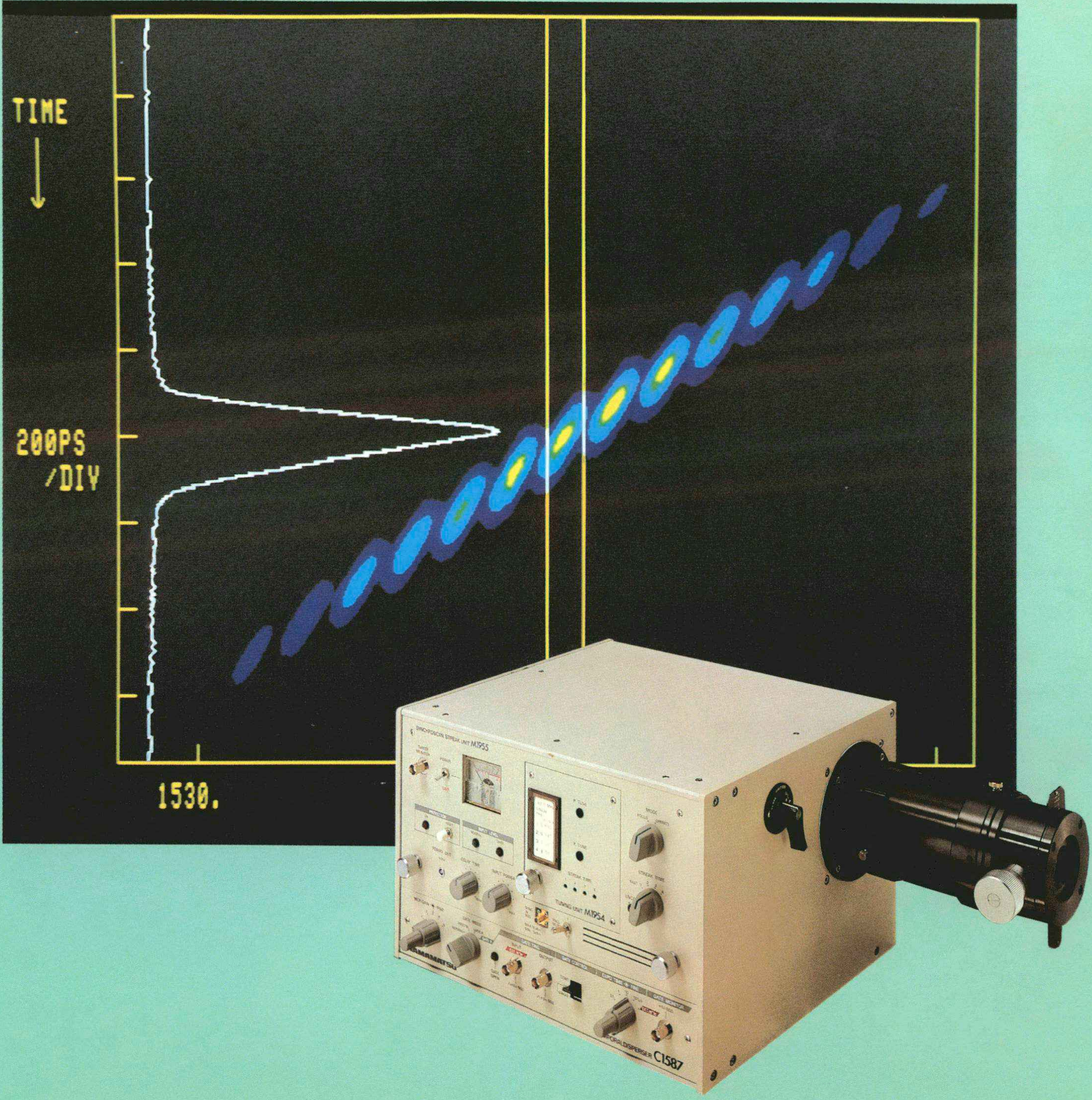
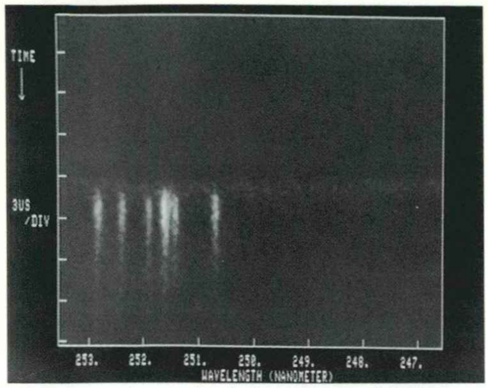
C1587

UNIVERSAL STREAK CAMERA

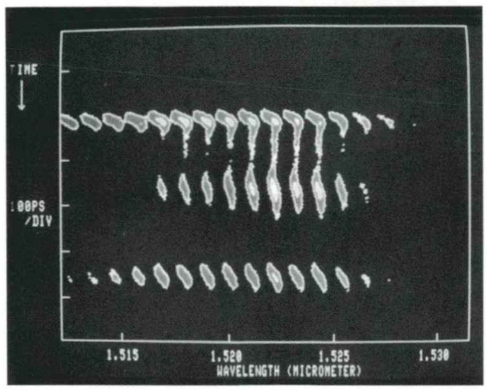
Selectable features to suit a variety of applications from the vacuum ultraviolet through the near infrared.



