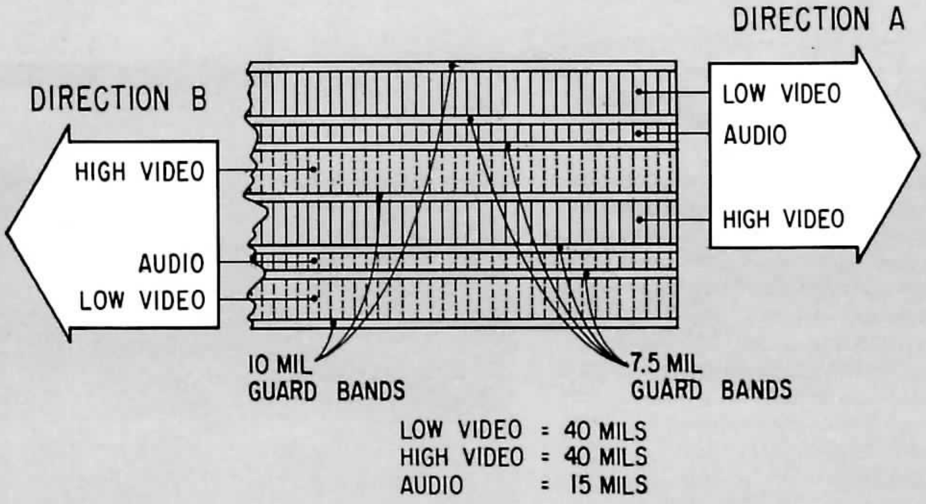

Fig. 1—Simplex track pattern recorded on ¼-inch tape.

Fig. 2—Portable video tape reproducer.

A COMPACT VIDEO TAPE REPRODUCER

This portable laboratory-model tape player reproduces both pictures and sound from prerecorded standard ¼-inch tapes. The complete player—including the transport mechanism, reproducing electronics, power supply and RF transmitter—is contained in a portable case measuring 16″ x 11″ x 12½″. Its self-contained miniature RF television transmitter can couple the reproduced video and sound signals to any number of standard television receivers. Compactness is achieved by using a small transport, printed circuits, and transistor circuitry throughout.

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Active research on the elements for video tape recording systems has been carried on at the RCA Laboratories for more than a decade. Early in 1956, the results of this effort were publically demonstrated in the form of a home type video tape reproducer. The term *Hear-See* was coined at that time to denote a video tape system for home use. Following this demonstration, several different types of Hear-See video tape recorders and reproducers were built as the art progressed.

Recently, a portable video tape reproducer, contained in a case measuring 16″ wide, 11″ high, and 12½″ deep, has been developed. The reproducer (Fig. 1) was built to show how the results of research on the basic system elements can be applied to the development of a small, compact, and relatively inexpensive reproducing unit for home use. The compactness was achieved through the use of the *simplex* video tape system (Fig. 1) combined with recent developments in both the video tape electronics and the tape transport mechanisms.

The simplex video tape recording system[1] permits the use of ¼-inch-wide magnetic tape on a transport mechanism which, in many respects, is quite similar to that used in high quality audio systems. That is, the heads are stationary, the tape is driven by a capstan and pressure roller assembly, and is drawn from a payoff reel and wound onto a take-up reel. Since the magnetic heads are stationary, a relatively simple head mounting assembly is employed. This feature permits a considerable reduction in both size and complexity compared with video tape systems where the magnetic heads rotate to scan tracks across the tape.

The electronic developments include complete transistor circuitry and the use of a miniature, transistor type, television transmitter which can be adjusted to any one of the lower VHF channels.

The use of transistor circuitry contributes greatly to the reduced size of the player and the miniature television transmitter provides a simple means for connecting the signals reproduced from the tape to the antenna terminals of any standard television receiver by coaxial cable, twin lead or an air path consisting of a simple antenna system.

The mechanical developments in the tape transport mechanism include the use of a single hysteresis synchronous motor and a brake-shoe arrangement with a mechanical feedback control. The motor is coupled to the tape drive capstan through a mechanical isolator and to the take-up reel through a belt and slip clutch assembly. The brake-shoe arrangement provides a constant hold back tension on the tape as it is drawn from the payoff reel.

