Marconi
Communication Systems

Line Array Telecine B3410

CCD Sensors
Full Digital Signal Processing
Microprocessor Control

Line Array Telecine B3410

Features

Solid-state line array CCD image sensors:
–long life, no regular replacement of tubes or photomultipliers;
–no routine adjustments required for colour registration or to stop field flicker;
–elimination of analogue scanning systems removes major cause of instability

Digital video processing ensures precision and complete stability. No circuit trimming

Microprocessor control of video processing and automatic facilities

Continuous-motion film transport:
–gentle film handling, including splices

Rapid start–1/10th second, and rapid stop

Automatic lamp change-over, vision and sound

Facilities

Automatic or manual control of
–black level
–exposure
–white and black colour balance

With change of pulses basic machine switchable between 625/50 and 525/60 scanning standards

16 or 35 mm film gauges by simple gate change

Positive or negative film

Forward or reverse running

Slow speed, forward and reverse

Single-frame jogging

Fast forward and reverse shuttle

Frame counter

Selectable film masking matrix values

Cinemascope facility–letter box or full height

Options

PREFIX, Programmable colour correction, search, start and stop

Super 8 by simple gate change

PAL, NTSC or SECAM Coders

Dolby noise reduction

35 or 8mm Commag

Remote Control Panels

Separate Sound Machine

Introduction

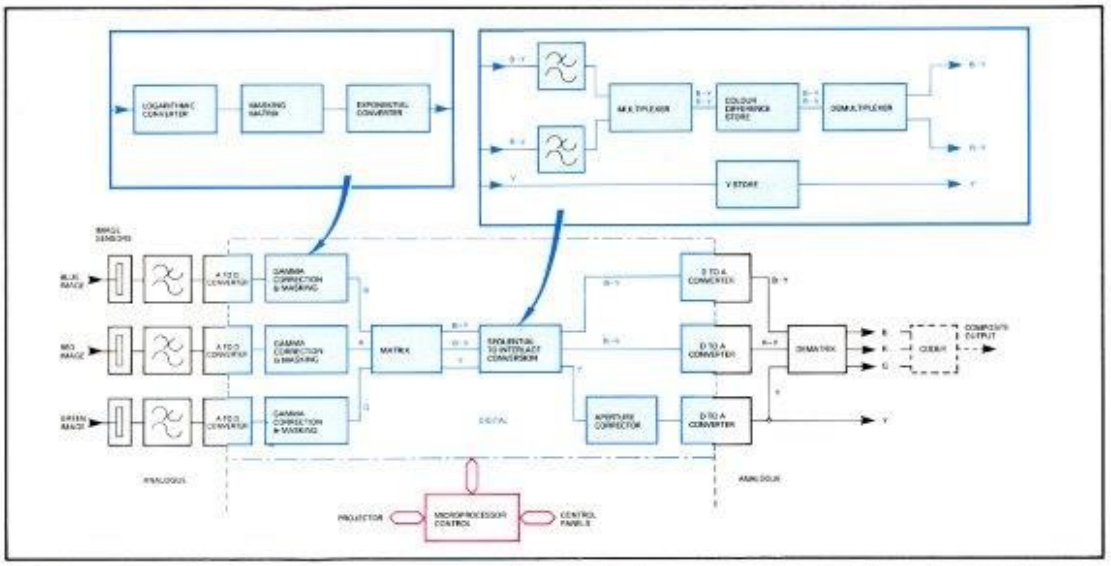
The Marconi B3410 is a 100% solid-state telecine machine, the camera tubes or flying spot tubes of previous designs being replaced by three linear-array silicon CCD image sensors.

Linear-array sensors offer an extremely simple method of scanning film, the vertical scan being provided entirely by the continuous motion of the film past the arrays. The output of each sensor is line-sequential, converted to line interlace in the video processing. The problems of producing a line interlace directly, using the twin-lens or jump-scan principles, are thus avoided, as are the registration and intermittent film motion problems associated with camera tube systems.

An important feature of the design is the use of digital video processing, ensuring precisely-defined, stable performance. The output of each sensor is clocked out in analogue form and after filtering to remove the clock pulses, is fed to an analogue-to-digital converter. To achieve the necessary accuracy the three video signals each have 11 bits per sample before gamma correction, and 8 bits per sample thereafter. After signal processing, the red, green and blue signals are matrixed to Y, R-Y and B-Y and passed to the sequential-to-interlace converter, which provides two fields of storage for the Y signal and two for the colour difference signals. This amount of storage offers a high degree of flexibility in both forward and reverse running speeds with coherent picture. Aperture correction is applied after sequential-to-interlace conversion, and the signal then converted to analogue form before encoding in standard PAL, NTSC or SECAM.