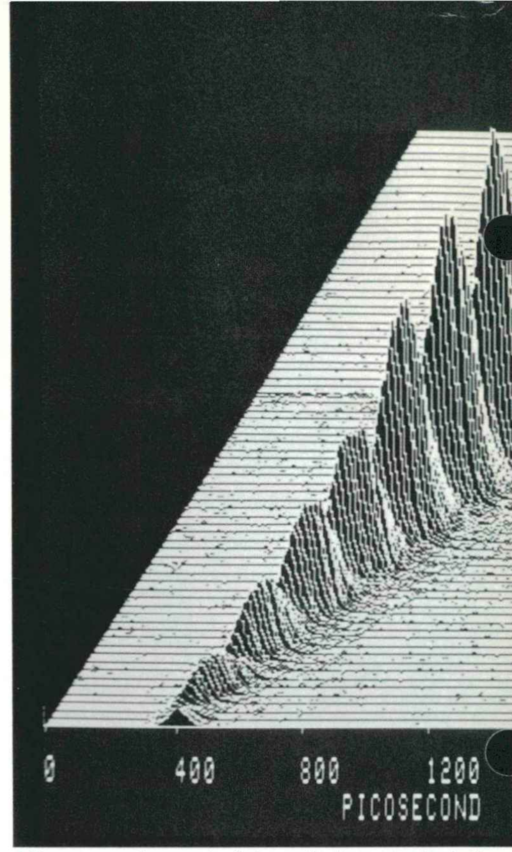
HAMAMATSU



▲Measurement example of microplasma emission of silicon by laser excitation



▲Measurement example of relaxation waveform of a laser diode (contour map)



▲Measurement example of chromatic dispersion in single-mo optical fiber (3-D display of the cover photo of this catalog)

Best temporal resolution: better than 2ps; frequency bandwidth: greater than 30GHz;

The streak camera is a device to measure ultra-fast light phenomena and delivers intensity vs. time vs. position (or wavelength) information. No other instruments which directly detect ultra-fast light phenomena have better time resolution than the streak camera.

Since the streak camera is a two dimensional device, it can be used to detect several tens of different light channels simultaneously. For example, used in combination with a monochromator, time variation of the incident light intensity with respect to wavelength can be measured (time-resolved spectroscopy). Used in combination with proper optics, it is possible to measure time variation of the incident light with respect to position (spatially time-resolved measurement).

The C1587 Universal Streak Camera meets the needs of various applications by using interchangeable plug-in sweep units and by providing additional function expansion units.

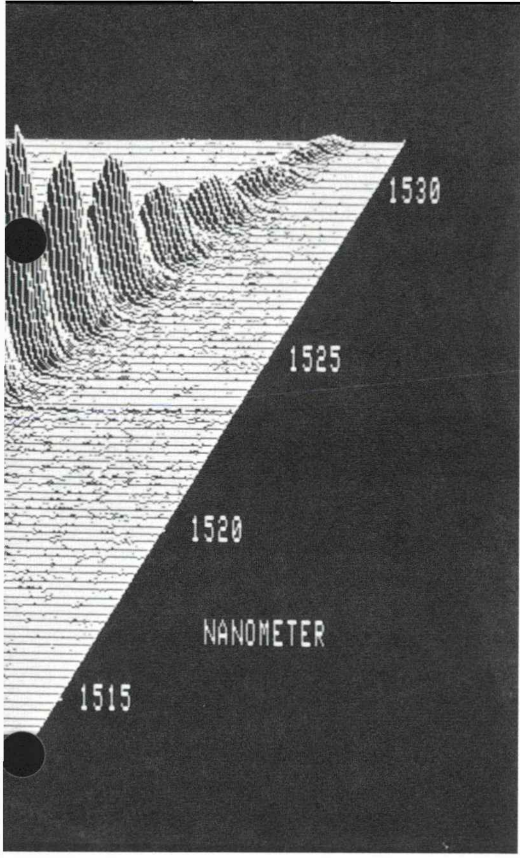
The sweep plug-ins include a fast single sweep unit (time resolution: better than 2ps), a slow single sweep unit (time resolution: better than 100ps) and a synchroscan unit (repetition frequency: 75 to 165 MHz), permitting a variety of measurement capabilities for multiple experimental requirements. In addition, the use of other sweep options permits the observation of repeated phenomena with frequencies in the gigahertz region.

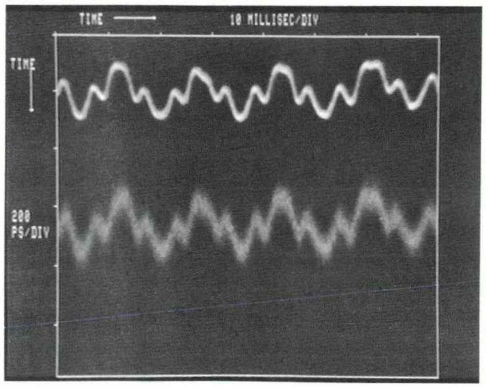
By using an infrared streak tube having an S-1 photocathode, the C1587 makes possible the measurement at longer wavelength up to 1.6 μm, which had not been possible with a conventional streak camera.

The C1587 can be further enhanced by use of a real-time readout system. This system is composed of a high-sensitivity TV camera, a Temporalanalyzer and other peripheral equipments and it can perform real-time analysis of the optical phenomena which are captured by the C1587.

