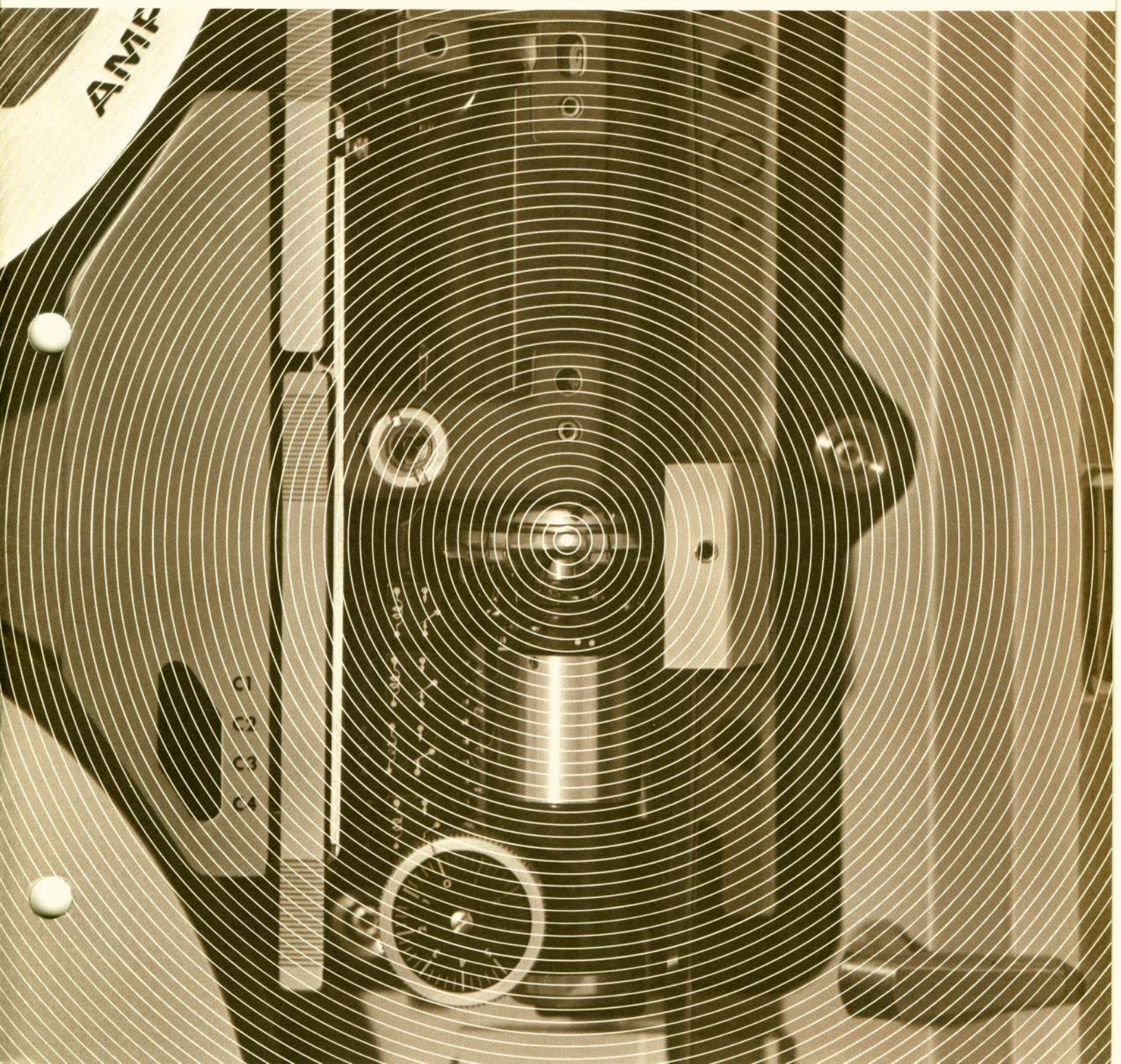
AMPEX

FR-900A/950 wideband recorder/reproducer



AMPEX

FR-900A/950

- **6MHz bandwidth**
- **Transient-free performance**
- **Time-base stability ±15 ns, p-p**
- **630 hours MTBF (for FR-900A)**

Use the FR-900A/950 for incomparable radar recording, communications monitoring, predetection recording, high-rate digital recording — or other advanced, wideband system applications. FR-900 Systems deliver the widest bandwidth with the highest time-base stability.

Specifications are impressive, even by Ampex standards. They include 3dB bandwidth from 1Hz to 6MHz (DC to 6MHz on special order), 40dB peak-to-peak signal-to-rms-noise at full bandwidth, and time-base stability within ±15 nanoseconds, peak-to-peak. These specifications are unmatched by any other recorder. Full performance specifications are contained in Ampex Specification Sheet Number D093.

An entire FR-900A single-channel system mounts in one nineteen-inch rack. The dual-channel FR-950 requires two racks. One rack contains the transport, transport controls and electronics for one wideband channel; the second rack contains electronics for the other wideband channel. Both FR-900A and FR-950 operate on standard 117V, single-phase, 50Hz or 60Hz input power. Tapes made on any recorder in the series, 50Hz or 60Hz, will play back on any other recorder in the series without change in performance. This is also true of tapes made on Ampex AR-500 or AR-550 Airborne Recorders; these tapes can be reproduced on any FR-900A/950 System with perfect compatibility.

Six versions available

Basic FR-900 Systems are available in six versions. Versions are divided into two categories: RECORD/REPRODUCE and DATA ACQUISITION models. Modular construction of basic equipment readily allows conversion of data acquisition models to transient-free, time-base stabilized record/reproduce models—via plug-in accessories. Designations and brief descriptions of each version are as follows:

FR-900A-1 and FR-950-1

Transient-free, time-base stabilized record/reproduce models. 900A-1 is equipped with a single wideband channel; 950-1 with dual wideband channels.