The film gate can be quickly changed to handle 16 mm, 35 mm or Super 8 film, and video processing allows for the use of positive or negtive film, the matrix factors being adjustable to suit the film. A micro-processor control system is used to set up gamma correction, matrix correction, aperture correction and other basic parameters, and supports the automatic facilities.

It is difficult on other types of telecine to change standards. With the basic B3410 machine the RGB output can be quickly changed between 625/50 and 525/60 by a simple switch and either changing the input pulses or substitution of the appropriate SPG plug-in module.



Video processing block diagram.

Line Array Sensors

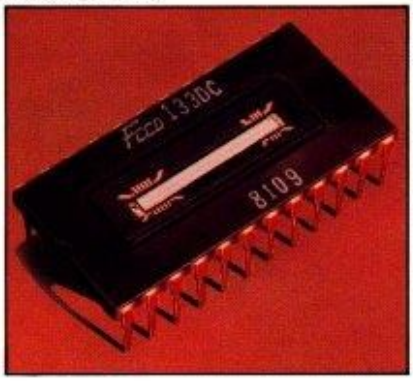
The three solid-state line array sensors used on the B3410 Telecine are second-generation charge-coupled devices (CCDs) having an improved performance including higher sensitivity, an enhanced blue response and a lower dark signal.

These sensors have the reliability and practically unlimited life typical of silicon semiconductor devices. Their application to telecine therefore represents an important advance in replacing the pick-up tubes of camera type telecines or the cathode ray tubes and photomultipliers of flying spot machines, all of which require routine attention and replacement. With the elimination of tubes goes also the elimination of their scanning systems and high-voltage supplies, major causes of instability and unreliability.

In the image sensor horizontal scanning is by the digitally-controlled precise step-by-step operation of a shift register, while vertical scanning is obtained by the continuous motion of the film. A further advantage is the high-level, low impedance sensor output, requiring no head amplifier.

Each sensor consists of an in-line array of 1024 photo-sensitive elements with, alongside, a system of transfer gates and transport shift registers. During each television line an electronic charge accumulates in each element proportional to the light falling on it. In the following horizontal blanking interval the charge from each element is transferred to its discrete location in the transport shift registers by momentary operation of the transfer gates. The contents of the shift registers are then clocked out serially during the active line period, in the form of analogue sample pulses at the clocking frequency, approximately 19 MHz, and constitute the output video signal.

Line array sensor.



After clamping, the signal from each sensor is applied to a 5.5 MHz low pass filter to produce a continuous video signal and eliminate the 19 MHz components. From the filters each signal, G, R and B, goes to an analogue-to-digital converter in readiness for the digital video processing chain.

The sensors, each contained in a dual-in-line ceramic package, are mounted directly on substantial metal plates forming part of the colour-splitting prism assembly so as to achieve precise and stable location relative to the optical image and, at the same time, to make good thermal contact.

Digital Video Processing

To complement and fully exploit the excellent characteristics of the line sensor, substantially all the video signal processing is carried out digitally, with the advantages of precisely-defined, drift-free operation.

The G, R and B signals from the image sensors are each converted to an 11-bit per sample parallel digital signal, 11 bits providing the necessary amplitude resolution for gamma correction, after which coding is the standard 8 bits/sample.

Gamma correction and masking are carried out by logarithmic conversion, multiplication/matrixing and exponential conversion, up to 13 bits/sample being retained to avoid rounding-off errors. Extended black stretch, following a true power law, provides gamma values down to 0.15. After gamma correction and masking the G, R and B signals are matrixed to a luminance, Y, and two colour difference signals B-Y and R-Y, each at 8 bits/sample, for sequential-to-interlace scan conversion.

The continuous film motion creates complete frames sequentially-scanned. Conversion of these frames to pairs of interlaced fields is carried out in four field stores, two fields for Y and two shared by B-Y and R-Y multiplexed.

Digital vertical and horizontal aperture correction is applied to the Y signal, followed by digital-to-analogue conversion of all three signals. By 'dematrixing', G, R and B signals are formed to feed out to standard PAL, NTSC or SECAM coders. Y outputs are also provided.

