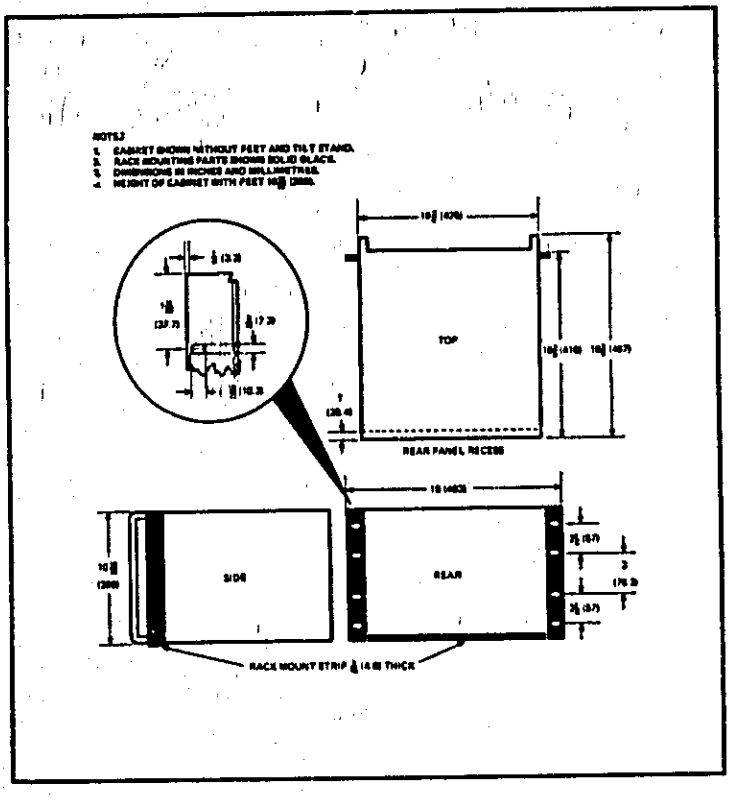


Table 1-1 Specifications (continued)

OPTIONS

Delay offset Option Series 01.
Option 011 Correlator with 150Δt offset facility
Option 012 Correlator with 250Δt offset facility
Option 014 Correlator with 450Δt offset facility
Option 019 Correlator with 1050Δt offset facility

Without offset, first point on display represents zero delay; with offset, delay represented by first point is selectable from 50Δt to 1050Δt in multiples of 50Δt.

All settings may be controlled from the front panel, or, if set to EXT. CONTROL position, remotely through the DATA INTERFACE connector on the rear panel.

Data Interface Option Series 02.
Option 020 Computer Interface
Option 021 Tape-punch (*hp* 2753A) Interface
Option 022 Tape-punch (*hp* 8100A) Interface

Option 020. Comprises a buffer card and connecting cable to interface the Correlator with any *hp* computer in the 2114, 2115 or 2116 series, provided that the computer has a 16-bit positive General Purpose Register Interface Kit (*hp* Model 12554A) fitted. Software is available to control the Correlator processing states and to control the DELAY OFFSET (where fitted).

Data output*. Signals containing VERTICAL ordinate information transmitted to the computer. The 100 displayed points are scanned in sequence on command from the computer. Each point is represented by 16-bits of parallel information comprising 12-bits binary amplitude data and 4-bits control data. Ordinates are presented to the computer for a period of approximately 90μs and a data ready signal, 40μs long, marks the changeover from one point to the next.

Computer commands*. Signals from computer controlling the Correlator processing.

RUN: Signal from computer which sets Correlator into RUN state.

HOLD: Signal from computer which sets Correlator into HOLD state.

RESET: Signal from computer which sets Correlator into RESET state.

DATA: Signal from computer which commands Correlator to output a series of 100 data words.

Option 021. Provides interface kit (buffer card and connecting cable) to connect Correlator to *hp* 2753A Tape Punch.

Data output. VERTICAL amplitude data on the 100 displayed points is fed to the Tape Punch sequentially in 4-digit octal code compatible with ASCII and ISO recommendations. Data is fed out at X-Y recorder speed (1 point/270ms), a scan being initiated by depressing the RECORD pushbutton. Adjacent points are separated by a delimit signal **CR LF** (carriage return, line feed).

EVEN PARITY is normally indicated for check purposes, but ODD may be selected if required.

Signal levels – negative logic

TRUE or low state 0 to + 0.8V, sinking up to 12mA.

FALSE or high state +12V, output impedance 1kΩ.

Option 022. Identical to Option 021 except for the connecting cable, which interfaces with *hp* 8100A Tape Punch, and positive logic levels.

Signal levels – positive logic

FALSE or low state 0 to +0.8V, sinking up to 12mA.

TRUE or high state +12V, output impedance 1kΩ.

***Denotes signals specified as follows:**

Correlator input signals.
TRUE or low state -8 to +2.8V.
FALSE or high state +5.5 to +12.5V.

Correlator output signals.
TRUE or low state 0 to +0.8V, sinking up to 12mA.
FALSE or high state +12V, output impedance 1kΩ.

INSTALLATION

SECTION II
INSTALLATION

2-1 INTRODUCTION

2-2 This section contains information on unpacking, inspection, storage, shipment and installation.

2-3 UNPACKING AND INSPECTION

2-4 If the shipping carton is damaged in any way, ask the carrier's agent to be present when the instrument is unpacked. Inspect the instrument for mechanical damage (stratches, dents, broken knobs, etc.). If the instrument is damaged, or fails to meet its specifications, notify the carrier and your nearest Hewlett-Packard Sales and Service Office immediately; there is a listing at the rear of this manual. The instrument can be checked using the Performance Check given in the Service Manual. Retain the shipping carton and padding material for the carrier's inspection. The Sales and Service Office will arrange for the repair of the instrument without waiting for any claim against the carrier to be settled.

2-5 STORAGE AND SHIPMENT

2-6 **Repacking.** Use the original shipping carton and material if available. Your Hewlett-Packard Sales and Service Office will provide information and recommendations on materials to be used if the original material has been discarded, or is not reusable.

2-7 Material should include:

a. A double-walled carton 25kg/cm^2 (350lb/in^2) bursting test.

b. Heavy paper, polythene or sheets of cardboard to protect all instrument surfaces. Use extra material around projecting parts.

c. At least 10cm (4in) thickness of tightly-packed shock-absorbing material surrounding the instrument.

2-8 Close the carton securely with durable shipping tape. If the instrument is to be shipped to a Hewlett-Packard Sales and Service Office, attach a tag to the instrument showing owner's name and address, model number, serial number, trouble symptoms and/or repairs required. Cartons are available *hp* Part No 9211-1354).

2-9 **Environment.** Temperatures during storage and shipment should be limited as follows:

Minimum Temperature: -40°C (-40°F).
Maximum Temperature: +75°C (+167°F).

2-10 POWER CONNECTION

2-11 **Line Voltage.** The 3721A will operate from either 115V or 230V ac power lines. A slide switch (SELECTOR) on the rear panel permits rapid selection of the appropriate line transformer tappings. Insert a screwdriver into the switch slot and slide the switch to expose the appropriate setting (115 or 230).

CAUTION

BEFORE CONNECTING THE 3721A TO ANY POWER LINE, CHECK THAT THE SELECTOR SWITCH IS IN THE CORRECT POSITION AND THAT THE FUSE IS CORRECTLY RATED.

2-12 **Fuse Ratings.** The recommended ratings for the rear-panel mounted fuse are given in Table 2-1.

Table 2-1 115/230V conversion

Line Voltage	115V	230V
Selector Switch	115	230
Fuse	2.5AT Slow-blow	1.25AT Slow-blow
Part No	*hp* 2110-0380	*hp* 2110-0305

2-13 **Power Cable.** The 3721A is equipped with a detachable 3-wire power cable. Proceed as follows for installation:

1. Plug the flat connector on the power cable into the 3-pin jack on the rear panel of the instrument.
2. Connect the power cable to a 3-wire power outlet.

2-14 Exposed metal parts of the instrument are earthed through the ground pin on the plug. If the plug does not fit your power outlet, either use a suitable adaptor or cut off the plug and fit one suitable to your requirements. If the instrument is powered, via an adaptor, from a 2-contact outlet, the green or green/yellow pigtail of the adaptor should be connected to ground.

2-15 Power cable connections are as follows:

Brown wire (Black – USA) .. .. LINE
Blue wire (White – USA) .. ..NEUTRAL
Green/Yellow wire .. .. GROUND

2-16 SIGNAL CONNECTIONS

2-17 All signal inputs and outputs, with the exception of the Data Interface output, are via female BNC bulkhead connectors.

2-18 INSTRUMENT MOUNTING

2-19 Bench Use. As shipped from the Factory, the 3721A is ready for bench use. The cabinet is fitted with a foldaway tilt stand which allows the instrument to be inclined for more convenient viewing of the display and controls. Plastic feet on the cabinet provide positive location for the 3721A when stacked with other *hp* full-width modular instruments. A control panel cover (*hp* Part No 5060-0830) is available for the 3721A. The cover, which provides protection in transit, fits between the handles at the front of the instrument, and is held in place by two pushbutton latches.

2-20 Rack Installation. A rack mounting kit (*hp* Part No 5060-0778) is supplied with the 3721A. For positioning of the rack mounting parts, see Figure 2-1. The assembly procedure is as follows:

1. Spring the tilt stand free from the feet at the front of the instrument.
2. Remove the feet (press the release button, slide each foot towards the centre of the instrument and lift clear).
3. Remove the adhesive-backed corrugated trim strips from the side frames.
4. Attach the two rack mount flanges to the side frames, with the large corner-notch in the flanges towards the bottom of the instrument.
5. Attach the wedge-shaped grey plastic filler strip to the bottom edge of the front panel, with the thicker edge of the filler strip towards the front of the instrument.

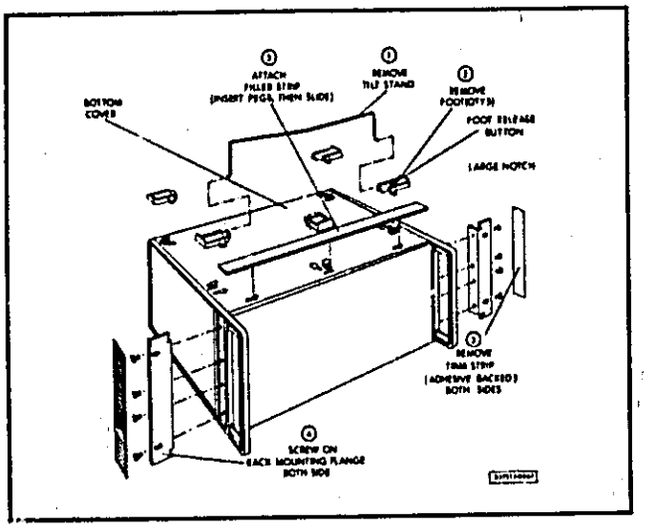


Figure 2-1 Rack mounting the 3721A

CAUTION

THE AMBIENT TEMPERATURE IN THE RACK SHOULD NOT EXCEED 50°C. ENSURE THAT THE RACK PERMITS AIR CIRCULATION TO THE INSTRUMENT, AND THAT NEARBY INSTRUMENTS DO NOT DISCHARGE HOT AIR NEAR THE INTAKES.

2-21 STANDARD ACCESSORIES

2-22 All Correlators are delivered with a Detachable Power Cable and the following accessories:

Extender Board (large) (hp Part No 03721-70028)
Extender Board (small) (hp Part No 03721-70027)
Coaxial Cable Extender (hp Part No 03721-70053)
50-way Connector (hp Part No 1251-0086)
Rack Mounting Kit (hp Part No 5060-0778)
Trimming Tool (hp Part No 8730-0013)
Time Constant Calculator (hp Part No 03721-95011)
Operating Manual (hp Part No 03721-95003)
Service Manual* in two volumes
(hp Part No 03721-95004 and 03721-95005)

2-23 If any of these accessories are missing, contact your local Hewlett-Packard Sales and Service Office.

*Initial instruments will be shipped with the Preliminary Manual (hp Part No 03721-95001); to be replaced by the final manuals when available.

OPERATION

Model 3721A

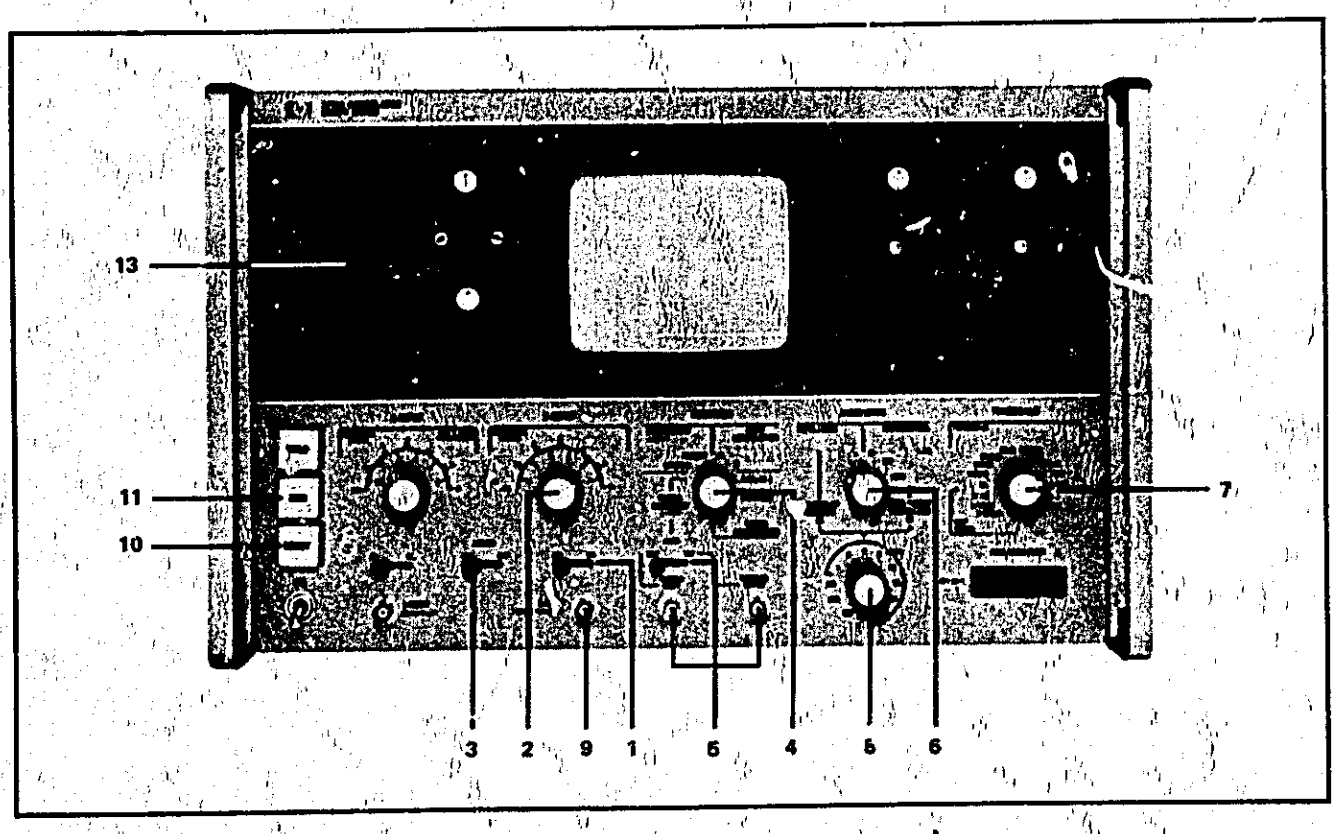
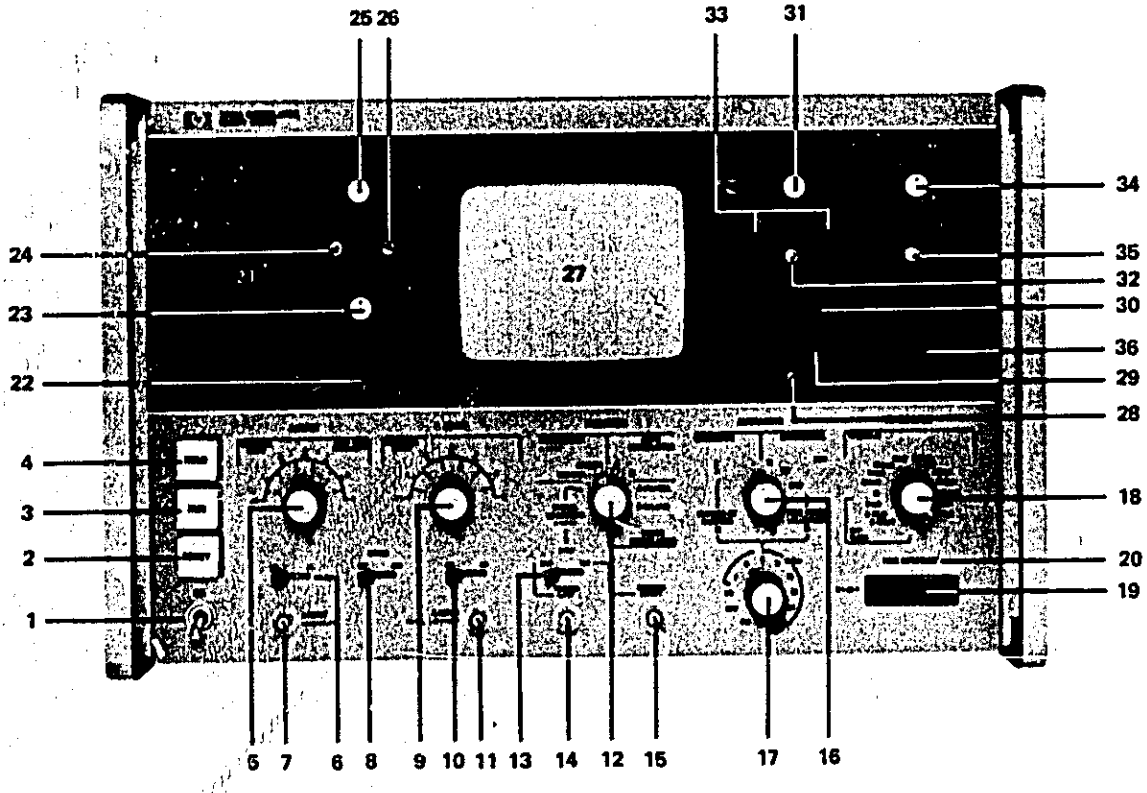


Figure 3-8 Signal Recovery measurement procedure

SECTION III
OPERATING INSTRUCTIONS

BEFORE OPERATING THE INSTRUMENT, READ THE DESCRIPTION OF THE FRONT AND REAR PANEL CONTROLS GIVEN IN FIGURES 3-1 AND 3-2.



1. LINE ON: toggle switch. Controls ac supply to the instrument. (Illuminated pushbutton control to instruments serial number lower than U960-00141).

2. RESET: pushbutton control. Clears stores and presets registers and counters to their initial states. Glows when operating.

3. RUN: pushbutton control. Starts Correlator processing. Glows when operating.

4. HOLD: pushbutton control. Stops processing but retains display information already processed. Glows when operating. The Correlator goes into the HOLD state automatically when any of the major front-panel controls are operated.

5. A INPUT RMS VOLTS RANGE: rotary switch. Sets gain of channel A amplifier. In Probability modes the inner (red) scale provides calibration for the horizontal axis of the display.

6. A INPUT AC/DC: lever switch. Determines signal coupling to channel A amplifier. Lower ac cut-off frequency 1Hz.

7. A INPUT/PROBABILITY: BNC connector. Signal input connector for channel A and Probability measurements.

8. DITHER ON/OFF: lever switch. Introduces wideband Gaussian noise into the delayed channel; improves the analog-to-digital conversion linearity for non-Gaussian signals.

9. B INPUT RMS VOLTS RANGE: rotary switch. Sets gain of channel B amplifier.

Figure 3-1 Front panel controls, connectors and indicators

10. B INPUT AC/DC: lever switch. Determines signal coupling to channel B amplifier. Lower ac cut-off frequency 1Hz.

11. B INPUT/SIGNAL RECOVERY: BNC connector. Signal input connector for channel B and Signal Recovery measurements.

12. FUNCTION: rotary switch. Selects measurement required:
PROBABILITY A INPUT only; DENSITY or INTEGRAL
AUTOCORRELATION; A or B
CORRELATION; A DELAYED OR B DELAYED
SIGNAL RECOVERY B INPUT only.

13. SYNC EXT/INT: lever switch. Operational in Signal Recovery mode only. Selects trigger source (EXTernal or INTernal) for initiating averaging sweep.

14. TRIGGER INPUT: BNC connector. Input for external synchronising pulse to initiate Signal Recovery averaging sweep. Operational in Signal Recovery mode only.

15. STIMULUS OUTPUT: BNC connector. Provides output pulse to excite external event being recovered. Operational in Signal Recovery mode only.

16. AVERAGING: rotary switch. Selects method of averaging — SUMMATION or EXPONENTIAL.

17. NUMBER OF SAMPLES N/TIME CONST MULTIPLIER N: rotary switch. In SUMMATION averaging mode selects Number of Samples; in EXPONENTIAL selects the Time Constant Multiplier.

18. TIMESCALE TIME/MM Δt: rotary switch. Sets delayed sampling interval for Auto and Crosscorrelation modes and the sampling interval for the Signal Recovery and Probability modes. Provides calibration of the horizontal axis of the display in modes other than Probability.

19. TIME CONSTANT: illuminated panel indicator. Enables experiment time (Summation) or averaging time constant (Exponential) to be estimated.

20. TIME CONSTANT: signal lamp. When lit, lamp indicates experiment complete (Summation) or averaging time constant reached (Exponential).

21. DISPLAY SENSITIVITY: illuminated panel indicator. Provides calibration of the vertical axis of the display in modes other than Probability.

22. INTERPOLATION ON/OFF: lever switch. In the ON position, adjacent points of the display are interconnected.

23. FOCUS: potentiometer. Controls sharpness of CRT beam.

24. ASTIG: potentiometer. Adjusts geometry of CRT beam.

25. INTENSITY: potentiometer. Controls brightness of CRT beam.

26. TRACE ALIGN: potentiometer. Rotates trace around centre of CRT screen.

27. DISPLAY: 10cm wide by 8cm high Cathode Ray Tube with graticule calibrated in 1cm squares. Major axes calibrated in 2mm graduations.