FR-900A-2 and FR-950-2

Data acquisition models with minimum playback facilities for "quick look," on-site verification of recorded data. 900A-2 is equipped with a single wideband channel; 950-2 with dual wideband channels.

FR-900A-3 and FR-950-3

Data acquisition models with improved time-base stability, compared to the -2 models above. 900A-3 is equipped with a single wideband channel; 950-3 with dual wideband channels.

Data acquisition models of the FR-900A/950 can be easily adapted to -1 models by the addition of plug-in accessories.

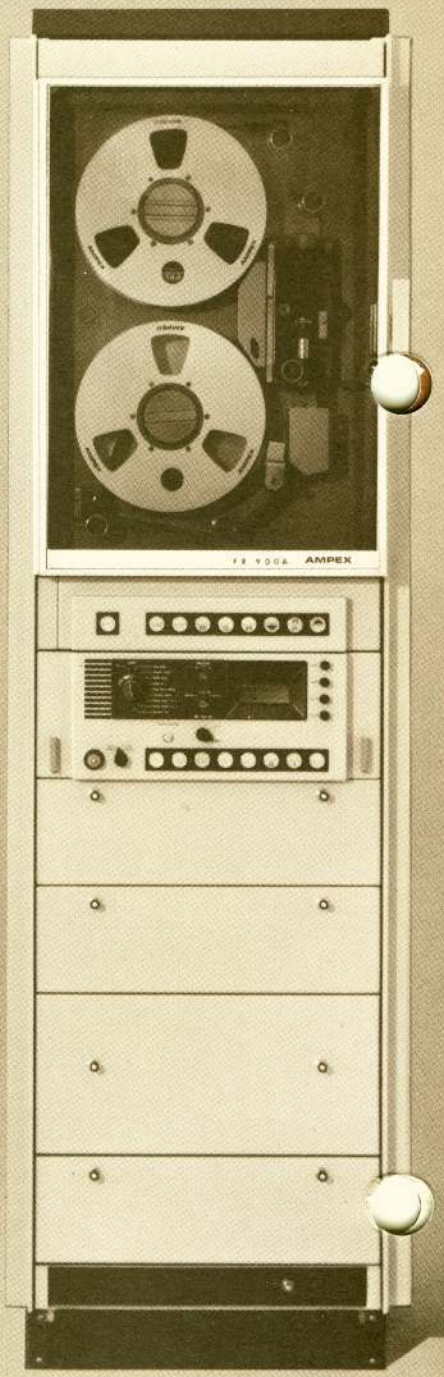
Standard equipment

The FR-900 Series of recorders marks the latest advancements in rotary head technology, pioneered by Ampex with the introduction (in 1956) of the first broadcast television tape recorder. Design and construction of FR-900 Systems, utilizing modular solid-state electronics, affords the user unmatched wideband performance, long life, high reliability and convenience of operation and maintenance. Wideband recording capability is augmented by two auxiliary data channels, each having a bandwidth from 300Hz to 30kHz. Standard operating tape speed for the FR-900A Series is 12.5 in/s; standard tape speed for the FR-950 Series is 25 in/s.

The FR-900 Series of wideband recording systems incorporates provisions for optimal recording of both analog and pulse data inputs, as well as FM predetection data. A built-in monitor bay, with integral oscilloscope and calibration signal generation facilities, provides all functions necessary for operations monitoring and routine system alignment. A microphone and speaker/amplifier are also built in for recording voice annotation on an auxiliary channel.

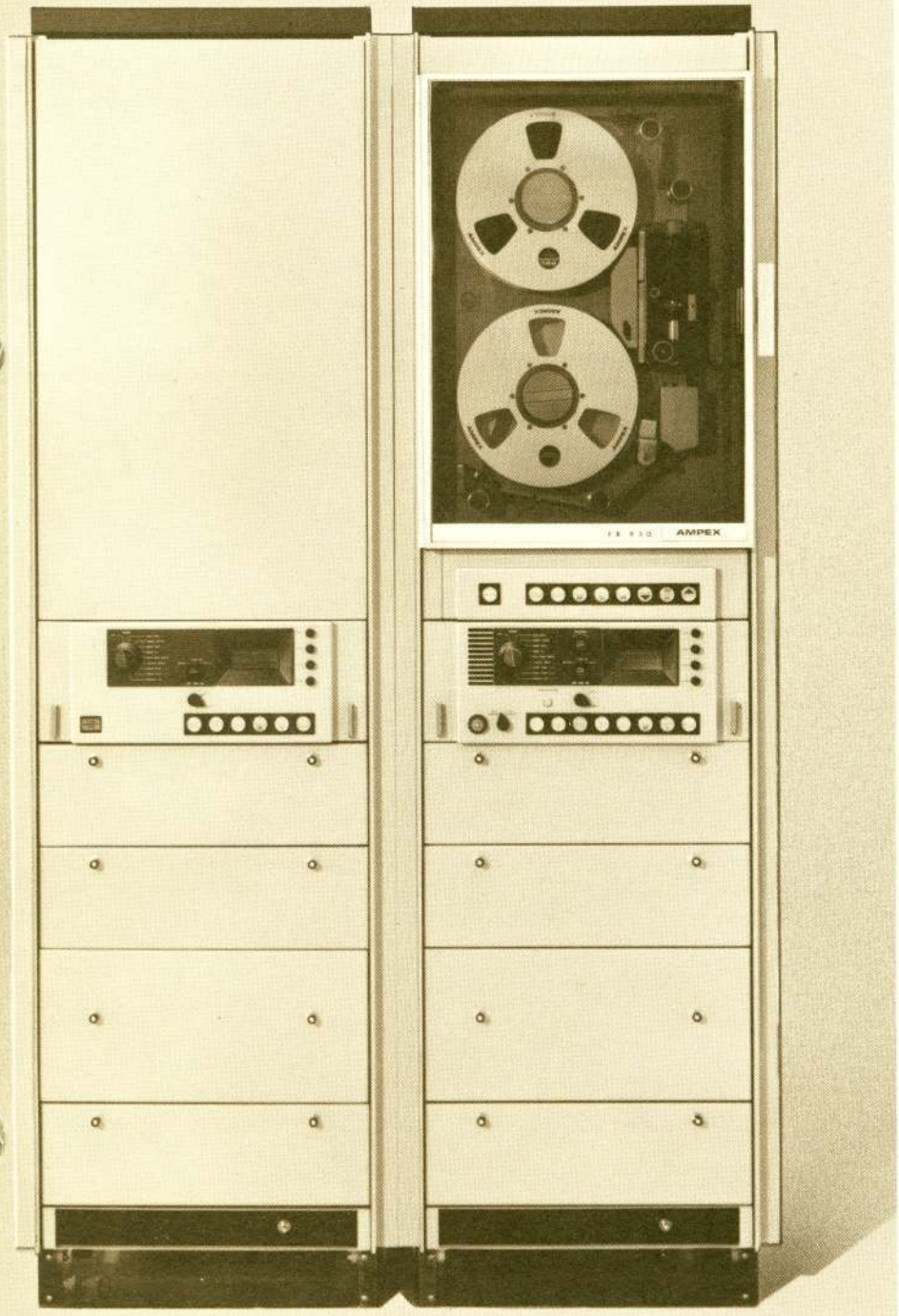
FR-900 Systems provide the capability for searching out specific segments of previously recorded data. A SLOW SEARCH MODE can be performed at the standard tape speeds. In addition, a HIGH-SPEED SEARCH MODE (at 125 in/s) is also provided in both models. Other features of FR-900 Systems include a tachometer controlled capstan servo and pilot controlled rotary head drum servo.