A de-patterning system, ensuring a particularly clean image background, is included in the video processing, activated when power is applied and by a push button on the film transport deck. With no film in the gate, any fixed pattern resulting from small variations across the sensor array or slight illumination non-uniformity is stored in memory and automatically corrected.

Microprocessor Systems

Interfacing between the operational controls and the video processing chain is carried out by a first microprocessor system, which has also a general housekeeping role. The system gives flexibility and ensures that the advantages of digital signal processing are fully realised. The system is programmed to monitor control settings continuously, to process the data and to send the necessary commands to the video circuits. The system also interfaces with the film transport, and provides the control signals for the light control servo.

The automatic control systems incorporate a second microprocessor which determines optimum control settings. A third microprocessor gives intelligence to the capstan servo, ensuring precise film speed control under all conditions. A further microprocessor is used in the programmable control system.

Resident monitor programmes provide for very rapid system checks by diagnostic aids.

Film Transport

Features of the film transport design are superior performance in respect of picture steadiness and speed constancy, ease of operation, gentle film handling and quiet running.

The transport, together with the optical system, is constructed on a substantial rectangular aluminium-alloy plate. To achieve very low levels of noise and vibration the deck-to-frame fixing is by rubber isolation mounts. To protect personnel, reduce dust ingress and further reduce noise, a two-part smoked acrylic transparent cover extends over the whole deck. For loading, the cover slides into a recess above the deck. For rear access, the entire deck pivots on its horizontal axis.

Film drive is by capstan with a specially-designed, direct-coupled multipole torque motor with a 5000-line optical encoder disc for velocity feedback. Incorporating a microprocessor, the system gives extremely smooth and precise film speed control even with shrunk film. The capstan surface is of hardwearing synthetic rubber, finished to very close tolerances. The feed and take-up spools are directly driven by powerful, fast-response printed circuit motors. Film tension is sensed by compliance arm assemblies providing servo feedback. A lever control, interlocked for safety, enables reverse-wound film or film loops to be used. So that the telecine can be quickly and easily changed between film gauges, triple gauge sprockets and rollers are used throughout. All that is necessary is to change the gate assembly, and spools are accomodated simply by reversing the spool retainers. For Super 8 film, spool adaptors are employed.

A frame counter is incorporated with an l.e.d. display on the transport deck indicating hours, minutes, seconds and frames (related to normal speed).

Sound

Optical sound heads are fitted for both 16mm and 35mm film. Magnetic heads are fitted for 16mm and are optional for 35mm and Super 8 film. The appropriate preamplifier outputs are selected automatically. Automatic changeover to a spare lamp is provided for optical sound.

Optical System

The optical system mounted on the film transport deck consists of a light source, with field and gate lenses comprising a relay light path, and behind the film, a projection lens and colour splitting block, through which the film is imaged on the sensors.

The light source is a quartz halogen lamp providing adequate reserves of illumination for dense film. Automatic changeover to a spare lamp by a motorised transport rapidly moves the spare lamp into position on lamp failure. A compound infra-red and heat filter establishes the correct illumination spectrum and greatly reduces the heat and far-red radiation reaching the film and image sensors. This ensures very low sensor dark current and stable black level. A servo-controlled graded neutral-density disc provides a 100:1 light variation for exposure control. For negative film a cyan correction filter is brought in by an electro-magnetic actuator. The gate and projection lenses form part of the gate assemblies so that no separate lens change is required on changing film gauge. Pro-vision is made for gate-cleaning air blast.

The colour-splitting system is of the well-proven dichroic prism type. The three image sensors are mounted directly on the prism assembly in a rigid structure ensuring high accuracy and stability of image registration and geometry. Micro-meter screws provide a small range of adjustment for initial factory registration and focus setting.

Automatic Controls

The detailed design of the B3410 auto-matics reflects many years experience of operationally effective automatic systems both in telecines and live cameras, now given greater power by microprocessor control. Picture signals are monitored with appropriate weighting and peripheral picture areas are excluded. Response times are optimised for artistic presentation and to avoid mal-operation, for example on intentional fades to black.