28. RECORD: pushbutton control. Initiates a single sweep at a speed suitable for X-Y recorder.

29. DISPLAY/ZERO/CAL: lever switch. Left in DISPLAY position for normal operation. ZERO and CAL positions provide calibration points in centre and lower left hand corner of display respectively for X-Y recording.

30. DISPLAY GAIN MIN/1/MAX: lever switch. Provides three magnifications of the vertical axis of displayed trace.

31. VERTICAL SHIFT: potentiometer. Moves trace vertically on the CRT screen.

32. CAL: potentiometer. Calibrates vertical axis of display.

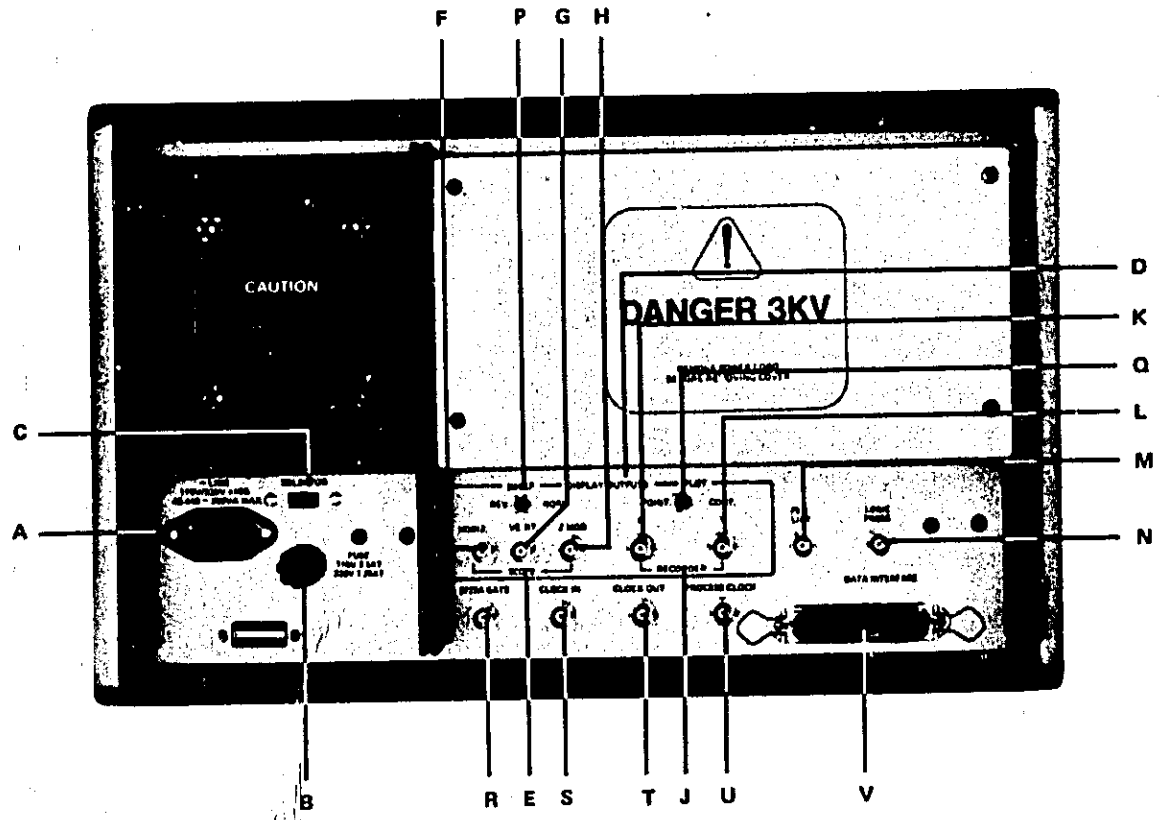
33. RESTORE UP/DOWN: pushbutton switches. Enable trace to be moved vertically on the CRT screen for investigation of points on the trace overrunning the screen, without disturbing the setting of the VERTICAL SHIFT control (31).

34. HORIZONTAL SHIFT: potentiometer. Moves trace horizontally on the CRT.

35. CAL: potentiometer. Calibrates horizontal axis of display.

36. DELAY OFFSET (if Option Series 01 fitted): rotary switch. Not fitted to standard 3721A. See Section IV of this manual for more details.

Figure 3-1 Front panel controls, connectors and indicators (continued)



A. ~LINE 115V/230V ±10% 48 – 440~250VA MAX: line connector for ac power cable. (50 to 400Hz on models with serial number lower than U960-00141.)

B. FUSE 115V 2.5AT 230V 1.25AT: line fuse. Bayonet fuse holder.

C. SELECTOR: slide switch. 115 or 230V line voltage selector.

D. DISPLAY OUTPUTS: Alternative analog outputs for displayed data.

E. SCOPE: Outputs for external oscilloscope.

F. HORIZ: BNC connector. Output signal for horizontal input to external oscilloscope.

G. VERT: BNC connector. Output signal for vertical input to external oscilloscope.

H. Z MOD: BNC connector. Provides blanking for external oscilloscope. (Not fitted on instruments serial number lower than U980-00211).

J. RECORDER: Outputs for external X-Y recorder.

K. X: BNC connector. Output signal for X axis of external X-Y recorder.

L. Y: BNC connector. Output signal for Y axis of external X-Y recorder.

M. PEN LIFT: BNC connector. Output of control pulses for X-Y recorder with remote pen control.

N. LOGIC PROBE: BNC connector. Power supply for hp Model 10525A Logic Probe.

P. SWEEP REV/NORM: toggle switch. In REVerse, display is a 'mirror image' of the NORMal display. Also reverses all other output display data.

Q. PLOT POINT/CONT: toggle switch. Selects POINT (discrete) or CONTinuous point plot. If discrete point plot is required, PEN LIFT (M) output must be connected.

R. 3722A GATE: BNC connector. Input for GATE signal from 3722A. Allows 3722A to control correlation experiment times to coincide with a pseudo-random binary sequence from the 3722A.

S. CLOCK IN: BNC connector. Input for external clock.

T. CLOCK OUT: BNC connector. Output from internal clock (selected by TIMESCALE switch).

U. PROCESS CLOCK: BNC connector. Provides an output of a single pulse for each updating of the display (process cycle).

V. DATA INTERFACE: 50-contact connector. Output socket for displayed data in digital form (Option Series 02) and for remote control connections.

Figure 3-2 Rear panel controls and connectors

3-1 INTRODUCTION

3-2 This section contains information and instructions for the operation of the 3721A Correlator. Paragraphs 3-3 through 3-45 give information on preliminary setting up procedures and Paragraphs 3-46 through 3-50 give detailed step-by-step measurement procedures.

3-3 SETTING CRT CONTROLS

CAUTION

BEFORE CONNECTING THE CORRELATOR TO THE AC POWER SUPPLY BE SURE THAT THE CORRECT VOLTAGE IS SELECTED AND THAT THE FUSE IS CORRECTLY RATED

3-4 Set the CRT controls, which are similar to those of a conventional oscilloscope, as follows:

1. Connect the instrument to the correct power supply and switch on. Allow 15 minutes for warm-up.
2. Make sure that the instrument is in the RESET condition.
3. Set DISPLAY/ZERO/CAL switch to ZERO.
4. Adjust INTENSITY, VERTICAL SHIFT and HORIZONTAL SHIFT controls for a spot trace of suitable brightness near the centre of the screen.
5. Adjust FOCUS and ASTIG controls for a clear circular spot.
6. Adjust VERTICAL SHIFT and HORIZONTAL SHIFT controls to place the spot on the screen centre.
7. Set AVERAGING switch to SUMMATION.
8. Set DISPLAY GAIN switch to MIN.
9. Set DISPLAY/ZERO/CAL switch to DISPLAY. Readjust INTENSITY control for normal trace brightness.
10. Adjust TRACE ALIGN control for trace parallel to the horizontal axis.
11. Adjust HORIZONTAL CAL control for 9.9cm trace width, starting at left hand origin.
12. Set FUNCTION switch to PROBABILITY INTEGRAL.
13. Set TIMESCALE switch to 333μS.
14. Set NUMBER OF SAMPLES N switch to 1 X 1024.
15. Press RESET and then RUN pushbuttons.
16. The trace will split, one half rising to the top of the graticule and the other half remaining on the bottom. If necessary, adjust VERTICAL SHIFT and CAL controls for correct display.

3-5 PROCESSING CONTROLS

3-6 **Local Control.** The three pushbutton controls operate as follows:

a. RUN sets the Correlator into the processing state.

b. HOLD stops the processing at the end of the current updating cycle. On pressing the RUN pushbutton. processing restarts. Information already in the delay store is not cleared on restart. Operation of any of the major front-panel controls automatically sets the HOLD condition.

c. RESET clears all information from the stores. The Correlator is in the RESET condition when it is switched on.

3-7 **Remote Control.** Remote control and indication of the Correlator processing state is made possible through the data interface connector on the rear panel (see Figure 3-2). Momentary connection of the appropriate pin to ground, sets the processing state which is indicated by the relevant pin going 0V (TRUE). Pin numbers and their functions for remote control and indication are given in Table 3-1.

Table 3-1 Remote control

Pin Number	Function
1	RESET control
2	HOLD control
3	RUN control
4	RUN indication
5	HOLD indication
6	RESET indication

3-8 INPUT SIGNALS

3-9 The Correlator accepts signal frequencies from 0 (dc) to 250Hz. If the signal contains frequencies

of about 1Hz or lower, set the AC/DC coupling switch(es) to DC; otherwise to AC. For normal use of the analog-digital converters, input signals should be Gaussian and have amplitudes lying within the range 40mV to 4V rms. If the signal is non-Gaussian the DITHER switch should be set to ON.

3-10 If the level of the signal to be investigated is unknown it is necessary to measure it using a suitable voltmeter (eg, *hp* 3400A) and set the INPUT range switch(es) accordingly. If the level is above or below the range of the 3721A it will be necessary to insert suitable attenuation or pre-amplification.

3-11 CRT DISPLAY

3-12 Functions computed by the Correlator are displayed on the internal CRT. Calibration of the screen varies with the function being displayed.

3-13 **Signal Recovery and Correlation Calibration.** In Signal Recovery and all Correlation modes horizontal calibration is in TIME/MM and may be read directly off the TIMESCALE switch scale, whilst vertical calibration is automatically given on the illuminated DISPLAY SENSITIVITY† panel to the left of the CRT.

†This calibration is correct for all combinations of switches affecting the vertical calibration: but, because there are many combinations it has been found necessary to minimize the ranges used and to adjust the scale of the CRT display in other cases. This means that although normally the full-scale vertical display can occupy 8cms (full screen height), occasionally it will occupy 10cms (2cms more than full screen height) or only 6.4cms (less than full screen).

In probability modes the DISPLAY SENSITIVITY indicator is inoperative and the full-scale vertical display can always occupy 8cms, irrespective of switch combinations.

3-14 **Probability Calibration.** In PROBABILITY modes horizontal calibration is in V/CM and may be read off the A INPUT RMS VOLTS RANGE switch scale (red scale). Vertical calibration varies with the mode selected (DENSITY or INTEGRAL) and with the method of AVERAGING.

3-15 With EXPONENTIAL averaging the vertical axis is uncalibrated.

3-16 With SUMMATION averaging and PROBABILITY INTEGRAL mode the display freezes when the input signal has been sampled 4N* times. (See Table 3-2 for difference between N and N*.) Calibration is automatic in that the highest point on the screen represents 100% probability and the lowest point represents zero probability. With the DISPLAY GAIN switch set at MIN, these are top and bottom of the CRT screen respectively.

Table 3-2 Corresponding values of N and N*

Setting of NUMBER OF SAMPLES N Switch	Value of N	Value of N*
128	128	127
256	256	254
512	512	508
1 x 1024	1024	1016
2 x 1024	2048	2032
4 x 1024	4096	4064
8 x 1024	8192	8128
16 x 1024	16384	16256
32 x 1024	32768	32512
64 x 1024	65536	65024
128 x 1024	131072	130048

3-17 With SUMMATION averaging and PROBABILITY DENSITY mode the display freezes when N* counts have been made in the most measured amplitude interval (see Table 3-2 for difference between N and N*).

3-18 For calibration the display may be normalized; this can be accomplished by using the procedure detailed below.

i. Measure the rms value of the signal using a suitable voltmeter, and let this value equal q.

ii. Connect the signal to A INPUT/PROBABILITY connector and set A INPUT RMS VOLTS RANGE switch accordingly.

iii. Set 3721A FUNCTION switch to PROBABILITY DENSITY, AVERAGING switch to SUMMATION and DISPLAY GAIN switch to MIN.

iv. Connect rear-panel PROCESS CLOCK †† output connector to a suitable counter (eg, *hp* 5245L).

v. Set the counter to zero and press RESET pushbutton on 3721A.

vi. Press RUN pushbutton. When one point of the display reaches 8cm deflection (the top of the CRT screen), processing stops. The reading on the counter is the number of process cycles; let this equal A.

vii. The probability at the highest point of the display is:

$$p\,(x)\ \text{peak} = \frac{N^*}{A}$$

where N* is the number of samples in the voltage window where the highest point lies. N* is derived from the setting of the NUMBER OF SAMPLES switch by reference to Table 3-2.

viii. The normalized probability at the highest point $\overline{p}(x)_{peak}$ is given by:

$$\frac{N^*q}{Aw}$$

where w is the voltage window at which the highest point lies.

$$w = \frac{(\text{HORIZ V/CM setting})}{10}$$

ix. With one point calibrated, all other points on the plot can be calibrated in proportion. For example, if one point is y cm from the baseline and x cm from the centre line, the normalized coordinates are:

$$\overline{p}(x) = \frac{y}{8}.\ \overline{p}(x)_{peak}$$

$$\overline{x} = \frac{x\ (\text{HORIZ V/CM setting})}{q}$$

†† Instruments fitted with an option from Series 01 have a PROCESS CLOCK output that does not stop after processing is complete. Instead, use Pin 19 of the 50-way connector on the rear of the Correlator as an external stop signal for the Counter. This pin is at 12V whilst the time constant lamp is not lit and falls to 0V when it lights.

3-19 OUTPUT SIGNALS

3-20 The information displayed on the internal CRT may be taken, in analog form, to an external X-Y recorder and/or a display oscilloscope and, in digital form, to an *hp* computer or tape-punch.

3-21 External Oscilloscope. To reproduce the display on an external oscilloscope, connect the rear panel SCOPE HORIZ and VERT outputs to the oscilloscope, and set the controls in the normal manner. For full suppression of the trace between points connect the SCOPE Z MOD output to the oscilloscope also. Note that if the external oscilloscope INTENSITY is set too high the Z MOD signal will have no effect on the displayed trace.

3-22 X-Y Recorder. To reproduce the display on an external X-Y recorder, proceed as follows:

1. Set the recorder X and Y ranges for the following input signal ranges:

   a. X input, -5 to +5V. (The X signal from the 3721A is a 10V, 100 equilevel staircase).

b b. Y input, -4 to +4V, ie, 8V full scale deflection.

   NOTE: These output signal amplitudes from the Correlator are nominal and may vary by up to 20%.

2. Ensure the dwell/step time of the Correlator output signal is compatible with the recorder to be used. The dwell/step time is normally set at 270ms, but, if this is too fast for the recorder, a dwell time of 1.35s/step can be selected by an internal plug-in link as detailed in instructions (i) through (iv).

CAUTION

REMOVE POWER CABLE BEFORE REMOVING THE COVER

i. Remove the bottom cover by removing the four screws and sliding the cover about 1in (2.5cm) to the rear and lifting clear.

ii. Locate assembly 03721-70005 which is on the same side as the main pushbutton controls.

iii. Change the small plug-in link on assembly 03721-70005 from the F to the S position.

iv. Replace the bottom cover, screws and power cable. Switch the Correlator on.

3. If the recorder is fitted with a pen lift mechanism capable of being remotely controlled and it is desired to make use of this facility, connect the rear-panel PEN LIFT output from the 3721A to the recorder. Note that the recorder pen lifting system must be of the type where the pen will lower by grounding a contact from the recorder, and lift by restoring open circuit. The maximum allowable signal voltage from the recorder is +40V.

4. Connect the 3721A rear-panel X and Y RECORDER OUTPUTS to the recorder X and Y inputs.
5. Set the 3721A front-panel DISPLAY/ZERO/CAL switch to ZERO and adjust the recorder ZERO controls to place the pen on the centre of the chart.
6. Set the DISPLAY/ZERO/CAL switch to CAL and adjust the recorder X and Y GAIN and VERNIER controls to place the pen on the bottom left hand corner of the chart.
7. Repeat steps 5 and 6 to check that calibration is correct.
8. Set DISPLAY/ZERO/CAL switch to DISPLAY. The 3721A is now ready to control the X-Y recorder.
9. Once the desired display is on the CRT screen, press the RECORD pushbutton on the front panel to initiate a single plot.

3-23 Digital Outputs. If the 3721A is fitted with Option 020 the displayed information may be taken to an *hp* computer. (See Section V).

3-24 Alternatively, if fitted with Option 021 or 022 the displayed data may be taken to *hp* 2753A or *hp* 8100A Tape Punch respectively. (See Section VI).

3-25 SAMPLING RATE

3-26 The choice of the TIMESCALE control setting in Correlation and Signal Recovery modes is important if maximum statistical information is to be recovered. Firstly, in these modes the choice of the sampling interval must comply with the requirements of the Sampling Theorem which states that, for complete recovery of the statistics of a signal, the rate at which it is sampled be at least twice the highest significant frequency present in the signal. Secondly, if the CRT display is being used as the output device, erroneous results may be interpreted due to the inability of the eye to interpolate in certain circumstances. This can happen with a periodic signal when there are less than about five display points per cycle.

3-27 Figure 3-3 shows the autocorrelogram of a sinewave where the number of points per cycle is more than two (thus fulfilling the requirements of the Sampling Theorem).

3-28 However the eye tends to see the trace shown solid rather than the correct dotted one. If the TIMESCALE setting is decreased the correct trace becomes readily apparent and the possibility of false interpretation no longer exists (see Figure 3-4).

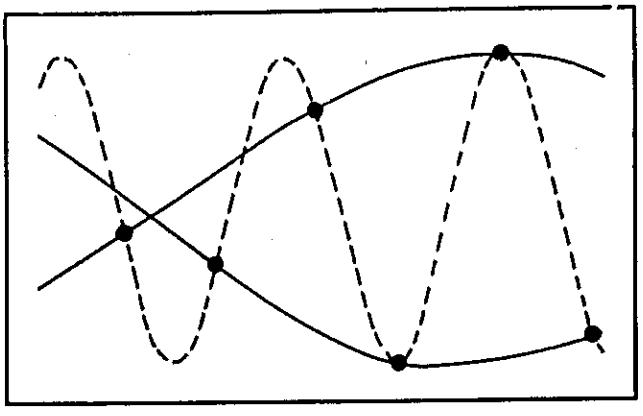


Figure 3-3 Autocorrelogram of a sinewave

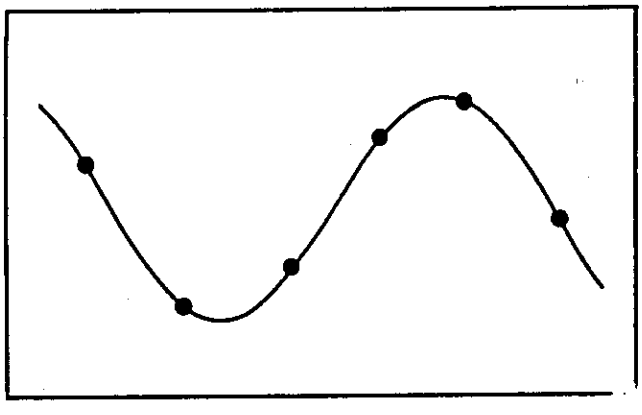


Figure 3-4 The autocorrelation function with the timescale setting decreased

3-29 Note that the appearance of the trace is purely a subjective matter and that the accuracy and usefulness of any calculations are not affected provided the correct information to be used is appreciated.

3-30 This effect, sometimes termed "Optical Aliasing", must not be confused with true aliasing, which occurs when the Sampling Theorem requirements are not met. Optical aliasing may occur both in the presence, and absence, of true aliasing, and providing the sampling requirements are met, may always be removed by decreasing the sample interval. Use of the INTERPOLATION facility offered in the 3721A will often help in detecting Optical Aliasing, and in general display interpretation.

3-31 AVERAGING

3-32 Two methods of averaging are provided on the Correlator; SUMMATION and EXPONENTIAL.

3-33 Summation. When making Auto and Cross-correlation measurements or performing Signal Recovery experiments using Summation averaging the computation stops automatically after N updatings of the displayed function. N, the number of samples taken, is set by the front panel selector switch in the range 128 to 128 x 1024 (2^7 to 2^{17}) in binary steps.

3-34 Completion of the number of samples, N, being taken, is indicated when the TIME CONSTANT lamp lights: a further 100 samples are then taken for complete updating of all 100 displayed points.

3-35 In Probability Density measurements the processing is arranged such that when the highest point has occurred N* times processing ceases. For convenience it is arranged that this point occupies 8cms (full screen height). (See Table 3-2 for difference between N and N*.)

3-36 In Probability Integral measurements processing ceases after 4N* samples have been taken. Again for convenience the highest point occupies 8cms (full-screen).

3-37 Exponential. Exponential averaging on the 3721A is the digital equivalent of resistance capacitance averaging where the time constant may be varied. This averaging time constant is the product of N x Δt x number displayed on the illuminated TIME CONSTANT panel. (See Paragraph 3-40).

3-38 With Exponential averaging in the 3721A this time constant is progressively increased, automatically, from a low value at the start of the experiment, to the value given by the front panel TIME CONSTANT indicator. The CRT display is calibrated throughout this progression giving the Operator a 'quick-look' facility, from which he can gain useful information about the signals under investigation, without having to wait until the final time constant is reached.