FR-900A
single wideband channel

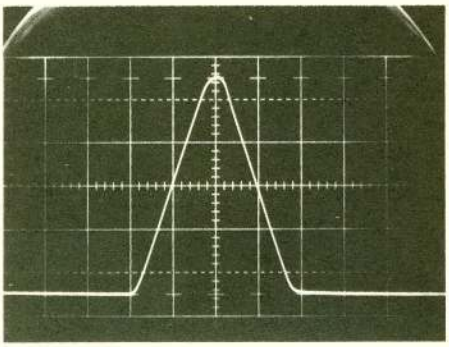


outstanding fidelity over a wide bandwidth

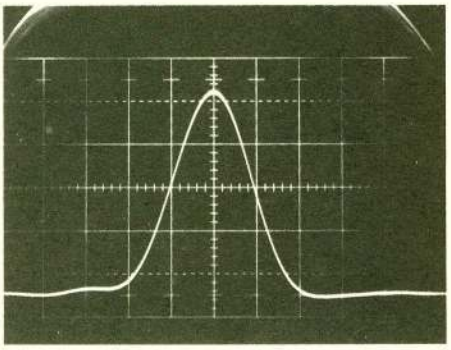
FR-950
dual wideband channels



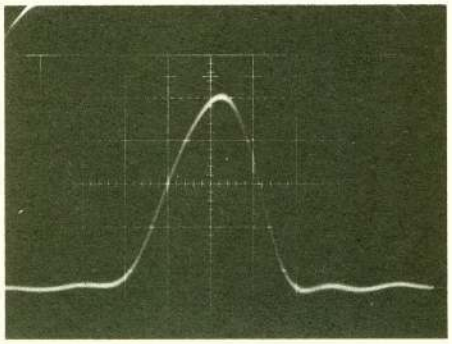
Typical photos of waveforms from an FR-900A. Oscillograms demonstrate low amplitude variation off tape and outstanding pulse fidelity. Oscillograms are of a 200 nanosecond pulse. Horizontal sweep rate is 100 nanoseconds/cm; vertical amplitude is 0.2 volts/cm.



200 Nanosecond Pulse Input



Output (Electronics to Electronics)

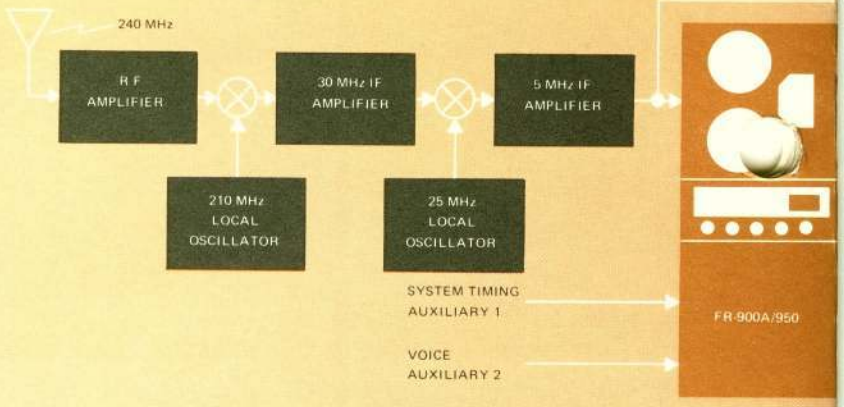


Output (Off Tape)

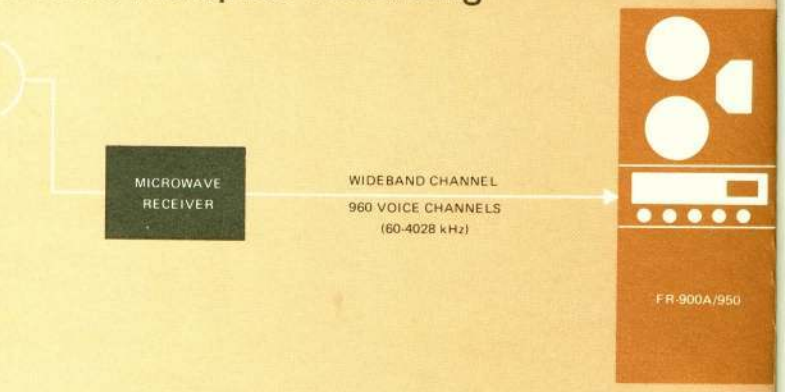
typical wideband recording applications

FR-900A/950 Systems are readily adapted to a number of unique recording tasks. External equipment, for specific applications, can be attached with a minimum of interconnection considerations. Many specialized functions can be incorporated in the recording system itself — and are available from Ampex in kit form for factory installation. A few typical FR-900A/950 applications are illustrated at the right.