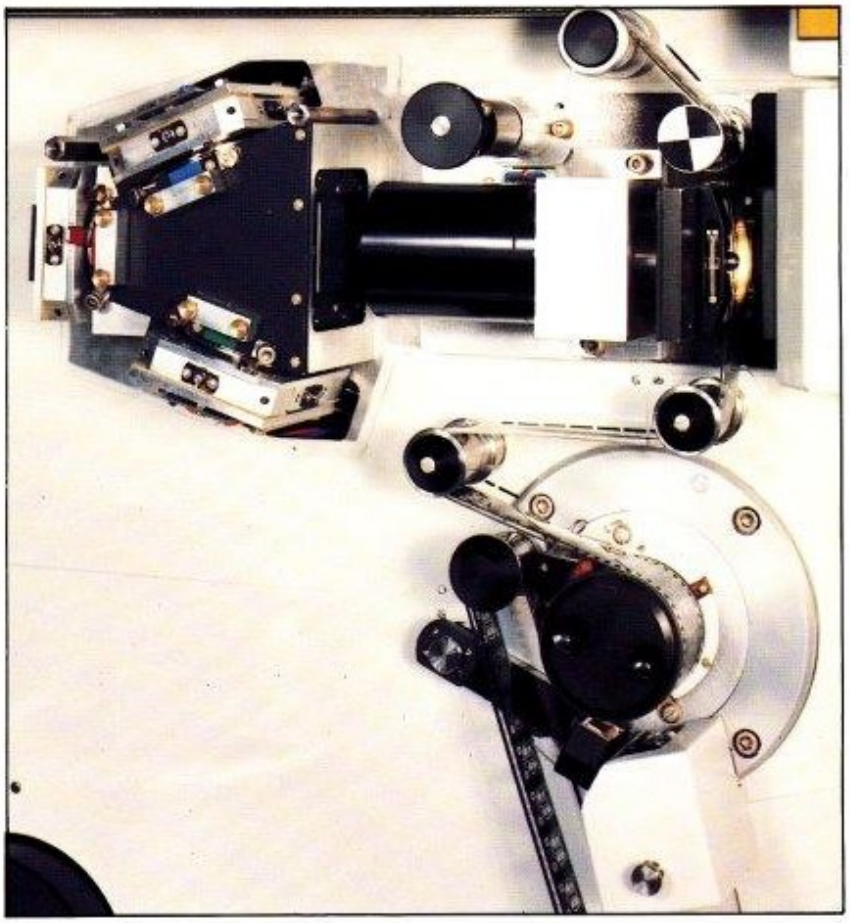
The following facilities are brought into operation by push buttons on the desk control panel:

Automatic Master White Control: maintains correct exposure by monitoring maximum signal levels and adjusting light control neutral density disc accordingly.

Automatic Master Black Control: monitors lowest black levels and adjusts black level setting d.c. potentials.

Automatic White Balance: maintains colour balance at white by monitoring green, red and blue signal levels and adjusting them on the 'integrate to grey' principle.

Automatic Black Balance: similarly maintains colour balance at black.



Capstan area, 35mm gate assembly and optical splitter block with covers removed.

Controls

Main Control Panel

The following controls, all push buttons unless otherwise noted, are fitted on the main control panel, the local control position:

(a) Projector Controls

STILL: Switches on the projector lamp and scans the film to produce a still frame.

SHOW: Switches on projector lamp.

PLAY: Selects show, engages normal forward speed and displays a still frame until the servo is locked.

STOP: Stops the machine and cancels SHOW if it is not held down.

FRAMING Up:
FRAMING Down: For framing (racking) control.

JOG Forward:
JOG Reverse: Moves film one frame.

SLOW Forward: Produces a locked picture
SLOW Reverse: at one half normal speed.

PLAY Rev: Reverse play function.

SHUTTLE On: Activates SHUTTLE control.

SHUTTLE: Continuously variable film speed control, gives from stationary (central position) to high speed forward and reverse.

COMMOPT:
COMMAG:
SEPMAG: Selection of appropriate sound facility. Electrically interlocked.

SOUND LEVEL: Variable control, sets sound level.

PROJECTOR Local/Remote: Rotary switch, remotes projector controls. Warning light on transport deck. Any of above controls can be remoted up to 150 m.

(b) Video Controls

WHITE: Lever control, manual master white (exposure).

BLACK: Rotary control mounted on WHITE lever, manual master black.

MASTER GAMMA: Rotary control.

APERTURE CORRECTION: Rotary control of amount of preset mixed vertical and horizontal aperture corrections.

WHITE:
GAMMA:
BLACK: Joystick trimming controls each with ON switch. Provide small differential green, red and blue adjustments from preset values.