3-39 The TIME CONSTANT lamp will light when the final value of time constant (as indicated by the TIME CONSTANT indicator) has been reached, but processing will continue indefinitely, until stopped by the Operator.

3-40 CALCULATION OF TIME CONSTANTS AND SUMMATION TIME

3-41 The estimation of the variance or statistical accuracy likely in analyzing a signal using the 3721A involves the calculation of suitable Experiment Times (in Summation averaging) or Time Constants (in Exponential averaging) to obtain the desired accuracy and the relationship of the TIME CONSTANT lamp to these. Table 3-3 below sets out the calculations involved for various combinations. The Averaging Time Constant Calculator (*hp* part number 03721-95011) supplied with the instrument, aids in calculating these results.

NOTE: Δt is the setting of the TIMESCALE switch and N is the setting of the NUMBER OF SAMPLES/ TIME CONST MULTIPLIER switch.

3-42 Signal Recovery. The process of Signal Recovery is a method of improving the signal-to-noise ratio in the observation of a repeated event. The improvement is in proportion to the square root of N (as set by the NUMBER OF SAMPLES/ TIME CONST MULTIPLIER switch) and therefore the length of any experiment is dependent on the signal-to-noise ratio improvement required and on the time between the trigger pulses denoting the start of each repeated event.

3-43 With Summation averaging the experiment time will be equal to:

(N x time interval between trigger pulses)

3-44 With Exponential averaging the signal is in effect, smoothed by a resistance capacitance filter of a preselected time constant equal to:

(N x time interval between trigger pulses)

3-45 Consider this time interval for the two cases of external and internal trigger pulses.

a. External Trigger signal. With both methods of averaging the time interval between trigger pulses should be at least [100 Δt + (200 x 10^{-6})] seconds if all repetitions are to be averaged; if less than this the instrument will function, but less efficiently, as some repetitions will be ignored.

b. Internal Trigger (Stimulus) signal. With both methods of averaging the time interval between trigger pulses is [100 Δt + (200 x 10^{-6})] seconds.

Table 3-3 Calculation of Time Constants and Experiment Times

$\Delta t \geq 333\mu S$ (Normal mode)	$\Delta t = 100\mu S$ or $33\mu S$ (10:1 Batch mode)	$\Delta t = 10\mu S$, $3.33\mu S$ or $1\mu S$ (100:1 Batch mode)
AUTOCORRELATION/CROSSCORRELATION		
Summation: The TIME CONSTANT lamp will light $N.\Delta t$ secs after the RUN pushbutton is pressed. This is the value to be used in the calculation† of both variance and experiment times.	**Summation:** The TIME CONSTANT lamp will light $10.N.\Delta t$ after the RUN pushbutton is pressed. This is the value to be used in the calculation† of experiment times. For variance calculations†, the product $N.\Delta t$ must be used.	**Summation:** Approximate time for the TIME CONSTANT lamp to light is given by the Calculator and is used for estimating experiment times. The product $N.\Delta t$ is to be used for variance calculations†.
†Note: A further $100\Delta t$ must be included in these calculations, to allow for the final updating of all 100 points.		
Exponential: The averaging time constant is $N.\Delta t$ x the white illuminated factor in the TIME CONSTANT indicator panel. This is the value to be used in the calculation of both variance and experiment times.	**Exponential:** The averaging time constant is given by the Calculator. The value to be used in variance calculations is the product of $N.\Delta t$ and the white illuminated factor, (Note that the green illuminated factor should be ignored is these calculations.)	**Exponential:** The averaging time constant is given by the Calculator. The product of $N.\Delta t$ and the white section of the illuminated panel is to be used for variance calculations.
PROBABILITY DENSITY		
Summation: Processing time is a function of the characteristics of the signal being measured. Without prior knowledge of the amplitude probability of the signal, it is not possible to predict experiment times. The time for variance calculations is the same as the experiment time. **Exponential:** The averaging time constant for calculating both experiment times and variance is given by the product of $N.\Delta t$ and the white section of the illuminated panel.	Sampling set at $333\mu S$ – calculations as for Normal mode.	Sampling set at $333\mu S$ – calculations as for Normal mode.
PROBABILITY INTEGRAL		
Summation: The TIME CONSTANT lamp will light $4.N^*.\ \Delta t$ after the RUN pushbutton is pressed. This value is used to predict experiment times and for variance calculations. NOTE: for the significance of the expression N^* please refer to Table 3-2. **Exponential:** The averaging time constant is $N.\Delta t$ x white section of the illuminated panel and this is the value used to predict experiment times and for variance calculations.	Sampling set at $333\mu S$ – calculations as for Normal mode.	Sampling set at $333\mu S$ – calculations as for Normal mode.
SIGNAL RECOVERY		
Not directly applicable (see Paragraph 3-42)		

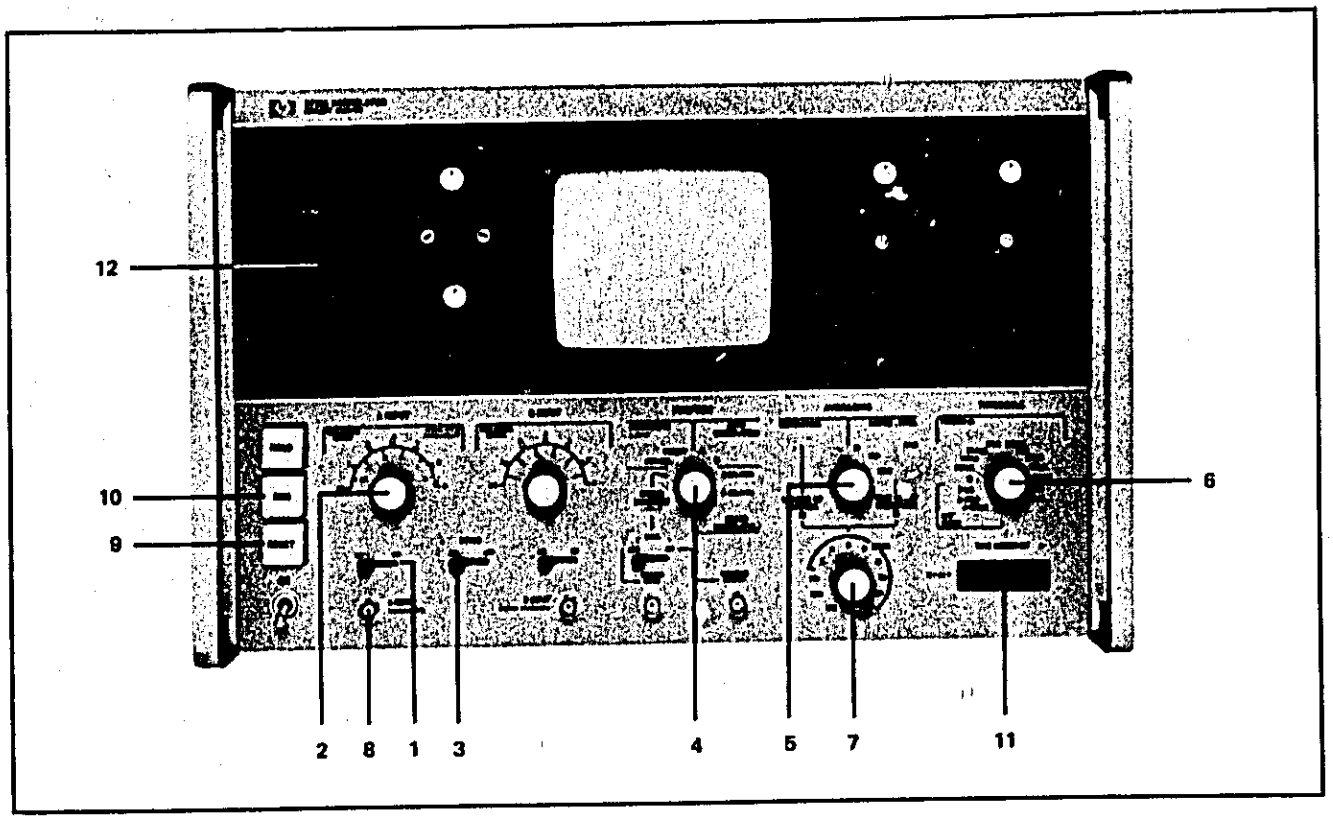


Figure 3-5 Autocorrelation measurement procedure

3-46 MEASUREMENT PROCEDURES

3-47 Autocorrelation. Autocorrelation gives a measure of the similarity between a signal and a delayed version of itself, expressed as a function of the delay. Autocorrelation measurements can be made on either input A or input B. Input A measurement procedure is as follows, (for channel B measurements set appropriate B INPUT controls and turn FUNCTION switch to AUTOCORRELATION B):

1. Set AC/DC switch for coupling required. When the input signal is dc or has frequency components less than approximately 1Hz, the DC position must be selected.
2. Set A INPUT RMS VOLTS RANGE switch for level of the signal being investigated (see Paragraph 3-8).
3. If the signal is Gaussian, set DITHER switch to OFF, otherwise to ON.
4. Set FUNCTION switch to AUTOCORRELATION A.
5. Set AVERAGING switch to SUMMATION or EXPONENTIAL as required.
6. Set TIMESCALE switch for correct sampling rate for signal being measured. Sampling rate must be at least twice the highest significant frequency component of the input signal. Horizontal calibration of the display given directly from the setting of the TIMESCALE control in TIME/MM.
7. Set NUMBER OF SAMPLES N/TIME CONST MULTIPLIER N switch as required.
8. Connect input signal to A INPUT connector.
9. Press RESET pushbutton.
10. Press RUN pushbutton.
11. Allow processing to continue for a suitable length of time. The TIME CONSTANT indicator and lamp enable approximate measurement times to be calculated. (See Paragraph 3-40).
12. Vertical calibration of the display is shown on the DISPLAY SENSITIVITY panel in V^2/CM.

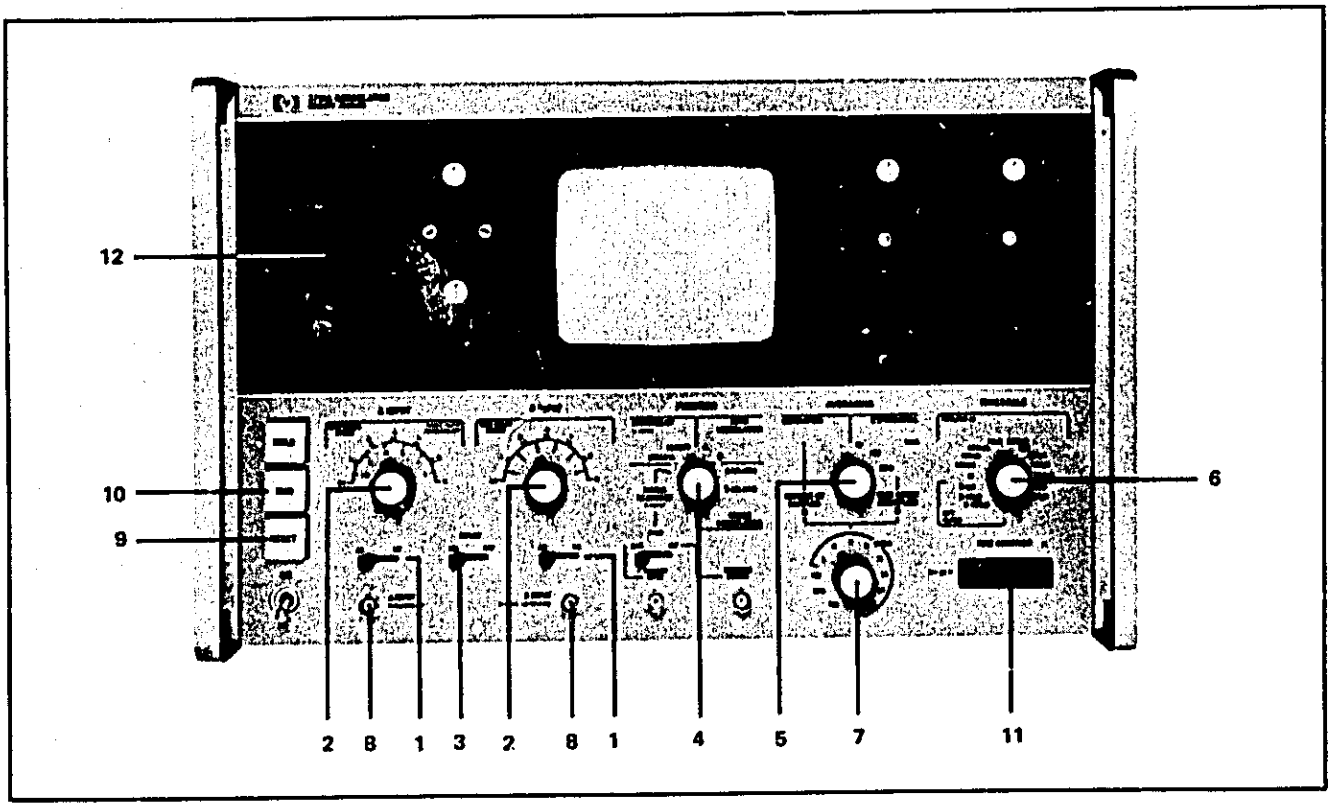


Figure 3-6 Crosscorrelation measurement procedure

3-48 Crosscorrelation. Crosscorrelation gives a measure of the degree of similarity between two signals, expressed as a function of the time shift between them. Crosscorrelation measurements can be made with either input A or input B delayed. Measurement procedure is as follows:

1. Set AC/DC switches for A INPUT and B INPUT couplings required. When an input signal is dc or has frequency components less than approximately 1Hz, the DC position must be selected.
2. Set A INPUT RMS VOLTS RANGE and B INPUT RMS VOLTS RANGE switches for levels of the signals being investigated (see Paragraph 3-8).
3. If the signal connected to the delayed channal (coarse quantiser) is Gaussian, set DITHER switch to OFF, otherwise to ON.
4. Set FUNCTION switch to CROSSCORRELATION; A DELAYED or B DELAYED as required.
5. Set AVERAGING switch to SUMMATION or EXPONENTIAL as required.
6. Set TIMESCALE switch for correct sampling rate for signals being measured. Sampling rate must be at least twice the highest significant frequency of the higher frequency input signal.

   Horizontal calibration of the display is given directly from the setting of the TIMESCALE control in TIME/MM.
7. Set NUMBER OF SAMPLES N/TIME CONST MULTIPLIER N switch as required.
8. Connect input signals to A INPUT and B INPUT connectors.
9. Press RESET pushbutton.
10. Press RUN pushbutton.
11. Allow processing to continue for a suitable length of time. The TIME CONSTANT indicator and lamp enable approximate measurement times to be calculated. (See Paragraph 3-40).
12. Vertical calibration of the display is shown on the DISPLAY SENSITIVITY panel in V^2/CM.

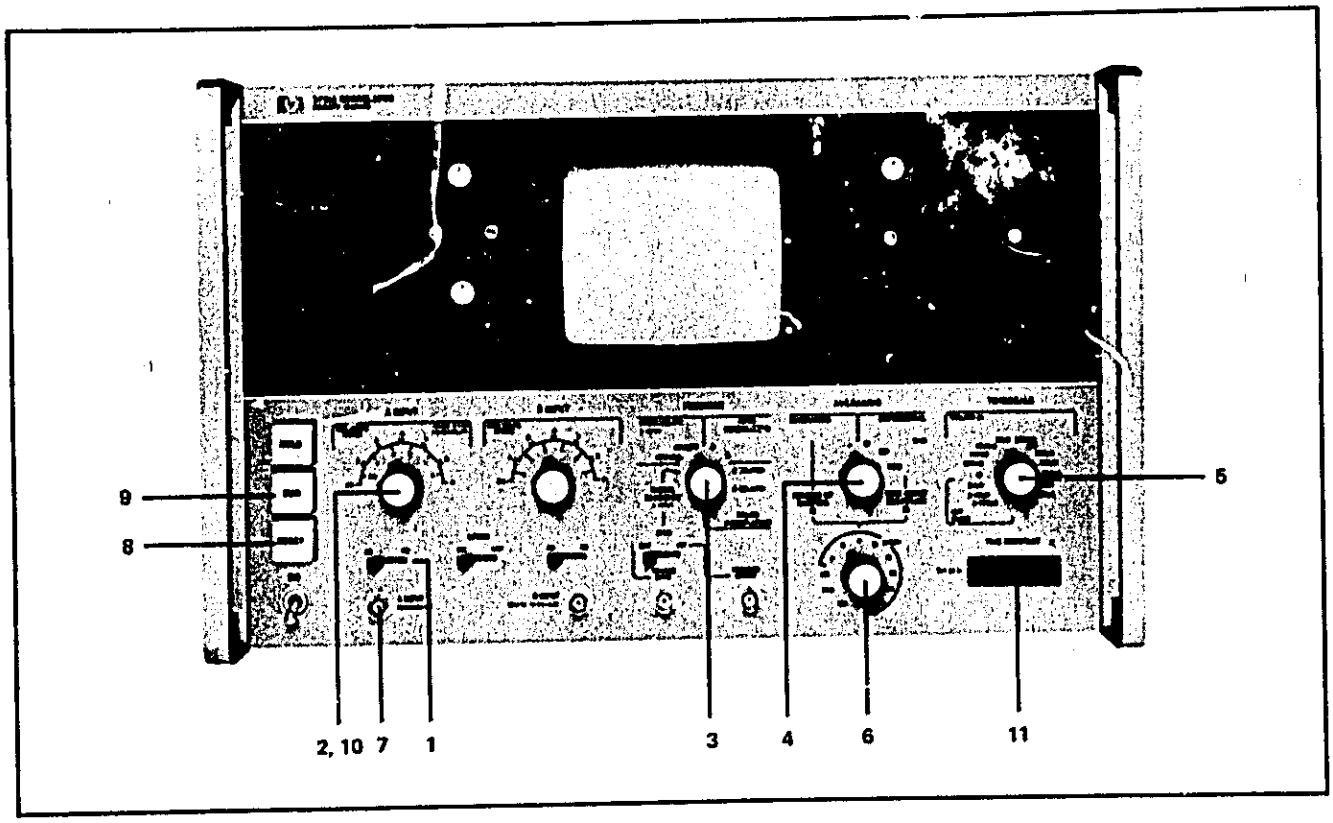


Figure 3-7 Probability measurement procedure

3-49 Probability. Probability measurements give a statistical assessment of the amplitude characteristics of the signal under investigation. Measurements can be made of Probability Density Function (pdf) or the integral of pdf, the Cumulative Distribution Function (cdf). Probability measurement procedure is as follows:

1. Set AC/DC switch for coupling required. When the input signal is dc or has frequency components less than approximately 1Hz, the DC position must be selected.
2. Set A INPUT RMS VOLTS RANGE switch for level of signal being investigated (see Paragraph 3-8).

   Horizontal calibration of the display is provided by the red scale (HORIZ V/CM PROBABILITY) on the A INPUT switch.
3. Set FUNCTION switch to PROBABILITY DENSITY (pdf measurement) or to PROBABILITY INTEGRAL (cdf measurement).
4. Set AVERAGING switch to SUMMATION or EXPONENTIAL as required. Generally, SUMMATION averaging will be found to be most useful. (With EXPONENTIAL averaging the vertical axis of the display is uncalibrated).
5. Set TIMESCALE switch for sampling rate for signal being measured: For TIMESCALE switch settings below 333μS, sampling is limited at the fixed period of 333μS.

   In Probability measurements the TIMESCALE setting determines the sampling rate only and does not provide calibration of the horizontal axis of the display as in other modes
6. Set NUMBER OF SAMPLES N/TIME CONST MULTIPLIER N switch as required.
7. Connect input signal to A INPUT connector. (Probability measurements cannot be made on the B channel.)
8. Press RESET pushbutton.
9. Press RUN pushbutton.
10. Check that the display adequately fills the CRT screen horizontally. If not, adjust A INPUT HORIZ V/CM PROBABILITY switch for suitable display.
11. Allow processing to continue for a suitable length of time. The TIME CONSTANT indicator and lamp enable approximate measurement times to be calculated. (See Paragraph 3-40).
12. For vertical calibration of the display see Paragraph 3-14.