predetection recording

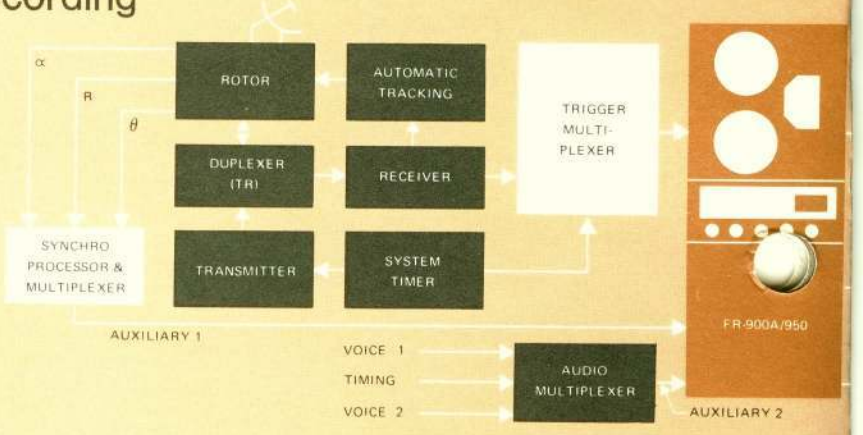


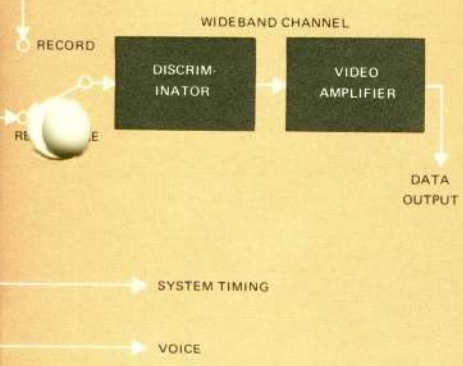
frequency division multiplex recording



digital recording

radar recording

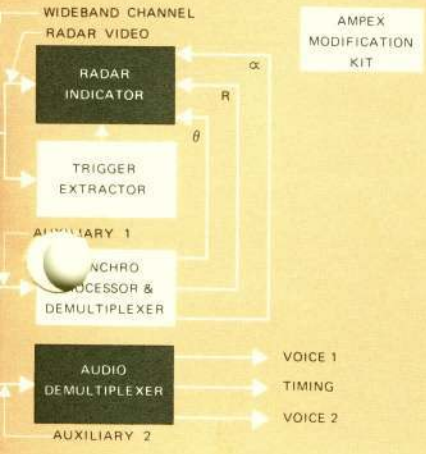




The FR-900A/950 can record FM-modulated data, prior to detection, at an IF rate. The upstream recording provided by the predetection concept increases data reliability, provides excellent fidelity and can handle most types of telemetry formats. Standard IRIG telemetry data can be recorded and reproduced with exceptionally low flutter modulation.

The FR-900A can record 960 channels of voice multiplex on a single wideband channel — with one hour recording time. Information is reproduced with low flutter and a complete absence of switching transients. The FR-950 will record two such channels for 30 minutes. Slot noise ratios of the order of 25dB can be realized for 99% of the the channels.

The FR-900A/950 permits transient-free reproduction of high-speed digital data at synchronous transfer rates up to 10 megabits/second. Timing can be controlled from a stable, external clock lying within ±5% of a multiple of 500kHz. Alternatively, an internal clock will provide control rates at precise multiples of 500kHz. The recorder can also accept self-clocking data at any non-synchronous rate up to 5 megabits/second. Typical data accuracy is one error in 10^5 bits. The FR-950 will handle two such data channels. On special order, provisions can be made to enable spatially redundant recording on each FR-950 channel—to yield data accuracy of typically less than one error in 10^9 bits with the same transfer rate.



The FR-900A/950 can record radar pulses of 0.16 microsecond, minimum. Such a system is diagramed at the left. Note that a number of Ampex modification kits can be installed in the recorder to facilitate application of the equipment to this type of recording. A brief description of the function of each kit follows:

Kit Number 1

Multiplexes (and demultiplexes) a radar trigger pulse together with the radar signal. The combined signal is applied to the wideband channel in such a manner as to give no degradation of either signal. One kit is required for the FR-900A; two kits are required for the FR-950.

Kit Number 2

Two limited-bandwidth radar channels are multiplexed together, with a trigger pulse, on one wideband channel. The limited-bandwidth channels are 1.2MHz and 1.5-MHz. One kit is required for the FR-900A; two kits are required for the FR-950.

Kit Number 3A and 3B

Three-phase radar azimuth synchro data (plus reference) are translated into digital format and recorded on one of the auxiliary longitudinal channels. Alternatively, coarse and fine synchro data are frequency multiplexed, using narrow band FM techniques, and recorded on an auxiliary longitudinal channel. This kit can be used on either the FR-900A or FR-950.

transport, rotary heads and auxiliary channels

Transport
FR-900A/950 transports are built on aluminum castings with precision-milled mounting surfaces for all guides, heads and other components. Tape handling is smooth and uniform in all modes of operation. Hysteresis clutch control, tape supply photo sensing and servoed capstan motor assure gentle tape handling — and machine-to-machine compatibility. The transport is mounted on hinges so it can be swung out for easy access to power supplies, capstan and head drum servo electronics, audio/video amplifiers and other components.