AUTO MASTER WHITE:
AUTO MASTER BLACK: Activate automatic master level control systems.

AUTO BALANCE WHITE:
AUTO BALANCE BLACK: Activate automatic colour balance systems.

MASKING 0:
MASKING 1:
MASKING 2:
MASKING 3: For selection of two pre-programmed film masking characteristics and one presettable. Electrically interlocked.

A group of four binary-action push buttons:
PIC/BARS: Picture or colour bars selection. (Provision for colour black output).

COL/MONO: Colour or monochrome operation.

POS/NEG: Positive or negative film.

NORM/C'SCOPE: Normal or cinemascope film.

VIDEO Local/Remote: Remotes video controls–any of above can be remoted up to 150 m.

A warning lamp on the main control panel indicates selection of any condition other than normal.

(c) Auxiliary Controls

Under a lift-up cover in the main control panel the following pre-set controls are located:

(i) Trim controls for positive white, gamma and black, each for red and blue.

(ii) Trim controls for negative white, gamma and black, each for red and blue.

(iii) Pre-settable masking controls for MASKING 3.

(iv) Aperture correction controls for horizontal and vertical correction and coring.

Film Transport Deck Controls

Operational controls on the transport deck are:

LACE: Prepares mechanism for loading.

READY: Applies film tension and enables traction controls.

REVERSE/NORMAL/LOOP: Interlocked lever, allows use of reverse-wound film on feed spool. Switches off spool drives for film loop operation.

EMULSION IN/OUT: Sets vision focus as required.

DEPATTERN: Operates circuits which remove fixed image patterning.

16/17 F.P.S: Selects 16⅔ or 17½ frames per second.

Remote Control

Optional remote control panels are available for projector, video and sound respectively.

PREFIX Programmable Control System

An optional microprocessor-based system, PREFIX, enables all the telecine controls to be pre-programmed. Thus, control settings can be optimised for best colour reproduction shot-by-shot during a pre-run, the control data being automatically stored. The system also includes a facility enabling individual frames to be located automatically at high speed. Selected locations can be stored and the film organised into segments which can be rapidly accessed as required. Magnetic storage can be added to the system to increase memory capacity and provide a removable data recording.

Main control panel.

Monitor Bridge

A monitor bridge mounts across the top of the telecine, angled forward for clear viewing and comfortable access to the controls. It accommodates a colour or black and white picture monitor, a waveform monitor and a good-quality loudspeaker, complete with 2W amplifier with volume control and 20dB dim switch. Push button switches provide selection of a range of video signals. Various points in the digital system can be monitored by means of a probe. An optional Video Test Board enables the inputs to each digital processing board to be displayed as an analogue signal.

Test Facilities

Either external signals via the test input or an internally-generated sawtooth can be injected at the outputs of the G, R and B image sensors for checking the entire channels. An internally-generated 8-bit digital 2T pulse, bar and sawtooth signal is provided for checking each channel from the output of the analogue-to-digital converters.

Construction

The telecine is constructed on a substantial welded steel framework, the sloping film transport deck occupying the central position. The desk area below contains the main operational control panel and in the cabinet area below the desk most of the electronics and power supplies are housed. Above the film transport deck is the Monitor Bridge.

Access to the cabinet is by two doors behind each of which are two standard equipment racks with fan-assisted ventilation. On the left are the digital video processing circuits, colour coder, microprocessor and general housekeeping electronics. On the right the film transport electronics, logic and sound circuits, and power supplies for the spooling motors. In the central section between the doors is the main blower with filtered air intake providing cooling air to the projector lamp, etc. Below the air intake is a panel carrying the main power on-off switch, fuses, main circuit breaker and a utility power outlet. Behind the panel are power supplies for the video processing, control and general electronics.

Ordering Information

To ensure that your order is quickly processed and that you receive the correct items, please specify:

(1) The television standard and colour system.

(2) A.C. supply voltage and tolerance.

(3) Film gauges to be used.

Also please advise whether the following options are required:

(4) PREFIX programmable control system.

(5) Remote control facilities (please quote distance from machine).

(6) Sound followers (separate magnetic machine).

(7) Test Boards and servicing accessories.