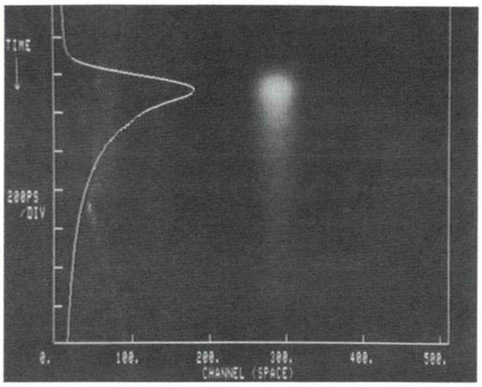
Power Supply　　Main Unit

C1587 Streak Camera





◄Measurement example of a mode-locked picosecond laser with a dual time base (top: dye laser, bottom: excitation light)



◄Measurement example of fluorescence lifetime of a cloverleaf epidermal cell

spectral response: 200 ~ 1600nm; Optional functions according to the application.

FEATURES

- **Simultaneous measurement of Time, Position (wavelength), and Intensity**
- **Temporal resolution: better than 2ps**

With three sweep plug-ins, the C1587 provides a time resolution from better than 2ps to 100ps.

- **Wide frequency range: 75MHz to 30GHz**

Using the M1955 synchroscan unit and the M2567 synchronous blanking unit, repeated optical phenomena with frequencies greater than 1 gigahertz can be measured.

- **Observations using dual time axes**

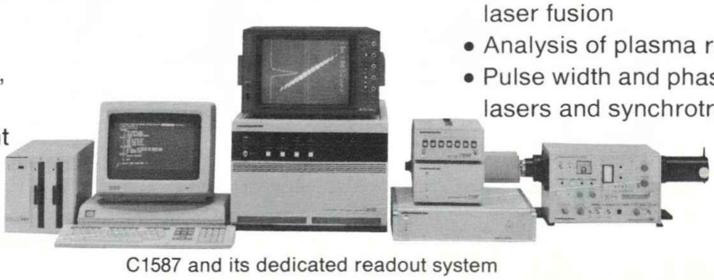
Pulse width, phase and temporal variations of intensity for ultra-fast repeated optical phenomena can be measured by using the dual time base unit.

- **Highspeed gate function (0.1 μs to continuous)**

Unnecessary incident light which causes noise before and after a sweep is cut off for accurate measurements.

- **Observations possible up to 1.6 μm wavelength (when using an infrared streak tube)**
- **Real-time readout system for the C1587**

A streak image analysis system composed of a high-sensitivity TV camera, a Temporalanalyzer and other peripheral equipment are provided.



C1587 and its dedicated readout system

APPLICATIONS

- **Semiconductors and optical communications**
  - Evaluation of response characteristics of laser diodes and optical IC's
  - Evaluation of transmission characteristic of devices for optical communications such as optical fibers
  - Observation of photoluminescence from semiconductor compound material
- **Biology**
  - Fluorescence lifetime measurement of living tissue and cells under a microscope
  - Fluorescence lifetime measurement in ultraviolet-region and ultra-low light lever for the field of genetic engineering
- **Research and analysis**
  - Measurements of infrared fluorescence spectra for a process of photochemical reactions
  - Observations of explosions, combustion and shock-waves
  - Time-resolved Raman spectroscopy
  - Precision land and space distance measurement
  - Measurements of highspeed optical phenomena in laser fusion
  - Analysis of plasma radiation
  - Pulse width and phase observations for mode-locked lasers and synchrotron radiation

OPERATING PRINCIPLE

The streak camera converts incident light to electrons and performs a highspeed sweep (deflecting electrons from top to bottom), enabling the detection of the time variation of the incident light intensity by converting these to different positions on the screen. Fig. 1 shows the operating principle of the streak tube, which forms the heart of the streak camera.

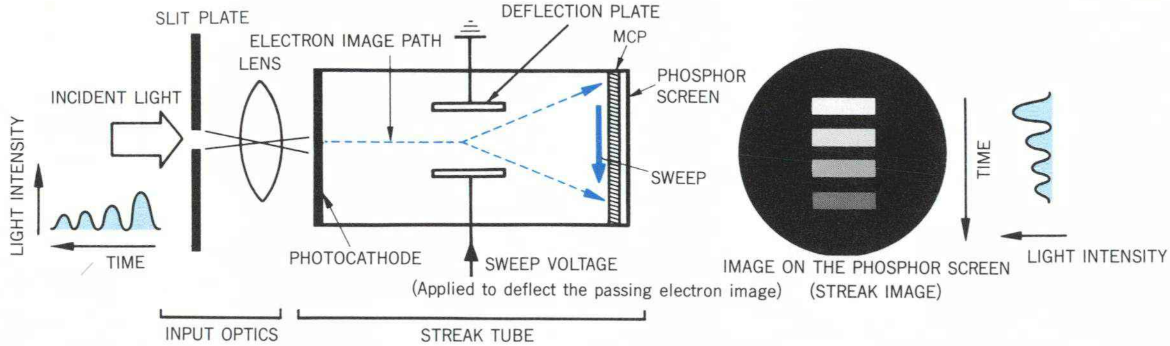


Figure 1: Streak Tube Operating Principle

SWEEP METHOD The C1587 can be used with sweep units and sweep function expansion units to enable four types of sweep.

SINGLE SWEEP

This is the sweep method using M1952 fast single sweep unit or M1953 slow single sweep unit. The streak sweep is performed from top to bottom as shown in Figure 1 and this single sweep is used for the measurement of a single shot phenomenon or repeated phenomena with repetition rate of less than 18KHz. By using the highspeed gate function, it is possible to sample a part of a highspeed repeated event or continuous event and perform measurements with high time resolution.