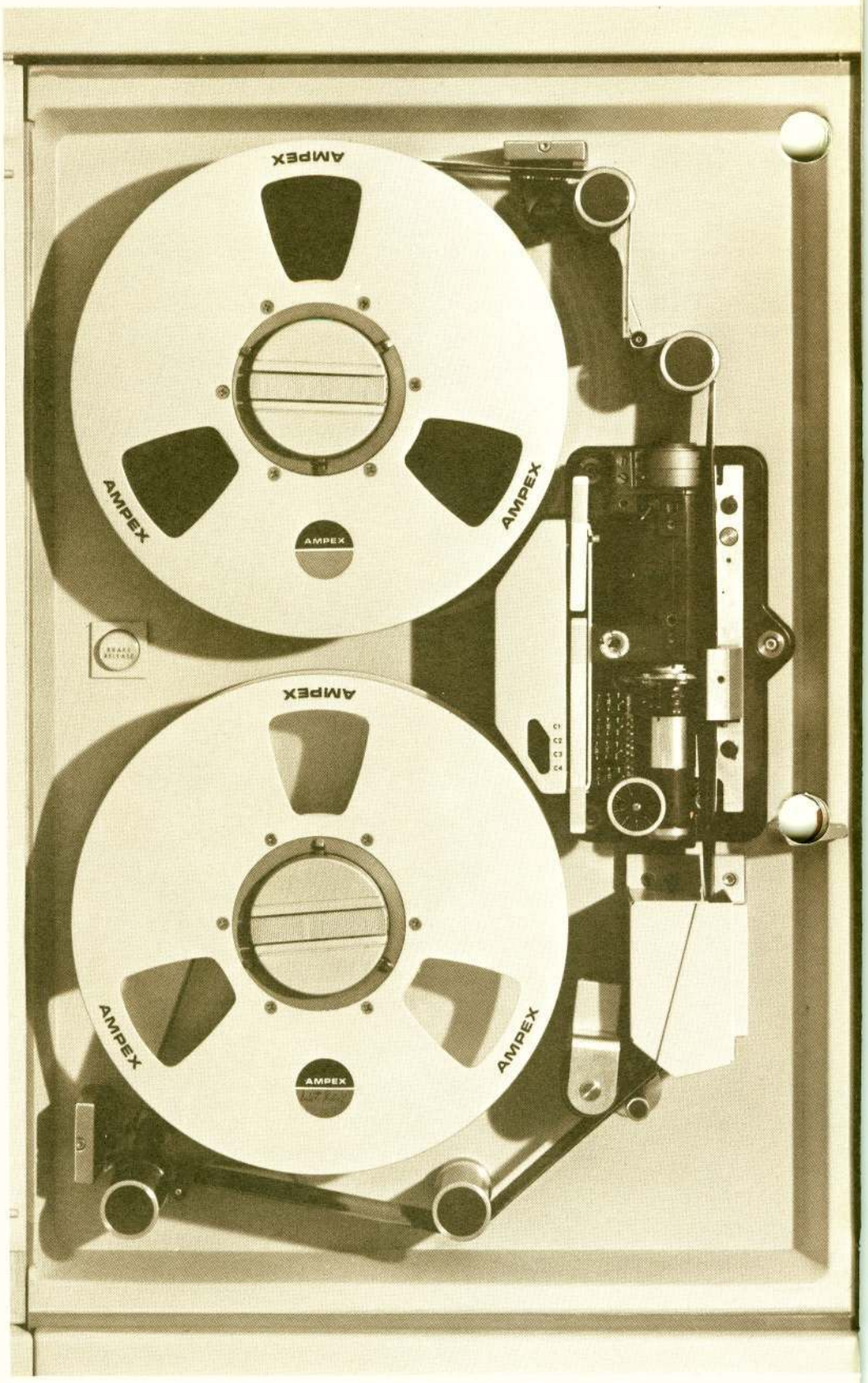
A control panel is located immediately below the transport. Its mechanically interlocked control buttons initiate the following functions: RECORD, REPRODUCE, STOP, FAST FORWARD, REWIND and REMOTE. In the REMOTE mode, all transport functions can be operated at a distance with an optional remote control accessory.

The FR-900A/950 transport can also be controlled with the Ampex TCS-100 Time Code System. This system permits electronically controlled starting, stopping, search and shuttle modes — plus recording of a continuous time code on the tape. Any segment of information on the tape can be positively identified and searched for. It can also shuttle tape automatically between two points when repetitive analysis of a particular segment of data is required. For some applications, this automatic shuttle feature can eliminate the necessity for recording data on a separate loop recorder.

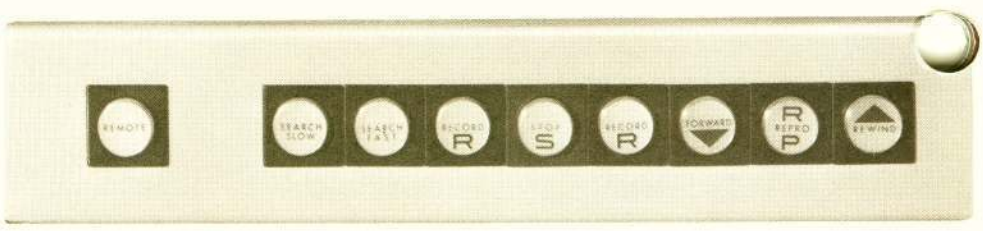
Rotary heads
The FR-900A/950's wide bandwidth and transient-free performance (with maximum time-base stability) is largely due to the precision of its unique rotary head. In this assembly, wideband data are recorded transversely on 10-mil wide tracks, with a track spacing of 12.5 mils. On the FR-900A, four heads are mounted 90° apart on one rotating drum. On the FR-950, eight heads are mounted 45° apart and interleaved on one drum. Head tips utilize long-life AlFeSil pole tip material. A rotary transformer provides noise-free signal coupling of the heads to the recorder. Transformer coupling eliminates slip rings and their associated noises which can look like radar pulses.