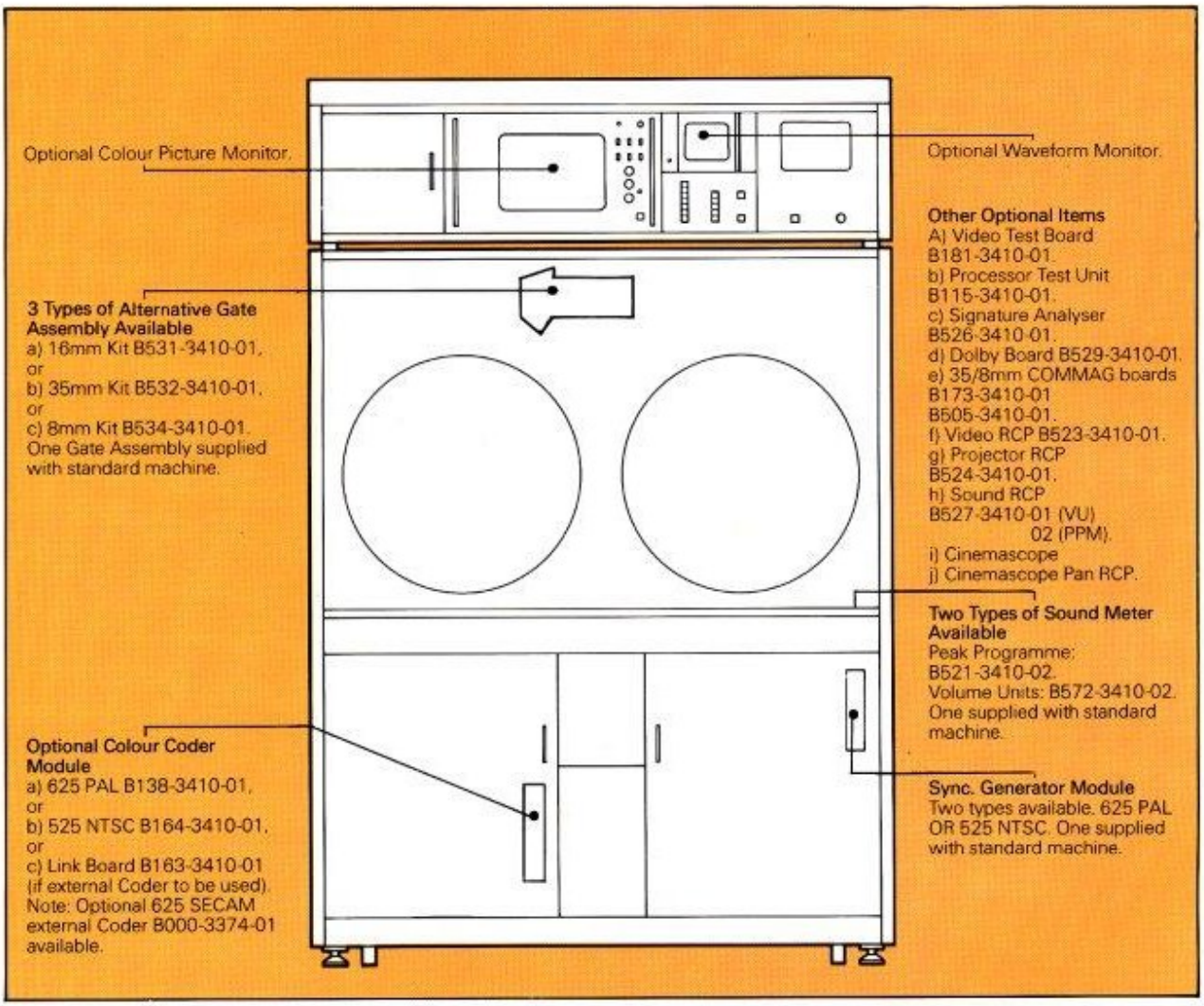
(8) Black/White or Colour Picture Monitor and/or Waveform Monitor.

(9) Communications facilities, none in-built

(10) Training.

(11) Spares.

(12) Additional copies of the handbook.



Data Summary

Systems
CCIR 625 lines, 50 fields and EIA 525 lines, 60 fields, switchable (not including colour coder or sync. pulse generator).

Power Supply
100-125 V and 200-250 V, 48-62 Hz.
Consumption 2.5 kVA approx.
A voltage variation of ±6% from nominal will not affect performance.

Video Inputs
All 75 ohm, BNC connectors, bridging.
Return loss 36 dB for 2T pulse and bar.
(a) Test Input: 0.75 V non-composite.
(b) Reference Picture: 1.0 V composite (for locking internal sync. generator).
(c) External Video: 0.75 V non-composite.