SYNCHROSCAN

This is the sweep method using M1955 Synchroscan Unit. The sweeping voltage applied to the deflection plates has the form of a sinusoid and it offers an increased sweep repetition rate of 75MHz to 165MHz.

This sweeping voltage is synchronized to the repeating incident light pulses, then the streak images are generated continuously and accumulated at a fixed position on the phosphor screen. Therefore, it becomes possible to detect very faint phenomena with a high S/N ratio and high dynamic range.

This synchroscan method can be combined with an infrared streak tube (N2367 or N2367-01) to enable observations of light phenomena up to 1.6 μm.

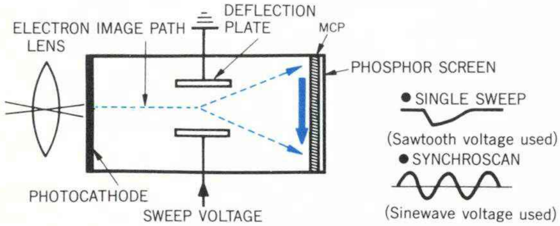


Figure 2: Sweep Voltages for Single-sweep and Synchroscan

SYNCHRONOUS BLANKING

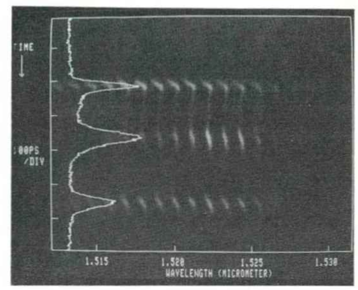
This sweep method uses a combination of the M2567 synchronous blanking unit and the M1955 synchroscan unit and enables observations of repeated events from 75MHz to 30GHz.

In standard synchroscan streak cameras, a sine wave is applied to the vertical deflection plates only and the electron image is scanned vertically at the same horizontal position on the phosphor screen. For this reason, in the case of measuring phenomena such as a semiconductor laser modulated in the gigahertz region, the top-to-bottom and bottom-to-top sweep signals are overlapped, making proper measurement difficult. Also, in the standard synchroscan streak camera, when measuring the lifetime of the fluorescence, samples which have a long decay time in the order of one-half the sweep period exhibit the trailing edge of the fluorescence on the flyback, making it difficult to measure the exact decay time.

The M2567 synchronous blanking unit provides a synchroscan not only in the vertical direction but also in the horizontal direction, so that the flyback is deflected off the phosphor screen, thus preventing the flyback signal from being recorded. As a result, gigahertz region repeated phenomena and the long decay time of fluorescenses can be observed.

The light pulse to be measured is projected onto the slit. The slit-image of the incident light is focused by a relay lens onto the photocathode of the streak tube where the photons are converted into electrons. The electrons are then accelerated by the strong electro-static field between the photocathode and the mesh-electrode, and conducted into the deflection field. The electrons are then swept at highspeed in a direction perpendicular to the slit-length by applying a deflection voltage synchronized with the arrival of the electrons to the deflection field.
Since it is necessary that the timing of the highspeed deflection is synchronized to the arrival time of electrons at the deflection field, the incident light is usually split to a PIN photodiode detector to generate a trigger signal for the sweeping.

The electrons are then multiplied in the MCP by a factor of approximately 3×10^3. Electrons exiting the MCP then bombard the phosphor screen of the streak tube and are converted to the optical image (called "streak image"). As a result of this structure and the sweeping system used, the time at which electrons were released from the photocathode surface can be determined by their deflected angle (vertical position on the phosphor screen). Therefore, the time axis of the incident light corresponds to the vertical axis on the phosphor screen, and the intensity of the incident light can be determined by the density of the streak image. By projecting a spectrum on the slit via a monochromator, the horizontal axis of the streak image would then correspond to wavelength, so that time-resolved spectroscopy is carried out.



• Example of time resolved spectroscopy

In this example, the dedicated readout system for the C1587 is used to analyze the relaxation oscillations of a laser diode. The wavelength information can be read from the horizontal axis and the temporal intensity information can be read from the density of the image.

Comparison of Methods of Observing a 1.5μm Semiconductor Laser (modulated at 2GHz)

• Synchroscan

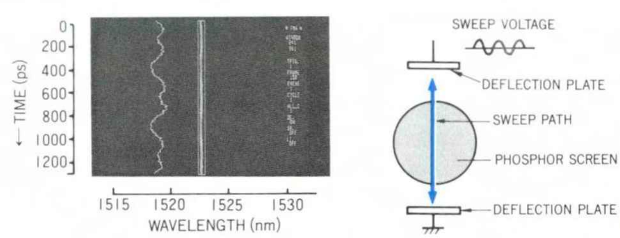


Figure 3-a: Sweep Path Using Synchroscan

The image resulting from incident light during the return sweep overlaps with the signal from the main sweep.

• Synchronous Blanking

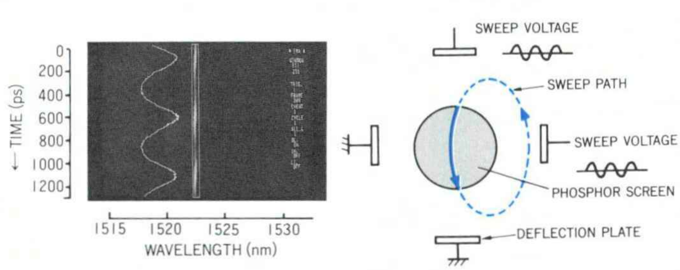


Figure 3-b: Sweep Path Using Synchronous Blanking

The use of elliptical sweep so that the return sweep does not pass over the phosphor screen enables measurement of only the signal from the main sweep. (The photo was obtained using the C2280 Temporalanalyzer to perform vertical compensation for streak image bending.)