The drum, on which the heads are mounted, is driven at a constant speed by a servo-controlled motor drive amplifier locked to a precise frequency standard. A control track insures that the heads will always accurately track on the proper transverse track during reproduce modes.

Auxiliary channels
Two auxiliary channels are available on the FR-900A/950. These record information longitudinally on the tape, and provide a response of 300Hz to 30kHz. They can be used for audio information and timing signals, or, to record and reconstitute digital data inputs up to 10k bits/second.



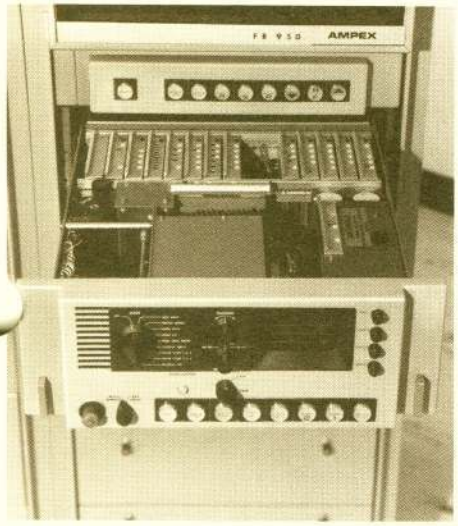
FR-900A/950 transport and transport controls.



electronics and monitor bays

Electronics

In FR-900 Systems, wideband data is recorded on the tape in frequency-modulated form. This provides a response to DC with a minimum number of octaves. Limiting action of the wideband FM system also provides a means of eliminating undesired signal amplitude variations. All signal electronics are solid-state, and are comprised of the system's modulator/demodulator, equalization and time-base correction circuits — plus associated power supplies. Subassemblies are all built into plug-in printed circuit modules for minimum bulk and maximum reliability. Modular, logical arrangement of electronics facilitates system checkout, service and maintenance.



Unit-1 monitor bay of an FR-900A/950. Shown in the "slide-out" position. Plug-in electronics are located inside the drawer.

Monitor bays

Two types of monitor bays are used in FR-900 Systems. The Unit-1 monitor bay is always located in the transport rack of the system, whether the system is a single wideband channel FR-900A or dual wideband channel FR-950. This bay contains facilities for continuous monitoring of critical waveforms and voltages in one wideband channel. It also contains an oscilloscope with sweep circuits and vertical amplifier. A nine-position switch selects input to the scope for internal monitoring during record or reproduce modes.

A mode selector panel is located across the bottom of the monitor bay. It controls various calibration signals and operational modes — for use during the record and reproduce process. An electronics-to-electronics switch (EE) allows the modulator/demodulator circuits to be checked. A microphone (with retractable cord) and built-in speaker allow voice recording and playback.

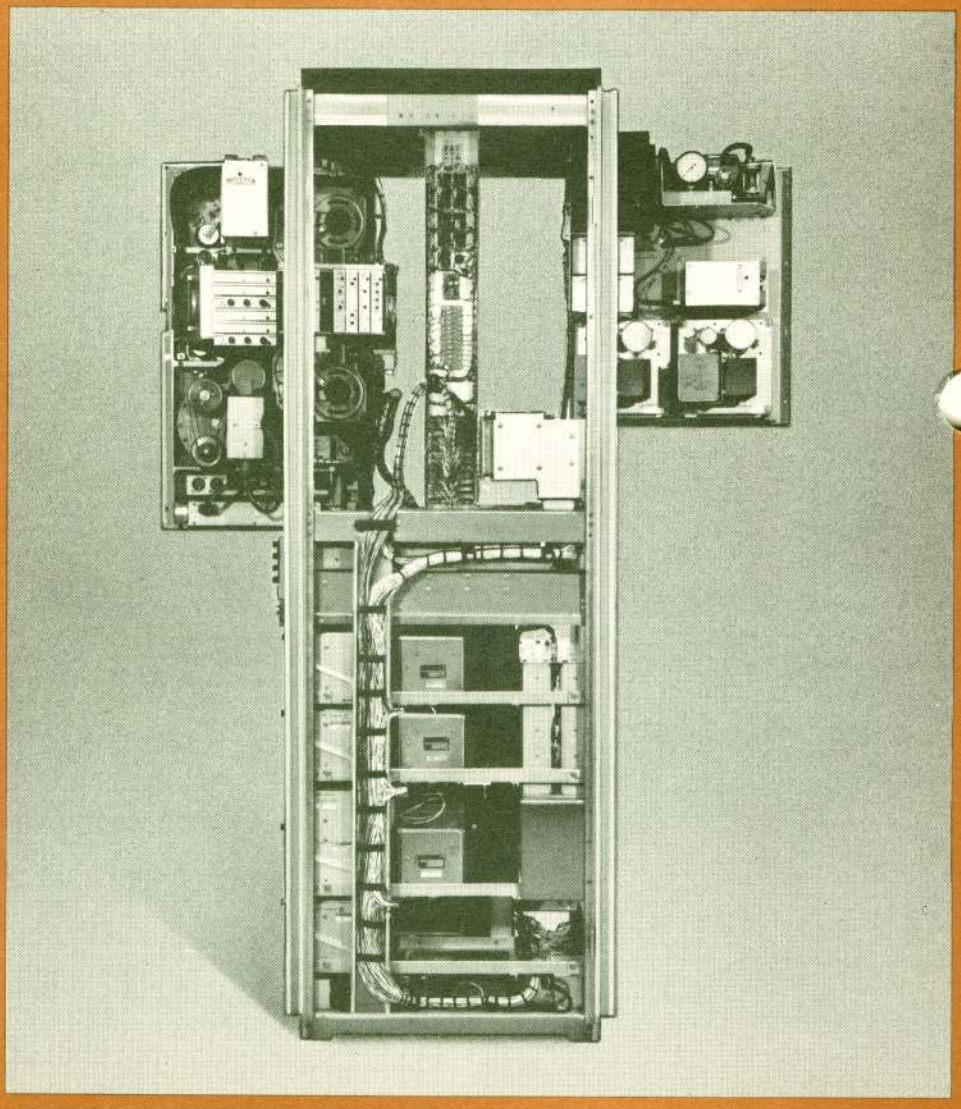
A card rack inside the monitor bay contains electronics for the audio speaker-amplifier, continuous phase shifter (which adjusts the capstan servo for maximum reproduced signal off-tape), calibrating signal generator (including multiburst for calibration of frequency response, and 250kHz square waves for adjustment of fixed delays). It also contains cards for 200 nanosecond width, 15-kHz rep-rate test pulses, frequency standard and dividers for the head drum and capstan servo references, and pilot signal for electronic time-base correction.