Pulse Inputs
All 75 ohm, BNC connectors, bridging.
Return loss 30 dB for 2T pulse and bar.
(a) Colour Step Sync: 1.5-6 V.
In place of the internal sync. generator outputs, pulse inputs can be accepted as follows:
(b) Mixed Blanking: 1.5-6 V.
(c) Mixed Sync: 1.5-6 V.
(d) Burst Gate (PAL): 1.5-6 V.
(e) Subcarrier: 0.5-3 V. (Return loss 30 dB at subcarrier frequency).

Video Outputs
All video outputs 75 ohm, BNC connectors.
Return loss better than 30 dB for 2T pulse and bar.
(a) Coded Video: four outputs, 1.0 V composite (if internal coder used).
(b) G, R and B signals: two outputs each (one if internal coder used) 0.7 V non-composite.
(c) Y signal: 0.7 V non-composite, two outputs (one if internal coder used).
(d) Waveform Monitoring Output: non-composite.
(e) Picture Monitoring: two outputs, one 1.0 V composite, one either composite or non-composite.

Pulse Outputs
(a) Colour Step Sync: 75 ohm source, 2 V.
(b) Colour Step Waveform: 2 to 15 V adjustable, output impedance less than 500 ohms.
(c) Waveform Monitor Sequence: isolated relay contacts.

Sound Inputs
SEPMAG input: balanced, XLR 3-pin connector 0 dBm or −20 dBm.

Sound Outputs
Transmission output: balanced, for 600 ohm load, XLR 3-pin connector, 0 dBm (40% modulation).

Tally
Internal link permits operation of on-air cue lamp, transistor isolated, either by external contact closure to ground or +24 VDC application. MRAC 26 way connector.

Video Performance

Signal-to-Noise Ratio
Y channel: 50 dB in 5 MHz bandwidth unweighted (gain to set to normal, gamma unity and corrections off).

Resolution
With aperture correction, 100% modulation depth at 400 lines can be obtained with both 16 mm and 35 mm film.

Registration
Accuracy: 0.1% of picture height in all parts of the picture.

Video Bandwidth
From test input to G or Y outputs, gamma and aperture correction off, with respect to 100 kHz: to 5 MHz, ±0.5 dB, at 5.5 MHz −3 dB.

Geometry
Geometric distortion less than 1.0% of picture height in all parts of the picture.

Gamma Correction
Positive film: continuously variable power law from 0.15 to 0.65 (contrast range 250:1).
Negative film: continuously variable power law from −0.5 to −1.2 (contrast range 20:1 to 5:1).

Picture Steadiness
Horizontal weave: less than ±0.1% of picture height.
Vertical jump: less than ±0.1% of picture height.

Sound Performance

Frequency Response
Overall, COMOPT, 16 mm and 35 mm: 50 Hz to 8 kHz, ±2 dB.
COMMAG, 16 mm and 35 mm: 40 Hz to 14 kHz, ±2 dB.
Amplifier: 30 Hz to 15 kHz, ±0.5 dB.

Harmonic Distortion
Amplifier: less than 0.5% at +20 dBm.

Wow & Flutter
Weighted, peak value, measured at 3150 Hz 0.5 s after start: less than 0.15%.

Signal-to-Noise Ratio
Random, peak, unweighted, COMOPT (open gate): 55 dB; COMMAG (erased test film): 45 dB.

Film Transport

Type: Marconi Continuous Motion.
Film Gauges: 16 mm, 35 mm or Super 8 by quickly interchangeable gates and reversible spool retainers.

Speeds
(a) Normal, 625/50: 25 frames per second; 525/60: 24 frames per second.
(b) Slow, half normal speed.
(c) 16⅔ f.p.s. (625/50) or 17½ f.p.s. (525/60) for Super 8. Usable for 16 or 35 mm.
(d) Still frame.
(e) Reverse running: at speeds (a), (b) and (c) above.
[Note: (b) and (c) and reverse speeds are at half normal vertical resolution].

For search and editing purposes, giving a recognisable picture:
(f) One frame forward or backwards.
(g) Fast forwards or backwards, speed variable from still frame.

Start Time: Normal forward running reached in 100 ms.

Spools

Maximum spool diameter 550 mm (capacity 5000 ft [1500 m]).
Minimum spool core diameter: 2 in (50.8 mm).