DUAL TIME BASE SWEEP

This is the sweep method provided by the M2887 Dual Time Base Extender Unit and it is used normally in combination with the M1955 Synchroscan Unit. By shifting the repeated vertical sweep in the horizontal direction (horizontal sweep), it is possible to capture temporal information in the horizontal direction as well as the vertical direction. By having two time axes, it is possible, for example, to measure pulse widths and phase variations which are sufficiently longer than the repetition frequency of events which repeat at highspeed.

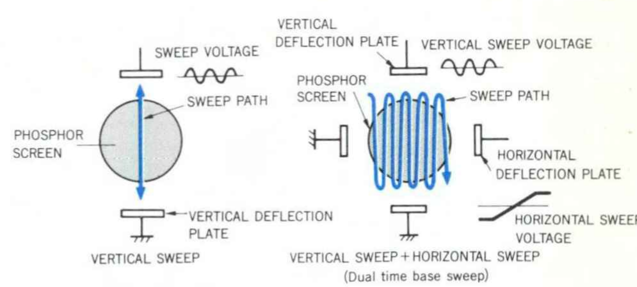
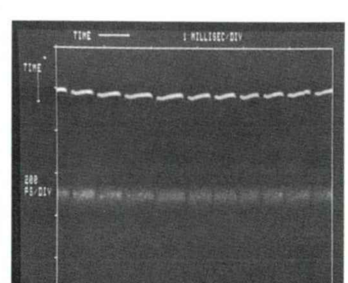


Figure 4: Sweep Path Using Dual Time Base



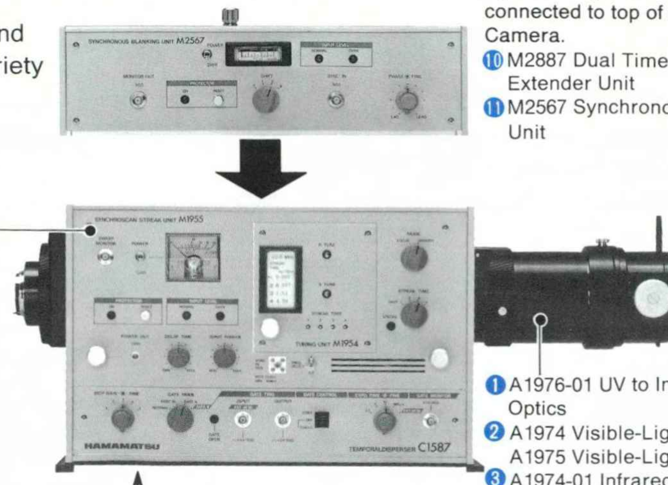
Jitter measurement example of a mode-locked YAG laser and a sync pump dye laser excited by the YAG laser's second harmonic
(top: dye laser, bottom: YAG second harmonic)

FUNCTIONAL CONFIGURATION

The C1587 permits selection of plug-in sweep units and sweep function expansion units to customize it for a variety of applications.

Optional Expansion Units (choice of one) connected to top of mainframe C1587 Strea
Camera.
⑩ M2887 Dual Time Base Extender Unit
⑪ M2567 Synchronous Blanking Unit

Choice of one plug-in:
⑦ M1952 Fast Single Sweep Unit
⑧ M1953 Slow Single Sweep Unit
⑨ M1955 Synchroscan Unit



① A1976-01 UV to Infrared Input Optics
② A1974 Visible-Light Input Optics
A1975 Visible-Light Input Optics
③ A1974-01 Infrared Input Optics
A1975-01 Infrared Input Optics

④ N1643-01 Vacuum UV to Visible-Light Streak Tube ⑤ N1643 UV to Visible-Light Streak Tube or
⑥ N2367/N2367-01 Infrared Streak Tube

Figure 5: C1587 Configuration

① A1976-01 UV to Infrared Input Optics

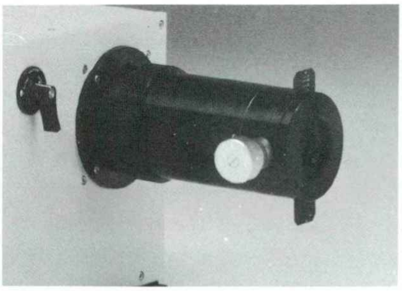
These input optics have a wide, flat spectral transmittance from 200 to 1600nm. (magnification ratio 1:1)

② A1974/A1975 Visible-Light Input Optics

These input optics have spectral transmittance in the range 400 to 900nm and a magnification of 1:1 for the A1974 and 3:1 for the A1975.

③ A1974-01/A1975-01 Infrared Input Optics

These input optics have spectral transmittance over the range 400 to 1600nm and are designed to have maximum transmittance at 1300~1600nm. The magnification ratios are 1:1 for the A1974-01 and 3:1 for the 1975-01.



④ N1643-01 Vacuum UV to Visible-Light Streak Tube

This streak tube has sensitivity over the range 115 to 850nm, making it usable in the vacuum UV region.

⑤ N1643 UV to Visible-Light Streak Tube

This streak tube has sensitivity over the range 200 to 850nm.