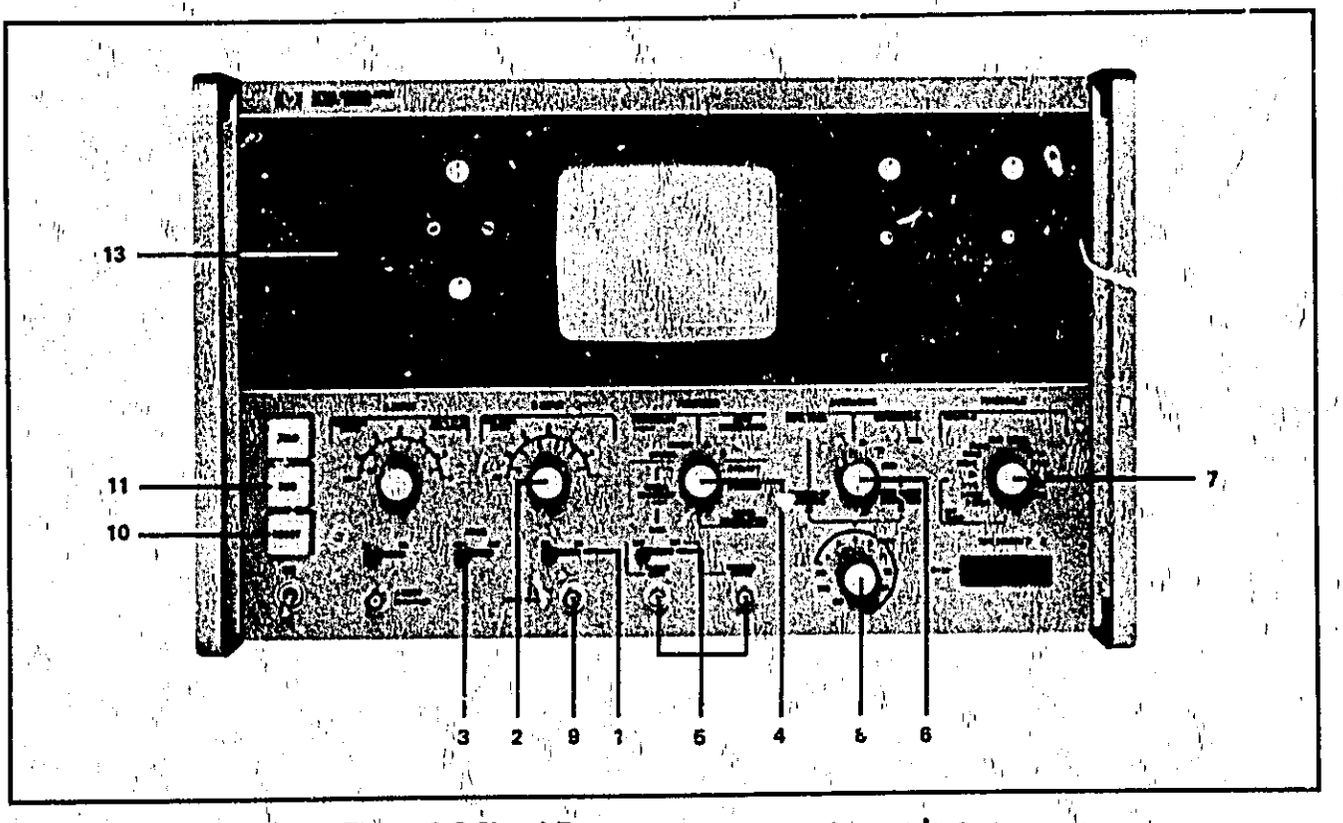


Figure 3-8 Signal Recovery measurement procedure

3-50 Signal Recovery. Many signals met in practice consist of a repeated component masked by noise. The repeated component can be recovered by, Signal Recovery. Measurement procedure is as follows:

1. Set AC/DC switch for the coupling required. When the input signal is dc or has frequency components less than approximately 1Hz, the DC position must be selected.
2. Set B INPUT RMS VOLTS RANGE switch for level of the signal being investigated (see Paragraph 3-8).
3. If the total signal is Gaussian, set DITHER switch to OFF, otherwise to ON.
4. Set FUNCTION switch to SIGNAL RECOVERY.
5. Set SYNC switch according to triggering required.

   TRIGGERING:
   For triggering from an external source set SYNC switch to EXT and connect trigger signal to TRIGGER INPUT connector. Alternatively, use the 3721A internal trigger. Set SYNC switch to INT. A synchronising signal will then be available from the STIMULUS OUTPUT connector, to be used as a stimulus to excite the external event whose data is to be recovered.
6. Set AVERAGING switch to SUMMATION or EXPONENTIAL as required.
7. Set TIMESCALE witch for correct sampling rate for signal being measured.

   Horizontal calibration of the display is given directly from the setting of the TIMESCALE control, in TIME/MM.
8. Set NUMBER OF SAMPLES N/TIME CONST MULTIPLIER N switch as required.
9. Connect input signal to B INPUT connector. (Signal Recovery is performed on the B channel only.)
10. Press RESET pushbutton.
11. Press RUN pushbutton.
12. For information on measurement times see Paragraph 3-42.
13. Vertical calibration of the display is given directly in V/CM on the DISPLAY SENSITIVITY panel.

OPTIONS

SECTION IV
OPTION SERIES 01

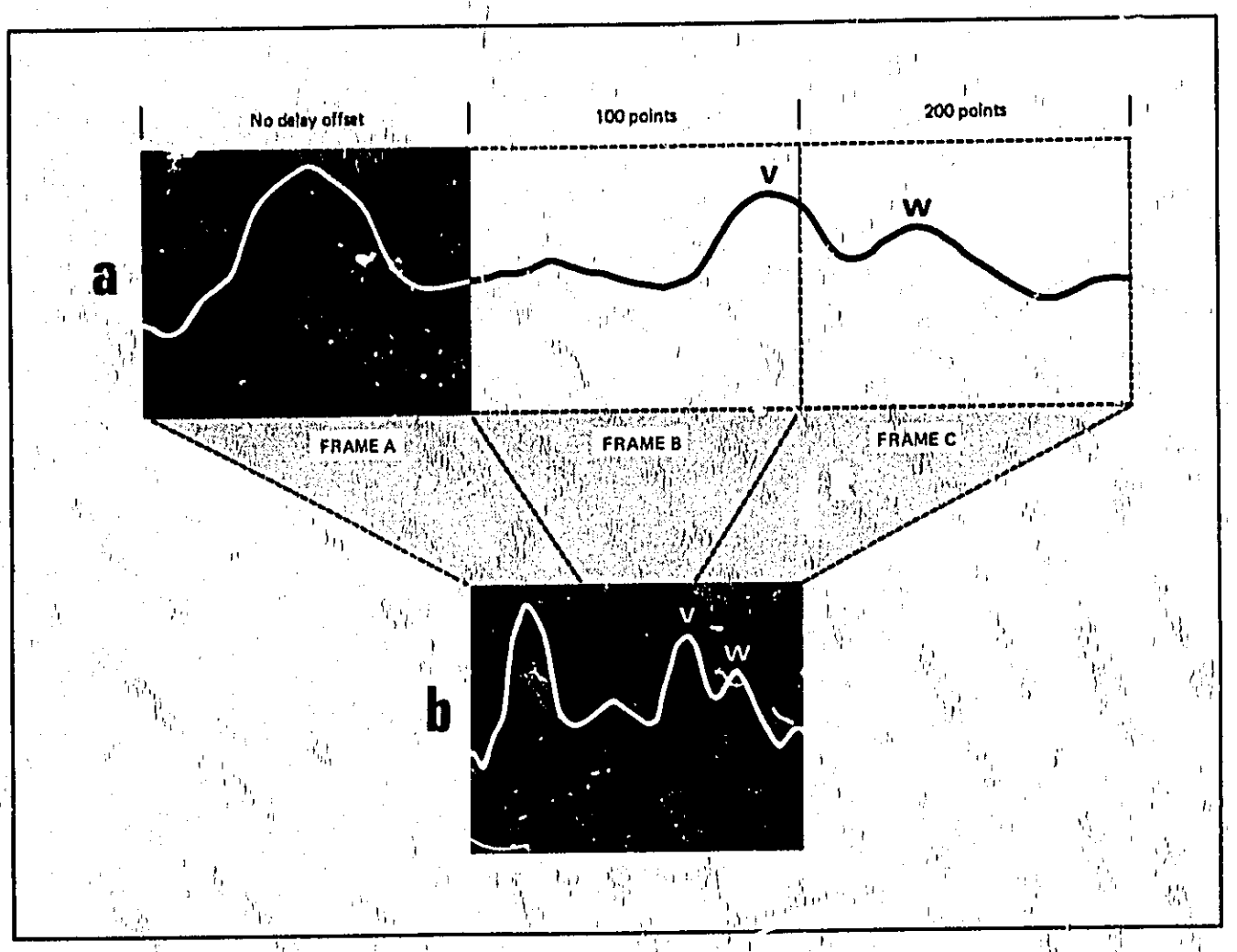


Figure 4-1 Delay Offset increases display resolution

4-1 INTRODUCTION

4-2 The Option Series 01 for the 3721A Correlator provides Delay Offset in Auto and Cross-correlation modes as follows:

Option 011, Delay Offset 150 Points
Option 012, Delay Offset 250 Points
Option 014, Delay Offset 450 Points
Option 019, Delay Offset 1050 Points

4-3 The Delay Offset options are not operational in the Signal Recovery mode.

4-4 DESCRIPTION

4-5 In correlation measurements, the part of the function of interest may be small and occur at a large value of delay. In order to inspect this part, the timescale could be lengthened by increasing the TIMESCALE setting but this would sacrifice resolution. By use of Delay Offset, the whole display can, in effect, be shifted to the right by the number of delay offset points selected. In Figure 4-1a a trace of a function is shown. The TIMESCALE is set to give an acceptable resolution but the main areas of interest, V and W, are not visible on the screen, Frame A. By reducing the TIMESCALE setting, the display of the function can be condensed so that points V and W are on the screen but, as Figure 4-1b shows, the resolution is so poor that it is not possible to gain much information about the shape. If a delay offset of 100 points is introduced, the display on the screen will be as

Frame B and 200 points will produce Frame C. Thus, the whole function can be examined without loss of resolution.

4-6 **Manual Control.** The DELAY OFFSET control (Figure 4-2) consists of two concentric rotary switches, the outer selecting the predelay in blocks of 100 points and the inner the intermediate blocks of 50 points. Operation of the DELAY OFFSET control will automatically set the Correlator in the HOLD condition so that, after changing the amount of delay offset, it will be necessary to press the RESET and then the RUN pushbuttons.

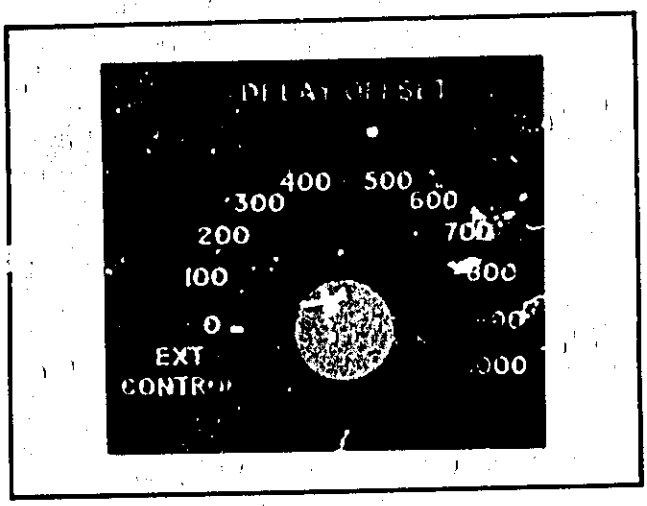


Figure 4-2 Delay Offset control

4-7 In SUMMATION averaging, the TIME CONSTANT lamp lights when N samples have been taken after which no further samples are taken at the delayed input. Processing of the data passing through the predelay and delay store will continue, however, so that even when the TIME CONSTANT lamp lights processing will not be complete. The time delay between lighting of the lamp and the end of processing is given in Table 4-1.

4-8 In the EXPONENTIAL averaging mode, allow an additional period of time (as given in Paragraph 4-7) to the required experiment time before interpreting the displayed information.

4-9 **Remote or Computer Control.** In addition to manual control the DELAY OFFSET can be switched remotely. The DELAY OFFSET switch is set to EXT. CONTROL and switching can then be effected through the 50-way DATA INTERFACE connector on the rear panel. Eight of the pins on this connector are used for remote switching, pin numbers 18, 17, 13, 16, 12, 15, 11 and 14. With the 0/50 Delay switch set to the 0 position the voltage levels for remote control are:

LO (TRUE) = 0V or GROUND
HI (FALSE)= +12V or OPEN CIRCUIT

Table 4-2 shows the settings of these pins for the different values of delay offset; the heavy lines showing the limit of each of the four options.

Table 4-1 Time delay after Time Constant lamp lights

TIMESCALE SETTING	TIME DELAY AFTER TIME CONSTANT LAMP LIGHTS
1, 3 and 10μs	$(A \times \Delta t) + (135 \times 10^{-6})$ seconds
33.3μs and over	$(A + 100) \times \Delta t$ seconds
where A = number of points of delay offset selected and Δt = TIMESCALE setting in *seconds*	

Table 4-2 Truth table for external control of Delay Offset Option

PIN NO 50-WAY CONNECTOR		18	17	13	16	12	15	11	14
DELAY OFFSET REQUIRED									
	0 Δt	LO	HI	HI	HI	HI	HI	HI	HI
	50 Δt	LO	LO	HI	HI	HI	HI	HI	HI
	100 Δt	HI	HI	LO	LO	HI	HI	HI	HI
011	150 Δt	HI	LO	LO	LO	HI	HI	HI	HI
	200 Δt	HI	HI	HI	LO	HI	HI	HI	HI
012	250 Δt	HI	LO	HI	LO	HI	HI	HI	HI
	300 Δt	HI	HI	LO	HI	LO	HI	HI	HI
	350 Δt	HI	LO	LO	HI	LO	HI	HI	HI
	400 Δt	HI	HI	HI	HI	LO	HI	HI	HI
014	450 Δt	HI	LO	HI	HI	LO	HI	HI	HI
	500 Δt	HI	HI	LO	HI	HI	LO	HI	HI
	550 Δt	HI	LO	LO	HI	HI	LO	HI	HI
	600 Δt	HI	HI	HI	HI	HI	LO	HI	HI
	650 Δt	HI	LO	HI	HI	HI	LO	HI	HI
	700 Δt	HI	HI	LO	HI	HI	HI	LO	HI
	750 Δt	HI	LO	LO	HI	HI	HI	LO	HI
	800 Δt	HI	HI	HI	HI	HI	HI	LO	HI
	850 Δt	HI	LO	HI	HI	HI	HI	LO	HI
	900 Δt	HI	HI	LO	HI	HI	HI	HI	LO
	950 Δt	HI	LO	LO	HI	HI	HI	HI	LO
	1000 Δt	HI	HI	HI	HI	HI	HI	HI	LO
019	1050 Δt	HI	LO	HI	HI	HI	HI	HI	LO

Table 5-1 Interconnecting cable details

3721A Pin No	Colour	Computer Pin No	Function
1	Black	A	RESET (in)
2	Brown	B	HOLD (in)
3	Red	C	RUN (in)
4	Green	14	RUN (out) Bit 13 of Word Format
5	Yellow	16	HOLD (out) Bit 15 of Word Format
6	Orange	13	RESET (out) Bit 12 of Word Format
7 through 10	*No connection*		
11	Blue	D	Delay Offset
12	Violet	E	
13	Grey	F	
14	White	H	
15	Black – White	J	
16	Brown – White	K	
17	Red – White	L	
18	Orange – White	M	
19 through 24	*No connection*		
25	Yellow	24	Ground
26	Yellow – White	1	Vertical Amplitude Bits 0 to 11 of Word Format
27	Green – White	2	
28	Blue – White	3	
29	Violet – White	4	
30	Grey – White	5	
31	Brown – Black – White	6	
32	Red – Black – White	7	
33	Orange – Black – White	8	
34	Yellow – Black – White	9	
35	Green – Black – White	10	
36	Violet – Black – White	11	
37	Grey – Black – White	12	
38	Red – Brown – White	AA	Record Cycle
39	Orange – Brown – White	BB	Fast Cycle
40	Yellow – Brown – White	23	Data Ready
41 & 42	*No connection*		
43	Blue – Brown – White	15	ARRET Bit 14 of Word Format
44 through 49	*No connection*		
50	White	BB	Ground

SECTION V
OPTION 020

5-1 DESCRIPTION

5-2 The 3721A Correlator fitted with Option 020 will interface with any of the *hp* range of Digital Computers. The option has not been designed to interface with computers of other manufacture.

5-3 The Option 020 consists of the following:
a. Interconnecting cable between the Correlator and the Computer.
b. Circuit board for insertion into a slot in the Correlator.
c. Software to drive the 3721A from an ALGOL or FORTRAN program.

5-4 This Section contains a functional description of the option and simple operating instructions on the use of the software. In the software descriptions, a certain amount of knowledge on the operation of the *hp* Computer has been assumed and, as a guide, references are given to the appropriate Sections of the Computer Manuals.

5-5 EQUIPMENT REQUIREMENTS

5-6 The software provided allows control of one or more 3721A Correlators by a single Computer. Each Correlator must be fitted with Option 020 and be connected to an I/O slot in the Computer containing an Interface Kit *hp* 12554A – General Purpose Positive 16-Bit Duplex Register. It is assumed in the descriptions that the Computer has, in addition, a Teletypewriter, a Punched Tape Reader and a Tape Punch.

5-7 **Function.** Communication between the Correlator and the Computer is two-way, the Correlator being controlled by the Computer and the Computer being fed information by the Correlator. The data from the Correlator is presented in the form of a 16-Bit parallel word plus a DATA READY signal. This signal indicates that the 16-Bit word is in the output register of the option and is ready for transfer to the Computer. The signal goes FALSE for approximately 40μs before each point of the display is presented to the Computer and then goes TRUE for 90μs whilst the point is presented to the Computer. The format and functions of the 16-Bit word are shown in Figure 5-1.

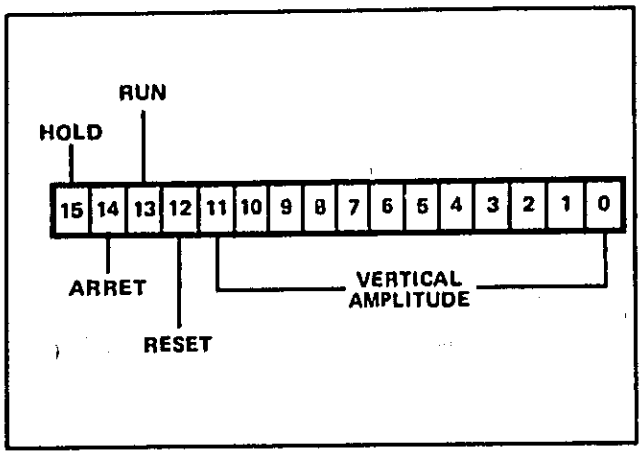


Figure 5-1 Format of 16-Bit word

5-8 The 16-Bit word is made up as follows:

Bits 0 to 11 give the amplitude of the displayed points in 12-Bit binary 2's complement form, 11 being the most significant Bit.

Bit 12 is TRUE if the 3721A is in the RESET condition.

Bit 13 is TRUE if the 3721A is in the RUN condition.

Bit 15 is TRUE if the 3721A is in the HOLD condition.

Bit 14 goes FALSE, with the 3721A in the SUMMATION averaging mode only, when the TIME CONSTANT lamp lights. In EXPONENTIAL averaging, Bit 14 is always TRUE.

5-9 Control signals from the Computer set the Correlator in the RUN, HOLD and RESET conditions and, if the Correlator is fitted with Option 01 series, Delay Offset, the Computer can also control the delay offset introduced. (For details of Option 01 series, please refer to Section IV of this Manual).

5-10 All data and control signals are taken from the Correlator through the rear-panel 50-way connector. Details of the connections from this socket to the computer I/O slot are given in Table 5-1.

5-11 Pins 4, 5, 6, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37 and 43 make up the 16-Bits of the word format given in Figure 5-1.

If Pin 1 is set TRUE by the Computer, the 3721A will RESET.

If Pin 2 is set TRUE by the Computer, the 3721A will HOLD.

If Pin 3 is set TRUE by the Computer, the 3721A will RUN.

Pin 39 is set TRUE by being connected to ground. When Pin 38 is set TRUE by the Computer, the Correlator will output the 100 displayed points at the rate of one word (ie, one displayed point) every 133μs. If Pin 38 is set TRUE and Pin 39 is set FALSE (by being disconnected), the data is fed out at X-Y recorder speed.

5-12 SOFTWARE PROVIDED

5-13 The option is provided with the following software:

a. Basic Control System (BCS) Driver D.6Ø Tape to be used in conjunction with the Prepare Control System (PCS) program to produce a BCS configured to the needs of the system arrangement being used. Identification of this punched tape is: 15801-60001 Rev A – Binary Tape. Also available, but not supplied unless ordered, are:

15801-80001 Rev A – Source Tape
15801-90001 Rev A – Listing

b. 3721A Library Subroutines F/A.C, a tape containing the subroutines peculiar to the Correlator, compatible with ALGOL and FORTRAN languages. Identification is 15802-60001 Rev A – Binary Tape. Also available, but not supplied unless ordered, are:

15802-80001 Rev A – Source Tape
15802-90001 Rev A – Listing

c. 3721A Interface Diagnostic Tape CIT, an absolute tape to perform a functional check on the operating of the Option 020 Interface. Identification is 15803-60001 Rev A – Binary Tape. Also available, but not supplied unless ordered, are:

15803-80001 Rev A – Source Tape
15803-90001 Rev A – Listing

d. A BCS tape configured for a system consisting of one Correlator, a high-speed tape punch, a tape reader and a teletypewriter. The tape is not identified by a number but is designated CONFIG BCS XCORR.

5-14 The following Paragraphs outline the operational procedures to use these tapes but the information given cannot be considered as complete and the user should consult the appropriate Computer Manuals for full details. Where applicable, the references are given.

5-15 GENERAL DESCRIPTION OF F/A.C.

5-16 This tape contains a number of subroutines which can be called from either an ALGOL or a FORTRAN program. The calls are necessary to give the user control over his Correlator(s) via the Computer.

5-17 Calls Available in F/A.C. The various subroutines in this tape can be called in the user's program to control the operation of the 3721A. The number N in the call is the unit reference number (see Paragraph 2.1.2 of the BCS Reference Manual). The calls are as follows:

1. **RUN (N).** Switches Correlator N to RUN.
2. **HOLD (N).** Switches Correlator N to HOLD.
3. **RESET (N).** Switches Correlator N to RESET.
4. **ARRET (N).** If the Correlator N has previously been set to RUN, the ARRET call will cause a pause in the program until the Computer recognizes that the 3721A TIME CONSTANT lamp is lit when the 3721A is in the SUMMATION averaging mode. This is indicated by pin 43 of the 3721A rear-panel 50-way connector going to a TRUE state. The ARRET call may only be used when the Correlator is in the SUMMATION averaging mode; it is meaningless if EXPONENTIAL averaging has been selected. The 3721A is never under interrupt control so that, during the ARRET call, the Computer is locked out until the 3721A TIME CONSTANT lamp lights when the program proceeds to the next instruction after ARRET.

   Two possible causes can result in a permanent lockout of the program such that the Computer does not receive a signal from the 3721A TIME CONSTANT lamp. These causes are:
   a. If the Correlator was not in the RUN state when ARRET was called.
   b. If the Correlator was not switched on.

   If either of these conditions occurs, the error message *EOR will be typed on the teletypewriter and the Computer goes into the

HALT state. The B register of the Computer then contains a status word which indicates the condition. Note that the *hp* 2115 and 2116 Computers display the B register but the 2114 does not. The B register data can be displayed on the 2114 by loading address 000001 and pressing DISPLAY MEMORY pushbutton. The data in the MEMORY DATA register are then the B register contents.

a. If Bit 1 of the B register is lit, the 3721A was not in the RUN mode when ARRET was called.

b. If Bit 2 of the B register is lit, the 3721A was not switched on when ARRET was called.