The Unit-2 monitor bay is used only in FR-950 Systems. This bay provides a duplicate of all test, monitoring, operational mode control and calibration functions of the Unit 1 monitor bay. It is used for the second wideband channel, and also contains a tape speed selector.

FR-900A/950 Unit-1 monitor bay front panel

FR-950 Unit-2 monitor bay front panel

FR-900 systems are compact and accessible



Side view of FR-900A/950 transport section. Both sides of rack are removable for access to internal cabling, plug-in cable connectors and terminal strips. Both transport and upper rear panel swing out to allow easy check-out, servicing and routine maintenance of mechanical elements or transport-mounted amplifiers. All signal, test and control electronics are modular plug-in assemblies. The entire "look" of the FR-900A/950 is clean and compact — indicative of its highly refined design that offers users maximum information storage capability in minimum space.

AMPEX

Ampex Corporation, Instrumentation Division
401 Broadway
Redwood City, California 94063

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AMPEX

specifications

FR-900A/950 wideband recorder/reproducer

Effective January 1968

DESCRIPTION

The **FR-900A** is a single-channel, wideband (6MHz) instrumentation recorder equipped with two 30kHz auxiliary channels. The **FR-950** is a dual-channel wideband (6MHz in each channel) instrumentation recorder equipped with two 60kHz auxiliary channels. The FR-950 can be operated (by pushbutton selection) as a single-channel wideband recorder with two 30kHz auxiliary channels. In this case, all specifications stated for the FR-900A are applicable. Both FR-900A and FR-950 are available in three standard configurations each:

FR-900A-1 or FR-950-1 — a continuous and transient-free recorder/reproducer with electronic time-base correction

FR-900A-2 or FR-950-2 — data acquisition systems with minimum playback facilities to provide "quick look," on-site verification of recorded data

FR-900A-3 or FR-950-3 — data acquisition systems with improved long-term time-base stability, as compared to FR-900A-2 or FR-950-2

Any specification referring to one (or more) of the above equipment configurations will have the configuration at the left. If no configuration is given, the specification applies to all equipment. A wideband performance specification bearing a 950 number applies separately to each of the two wideband signal channels on a 950 configuration.

INTERCHANGEABILITY

Any tape recorded on a machine in one of the six configurations described above can be reproduced within the specifications stated herein on any machine of the same configuration, or, on the same machine with a different rotary head assembly. Any tape recorded on an FR-900A-2 or FR-900A-3 can be reproduced on any one recorder out of the six configurations above, within the specifications stated for the reproducing machine. Any tape recorded on an FR-950-2 or FR-950-3 can be reproduced on an FR-950-1, within the specifications of the FR-950-1.

Tapes recorded on AR-500 or AR-550 airborne, record-only machines can be reproduced on any FR-900A or FR-950, respectively.

WIDEBAND SIGNAL PERFORMANCE

Signal Inputs and Outputs:
Push-button selectable on Unit #1 for signal channel #1, on Unit #2 for signal channel #2:
Mode 1: for unipolar input signals; channel capacity 0 to 6MHz.
Mode 2: for bipolar input signals; channel capacity 0 to 6MHz.
Predetection: for FM carrier input signals; channel capacity 1 to 10MHz.

Input Impedance:
75 ohms unbalanced to ground

Input Signal Level:
1V p-p nominal; 0.75V p-p minimum for obtaining nominal output level

Output Impedance:
75 ohms unbalanced to ground

Output Signal Level:
1V p-p nominal at nominal recorded level

Frequency Response:
Within ±1.5dB from 5Hz to 5MHz and down not more than 3dB at 1Hz and 6MHz, referenced to 1MHz. Extended response to dc available on special order.

Signal-to-Noise Ratio:
900A-1, 950-1 — 40dB p-p signal to rms noise, referenced to 1V p-p signal

900A-2, 900A-3, 950-2, 950-3 — 38dB p-p signal to rms noise, referenced to 1V p-p signal.

Rise Time, Fall Time
100ns, or less, measured between the 10% and 90% signal levels, using a square wave of not more than 250kHz (e.g., the internally generated test signal square wave), having rise and fall times of not more than 25ns.

Overshoot, Preshoot:
12½%, or less, measured with a square wave of not more than 250kHz, having rise and fall times of not more than 25ns, and excluding noise, i.e., reading the center of the oscilloscope trace.

Minimum Width Pulse:
A 160ns wide rectangular input pulse ensures no amplitude loss in comparison with a wide pulse.

Amplitude Linearity:
900A-1, 950-1 — Within ±0.5dB referenced to the applied signal level. This specification is applicable for minimum width pulses and over an applied signal range from 1V p-p (0dB) to 0.1V p-p (−20dB), by using a calibrated attenuator and oscilloscope display. Pulses of lower levels cannot be measured without special test equipment due to their noise content.