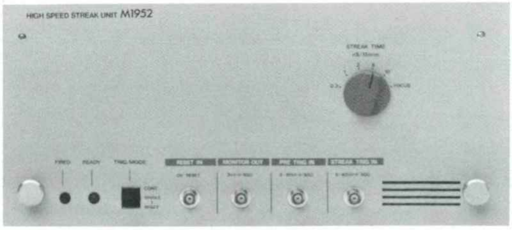
⑥ N2367 & N2367-01 Infrared Streak Tubes

These streak tubes are for obsevation in the infrared region and, used in combination with the M1955 Synchroscan Unit, enable observation of optical phenomena over the wavelength range 400 to 1600nm*. The N2367-01 has higher sensitivity in the region above 1300nm than the N2367.

* While intrinsic spectral sensitivity of the streak tube is 300 to 1600nm, the use of infrared input optics limits it to 400 to 1600nm.

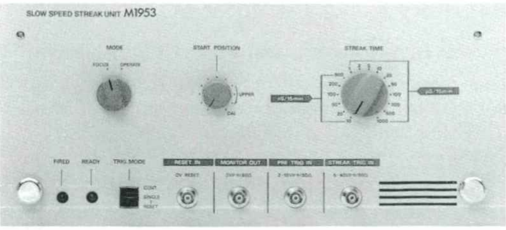
⑦ M1952 Fast Single Sweep Unit

This unit provides a temporal resolution of better than 2ps and a sweep time of 0.3 to 10ns/15mm (entire phosphor screen). The sweep time can be switch selected for 0.3, 1, 2, 5, or 10ns/15mm.



⑧ M1953 Slow Single Sweep Unit

This unit provides a temporal resolution of better than 100ps and a sweep time of 10ns to 1ms/15mm (entire phosphor screen). The sweep time can be switch selected for any of 16 steps.



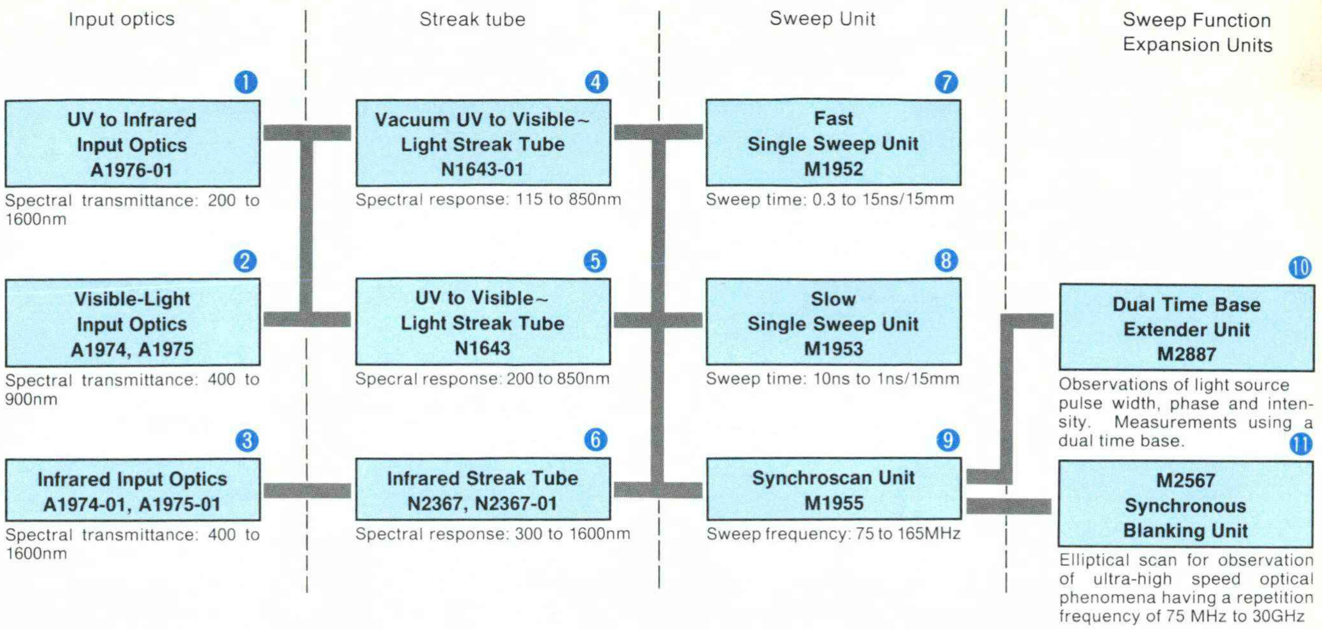
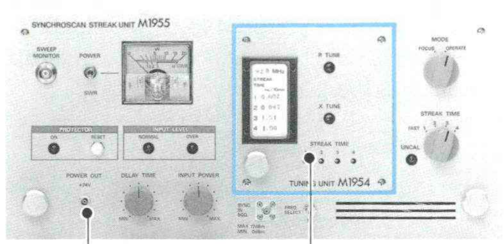


Figure 6: C1587 Functional Block Diagram

9 M1955 Synchroscan Unit

This unit was developed for observation of repeating phenomena having repetition (sync) frequencies in the range 75 to 165MHz with a temporal resolution of better than 10ps. Its ability to perform high-speed accumulation makes it suitable for the observation of low-intensity light phenomena and infrared observation. The center frequency is determined by the selection of the M1954 Tuning Unit (which is built into the M1955); frequencies of 80, 90, 100, 110, 120, 130, 140, 150 and 160MHz, (each adjustable ±5MHz) are available.