If the error message *EQR occurs, the Correlator can be brought to the desired state manually and the program restarted by pressing the Computer RUN pushbutton. The ARRET operation will function as if the Correlator had been set to RUN by the Computer.

5. DELAY (N, K). If Correlator N is fitted with an Option series 01, this call commands the Correlator to select the desired amount, K points, of delay offset. K must be specified in multiples of 50 up to a maximum value of 150 for 3721A Option 011: 250 for 3721A Option 012; 450 for 3721A Option 014; or 1050 for 3721A Option 019.

The subroutine DELAY only recognizes the field of numbers from 50 to 1050 in multiples of 50. If any number other than these, or a negative number, is called, the error message INVALID DELAY is typed and the program halts. This is an irrecoverable error.

WARNING: the call will accept a value of delay offset outside the range of an Option (eg, the call for a delay offset of 550 points on a 3721A Option 014) and the resulting state of the delay offset is undefined and, therefore, meaningless. ALWAYS ENSURE THAT ANY DELAY OFFSET CALLED IS WITHIN THE RANGE OF THE OPTION FITTED TO THE CORRELATOR.

6. WAIT (X). The WAIT call produces a pause in the program of X †milliseconds. X must be a real, positive number and has no practical upper limit (up to the order of several years). The minimum WAIT that can be called is 1ms.

†If a 2116 Computer is being used the WAIT will be X milliseconds. If either a 2114 or 2115 Computer is being used, the WAIT will be 1.25 X milliseconds. The discrepancy is due to the different main store cycle times in the two types of Computer.

WARNING: X MUST ALWAYS BE A REAL NUMBER – AN INTEGER WILL CAUSE A PROGRAM ERROR. If X is declared as a real but negative number, the subroutine treats it as zero WAIT.

The WAIT call produces a pause in the program and cannot be made specific to any peripheral.

5-18 Use of the WAIT Call. If the Correlator is in either the Auto- or Crosscorrelation mode with SUMMATION averaging selected, and has been set to the RUN state, after a period of time the TIME CONSTANT lamp will light indicating that the instrument has ceased to sample on the delayed channel. The 3721A will, however, continue to process until the delay store (and delay offset store, if used) has been unloaded. If the Correlator is being called by the ARRET call, the Computer will sense when the TIME CONSTANT lamp lights but data should not be accessed immediately.

5-19 The user will have to insert a WAIT call after the ARRET call before data is accessed. The length of WAIT necessary depends on the TIMESCALE setting and the amount of delay offset in use. The necessary WAIT period can be calculated from the following expressions:

a. If the TIMESCALE setting (Δt) is 33.3μs or longer, processing stops (K + 100) Δt in time after the TIME CONSTANT lamp has lit, where K is the number of points of delay offset selected. The unit of time will depend on the unit of the TIMESCALE setting, ie, if the setting is 33.3μs, (K + 100) Δt = (K + 100) X 33.3μs. If the setting is 10ms, the expression will equal (K + 100) X 10ms and so on.

b. If the TIMESCALE setting is less than 33.3μs, processing stops (K Δt + 135) X 10^{-6} seconds after the TIME CONSTANT lamp has lit. The ARRET call, however, has the 135μs processing time incorporated in the subroutine so that the WAIT period need only be K.Δt μs.

NOTE: If the Correlator is in the EXPONENTIAL averaging mode, the ARRET call is meaningless because, although the TIME CONSTANT lamp will light, no signal is sent to the Computer. The

user must therefore decide, from theoretical considerations, the length of averaging time required for the experiment and, to this, add an amount equal to the expressions given above for SUMMATION averaging and insert a WAIT call of this amount in the program before accessing data. In Signal Recovery and Probability modes, with SUMMATION averaging, no additional WAIT instructions are necessary after the TIME CONSTANT lamp lights. In EXPONENTIAL averaging, the WAIT period is set according to theoretical requirements.

5-20 F/A.C. Calls in an ALGOL Program. The calls described in Paragraph 5-17 must be declared as code procedures in an ALGOL program as follows:

PROCEDURE RUN (N); VALUE N; INTEGER N; CODE;

PROCEDURE HOLD (N); VALUE N; INTEGER N; CODE;

PROCEDURE RESET (N); VALUE N; INTEGER N; CODE;

PROCEDURE ARRET (N); VALUE N; INTEGER N; CODE;

PROCEDURE DELAY (N, K); VALUE N, K; INTEGER N, K; CODE;

PROCEDURE WAIT (X); VALUE X; REAL X; CODE;

N is the unit reference number of the Correlator being called (see BCS Manual).

5-21 In the example of configuring a BCS shown in Appendix A of this manual, Correlator No 1 has a unit reference number of 10 (or 12_8) and Correlator No 2 has a unit reference number of 11 (or 13_8).

5-22 In the WAIT instruction, X can be declared as either a fixed or a floating point number. For example, a delay of 1200 milliseconds could be written as WAIT (1200.) or WAIT (12E+2).

5-23 F/A.C. Calls in a FORTRAN Program. Each call described in Paragraph 5-17 must be declared as CALL in a FORTRAN program, ie:

```
CALL RUN (N)
CALL HOLD (N)
CALL RESET (N)
CALL ARRET (N)
CALL DELAY (N, K)
CALL WAIT (X)
```

N is the unit reference number of the Correlator being called (see BCS Manual). In the example of configuring a BCS shown in Appendix A, Correlator No 1 has a unit reference number of 10 (12_8) and Correlator No 2 has a unit reference number of 11 (13_8). In the WAIT instruction, X can be declared as either a fixed or a floating point number. For example, a delay of 1200 milliseconds could be written as WAIT (1200.) or WAIT (12E+2).

5-24 Summary of Error Codes in F/A.C.

*EQR	Correlator not in RUN, or not switched on, when ARRET called. Can be recovered by manually setting Correlator to RUN. Diagnosis completed by examining the B register contents; if Bit 1 lit, Correlator was not in RUN state when ARRET was called. If Bit 2 lit, Correlator was not switched on when ARRET was called.
INVALID DELAY	Irrecoverable error caused by invalid number of points of delay offset selected in DELAY call.

5-25 TRANSFER OF DISPLAYED POINTS IN FORTRAN AND ALGOL

5-26 Data transfer from the Correlator to the Computer of the 100 displayed points is performed by using an unformatted READ statement. This is demonstrated below in both languages where the instructions are given to transfer the displayed points into a declared array:

FORTRAN

DIMENSION L(100) . . . declares the array L with 100 locations.

READ (N) L . . . . . transfers the 100 points from Correlator N into array L.

ALGOL

INTEGER N, P, ... declares that N and P are integers.

INTEGER ARRAY L [1; 100]; . . . . . reserves array with 100 locations.

READ (N, FOR P := 1 TO 100 DO L[P]); . . . transfers the 100 points from Correlator N into array L.

5-27 It is also possible to transfer the data points into more than one array, eg.

```
FORTRAN  DIMENSION J (50), K (50)
         READ (N) J, K
```

```
ALGOL   INTEGER N, P;
        INTEGER ARRAY J[1: 50],
                      K[1: 50];
        READ (N, FOR P ← 1 TO 50, DO
        J[P],
        FOR P ← 1 TO 50 DO K[P]);
```

5-28 These instructions reserve two arrays, J and K, each of 50 locations and then transfer the first 50 points of the display of Correlator N into array J, and the second 50 points into array K.

NOTE: care should be exercised in the use of READ instructions as incorrect instructions can give reasonable but quite misleading results. Some typical examples are given together with a description of the consequent results. The examples are given in ALGOL but similar results could be achieved by the improper use of FORTRAN instructions.

1. READ (N, FOR P ← 1 TO 50 DO J[P]);
   HOLD (N);
   READ (N, FOR P ← 1 TO 50 DO K[P]);
   This transfers the first 50 points on Correlator N into array J and the same 50 points into array K. HOLD is used here as a 'dummy' instruction to ensure the changeover from array J to array K when the 50 points have been read into array J.

2. READ (N, FOR P ← 1 TO 50 DO J[P]);
   READ (N, FOR P ← 1 TO 50 DO J[P]);
   This transfers the first 50 points into array J, misses ten points (because no changeover signal occurs until 60 points have been read – this is a feature of the formatter), then transfers the next 40 points of the display into array K followed by the first ten points. The general rule is – **'DO NOT HAVE READ INSTRUCTIONS OF LESS THAN 60 WORDS FOLLOWING ONE ANOTHER UNLESS SEPARATED BY A DUMMY INSTRUCTION'.**

3. FOR P ← 1 TO 100 DO READ (N, J[P]);
   This reads the first and the 60th point in repetition. Although this appears to be a reasonable instruction it is, in fact, a series of READ instructions to read one point at a time.

4. READ (N, FOR P ← 1 TO 70 DO J[P]);
   READ (N, FOR P ← 1 TO 50 DO K[P]);
   This reads the first 70 points of the display into J and the first 50 points into array K. These are reasonable READ instructions because the first is for more than 60 words.

5-29 SCALING AUTO AND CROSSCORRELATION FUNCTIONS

5-30 The vertical amplitude of a correlation display is presented as binary numbers over a range equivalent to -2048_{10} to 2048_{10}. The top and bottom of the CRT display are equivalent to $\pm 1024_{10}$, the full range of numbers representing the 8cm of the vertical display plus 4cm overrun top and bottom. To convert from the numbers transferred, to the calibrated values of the points, in V^2, the following scaling factors have to be applied. A and B are the upper limits of the settings of the 3721A front-panel A and B INPUT RMS VOLTS RANGE switch settings respectively and F is unity for SUMMATION averaging and the setting of the EXPONENTIAL GAIN (ie, 1, 10 or 100) for EXPONENTIAL averaging:

a. Autocorrelation on channel A. Multiply each of the transferred numbers by:

$$\frac{A^2}{F \times 1024}$$

b. Autocorrelation on channel B. Multiply each of the transferred numbers by:

$$\frac{B^2}{F \times 1024}$$

c. Crosscorrelation of A and B Inputs. Multiply each of the transferred numbers by:

$$\frac{A.B}{F \times 1024}$$

5-31 SCALING SIGNAL RECOVERY MEASUREMENTS

5-32 Multiply each of the transferred numbers by:

$$\frac{B}{F \times 1024}$$

to obtain the values of the displayed points in Volts.

5-33 SCALING PROBABILITY MEASUREMENTS

5-34 When the Correlator is operating in PROBABILITY mode (density or integral), the base (zero probability) line is represented by 0 and the top line of the display by 2032_{10}. The full field of numbers available, via the Computer interface, is from 0 to 4064_{10} representing the 8cm of the display plus up to a full screen overrun at the top. Calibration of Probability function is largely defined by the user and Paragraph 3-18 in Section III of this Manual describes the normalization of a Probability plot. If the Computer interface, however, is being used, some scaling factor is required. When making Probability DENSITY measurements with SUMMATION averaging and with the DISPLAY GAIN switch set to MIN, the display 'freezes' when the highest point reaches 8cm from the base line (ie, the top of the screen).

5-35 This means that the signal has occurred N*(as set by the 3721A NUMBER OF SAMPLES N control) times at the amplitude represented by the highest point, which is presented to the Computer as 2048_{10}. The amplitudes of other points are proportional fractions of the value N*.

5-36 If the Correlator is being used for Probability INTEGRAL measurements with SUMMATION averaging, the total number of occurrences of the signal at all displayed amplitudes is 4N*when the display 'freezes'.

5-37 DESCRIPTION OF 'CONFIGURED BCS X-CORR'

5-38 This tape is provided for the convenience of the user who does not wish to configure a BCS using D.6Ø and Prepare Control System. It is configured for the following arrangement of peripherals:

EQUIPMENT	I/O SLOT
Tape Reader	1Ø
High Speed Tape Punch	11
Teletypewriter	12
3721A Correlator (via 16-Bit Duplex Register)	13

5-39 It is not adaptable to any other configuration of equipment. If any other arrangement is required a new BCS will have to be configured using D.6Ø and Prepare Control System. Appendix A gives an example of configuring a BCS and can be used as a guide.

5-40 SUMMARY OF BASIC BINARY LOADER

5-41 In the following Paragraphs the instruction 'Load tape using the Basic Binary Loader' appears. This procedure enables absolute binary tapes to be loaded into the Computer. The procedure is summarized here for convenience – detailed instructions are given in Section I of the Computer Operating Manual.

Computer *hp* 2115 or 2116

1. Place the tape in the tape reader and switch the tape reader to RUN.
2. If the Computer has 4K memory, set Switch Register to ØØ77ØØ; if 8K memory, Ø177ØØ.
3. Press Computer control LOAD ADDRESS.
4. Press Computer control CLEAR REGISTER.
5. Set Computer Loader Switch to ENABLED.
6. Press PRESET, press RUN.
7. After tape has run, set Loader Switch to PROTECTED.

Computer *hp* 2114

1. Place the tape in the tape reader and switch the tape reader to RUN.
2. Press Computer control CLEAR REGISTER.
3. Press Computer controls PRESET and LOAD together.

5-42 USING THE 3721A OPTION 020 WITH A FORTRAN PROGRAM

5-43 Paragraphs 5-44 through 5-46 explain the stages required to attain a running FORTRAN program. This is not intended to be a complete description but is, rather, a worked example showing how the features described in the foregoing Paragraphs are used in a practical program. The program reserves store, sets the delay offset (if the Correlator is fitted with the Delay Offset option), sets the Correlator into the RUN and HOLD states in Autocorrelation, reads the 100 displayed points and prints them out in $(Volts)^2$.

5-44 The user will need the configured BCS, X-CORR provided together with the two tapes of the FORTRAN Compiler, F/A.C. and the ALGOL-FORTRAN Library. The equipment layout is as specified in Paragraph 5-38.

5-45 Set the Correlator FUNCTION switch to AUTOCORRELATION A, the TIMESCALE switch to 33.3μs (or longer) and the AVERAGING switch

```
FTN,B,L
      PROGRAM TEST1
      DIMENSION M(100),X(100)
      WRITE (2,1)
      ICR1 = 10
      WRITE (2,2)
      WRITE (2,3)
      READ (1,*)VA
      WRITE (2,4)
      READ (1,*)KA
      WRITE (2,5)
      READ (1,*)T
      CALL DELAY (ICR1,KA)
      D=500.0
      P=FLOAT(KA+100)*T
      CALL RESET (ICR1)
      CALL WAIT (D)
      CALL RUN (ICR1)
      CALL ARRET (ICR1)
      CALL WAIT (P)
      CALL HOLD (ICR1)
      READ (ICR1)M
      C=VA*VA/1024.0
      DO 10 I=1,100
      X(I)=FLOAT (M(I))*C
   10 CONTINUE
      WRITE (2,6)X
      STOP
    1 FORMAT (21H3721A TRIAL PROGRAMME)
    2 FORMAT (33H100 AUTOCORRELATION VALUES IN V!2)
    3 FORMAT (49HWHAT IS UPPER LIMIT OF A-RANGE SETTING IN VOLTS ?)
    4 FORMAT (38HWHAT VALUE OF DELAY OFFSET IS NEEDED ?)
    5 FORMAT (39HWHAT IS TIMESCALE SETTING IN MILLISEC ?)
    6 FORMAT (9F8.3/)
      END
      END$
```

Figure 5-2 FORTRAN program

to SUMMATION. Connect a signal to the A INPUT connector. The signal can be any that will give a reasonable display; a sinewave and squarewave are both suitable.

5-46 Set the teletypewriter (TTY) to LOCAL and switch the punch unit on the keyboard to ON. Run out a length of feed holes by pressing keys **HERE IS** and **REPT** simultaneously (these feed holes are to facilitate tape handling). Type out the program shown in Figure 5-2.

5-47 Correct any typing errors using the Configured Symbolic Editor – see the SYMBOLIC EDITOR PROGRAMMER'S REFERENCE MANUAL. The final corrected tape will be called the *Source Tape.* Using this tape, go through the following compiling procedure (the test program shown here was run on a *hp* 2114B Computer with an 8K memory):

1. Ensure the Computer is in the HALT state.
2. Set the TTY to LINE.
3. Switch on Punch.
4. Load the FORTRAN PASS 1 using the Basic Binary Loader (see Paragraph 5-40).
5. Place the SOURCE tape in the tape reader and switch the tape reader to RUN.
6. Set Computer switch register to 000100.
7. Press Computer LOAD ADDRESS pushbutton.
8. Switch tape punch to ON.

```
HPAL,S,"TEST2"
BEGIN INTEGER N,W,P;REAL V,D,T;
      INTEGER ARRAY M[1:100];
      PROCEDURE RESET (N);INTEGER N; CODE;
      PROCEDURE RUN (N);INTEGER N; CODE;
      PROCEDURE HOLD (N);INTEGER N; CODE;
      PROCEDURE ARRET (N) ; INTEGER N; CODE;
      PROCEDURE DELAY (N,W); INTEGER N,W; CODE;
      PROCEDURE WAIT (D); VALUE D; REAL D; CODE;
FORMAT F1 ("3721A TRIAL PROGRAMME"),
       F2 ("100 AUTOCORRELATION VALUES IN V:2"),
       F3 ("WHAT IS UPPER LIMIT OF A-RANGE IN VOLTS"),
       F4 ("WHAT VALUE OF DELAY OFFSET IS NEEDED"),
       F5 ("WHAT IS TIMESCALE SETTING IN MILLISEC"),
       F6 (9F8.3);

BEGIN N←10;
      WRITE (2,F1);WRITE (2,F2); WRITE (2,F3);
      READ (1,*,V); WRITE (2,F4); READ (1,*,W);
      WRITE (2,F5); READ (1,*,T); DELAY (N,W);
      RESET (N); WAIT (500.0); RUN (N);
      ARRET (N);   WAIT ((W+100)*T);
      HOLD (N);
      READ(N, FOR P←1 TO 100 DO M[P]);
      WRITE (2,F6, FOR P←1 TO 100 DO M[P]*V↑2/1024)
      END;
      END$
```

Figure 5-3 ALGOL program

9. Press Computer RUN pushbutton.
10. The TTY will now list the program and indicate any errors that may have occurred. (If there are any errors, these should be corrected and steps 1 through 10 repeated).
11. The tape punch will generate an Intermediate Tape.
12. Load PASS 2 using the Basic Binary Loader.
13. Place the Intermediate Tape in the tape reader and switch the tape reader to RUN.
14. Set Computer Switch Register to 000100.
15. Press Computer LOAD ADDRESS pushbutton.
16. Press Computer RUN pushbutton. The tape punch will punch the *Relocatable Object Tape.*

NOTE: if the Computer has a 4K memory it will be necessary to load FORTRAN PASS 3 and then PASS 4.

5-48 This Relocatable object Tape can now be used with Basic Control System as described in Paragraph 5-52.

5-49 USING THE 3721A OPTION 020 WITH AN ALGOL PROGRAM

5-50 The procedure with ALGOL is similar to the procedure with FORTRAN, the only difference being in the preparation of the Object Tape. The following is an example to produce an ALGOL program identical to the FORTRAN program in Paragraphs 5-43 through 5-48: Set the Teletypewriter to LOCAL and switch the punch unit on the keyboard to ON. Run out a length of feed holes by pressing **HERE IS** and **REPT**. (These feed holes are no facilitate handling). Type out the program shown in Figure 5-3.

5-51 Correct any typing errors using the Configured Symbolic Editor – see the SYMBOLIC EDITOR PROGRAMMER'S REFERENCE MANUAL. The final corrected tape will be called the SOURCE Tape. Using this tape, go through the following compiling procedure (the test program shown here was run on a *hp* 2116A Computer with an 8K memory):

1. Ensure the Computer is in the HALT state.
2. Place the Configured ALGOL Compiler in the tape reader and switch the tape reader to RUN.
3. Set the TTY to LINE.
4. Load the ALGOL Compiler using the Basic Binary Loader.
5. Place the Source tape in the tape reader and switch the tape reader to RUN.
6. Set Computer switch register to 000100.
7. Press Computer LOAD ADDRESS pushbutton.
8. Set Computer switch register to 140100.
9. Switch tape punch to ON.
10. Press Computer RUN pushbutton. The tape punch will punch the Relocatable Object Tape.

5-52 ABSOLUTE TAPE

5-53 To generate an Absolute Tape from a Relocatable Object Tape in either FORTRAN or ALGOL, use the following procedure:

1. Place Configured BCS XCORR tape in the tape reader and set the tape reader to RUN.
2. Load BCS using the Basic Binary Loader.
3. Set Computer switch register to 000002.
4. Press Computer LOAD ADDRESS pushbutton.
5. Set Computer switch Register to 000000.
6. † Set Computer switch register to 040000.
7. Switch tape punch to ON.
8. Place Relocatable Object Tape in tape reader and switch the tape reader to RUN.
9. Press Computer RUN pushbutton.
10. Place F/A.C Tape in the tape reader and switch the tape reader to RUN.
11. Press Computer RUN pushbutton.
12. † Set Computer switch register to 040004.
13. Place FORTRAN/ALGOL Library in the tape reader and switch the tape reader to RUN.
14. Press Computer RUN pushbutton. At the end of the Library, the TTY prints *LST and the Computer goes into the HALT state.
15. † Set Computer switch register to 100000 and press RUN pushbutton.
16. The TTY types *END.

5-54 The tape from the tape punch is the Absolute Program and is ready for execution.

† These switch settings can be different depending on whether or not listing etc are required. See Basic Control System manual 3-15 (D) and (F).

5-55 To RUN Absolute Tape:

1. Load Absolute Tape using Basic Binary Loader.
2. Set Computer switch register to 000002.
3. Press Computer LOAD ADDRESS pushbutton.
4. Press Computer RUN pushbutton. The program will now start.
5. Answer the questions from the TTY and follow with **CR LF.** The program will run the 3721A and print out the 100 values of the autocorrelation function in V^2.

5-56 CORRELATOR – COMPUTER INTERFACE TEST PROCEDURE

5-57 This test procedure is an absolute assembly language program to test the operation of the interface between any *hp* Digital Computer and a 3721A Correlator. The Computer must be fitted with a *hp* 12554A +ve 16-Bit Duplex Register Card.