Warm Up time

Full performance available within 2 minutes of switching on.

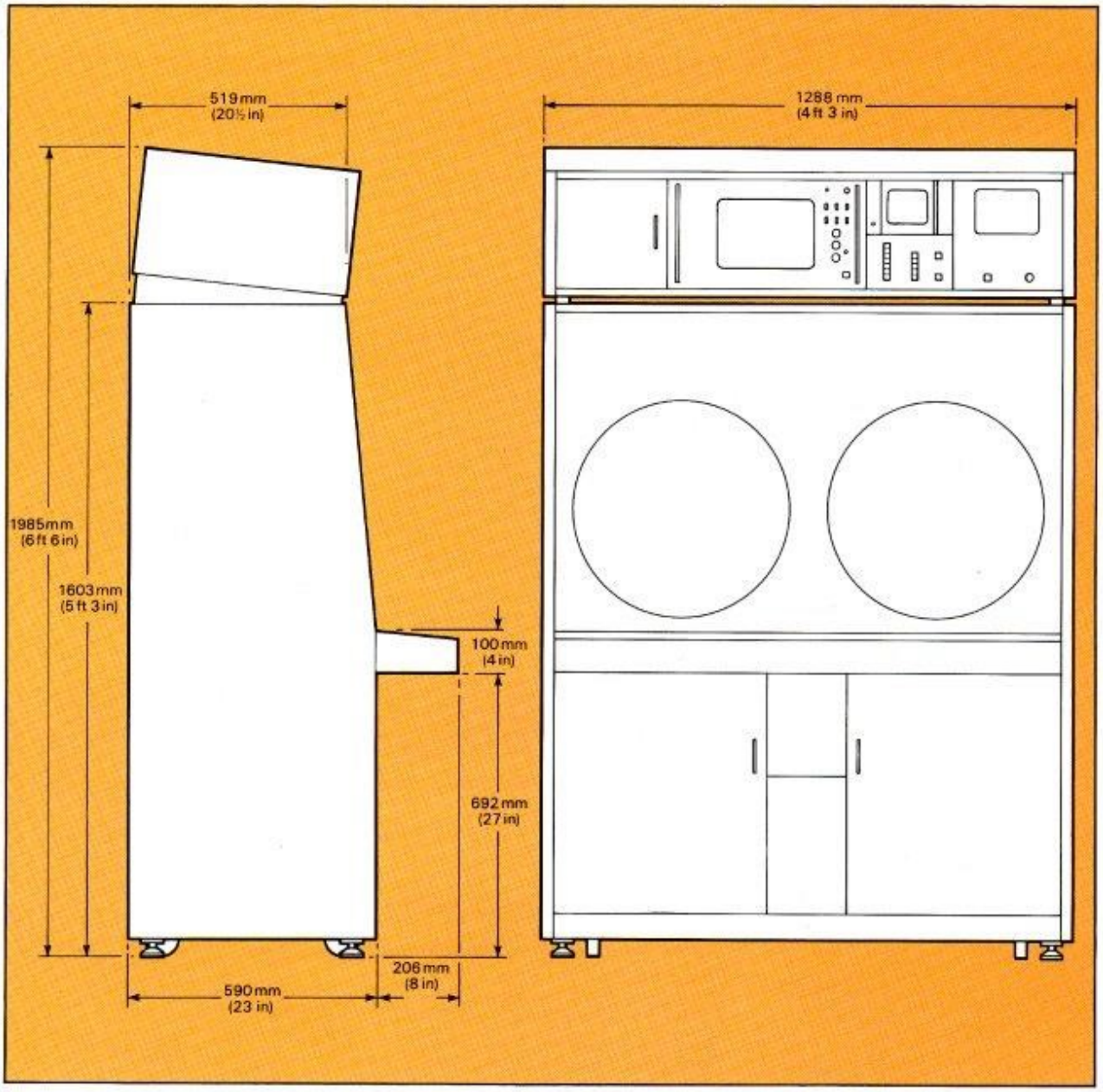
Ambient Temperature
(i) Storage: −20°C to +60°C.
(ii) Safe switch-on range: −20°C to +45°C.
(iii) Operational range: full performance will be obtained within ±10°C of temperature at time of setting-up, in the range 0°C to +40°C.

Dimensions

See diagram.

Weight

400 kg (880 lb).



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1982

TD-3-B3410