M1955 Synchroscan Unit M1954 Tuning Unit

10 M2887 Dual Time Base Extender Unit

Used in combination with the M1955 Synchroscan Unit, the M2887 provides a dual time base sweep (refer to P5). It can be used to observe the slow time variations of pulse width, phase and intensity of optical phenomena and in the measurement of the deflection of high-speed rotating or vibrating bodies.

11 M2567 Synchronous Blanking Unit

Used in combination with the M1955 Synchroscan Unit, the M2567 provides an elliptical scan (refer to P5), enabling the observation of high-speed repeating phenomena in the range 75MHz to 30GHz. It has a horizontal sweep sync frequency of 75 to 165MHz, settable by selection of the M2568 Tuning Unit (80, 90, 100, 110, 120, 130, 140, 150 and 160MHz each adjustable ±5MHz).

M2568 Tuning Unit

M2567 Synchronous Blanking Unit

• Highspeed Gate Function

The gate function is used in measuring a particular portion of a continuous optical phenomenon or in measuring the optical phenomena accompanying high-intensity light before and after the sweeping period. It is provided as standard with the C1587 and features a gate time variable over the range 0.1μs to continuous.

• Output Optics

A Nikon mount is provided for output optics. While this enables 35mm and Polaroid® cameras to be mounted, the recommended configuration includes a high-sensitivity TV camera mounted using a special adaptor and the dedicated readout system which enables real-time analysis.

SPECIFICATIONS

STREAK TUBES (built into the streak camera)

● N1643, N1643-01 UV to Visible-Light Streak Tubes

Photocathode/window material
- N1643 .... Multi-alkali/UV glass
- N1643-01 .... Multi-alkali/MgF_2

Useful photocathode area .... 1.5 x 6.7mm
Spectral response N1643 .... 200 to 850nm
N1643-01 .... 115 to 850nm
Radient sensitivity
- N1643, N1643-01: 820nm .... 1mA/W min.

Phosphor screen P-20
Useful phosphor screen area .... 15mm dia.
Image magnification 1: 2.3
MCP gain (at 900V) .... 3 x 10^3 Typ. (10^3 min.)
Spatial resolution
(on the center of photocathode) .... 25 lp/mm

● N2367, N2367-01 Infrared Streak Tubes

Photocathode S-1
Useful photocathode area .... 0.5 x 6.0mm
Spectral response .... 300 to 1600nm
Radiant sensitivity
- N2367: 1060nm .... 100 μA/W min.
- 1300nm .... 1 μA/W min.
- N2367-01*: 1060nm .... 100 μA/W min.
- 1300nm .... 10 μA/W min.

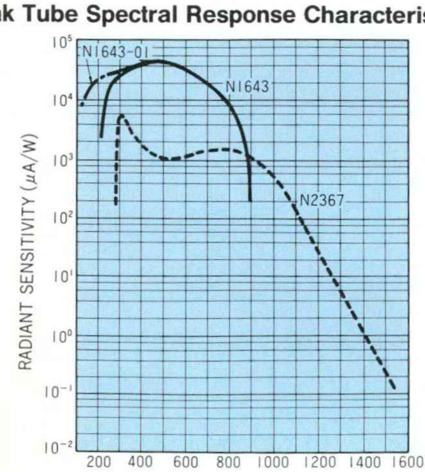
Phosphor screen P-20
Useful phosphor screen area .... 15mm dia.
Image magnification 1: 2.3
MCP gain (at 900V) .... 3 x 10^3 Typ. (10^3min.)
Spatial resolution
(on the center of photocathode) .... 25 lp/mm min.

*The N2367-01 is a selected version of the N2367 having extended sensitivity in the infrared region.

The C1587 model number depends on the streask tube used, as follows:

C1587	UV to Visible-Light streak tube (N1643)
C1587-01	Infrared streak tube (N2367)
C1587-02	Infrared streak tube (N2367-01)
C1587-03	Vacuum UV to Visible-Light streak tube (N1643-01)

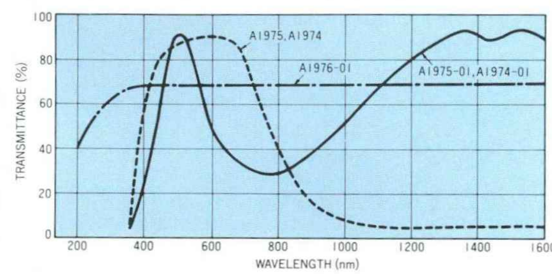
Streak Tube Spectral Response Characteristics



INPUT OPTICS

Item \ Name	UV type A1976-01	Visible-Light type A1974	Visible-Light type A1975	Infrared type A1974-01	Infrared type A1975-01
Spectral transmittance (nm)	200 ~ 1600	400 ~ 900		400 ~ 1600	
Image magnification	1 : 1	1 : 1	3 : 1	1 : 1	3 : 1
Effective F number	4.5	1.2	4.5	1.2	4.5
Slit width (mm)	0 ~ 5				
Slit width reading accuracy (μm)	5				
Effective slit length (overall screen) (mm)	0 ~ 6.7	0 ~ 6.7	0 ~ 20.1	0 ~ 6.7	0 ~ 20.1
Effective slit length (for SIT readout) (mm)	0 ~ 4.2	0 ~ 4.2	0 ~ 12.6	0 ~ 4.2	0 ~ 12.6
Overall length (mm)	98.2	190	190	159	200

● Spectral Transmittance of Input Optics



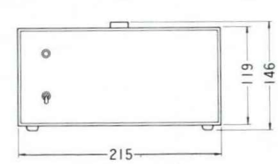
MAINFRAME AND OUTPUT OPTICS

Output Optics
- Image magnification .... 1:1 or 1: 2.1
- Effective F number F2.0

Gating method .... Simultaneous photocathode/ MCP or MCP only
Gate time .... 0.1 μs to continuous
Gate extinction ratio
- Simultaneous phtocathodes/MCP gating .... 1:10^6 min.
- MCP gating .... 1:10^3 min.