5-58 Description of Test. The tests performed are:
Test 1 and Test 2 confirm operation of the Correlator by testing RUN, HOLD and RESET commands and ARRET reply.

Test 3 confirms correct transfer of data to the Computer.

Test 4 confirms correct programming of Delay Offset, if fitted.

5-59 Sequence and Function of Tests

TEST 1; this is the first part of the RUN, HOLD and RESET test consisting of:

1. Visual check; the Correlator is cycled slowly ten times through the RUN, HOLD and RESET states so that the operator can see that these conditions are achieved.
2. The Correlator is then cycled rapidly ten times through the RUN, HOLD and RESET states and the reply signals are verified.

TEST 2; this is the second part of the RUN, HOLD and RESET test, consisting of the following steps:

1. The Correlator is set to the RESET state and all data points are checked to be zero. Correct operation of the ARRET signal is then also checked.
2. The Correlator is set to the RUN state for a short period of time and the program checks that the data points move from zero.
3. The Correlator is then set to the HOLD state and the program checks that the points are stationary.

4. The Correlator is set to the RESET and then RUN state and the timing of the ARRET signal is checked.

The sequence is repeated ten times.

TEST 3; this is the data transfer test. The Correlator is set in the RESET and then HOLD state for a short time, and then in the RUN state. The program checks the rate and smoothness of growth of the data from the Correlator. The sequence is repeated four times.

TEST 4; this is a test of the setting of the Delay Offset via the interface. The Delay Offset is initially set to zero and then increased in units of 50 points up to the maximum specified by the operator at the beginning of the program. Each setting is checked by the program and the sequence is repeated four times.

5-60 Equipment Required. In addition to the 3721A Correlator Option 020, the following equipment is required for the tests:

hp 12554A General Purpose Register Card
hp 2114, 2115 or 2116 Computer with Teletypewriter and Interface SIO Tape configured for the Computer System
hp 10503A Cable Assembly (50Ω coaxial cable terminated BNC male).

The *hp* 10503A Cable Assembly is required to connect the 3721A rear-panel LOGIC PROBE output to the front-panel A INPUT connector.

5-61 DIAGNOSTIC OPERATING PROCEDURE

5-62 The procedure for testing the Correlator Computer Interface is as follows:

1. Connect Correlator to correct ac supply and switch on. 15 minutes should be allowed for warm-up before the actual testing is begun.
2. Load Computer with SIO Configured Tape via the Basic Binary Loader (Paragraph 5-40).
3. Load Computer with Correlator Interface Test Tape via the Basic Binary Loader.
4. Connect Interface cable from 3721A rear-panel 50-way connector to the appropriate I/O slot in the Computer.
5. Set Computer switch register to 000100 and press LOAD ADDRESS pushbutton.
6. Press Computer RUN pushbutton.
7. The Computer types 'CORRELATOR SLOT NUMBER, PLEASE (OCTAL):'.
8. Type the slot number followed by **CR LF**. Press Computer RUN pushbutton.
9. Computer types 'THANK YOU' followed by 'PLEASE TYPE NUMBER OF POINTS OF DELAY OFFSET:'.
10. Type number of points of Delay Offset; Ø, 150, 250, 450 or 1050, depending on the number of points with which the Correlator being used is fitted, followed by **CR LF**. Press Computer RUN pushbutton.
11. The Computer types 'THANK YOU' followed by:
    'SET A INPUT TO 1 TO 2V R.M.S. RANGE
    SET A INPUT TO D.C. AND CONNECT IT TO LOGIC PROBE SOCKET ON REAR PANEL.
    SET DITHER OFF
    'SET FUNCTION TO AUTOCORRELATION A
    SET AVERAGING TO SUMMATION
    SET TIMESCALE TO 333 MICROSECONDS
    SET SWEEP SWITCH AT REAR OF CORRELATOR TO NORMAL'
12. Make these settings and connections and, when finished, press Computer RUN pushbutton.
13. Computer types:
    'TEST 1
    SET NUMBER OF SAMPLES (N) TO 256'
    If delay other than Ø was typed at step 10, the Computer will then type:
    'SET DELAY OFFSET TO ZERO DELAY'
14. Make the setting(s) and press Computer RUN pushbutton.
15. Correlator will be cycled through the sequence described in Paragraph 5-59 (TEST 1) and, if test is successful, will type:
    'TEST 1 COMPLETE
    TEST 2'
16. Correlator will now be cycled through the sequence for Test 2 as described in Paragraph 5-59 (TEST 2) and, if successful, will type:
    'TEST 2 COMPLETE
    TEST 3
    SET NUMBER OF SAMPLES (N) TO 8 x 1024'
17. Make this setting and then press Computer RUN pushbutton.
18. Correlator will be cycled through the sequence described in Paragraph 5-59 (TEST 3) and, if successful, will type:
    'TEST 3 COMPLETE'

19. If the Correlator is not fitted with Delay Offset and Ø was typed in at step 10, the Computer then types:
'INTERFACE TEST COMPLETE'
20. If the Correlator is fitted with Delay Offset, the Computer types:
'TEST 4
SET NUMBER OF SAMPLES (N) TO 256
SET DELAY OFFSET TO EXTERNAL'
21. Correlator will now be cycled through the sequence for Test 4 as described in Paragraph 5-59 (TEST 4) and, if successful, the Computer types:
INTERFACE TEST COMPLETE'
22. After the Computer has typed 'INTERFACE TEST COMPLETE', the program can be re-run, starting at any desired test, by setting the binary representation of the test number on the Computer switch register and pressing the Computer RUN pushbutton. Any changes in the Correlator control settings will be requested by the Computer, as in steps 13 through 20 above.
23. If a fault is found in a test, the Computer will type a message (for example: 'TEST 2 FAILED') and then HALT. The operator can then either:

a. Continue the test by setting the Computer switch register to ØØØØØØ and pressing the Computer RUN pushbutton, or,

b. Restart the same test or enter another test by setting the binary representation of the test number on the Computer switch register and pressing the Computer RUN pushbutton.

CAUTION: If the controls are incorrectly set the test will probably fail. If the Computer indicates that a test has failed, it is advisable to re-run the complete test starting at step 5, making sure that all connections and settings are correct.

5-63 ERROR DIAGNOSTICS

TEST 1 FAILED
Computer A-Register contains correct Bit reply pattern (see Figure 5-1).
Computer B-Register contains actual Bit reply pattern. Figure 5-4 shows Bit 8 to be permanently TRUE and Bit 5 permanently FALSE.

TEST 2 FAILED
Computer A-Register contains a binary number which can be decoded as follows:

1. Data point values supplied too quickly.
2. More than 100 data point values supplied.
3. Data supplied too slowly; check that Correlator is switched on and interface cable is securely connected.
4. RESET failure – values not zero in RESET state.
5. RUN failure – values stationary in RUN state.
6. HOLD failure – values not stationary in HOLD state.
7. ARRET too early – ARRET flag does not occur at time dictated by front-panel settings.
8. ARRET too late – ARRET flag does not occur at time dictated by front-panel settings.

TEST 3 FAILED
Computer A-Register contains as Ø those Bits which have reached a zero state during the course of the test.

Computer B-Register contains as 1 those Bits which have reached a 1 state during the course of the test.

Only the bottom 12 Bits of the Computer Registers are significant; these correspond to the Bits 0 to 11 of the 16 Bit word from the Correlator (see Figure 5-1).

EXAMPLE

Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
A-Register	x	x	x	x	Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
B-Register	x	x	x	x	1	1	1	1	1	1	Ø	1	1	1	1	1

Figure 5-4 Example of A and B Register indicating faults

TEST 4 FAILED

In this test, the Correlator output should consist of three parts:

i. a stream of constant values of duration equal to the Delay Offset selected in the program. (Zero for zero Delay Offset).

ii. a ramp whose gradient and duration is dictated by the front-panel control settings.

iii. a stream of constant values for the remainder of the section of the test.

These three parts are illustrated in Figure 5-5.

5-64 Incorrect operation is detected by examination of the three parts of the operation separately and recorded by a 3-Bit pattern, as follows:

Bit-1 is TRUE (1) if first part is not flat.
Bit-2 is TRUE (1) if second part is flat.
Bit-3 is TRUE (1) if third part is not flat.

The error message is formed by the addition of the bit pattern and the base number 8. The various possible faults are displayed in the Computer A-Register, as shown in Table 5-2.

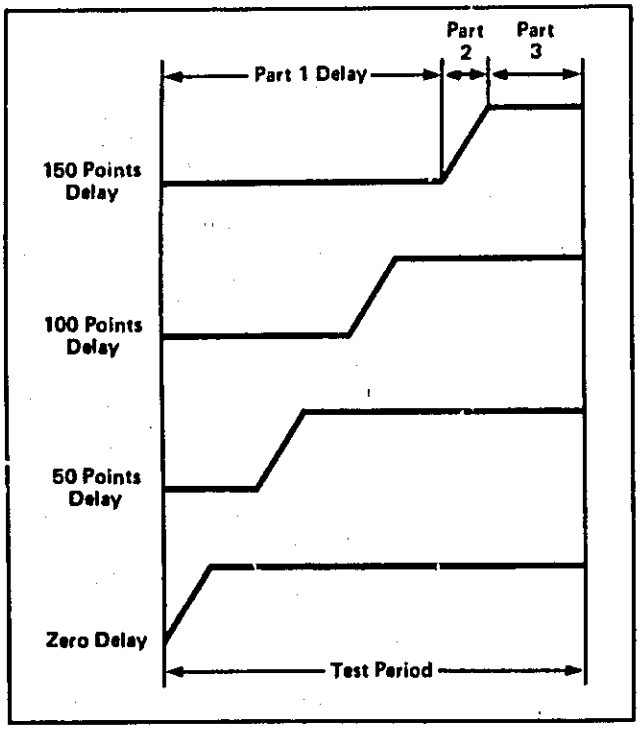


Figure 5-5 Test 4 Delay Offset

Table 5-2 Delay Offset fault conditions

A-Register Display	Fault
9*	Signal continuing to change after the end of the proper delay period in part 3.
10	Complete absence of signal change eg, open circuit in Correlator processor or Correlator not switched on.
11	Signal changes in part 3 only, ie, delay too long.
12*	Signal starts to change before beginning of the proper delay, ie, delay too short.
13*	Signal changes throughout test, ie, in all 3 parts.
14	Signal changes only in part 1, ie, delay period much too short.
15*	Signal changes in parts 1 and 3 but not in part 2.

*The diagnosis may be incorrect if the Correlator output signal is contaminated by noise. To examine the trace the test may be continuously cycled by setting Bit 15 of the switch register to 1 and pressing the Computer RUN pushbutton.

SECTION VI
OPTIONS 021 AND 022

6-1 DESCRIPTION

6-2 Options 021 and 022 interface the 3721A Correlator with *hp* 2753A and *hp* 8100A Tape Punches, respectively.

6-3 Each of these options consists of a plug-in printed circuit board (common to both) and an interconnecting cable assembly, as follows:

	Circuit Board	Cable Assembly
Option 021	03721-70022	15546A
Option 022	03721-70022	15547A

6-4 When in operation, either of these options will provide an output to the Tape Punch to record the data displayed on the CRT. Output is in ASCII code and each point on the display is represented by four OCTAL digits (1 punch frame/digit). After each set of four digits, characters **CR LF*** are punched as word delimiters; this allows the output to be listed using a conventional teletypewriter.

*** Carriage Return/Line Feed.**

6-5 DATA FORMAT

6-6 The levels of the logic outputs are 0V (LO) and 12V (HI). The code used is ASCII which, for the characters used, is identical to the ISO code as recommended in the ISO Recommendations R646 and R1113. A typical piece of tape is reproduced in Figure 6-1 with the format indicated.

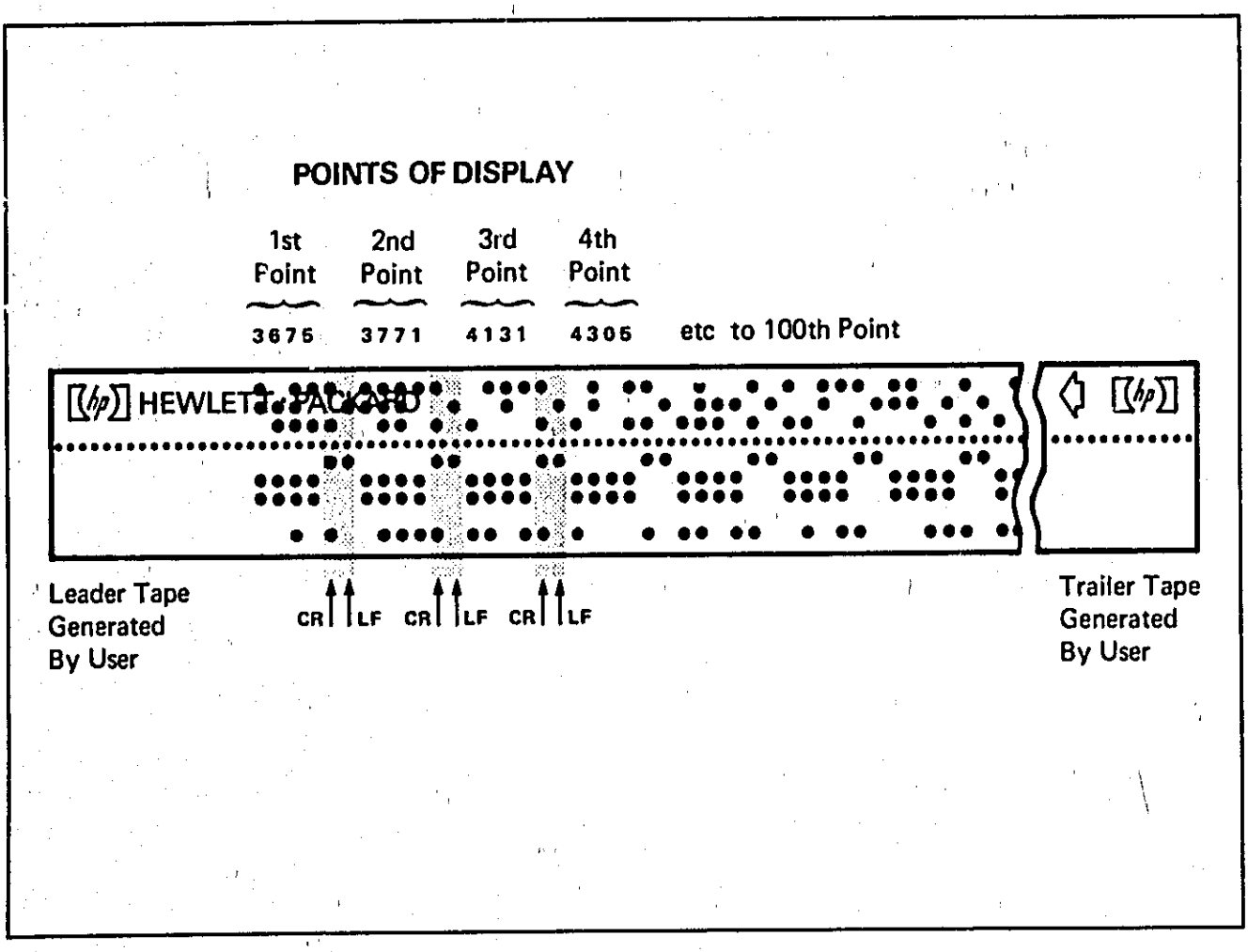


Figure 6-1 Sample of punched tape

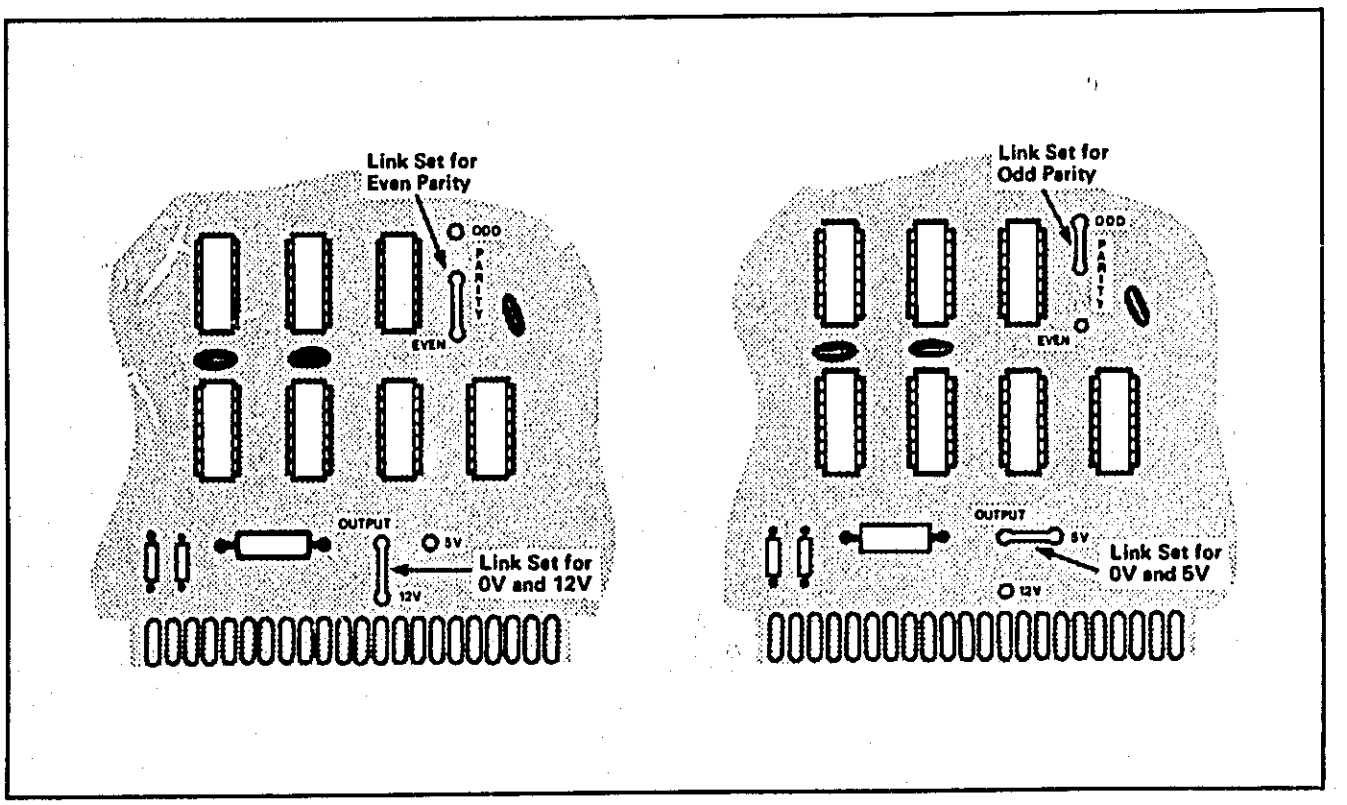


Figure 6-2 Position of solder links on circuit board

Table 6-1 Punch codes for characters

Character Punched	BIT NUMBER 7	6	5	4	3	•	2	1	0
0	0	0	1	1	0	•	0	0	0
1	1	0	1	1	0	•	0	0	1
2	1	0	1	1	0	•	0	1	0
3	0	0	1	1	0	•	0	1	1
4	1	0	1	1	0	•	1	0	0
5	0	0	1	1	0	•	1	0	1
6	0	0	1	1	0	•	1	1	0
7	1	0	1	1	0	•	1	1	1
CR	1	0	0	0	1	•	1	0	1
LF	0	0	0	0	1	•	0	1	0

parity — feed holes

6-7 Table 6-1 shows the punch codes for the characters used; 1 indicates a hole and 0 indicates no hole.

6-8 The option as supplied is set to generate *even* parity as shown in Table 6-1. Parity can be made *odd* by changing a wire link on the option printed circuit board as shown in Figure 6-2 (see also Paragraph 6-14).

6-9 The 2753A Tape Punch uses negative logic, that is to say a +12V level signal calls for *punch* and a 0V level calls for *no punch*. The 8100A Tape Punch uses positive logic, the necessary inversion being performed by the 15547A Cable Assembly.

6-10 DATA PRESENTATION

6-11 **Autocorrelation, Crosscorrelation and Signal Recovery.** In these modes, the zero amplitude level (ie, the horizontal line across the middle of the CRT screen) is represented by the octal number 4000_8, the bottom of the screen by 2000_8 and the top of the screen by 5777_8. The full range of numbers available is 0000_8 to 7777_8 representing up to 50% screen overrun at top and bottom. This is illustrated in Figure 6-3.

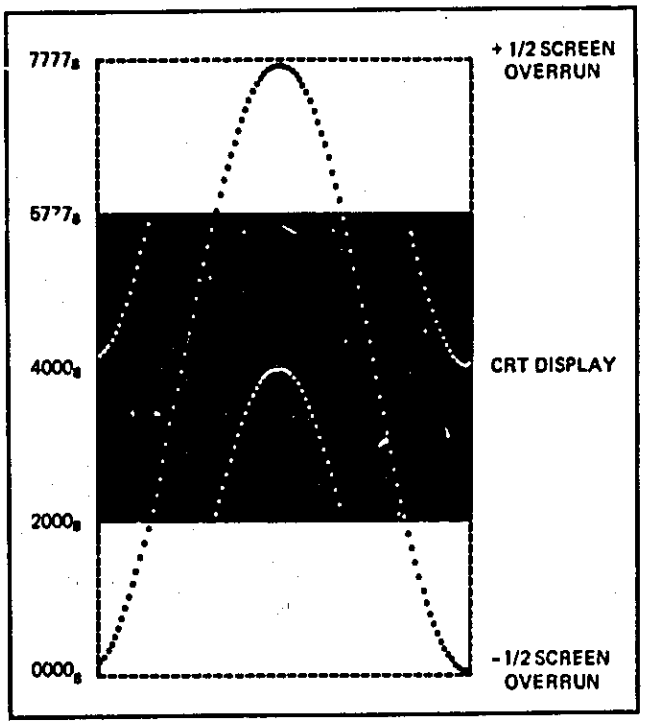


Figure 6-3 Data presentation — Correlation and Signal Recovery

6-12 When the numbers are subsequently processed it is necessary to subtract 4000_8 from each number used in the calculations. The number 4000_8 was chosen for the zero line to avoid the unnecessary complications of processing negative octal numbers.