Amplitude Stability:
900A-1, 950-1 — ±0.5dB, excluding wideband noise, measured with minimum width pulses at full nominal recording level.

(Continued on reverse side)

PHYSICAL SPECIFICATIONS

	SIZE	WEIGHT† (pounds)		POWER (108/132V, 48/62 Hz, single-phase)	
		Unit 1	Unit 2	Amps	Watts
900A-1	One rack or unit, 75" high X 22.2" wide X 24" deep	809		16.5	1650
900A-2		720		15	1500
900A-3		722		15	1500
950-1	Two racks or units,* each the same dimensions as single rack above	809	427	21	2100
950-2		720	340	17	1700
950-3		722	340	17	1700

*Unit 2 contains the second-channel wideband electronics and some monitoring and control facilities; it has 29" of rack space available for accessory or other electronics.

†Weight of other items: Dolly, 70 pounds; Rotary Head Assembly, 8.5 pounds; full reel of tape, 10.5 pounds; empty reel of tape, 2.5 pounds.

specifications
FR-900A/950 wideband recorder/reproducer

Relative Time-Base Stability:

900A-1, 950-1: ±15ns p-p maximum time-base error of reproduced data in each wideband channel with respect to the system timing reference, for the entire duration of a continuous recording, measured as jitter on an oscilloscope trace of a reproduced step, or pulse, with the oscilloscope triggered from the built-in frequency standard. The step, or pulse, must be recorded synchronously with the recorder timing reference. This measurement includes the wideband noise which results in a pulse jitter of approximately 5ns p-p.

900A-2, 950-2: ±150ns p-p maximum over 1ms, measured with a delay oscilloscope. Since this recorder configuration does not have a headdrum servo, the time-base error cannot be referenced to the built-in frequency standard.

900A-3, 950-3: ±150ns maximum time-base error of reproduced data in each wideband channel with respect to the system timing reference, for the entire duration of a continuous recording, measured as described above.

Absolute Time-Base Stability:

900A-1, 950-1: If the built-in frequency standard is calibrated prior to recording and prior to reproduction of the recorded data to within $\pm 1 \cdot 10^{-8}$ absolute time, then two events recorded X seconds apart will be reproduced within X seconds ±20Xns ±15ns. The specified drift rate of the built-in frequency standard is less than $1 \cdot 10^{-8}$ per day, after 30 day's aging.

Interchannel Time Displacement:

950-1: Within 25ns p-p time difference between the two wideband signals, measured by recording simultaneous pulses on both channels and displaying the reproduced pulses of one channel on an oscilloscope which is triggered from the reproduced pulses of the other channel.

AUXILIARY CHANNEL SIGNAL PERFORMANCE

Number of Channels:
Two auxiliary data signal channels; one of them can be connected internally to a built-in microphone (and speaker in playback) by means of a switch.

Input Impedance:
600 ohms unbalanced to ground

Input Signal Level:
1V rms nominal

Output Impedance:
600 ohms unbalanced to ground

Output Signal Level:
1V rms at nominal recorded level

Frequency Response:

900A-1, 900A-2, 900A-3: 300Hz to 30kHz, ±3dB, 1kHz reference

950-1, 950-2, 950-3: 300Hz to 60kHz, ±3dB, 1kHz reference

Signal-to-Noise Ratio:
30dB $\frac{\text{rms}}{\text{rms}}$ at 1% third harmonic distortion, for nominal recorded level.

Flutter:
0.4% rms maximum over a frequency range from 0.6Hz to 200Hz.

MECHANICAL SPECIFICATIONS

Tape:
Ampex 779, Part No. 750-257. As an alternate, Ampex 148 (or other tape of equivalent performance) may be used.

Tape Dimensions:
Thickness: 0.0014"
Width: 2.000", +0.000", −0.004"
Maximum Length: 3800 feet

Reel Size:
10.5" diameter with standard NAB hub.

Tape Speed:

900A-1, 900A-2, 900A-3: 12.5 in/s for single-channel operation.

950-1, 950-2, 950-3: 25.0 in/s for dual-channel operation.

Tape Running Time:

900A-1, 900A-2, 900A-3: 60 minutes at 12.5 in/s.

950-1, 950-2, 950-3: 30 minutes at 25 in/s.

Start Time, Wideband Channels:
From STOP mode to REPRODUCE mode, stable operation is achieved in less than five seconds.

Start Time, Auxiliary Channels:
From STOP mode to REPRODUCE mode, stable operation is achieved in less than two seconds.

Stop Time:
For wideband and auxiliary channels, from REPRODUCE mode to STOP mode in less than one second.

Fast Wind Time:
Less than four minutes for a full reel of tape (in either direction) with 60Hz primary power; less than five minutes with 50Hz primary power.

ENVIRONMENTAL SPECIFICATIONS

Temperature:
Operating, 50° to 95°F (10° to 35°C); non-operating, −67° to +185°F (−55° to +85°C).
Note: Tape storage temperature is limited to −20 to +120°F (−29° to +49°C).

Warm-Up Time:
Warm-up, from the turn-on of the main power breaker(s), is 30 minutes and until the thermostat of the frequency standard cycles. No warm-up time is required from the POWER OFF mode to the POWER ON mode, since the frequency standard and Modulator/Demodulator Bays are energized in the POWER OFF state. Maximum aging time of the frequency standard, from turn-on of the main power breakers until the specified drift rate of $1 \cdot 10^{-8}$ per day, is 30 days. Under intermittent operation, the frequency standard must be ON approximately twice the time it was OFF.

Humidity:
Operating, 15% to 90% R.H.; non-operating, 0% to 95% R.H.
Note: Tape storage limitations are 25% to 95% R.H.

Altitude:
Operating, 0 to 10,000 feet, non-operating, 0 to 50,000 feet.

Vibration and Shock:
Designed to withstand normal vibration and shock when properly packed in its shipping container.

AMPEX

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