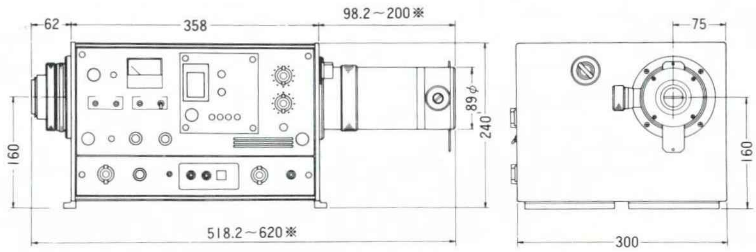
Monitor signal output .... +3Vp-p/50 Ω
Reset signal input .... reset at 0V
Gate signal input .... +2 to +10Vp-p/50 Ω
Power requirements 100/117/220/240VAC, 50/60Hz
Power consumption .... Approx. 150VA

● Power Supply Unit (approx. 8.2kg)



(DEPTH : 370mm)

● Mainframe (approx. 21.4kg)



※The input optics dimensions will depend upon the model.
Refer to the input optics' overall length in the above specifications.

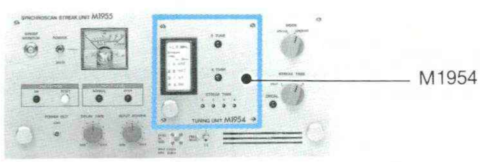
SWEEP UNIT (built into the mainframe as plug-in)

● M1955 Synchroscan Unit

Temporal resolution
(fastest speed range) .... better than 10ps
Streak time .... 600ps/10mm to 1/6f/10mm
(where f is the center frequency
of the synchroscan unit.)
Streak repetition rate .... 75 to 165MHz
Trigger jitter .... less than ±4ps
Dynamic range
(fastest speed range) .... more than 1:500
Streak trigger input .... 0.6 to 4.5Vp-p/50 Ω

● Frequency tuning unit M1954

Center frequency (f) 80, 90, 100, 110, 120,
130, 140, 150, 160MHz
Tuning frequency range .... f±5MHz
Streak range .... 4 range, selectable



● M1952 fast single sweep unit

Temporal resolution
(fastest speed range) .... better than 2ps
Streak time/full screen (15mm) 0.3, 1, 2, 5, 10ns
Trigger jitter .... less than ±20ps
Trigger delay (fastest speed range) .... approx. 20ns
Streak trigger signal input .... +5 to 40Vp-p/50 Ω
Gate trigger signal input .... +2 to 10Vp-p/50 Ω
Maximum sweep repetition rate .... max. 1kHz
Dynamic range
(fastest speed range) .... more than 1:30

● M1953 slow single sweep unit

Temporal resolution
(fastest speed range) .... better than 100ps
Streak time/full screen (15mm) 0.01, 0.02, 0.05,
0.1, 0.2, 0.5, 1, 2, 5,
10, 20, 50, 100,
200, 500, 1000μs
Trigger jitter .... less than ±50ps
Trigger delay (fastest speed range) .... approx. 60ns
Streak trigger signal input .... +5 to 40Vp-p
Gate trigger signal input .... +2 to 10Vp-p
Maximum sweep repetition rate 18kHz
Dynamic range
(fastest speed range) .... more than 1:200

SWEEP FUNCTION EXTENSION UNITS
(built into top of mainframe)

● M2567 Synchronous Blanking Unit

Horizontal shift width 11, 5.5, 2.3mm
(at phosphor screen)
Streak repetition rate .... 75 to 165MHz
Phase variable range .... 0 to 360°
Sync signal input level .... 0.2 to 4.5Vp-p/50Ω

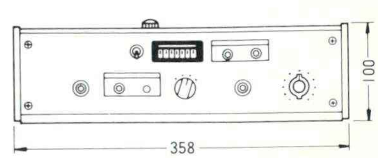
M2568 tuning Unit (built into the M2567)

Center frequency(f) 80, 90, 100, 110, 120,
130, 140, 150, 160MHz
Tuning frequency range .... f±5MHz

● M2887 Dual Time Base Extender Unit

Sweep time .... 100ns to 100ms/10mm, in 6 steps
(continuously variable in each range)
External triggering
Repetition frequency .... 10kHz max. (fastest range)
Trigger input .... +2V to +10Vp-p/50Ω
Internal triggering
Repetition frequency .... 0.1 to 10Hz,
continuously variable
Manual .... Single triggering using a lever switch
Trigger delay .... 300ns (fastest range)
(time from input of trigger until streak image appears at
the phosphor screen)
Sweep stop switch ...... Normal streak camera operation
Monitor output .... TTL level, "High" during sweep

● M2567 Synchronous Blanking Unit
(M2887 Dual Time Base Extender Unit has same dimensions.)



(DEPTH : 300mm)

Weight: approx. 8.3kg (approx. 8kg for M2887)