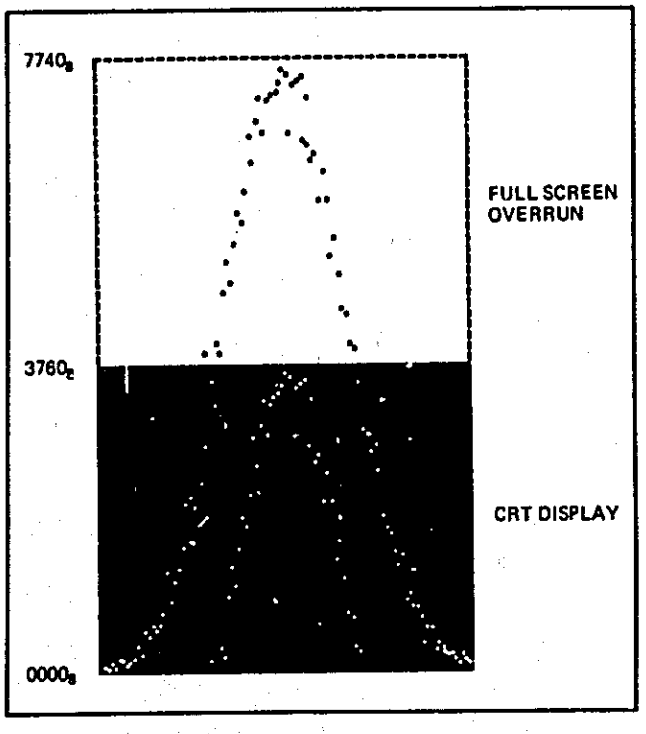


Figure 6-4 Data presentation — Probability

6-13 **Probability.** In this mode, the top of the screen is represented by 3760_8. The full field available is from 0000_8 to 7740_8 so there can be up to a full screen overrun at the top as shown in Figure 6-4.

6-14 **Other Punch Interfaces.** The 3721A Correlator fitted with Option 021 or 022 is designed to interface with the *hp* 2753A or 8100A Tape Punch and is not intended for use with other punches. The *hp* 8100A, however, is a *hp* modified version of the current FACIT 4070 Punch and the 3721A Option 022 should operate with this FACIT Punch. The *hp* 2753A is a *hp* modified version of the TALLY Punch but, because electrical modifications are made by *hp*, the 3721A Option 021 cannot be used with the standard TALLY Punch. It may be possible to interface with other punches by including suitable buffer circuitry and modifying the interconnecting cable. The output signal can be altered to TTL levels (0 and 5V) by changing a wire link on the option printed circuit board as shown in Figure 6-2.

6-15 **Conversion from Octal to Decimal.** Table 6-2 is an aid for converting from octal to decimal numbers.

Table 6-2 Octal to decimal conversion

Digit	$512(8^3)$	$64(8^2)$	$8(8^1)$	$1(8^0)$
0	0	0	0	0
1	512	64	8	1
2	1024	128	16	2
3	1536	192	24	3
4	2048	256	32	4
5	2560	320	40	5
6	3072	384	48	6
7	3584	448	56	7

EXAMPLE:
To find the decimal equivalent of octal number 7325_8:

Look up the value of 5 in column 8^0	=	5
Look up the value of 2 in column 8^1	=	16
Look up the value of 3 in column 8^2	=	192
Look up the value of 7 in column 8^3	=	3584
Decimal equivalent of 7325_8	=	3797

6-16 OPERATING INSTRUCTIONS

6-17 When the Option 021 or 022 is installed, switch on both the 3721A and the Tape Punch and the system is then ready for normal operation.

6-18 For ease of handling the finished tape it is recommended to run out a length of leader tape manually before starting to punch Correlator data. On the 2753A only feed holes are punched on the leader tape. On the 8100A either feed holes or erasures (all holes punched) can be used for a leader.

6-19 Once the desired display has been obtained on the 3721A CRT screen, recording is started by pressing the RECORD pushbutton on the 3721A front panel. The 3721A goes into the slow sweep mode (as provided for X-Y recording) and there are two slow sweep speeds of either 270ms or 1.35s per display point. The sweep speed is selected by an internal plug-in link mounted on circuit board assembly A5 which is normally set to the 270ms speed, this speed being suitable for either the 2753A or the 8100A Tape Punch. Once the 100 display points have been recorded on the tape, the Punch will automatically stop. It is recommended that the Operator runs out a length of trailer tape to facilitate handling later.

6-20 Data can be transferred to the Tape Punch with the Correlator in RUN, HOLD or RESET condition. (In the RESET state the punch will record 100 points equivalent to zero, see Figures 6-3 and 6-4.) If the Correlator is in RUN, processing continues normally during the punching operation.

6-21 CALIBRATION

6-22 Auto and Crosscorrelation. The vertical amplitude of a correlation display is presented as octal numbers as shown in Figure 6-3. To convert from the octal number punched to the calibrated value of any point in V^2, first subtract 4000_8 and then apply the following scaling factors, where A and B are the upper limits of the settings of the 3721A front-panel A and B INPUT RMS VOLTS RANGE switch settings respectively and F is unity for SUMMATION averaging and the setting of the EXPONENTIAL GAIN switch (ie, 1, 10 or 100) for EXPONENTIAL averaging.

a. Autocorrelation on Channel A. Multiply each of the punched values by:

$$\frac{A^2}{F \times 1777_8}$$

b. Autocorrelation on Channel B. Multiply each of the punched values by:

$$\frac{B^2}{F \times 1777_8}$$

c. Crosscorrelation of Channels A and B. Multiply each of the punched values by:

$$\frac{A.B}{F \times 1777_8}$$

6-23 Signal Recovery. Multiply each of the punched values by:

$$\frac{B}{F \times 1777_8}$$

to obtain the voltage value of the displayed points.

6-24 Probability. In Probability mode (Density or Integral) the base (zero probability) line is represented by zero and the top line of the display is represented by 3760_8. The full field of numbers available via the interface is from 0 to 7740_8 representing the 8cm of the display plus up to a full screen overrun at the top. Calibration of Probability functions is largely defined by the user and Section III of this Manual describes the normalization of a Probability plot.

6-25 If the Tape Punch interface, however, is being used, some scaling factor is required. When making Probability Density measurements with SUMMATION averaging and with the DISPLAY GAIN switch set to MIN, the display 'freezes' when the highest point reaches 8cm from the base line (ie, the top of the screen). This means that the signal has occurred N* times (as set by the NUMBER OF SAMPLES N control) at the amplitude represented by the highest point, which is presented to the Tape Punch as 3760_8. The amplitudes of other points are proportionate fractions of the value of N*. For Probability Integral measurements with SUMMATION averaging, the total number of occurrences of the signal at all displayed amplitudes is 4N* when the display 'freezes'.

APPENDIX

A

APPENDIX A
EXAMPLE OF CONFIGURING A BCS USING PREPARE CONTROL SYSTEM

A-1 INTRODUCTION

A-2 This Appendix describes a worked example of a configuring procedure using Prepare Control System (PCS) and the appropriate BCS drivers. The example was performed on a *hp* 2116A Computer equipped with an 8K memory and the following peripheral equipment.

Equipment	I/O Slot
Tape Reader	10
High Speed Tape Punch *hp* 2753A	11
Teletypewriter	12
3721A Correlator No 1	13
3721A Correlator No 2	14

A-3 If only one Correlator is to be used, the configured BCS obtained will function provided the Correlator is connected to I/O Slot No 13. For a full discussion of the use of the Prepare Control System procedure, see Section 5 of the *hp* BCS Manual.

A-4 The procedure followed was:
1. Ensure the Computer is in the HALT mode.
2. Load PCS using the Basic Binary Loader.
3. Set Computer Switch Register to 002000.
4. Press Computer LOAD ADDRESS pushbutton.
5. Set Switch Register to 002012.
6. Press Computer RUN pushbutton.

A-5 The teletypewriter asks a series of questions, makes statements and gives instructions. These, together with the answers typed out by the operator, are listed in Table A-1, the right hand column being coded *Q* for question, *A* for answer, *S* for Statement and *I* for instruction:

Table A-1 Prepare Control System procedure

HS INP?	*Q.*	*Which slot holds the tape reader?*
10	*A.*	*The tape reader is in slot 10.*
HS PUN?	*Q.*	*Which slot holds the tape punch?*
11	*A.*	*The tape punch is in slot 11.*
FWA MEM?	*Q.*	*What is first word of available memory?*
30	*A.*	*First word of available memory is word 30.*
LWA MEM?	*Q.*	*What is last word of available memory?*
17677	*A.*	*Last word of available memory is word 17677 (07677 if Computer has 4k memory).*
*LOAD	*I.*	*Computer instruction to load BCS drivers for peripherals in use. Place Tape Reader BCS driver, D.01, in the tape reader and press Computer RUN pushbutton.*
D.01	*S.*	*Statement that D.01 is acknowledged.*
17341 17677	*S.*	*D.01 occupies words 17341 through 17677 in memory.*
*LOAD	*I.*	*Place Tape Punch BCS Driver tape, D.02, in tape reader and press Computer RUN pushbutton.*
D.02	*S.*	*Statement that D.02 is acknowledged.*
17031 17340	*S.*	*D.02 occupies words 17031 through 17340 in memory.*
*LOAD	*I.*	*Place Teletypewriter BCS Driver tape, D.00, in tape reader and press Computer RUN pushbutton.*

Table A-1 Prepare Control System procedure (continued)

D.ØØ	*S.*	*Statement that D.ØØ is acknowledged.*
16275 17030	*S.*	*D.ØØ occupies words 16275 through 17030 in memory.*
*LOAD	*I.*	*Place Correlator BCS Driver tape, D.6Ø, in tape reader and press Computer RUN pushbutton.*
D.6Ø	*S.*	*Statement that D.6Ø is acknowledged.*
15474 16274	*S.*	*D.6Ø occupies words 15474 through 16274 in memory.*
*LOAD	*I.*	*Place Input/Output Control (IOC) Tape in tape reader and press Computer RUN pushbutton.*
IOC	*S.*	*Statement that IOC is acknowledged.*
15255 15473	*S.*	*IOC occupies words 15255 through 15473 in memory.*
*TABLE ENTRY	*S.*	*Computer is prepared for tables to be entered.*
EQT?	*Q.*	*What peripherals are operated by which drivers?*
1Ø, D.Ø1	*A.*	*Slot number 1Ø is driven by D.Ø1.*
11, D.Ø2	*A.*	*Slot number 11 is driven by D.Ø2.*
12, D.ØØ	*A.*	*Slot number 12 is driven by D.ØØ.*
13, D.6Ø	*A.*	*Slot number 13 is driven by D.6Ø.*
14, D.6Ø	*A.*	*Slot number 14 is driven by D.6Ø.*
/E	*A.*	*EQT? table ended.*
SQT?	*Q.*	*What is standard equipment table? (See BCS Manual).*
-KYBD?	*Q.*	*What is unit reference number of keyboard input?*
11	*A.*	*11.*
-TTY?	*Q.*	*What is unit reference number of teletypewriter input?*
11	*A.*	*11.*
-LIB?	*Q.*	*What is unit reference number of program library input?*
7.	*A.*	*7.(Unit reference number of tape reader).*
-PUNCH?	*Q.*	*What is unit reference number of tape punch output?*
1Ø	*A.*	*1Ø.*
-INPUT?	*Q.*	*What is unit reference number of input?*
7	*A.*	*7. (Unit reference number of tape reader).*
-LIST?	*Q.*	*What is unit reference number of list output?*
11	*A.*	*11. (Unit reference number of teletypewriter).*
DMA?	*Q.*	*Does the system have driect memory access channel?*
Ø	*A.*	*No.*
*LOAD	*I.*	*Load Relocating Loader Tape. Place tape in the tape reader and press Computer RUN pushbutton.*
LOADR	*S.*	*Loading acknowledged.*
12625 15221	*S.*	*Relocating Loader Tape occupies words 12625 through 15221 in memory.*

Table A-1 Prepare Control System procedure (continued)

INTERRUPT LINKAGE?	*Q.*	*What are memory locations and program labels used by driver linkages?†*
10, 20, I.01	*A.*	*Linkage addresses are stored in memory locations 10 and 20. The labels used to identify the second linkage is I.01.*
11, 21, I.02	*A.*	*Locations 11 and 21. Label I.02.*
12, 22, I.00	*A.*	*Locations 12 and 22. Label I.00.*
13, 23, I.60	*A.*	*Locations 13 and 23. Label I.60.*
14, 24, I.60	*A.*	*Locations 14 and 24. Label I.60.*
/E	*A.*	*Interrupt linkages table ended.*

†Each driver has two sections; the 'initiator' and 'continuator'. The program can be entered at the start of either section. The entry point of the initiator section of driver D.01, for example, is stored in memory location 10 and is automatically given the label D.01. The entry point of the continuator section of driver D.01 is stored in memory location 20 and the answer '10, 20, I.01' associates with the entry point the label I.01. For a fuller description of BCS drivers, refer to the *hp* book 'A Pocket Guide to Interfacing HP Computers', Section 2, 'How to Write a BCS Driver'.

The Computer will now type out a list of BCS entry points, finishing with:

```
*SYSTEM LINK
00030  00221
*BCS ABSOLUTE OUTPUT
```

I. The Computer is now ready to punch the configured BCS. Turn on the tape punch and press Computer RUN pushbutton. When punching stops, the Computer goes into the HALT state. Press the Computer RUN pushbutton and the teletypewriter will type:

```
*END
```

The tape produced is a configured BCS for the system described at the beginning of this Appendix. A similar procedure would be necessary if the system were physically altered.

APPENDIX

B

APPENDIX B
SOFTWARE LISTINGS

B-1 INTRODUCTION

B-2 This Appendix contains source listings of the D.60 BCS driver and the Fortran/Algol Library Subroutines (F/A.C) provided with the 3721A Option 020.

Table B-1 Computer listing of D.60

```
PAGE 0001


0001                    ASMB ?,B,L,T,Z
D.60   R 000000
I.60   R 000577
.BUFR  X 000001
WRITE  R 000046
WRIT1  R 000050
WRIT2  R 000056
DELDC  R 000070
FUNCT  R 000107
OTBIN  R 000130
EXIT1  R 000135
CLST1  R 000137
EXB1   R 000145
EXB2   R 000146
TEMP   R 000145
REJCT  R 000147
STOP   R 000153
STPR1  R 000165
STAT1  R 000177
STAT2  R 000200
MASK1  R 000201
DEMSK  R 000202
OTMSK  R 000203
.22    R 000204
RDPT   R 000205
SFSIN  R 000211
LIAIN  R 000213
CLRST  R 000216
FINIS  R 000224
SFCIN  R 000227
CLCIN  R 000233
BIT15  R 000237
POINT  R 000243
OTB0   R 000244
#A     R 000245
$A     R 000245
#B     R 000246
B77    R 000247
CHAN   R 000250
B5300  R 000251
B1600  R 000252
B100   R 000253
B600   R 000254
B17    R 000255
M50    R 000256
.3     R 000257
M22    R 000260
```

Table B-1 Computer listing of D.60 (continued)

```
M40    R 000261
M500   R 000262
DELAY  R 000263
READ   R 000264
NTRI   R 000301
ITBP   R 000305
STC02  R 000314
LOOP1  R 000315
TN     R 000324


 PAGE 0002


TNL    R 000326
TS     R 000340
CLRTN  R 00035
SECND  R 00035
WORDS  R 00040
RDERI  R 00046
CLEAR  R 000412
M100   R 000420
COUNT  R 000421
CHC    R 000422
T      R 000423
N      R 000424
Q      R 000425
TBUFP  R 000426
C      R 000427
CALBF  R 000430
MSKI   R 000201
.2     R 000431
BADDR  R 000432
**  NO ERRORS*


 PAGE 0003 #01  D.60 B.C.S. CORRELATOR DRIVER


0001                    ASMB,R,B,L,T,Z
0003*
0004****     21 OCT 1970     ****
0005*
0006*
0007**** ASSEMBLE WITH N FOR D.M.A. VERSION *****
0008****** AND WITH Z FOR NON-D.M.A. VERSION **********
0009*
0010*
0011*
0012******  INITIATOR SECTION  ******
0013*
0014*
0015  00000                     NAM D.60
0016                            ENT D.60,I.60
0017                            EXT .BUFR
0018*
0019*
0020  00000 000000  D.60  NOP
0021  00001 072245R       STA #A
0022  00002 076246R       STB #B
0023  00003 072146R       STA EXB2
0024  00004 160000        LDA 0,I
0025  00005 012247R       AND B77
```

Table B-1 Computer listing of D.60 (continued)

```
0026  00006 072230R          STA CHAN
0027  00007 032244R          IOR OTB0
0028  00010 072130R          STA OTBIN
0029  00011 072135R          STA EXIT1
0030  00012 022251R          XOR B5300
0031  00013 072213R          STA LIAIN
0032  00014 022252R          XOR B1600
0033  00015 072211R          STA SFSIN
0034  00016 022253R          XOR B100
0035  00017 072227R          STA SFCIN
0036  00020 032213R          IOR LIAIN
0037  00021 072153R          STA STOP
0038  00022 032137R          IOR OTBIN
0039  00023 072236R          STA CLCIN
0040  00024 022254R          XOR B600
0041  00025 072225R          STA FINIS+1
0042*
0043*
0044  00026 162246R          LDA #B,I
0045  00027 001700           ALF
0046  00030 012255R          AND B17
0047  00031 002003           SZA,RSS
0048  00032 026412R          JMP CLEAR
0049  00033 052257R          CPA .3
0050  00034 026107R          JMP FUNCT
0051  00035 036246R          ISZ #B
0052  00036 036246R          ISZ #B
0053  00037 066246R          LDB #B
0054  00040 164001           LDB 1,I
0055  00041 005275           RBL,CLE,SLB,ERB
0056  00042 026040R          JMP *-2
0057  00043 036246R          ISZ #B


 PAGE 0004 #01  D.60 B.C.S. CORRELATOR DRIVER


0058  00044 000050           CLE,SLA
0059  00045 026264R          JMP READ
0060*
0061*


 PAGE 0005 #01  D.60 B.C.S. CORRELATOR DRIVER


0063  00046 160001  WRITE LDA 1,I
0064  00047 066260R         LDB M22
0065  00050 002003  WRIT1 SZA,RSS
0066  00051 026056R         JMP WRIT2
0067  00052 042256R         ADA M50
0068  00053 006020          INB,SZB
0069  00054 026050R         JMP WRIT1
0070  00055 026147R         JMP REJCT
0071  00056 046204R WRIT2 ADB .22
0072  00057 005723          BLF,RER
0073  00060 036245R         ISZ #A
0074  00061 162245R         LDA #A,I
0075  00062 012203R         AND QTMSK
0076  00063 030001          IOR 1
0077  00064 172245R         STA #A,I
0078  00065 006000          LDA 1
0079  00066 016070R         JSB DELDC
```

Table B-1 Computer listing of D.60 (continued)

```
0080  00067 026135R          JMP EXIT1
0081*
0082  00070 000000  DELDC NOP
0083  00071 001121          ARS,ARS
0084  00072 001100          ARS
0085  00073 042260R          ADA M22
0086  00074 006400          CLB
0087  00075 000031          SLA,ARS
0088  00076 006004          INE
0089  00077 005700          ELF
0090  00100 000031          SLA,ARS
0091  00101 002001          RSS
0092  00102 006004          INB
0093  00103 042243R          ADA POINT
0094  00104 144000          ADE 0,I
0095  00105 005722          ELF,REL
0096  00106 126070R          JMP DELDC,I
0097*
0098*
0099*
0100  00107 162246R FUNCT LDA #B,I
0101  00110 001727          ALF,ALF
0102  00111 001222          RAL,RAL
0103  00112 012257R          AND .3
0104  00113 002003          SZA,RSS
0105  00114 026153R          JMP STOP
0106  00115 052257R          CPA .3
0107  00116 002004          INA
0108  00117 072145R          STA TEMP
0109  00120 036245R          ISZ #A
0110  00121 162245R          LDA #A,I
0111  00122 012201R          AND MASK1
0112  00123 172245R          STA #A,I
0113  00124 012202R          AND DEMSK
0114  00125 016070R          JSB DELDC
0115  00126 076263R          STB DELAY
0116  00127 046145R          ADB TEMP
0117  00130 000000  OTBIN NOP      OTB INSERT
0118  00131 062262R          LDA M500


 PAGE 0006 #01  D.60 B.C.S. CORRELATOR DRIVER


0119  00132 002006          INA,SZA
0120  00133 026132R          JMP *-1
0121  00134 066263R          LDB DELAY
0122  00135 000000  EXIT1 NOP      OTB INSERT
0123  00136 026141R          JMP *+3
0124  00137 016224R CLST1 JSB FINIS
0125  00140 016216R          JSB CLRST
0126  00141 062000R          LDA D.60
0127  00142 072145R          STA EXB1
0128  00143 002400          CLA
0129  00144 016001X          JSB .BUFR
0130  00145 000000  EXB1  NOP
0131  00146 000000  EXB2  NOP
0132  00145          TEMP  EQU EXB1
0133*
0134*
0135  00147 016216R REJCT JSB CLRST
0136  00150 006400          CLB
0137  00151 002404          CLA,INA
```

Table B-1 Computer listing of D.60 (continued)

```
0138  00152 126000R        JMP D.60,I
0139  00153 103777  STOP   STC 77B,C
0140  00154 016205R        JSB RDPT
0141  00155 026165R        JMP STPR1 (OVERDUE)
0142*
0143* STOP FLAG UP ? *
0144*
0145  00156 001222         RAL,RAL
0146  00157 000010         SLA
0147  00160 026137R        JMP CLST1 YES
0148*
0149* NO, CORRL. IN RUN ? *
0150*
0151  00161 002020         SSA
0152  00162 026153R        JMP STOP
0153*
0154* NO, SET STATUS FIELD *
0155*
0156  00163 066177R        LDB STAT1
0157  00164 002001         RSS
0158  00165 066200R STPR1  LDB STAT2
0159  00166 036245R        ISZ $A
0160  00167 162245R        LDA $A,I
0161  00170 012201R        AND MASK1
0162  00171 030001         IOR 1
0163  00172 172245R        STA $A,I
0164*
0165* SET A AND B REGISTERS *
0166*
0167  00173 016224R        JSB FINIS
0168  00174 066237R        LDB BIT15
0169  00175 002404         CLA,INA
0170  00176 126000R        JMP D.60,I      EXIT ****
0171  00177 040002  STAT1  OCT 40002  (CORR. NOT IN RUN)
0172  00200 040004  STAT2  OCT 40004  (CORR. NOT READY)
0173  00201 037770  MASK1  OCT 37770
0174  00202 000370  DEMSK  OCT 370

 PAGE 0007 #01  D.60 B.C.S. CORRELATOR DRIVER


0175  00203 037400  QTMSK  OCT 37400
0176  00204 000026  .22    DEC 22
0177*
0178*
0179  00205 000000  RDPT   NOP
0180  00206 002400         CLA
0181  00207 002007         INA,SZA,RSS
0182  00210 126205R        JMP RDPT,I
0183  00211 102377  SFSIN  SFS 77B
0184  00212 026207R        JMP *-3
0185  00213 103577  LIAIN  LIA 77B,C
0186  00214 036205R        ISZ RDPT
0187  00215 126205R        JMP RDPT,I
0188*
0189*

 PAGE 0008 #01  D.60 B.C.S. CORRELATOR DRIVER


0191  00216 000000  CLRST  NOP
```

Table B-1 Compl of D.60 (continued)

```
0192  00217 036245R          ISZ $A
0193  00220 162245R          LDA $A,I
0194  00221 012201R          AND MASK1
0195  00222 172245R          STA $A,I
0196  00223 126216R          JMP CLRST,I
0197*
0198*
0199  00224 000000  FINIS NOP
0200  00225 000000          NOP    CLF INSERT
0201  00226 062261R         LDA M40
0202  00227 000000  SFCIN NOP
0203  00230 026225R         JMP FINIS+1
0204  00231 002006          INA,SZA
0205  00232 026227R         JMP SFCIN
0206  00233 000000  CLCIN NOP
0207  00234 126224R         JMP FINIS,I
0208*
0209*
0210  00235 000040          OCT 40
0211  00236 000010          OCT 10
0212  00237 100000  BIT15 OCT 100000
0213  00240 000004          OCT 4
0214  00241 040000          OCT 40000
0215  00242 000002          OCT 2
0216  00243 000243R POINT DEF *
0217*
0218*
0219  00244 106600  OTB0   OTB 0
0220  00245 000000  #A     NOP
0221  00245         $A     EQU #A
0222  00246 000000  #B     NOP
0223  00247 000077  B77    OCT 77
0224  00250 000000  CHAN   NOP
0225  00251 005300  B5300  OCT 5300
0226  00252 001600  B1600  OCT 1600
0227  00253 000100  B100   OCT 100
0228  00254 000600  B600   OCT 600
0229  00255 000017  B17    OCT 17
0230  00256 177716  M50    DEC -50
0231  00257 000003  .3     DEC 3
0232  00260 177752  M22    DEC -22
0233  00261 177730  M40    DEC -40
0234  00262 177014  M500   DEC -500
0235  00263 002000  DELAY  OCT 002000
0236*
0237*******


 PAGE 0009 #01  D.60 B.C.S. CORRELATOR DRIVER


0239**********READ*********
0240*
0241*
0242  00264 162246R READ   LDA #B,I
0243  00265 076430R        STB CALBF
0244  00266 072425R        STA Q
0245*
0246* CHARACTERS REQUESTED ? *
0247*
0248  00267 002021         LSA,RSS
0249  00270 026400R        JMP WORDS     NO
0250*
```

Table B-1 Computer listing of D.60 (continued)

```
0251* N := -Q/2 *
0252*
0253  00271 003004          CMA,INA
0254  00272 001100          ARS
0255  00273 072424R         STA N
0256*
0257*  STATUS ???? *
0258*
0259  00274 062245R         LDA #A
0260  00275 002004          INA
0261  00276 160000          LDA 0,I
0262  00277 000010          SLA
0263  00300 026356R         JMP SECND  ( BIT = 1 )
0264*
0265* T := 1 *
0266*
0267  00301 002404  NTRI     CLA,INA
0268  00302 072423R          STA T
0269*
0270* C := SELECT CODE *
0271*
0272  00303 062250R          LDA CHAN
0273  00304 072427R          STA C
0274*
0275* INITIALISE TRANSFER BUFFER POINTER *
0276*
0277  00305 066432R ITBP     LDB BADDR
0278  00306 076426R          STB TBUFP
0279*
0280* INPUT 100 POINTS *
0281*
0282  00307 062153R          LDA STOP
0283  00310 072314R          STA STC02
0284*
0285                         IFZ
0286*
0287  00311 103100           CLF 0
0288  00312 062420R          LDA M100
0289  00313 072421R          STA COUNT
0290  00314 103777  STC02    STC 77B,C
0291  00315 016205R LOOP1    JSB RDPT
0292  00316 026404R          JMP RDER1   (OVERDUE)
0293  00317 170001           STA 1,I
0294  00320 006004           INB

 PAGE 0010 #01  D.60 B.C.S. CORRELATOR DRIVER

0295  00321 036421R          ISZ COUNT
0296  00322 026315R          JMP LOOP1
0297  00323 102100           STF 0
0298*
0299                         XIF
0300*
0301                         IFN
0302*
0303                         EXT DMAC1,DMAC2,IOERR
0304*
0305                         LDB DMAC1
0306                         CCE,SZB,RSS
0307                         JMP NODMA
0308                         SSB
```

Table B-1 Computer listing of D.60 (continued)

```
0309                        JMP CH2
0310                        LDA 1
0311                        RBL,ERB
0312                        STB DMAC1
0313                        JMP SDMA
0314                  CH2   LDB DMAC2
0315                        SZB,RSS
0316                        JMP *+3
0317                        SSB,RSS
0318                        JMP CONT
0319                        CLB,INB
0320                        JMP REJCT+2
0321                  NODMA LDB #B
0322                        ADB M4
0323                        LDA .3
0324                        JMP IOERR
0325                  CONT  LDA 1
0326                        RBL,ERB
0327                        STB DMAC2
0328                  SDMA  CLB
0329                        STB 0,I
0330                        STA DMA
0331                        IOR OTB0
0332                        STA OTBD1
0333                        IOR B100
0334                        STA CLCD1
0335                        XOR B5000
0336                        STA STCD1
0337                        XOR B1400
0338                        STA SFSD1
0339                        ADA M4
0340                        XOR B400
0341                        STA STCD2
0342                        XOR B4000
0343                        STA CLCD2
0344                        XOR B100
0345                        STA OTBD2
0346                        STA OTBD3
0347*
0348*
0349                        LDB CHAN
0350                  OTBD1 NOP

 PAGE 0011 #01  D.60 B.C.S. CORRELATOR DRIVER

0351                  CLCD2 NOP
0352                        LDB BADDR
0353                        ADB BIT15
0354                  OTBD2 NOP
0355                  STCD2 NOP
0356                        LDB M100
0357                  OTBD3 NOP
0358                  STC02 NOP
0359                  STCD1 NOP
0360                        CLA
0361                        INA,SZA,RSS
0362                        JMP RDER2 (0VERDUE)
0363                  SFSD1 NOP
0364                        JMP *-3
0365                        LDA DMA
0366                        SLA,RSS
```

Table B-1 Computer listing of D.60 (continued)

```
0367                              STA DMAC1
0368                              SLA
0369                              STA DMAC2
0370                    CLCD1 NOP
0371*
0372*
0373                              XIF
0374*
0375*
0376* TRANSFER N POINTS *
0377*
0378  00324 062424R TN    LDA N
0379  00325 003004        CMA,INA
0380  00326 166426R TNL   LDB TBUFP,I
0381  00327 005700        BLF
0382  00330 005121        BRS,BRS
0383  00331 005121        BRS,BRS
0384  00332 176430R       STB CALBF,I
0385  00333 036426R       ISZ TBUFP
0386  00334 036430R       ISZ CALBF
0387  00335 002004        INA
0388  00336 002020        SSA
0389  00337 026326R       JMP TNL
0390*
0391* PUT T IN STATUS *
0392*
0393  00340 036245R TS    ISZ #A
0394  00341 162245R       LDA #A,I
0395  00342 012201R       AND MSK1
0396  00343 032423R       IOR T
0397  00344 172245R       STA #A,I
0398*
0399* PUT N AND BIT 15 IN TRANSMISSION LOG *
0400*
0401  00345 066425R       LDB Q
0402  00346 062424R       LDA N
0403  00347 006020        SSB     CHARS REQUESTED ?
0404  00350 001000        ALS       YES
0405  00351 032237R CLRTN IOR BIT15
0406  00352 036245R       ISZ #A

 PAGE 0012 #01  D.60 B.C.S. CORRELATOR DRIVER

0407  00353 172245R       STA #A,I
0408*
0409  00354 002400        CLA
0410  00355 126000R       JMP D.60,I
0411*
0412*
0413* C = SC ? *
0414*
0415  00356 062427R SECND LDA C
0416  00357 052250R       CPA CHAN
0417  00360 002001        RSS       YES
0418  00361 026301R       JMP NTR1 NO
0419*
0420* T := 0 *
0421*
0422  00362 002400        CLA
0423  00363 072423R       STA T
0424*
```

Table B-1 Computer listing of D.60 (continued)

```
0425* M := TRANS LOG
0426*
0427  00364 062245R        LDA #A
0428  00365 042431R        ADA .2
0429  00366 160000         LDA 0,I
0430  00367 001265         RAL,CLE,ERA
0431*
0432* INITIALISE TRANSFER BUFFER POINTER TO BADDR+M/2 *
0433*
0434  00370 001100         ARS
0435  00371 042432R        ADA BADDR
0436  00372 072426R        STA TBUFP
0437*
0438* N := 100 - M/2 *
0439*
0440  00373 042420R        ADA M100
0441  00374 003004         CMA,INA
0442  00375 042432R        ADA BADDR
0443  00376 072424R        STA N
0444  00377 026324R        JMP TN
0445*
0446* N := Q *
0447*
0448  00400 072424R WORDS  STA N
0449*
0450* T := 0 *
0451*
0452  00401 002400         CLA
0453  00402 072423R        STA T
0454  00403 026305R        JMP ITBP
0455*
0456* T := \ + BIT 14 *
0457*
0458  00404 102100  RDER1  STF 0
0459  00405 062200R        LDA STAT2
0460  00406 072423R        STA T
0461*
0462* N := 0 *
```

PAGE 0013 #01 D.60 B.C.S. CORRELATOR DRIVER

```
0463*
0464  00407 002400         CLA
0465  00410 072424R        STA N
0466  00411 026340R        JMP TS
0467*
0468*
0469  00412 036245R CLEAR  ISZ #A
0470  00413 162245R        LDA #A,I
0471  00414 012203R        AND QTMSK
0472  00415 172245R        STA #A,I
0473  00416 002400         CLA
0474  00417 026351R        JMP CLRTN
0475*
0476*
0477************************
0478*
0479                       IFN
0480*
0481                 M4    DEC -4
0482                 DMA   NOP
```

Table B-1 Computer listing of D.60 (continued)

```
0483                    B5000 OCT 5000
0484                    B1400 OCT 1400
0485                    B400  OCT 400
0486                    B4000 OCT 4000
0487                    RDER2 LDA CLCD1
0488                          STA **1
0489                          NOP
0490                          JMP RDER1+1
0491*
0492*
0493                          XIF
0494*
0495  00420 177634      M100  DEC -100
0496  00421 000000      COUNT NOP
0497  00422 000000      CHC   NOP
0498  00423 000000      T     NOP
0499  00424 000000      N     NOP
0500  00425 000000      Q     NOP
0501  00426 000000      TBUFP NOP
0502  00427 000000      C     NOP
0503  00430 000000      CALBF NOP
0504  00201             MSK1  EQU MASK1
0505  00431 000002      .2    DEC 2
0506  00432 000433R     BADDR DEF **1
0507  00433 000000            BSS 100


 PAGE 0014 #01  D.60 B.C.S. CORRELATOR DRIVER


0509*
0510****DUMMY CONTINUATOR****
0511*
0512*
0513  00577 000000  I.60  NOP
0514  00600 126577R       JMP I.60,I
0515*
0516*
0517**************************
0518                        END
**  NO ERRORS*




$END ASMB

@MP    037700

@
```

Table B-2 Computer listing of F/A.C.

```
 PAGE 0001


0001                    ASMB,R,L,T
RUN    R 000011
HOLD   R 000006
RESET  R 000003
ARRET  R 000000
DELAY  R 000040
WAIT   R 000057
.IOC.  X 000001
.ENTR  X 000002
IFIX   X 000003
.FSB   X 000004
.FLUN  X 000005
.STOP  X 000006
ENDIO  X 000007
PRAM   R 000014
RERUN  R 000030
M2     R 000034
B77    R 000035
DEL    R 000036
B20K   R 000055
TIMEA  R 000056
LOOP   R 000065
LARGE  R 000103
MILLS  R 000113
MILLP  R 000115
TIME   R 000123
M16    R 000125
.2B15  R 000126
MILLN  R 000130
ERR    R 000131
ERK    R 000144
ERMES  R 000145
BADDL  R 000147
ERME2  R 000156
**   NO ERRORS*


 PAGE 0002 #01  FORTRAN ALGOL CALLS TO CORRELATOR DRIVER


0001                    ASMB,R,L,T
0003  00000                     NAM F/A.C
0004                            ENT RUN,HOLD,RESET,ARRET,DELAY,WAIT
0005                            EXT .IOC.
0006                            EXT .ENTR
0007                            EXT IFIX,.FSB,.FLUN
0008                            EXT .STOP
0009                            EXT ENDIO
0010*
0011*
0012*
0013  00000 000000  ARRET NOP
0014  00001 016014R       JSB PRAM
0015  00002 030000        OCT 030000
0016*
0017  00003 000000  RESET NOP
0018  00004 016014R       JSB PRAM
0019  00005 030100        OCT 030100
0020*
0021  00006 000000  HOLD  NOP
```

Table B-2 Computer listing of F/A.C. (continued)

```
0022  00007 016014R        JSB PRAM
0023  00010 030200         OCT 030200
0024*
0025  00011 000000  RUN    NOP
0026  00012 016014R        JSB PRAM
0027  00013 030300         OCT 030300
0028*
0029  00014 000000  PRAM   NOP
0030  00015 062014R        LDA PRAM
0031  00016 042034R        ADA M2
0032  00017 160000         LDA 0,I     GET ADDR OF 2ND WD IN CALL SEQ
0033  00020 164000         LDB 0,I     GET RETURN ADDRESS
0034  00021 076000R        STB ARRET
0035  00022 002004         INA
0036  00023 160000         LDA 0,I     GET PARAMETER ADDRESS
0037  00024 160000         LDA 0,I     GET ACTUAL PARAMETER
0038  00025 012035R        AND B77
0039  00026 132014R        IOR PRAM,I
0040  00027 072031R        STA *+2     CONFIGURED REQUEST CODE
0041  00030 016001X RERUN  JSB .IOC.
0042  00031 000000         NOP
0043  00032 026131R        JMP ERR     ERROR RETURN FROM  IOC.
0044  00033 126000R        JMP ARRET,I GO HOME
0045*
0046  00034 177776  M2     DEC -2
0047  00035 000077  B77    OCT 77
0048*
0049*
0050  00036 000000  DEL    NOP
0051  00037 000000         NOP
0052  00040 000000  DELAY  NOP
0053  00041 016002X        JSB .ENTR
0054  00042 000036R        DEF DEL
0055  00043 162036R        LDA DEL,I
0056  00044 012035R        AND B77
0057  00045 032055R        IOR B20K

 PAGE 0003 #01  FORTRAN ALGOL CALLS TO CORRELATOR DRIVER

0058  00046 072050R        STA *+2
0059  00047 016001X        JSB .IOC.
0060  00050 000000         NOP
0061  00051 026147R        JMP BADDL
0062  00052 100037R        DEF DEL+1,I
0063  00053 000001         DEC 1
0064  00054 126040R        JMP DELAY,I
0065  00055 020000  B20K   OCT 20000
0066*
0067  00056 000000  TIMEA  NOP
0068  00057 000000  WAIT   NOP
0069  00060 016002X        JSB .ENTR
0070  00061 000056R        DEF TIMEA
0071  00062 162056R        LDA TIMEA,I
0072  00063 036056R        ISZ TIMEA
0073  00064 166056R        LDB TIMEA,I
0074  00065 002020  LOOP   SSA
0075  00066 126057R        JMP WAIT,I  NEGATIVE, EXIT AT ONCE
0076  00067 072123R        STA TIME
0077  00070 076124R        STB TIME+1
0078  00071 016005X        JSB .FLUN   UNPACK EXPONENT
0079  00072 042125R        ADA M16     EXPONENT >= 16 ?
```

Table B-2 Computer listing of F/A.C. (continued)

```
0080  00073 002021          SSA,RSS
0081  00074 026103R         JMP LARGE  YES, A LARGE NUMBER
0082  00075 062123R         LDA TIME
0083  00076 066124R         LDB TIME+1
0084  00077 016003X         JSB IFIX   SMALL NUMBER, FIX IT
0085  00100 002002          SZA
0086  00101 016113R         JSB MILLS  IF NON-ZERO, WAIT (A)MSECS
0087  00102 126057R         JMP WAIT,I
0088  00103 002404  LARGE   CLA,INA
0089  00104 001300          RAR
0090  00105 016113R         JSB MILLS   WAIT FOR 2**15 MILLISECONDS
0091  00106 062123R         LDA TIME
0092  00107 066124R         LDB TIME+1
0093  00110 016004X         JSB .FSB    SUBTRACT 2**15
0094  00111 000126R         DEF .2B15
0095  00112 026065R         JMP LOOP    SEE HOW BIG IT IS NOW
0096*
0097  00113 000000  MILLS   NOP
0098  00114 003004          CMA,INA
0099  00115 066130R MILLP   LDB MILLN  1 MILLISECOND TIMER
0100  00116 006006          INB,SZB
0101  00117 026116R         JMP *-1
0102  00120 002006          INA,SZA
0103  00121 026115R         JMP MILLP
0104  00122 126113R         JMP MILLS,I
0105*
0106  00123 000000  TIME    NOP
0107  00124 000000          NOP
0108  00125 177760  M16     DEC -16
0109  00126 040000  .2B15   OCT 040000   (=2**15 IN FLOATING POINT FORM)
0110  00127 000040          OCT 000040
0111  00130 177311  MILLN   DEC -311  (FOR 2116: IS -249 FOR 2114)
0112*
0113*


 PAGE 0004 #01  FORTRAN ALGOL CALLS TO CORRELATOR DRIVER


0114*
0115  00131 072144R ERR     STA ERK
0116  00132 016001X         JSB .IOC.
0117  00133 020002          OCT 020002        PRINT
0118  00134 026132R         JMP *-2
0119  00135 000145R         DEF ERMES         "*EQR"
0120  00136 177774          DEC -4
0121  00137 016007X         JSB ENDIO
0122  00140 000141R         DEF *+1
0123  00141 066144R         LDB ERK
0124  00142 102000          HLT
0125  00143 026030R         JMP RERUN
0126  00144 000000  ERK     NOP
0127  00145 025105  ERMES   ASC 2,*EQR
      00146 050522
0128*
0129*
0130  00147 016001X BADDL   JSB .IOC.
0131  00150 020002          OCT 020002
0132  00151 026147R         JMP *-2
0133  00152 000156R         DEF ERME2
0134  00153 177763          DEC -13
0135  00154 002400          CLA
0136  00155 016006X         JSB .STOP
```

Table B-2 Computer listing of F/A.C. (continued)

```
0137  00156 044516  ERME2 ASC 7,INVALID DELAY
      00157 053101
      00160 046111
      00161 042040
      00162 042105
      00163 046101
      00164 054440
0138*
0139*
0140                          END
**  NO ERRORS*
```

```
$END ASMB
```

MANUAL CHANGES

HP MANUAL CHANGES

MAKE ALL CORRECTIONS IN YOUR MANUAL ACCORDING TO ERRATA.

Check the following table for your instrument serial prefix and make any indicated changes to the manual:

*New or revised item.

MANUAL TITLE: 3721A Operating Manual
MANUAL PRINTED: April 1971
MANUAL PART NO: 03721-95003
CHANGE DATE: 9th January 1976

SERIAL PREFIX	MAKE CHANGE	SERIAL PREFIX	MAKE CHANGE	SERIAL PREFIX	MAKE CHANGE

ERRATA

Page V, list of contents
Change: Title of Section VI to be: OPTIONS 021 and 022.

Page 1-1, Section 1, Paragraph 1-5b
Change: Line 2 to read '....from 1uS/mm to 1S/mm.'

Page 1-7 Table 1-1
Under Accessories Furnished
Delete: Rack Mounting Kit

Page 2-2, Paragraph 2-20
Change: Change to read: "A Rack Mounting Kit is available to install the instrument in a 19-inch rack. Rack Mounting Kits may be obtained through your nearest Hewlett-Packard Office by ordering HP part no. 5060-8743.
Delete: Figure 2-1

Page 3-5, Section III, Paragraph 3-9
Change: Line 2 to read '....from 0(dc) to 250KHz'.

* Page 5-10, Paragraph 5-62, step 9
Change: Change to read: Computer types THANK YOU followed by PUNCH TEST. Type in NO then CR LF and the computer will type PLEASE TYPE NUMBER OF POINTS OF DELAY OFFSET.

Page 5-11, Section V, Paragraph 5-63
TEST 1 FAILED
Delete: Sentence 'Figure 4-5 shows... ...permanently FALSE'.
TEST 3 FAILED
Add: At the end of explanation, after '...from the Correlator (see Figure 5-1)'
- Include 'For example, Figure 5-4 shows Bit 8 to be permanently TRUE and Bit 5 permanently FALSE'.

Page 6-2, Section VI, Paragraph 6-9
Change: Line 2 to read '...a +12V level signal calls for no punch and an 0V level calls for punch'.
Change: All references to 'Solder link' to read 'Plug-in link".