SIMPLEX RECORDING

Since a description of the playback unit entails a discussion of the signals recorded on the tape, a brief outline of the simplex method of recording is in order.

The term *simplex* is a name given to the magnetic recording system in which the video signal is recorded along the length of the tape by stationary recording heads. This term is used to distinguish it from the quadraplex system[2] in which the video signal is recorded across the width of the tape by a rotating, headwheel assembly, and the helical-scan system[3] in which complete fields are recorded on a diagonal track across the width of the tape by a rotating-head arrangement.

Fig. 1 shows how the signals are recorded on the tape by the laboratory model Hear-See Simplex Recorder. As in audio tape recording systems, two separate recordings can be made on the tape by reversing the direction of the tape travel. That is, after a recording is made on half of the tape in one direction, the tape can be removed from the takeup reel shaft, placed on the payoff reel shaft, and a second recording made on the other half of the tape. The arrows show the tracks that are placed on the tape for each direction of tape travel and the numbers show the widths of the associated tracks and the spacing between tracks.

The video tracks are recorded by a magnetic head containing two separate elements with gap lengths of 40 microinches each; the audio track is recorded by a separate audio head containing a single element with a gap of 100 microinches. The different track widths (Fig. 1) are determined to provide the maximum signal-to-noise ratio with guard bands wide enough to prevent intertrack crosstalk.

Frequency modulation is employed in the recording of the audio and the low-frequency portion of the video band because at the 120-ips tape speed, considerable signal amplitude variations result from unevenness in the tape coatings, magnetic particle clumping and irregularities in the head-to-tape contact. The use of frequency modulation permits the use of clipping and limiting to greatly reduce the effects of these disturbances.

The high-frequency portion of the video signal is recorded directly on tape in order to take full advantage of the maximum head-to-tape response. That is, by recording the high video frequencies directly on the tape the highest frequency reproduced from the tape is used to contribute to the finest detail portions of the reproduced picture. If a carrier were used to record the higher frequencies, a considerable loss in high-frequency detail would result because the carrier would of necessity have to be higher than the highest frequency in the signal. Furthermore, since the high-frequency video band contains only the fine detail portions of the picture such as edge transitions and closely spaced line patterns, the effects of small-signal amplitude variations are not particularly noticeable in the reproduced picture.

Another consideration is that the tape-and-head combination exhibits a transfer characteristic that has a rapidly falling amplitude with increasing frequency. To compensate for this, it is necessary to provide an equalizing network which has a gain characteristic that increases with frequency. Thus, when the reproduced signal is equalized to a more or less constant amplitude the noise has a rising characteristic which appears as a fine-grain pattern in the reproduced picture. Although this noise is noticeable, it is not deleterious until the highest frequency signal-to-noise ratio falls below approximately 10 db.

If a single track were used to record the entire video band on a carrier, then the final picture resolution would be considerably lower for the same tape velocity because the carrier would require a minimum signal-to-noise ratio of 35 db for an adequate low-frequency video signal-to-noise characteristic. This requirement would cause the carrier frequency to be set at a value considerably below that of maximum system response. Furthermore, the highest video frequency would be limited to a value between 50% and 75% of the carrier to maintain an adequate signal-to-intermodulation beat ratio. Thus, for a single track carrier arrangement the speed would have to be increased to a value considerably higher than 120 ips to obtain the same resolution that is now possible in the two-rack system.

REPRODUCING SYSTEM

Audio

As shown in Fig. 3, the carrier, reproduced from the tape by the audio playback head, is amplified by a two-transistor low-noise input amplifier. The signal from the input amplifier is further amplified and then limited in a four-stage diode type limiter. The signal from the limiter is detected by a counter type detector and the audio is selected from the detector output by a lowpass filter. The recovered audio is connected to the sound section of the RF transmitter by a single transistor audio amplifier.

Video

The video section is divided into two parts—*high video* and *low video*—as shown in Fig. 4.

The high video chain contains a two-transistor low-noise high-frequency preamplifier, which amplifies the video band extending from 300 kc to over 2.5 Mc. The preamplifier output is then coupled to a seven-transistor equalizing amplifier with a gain characteristic that rises with increasing frequency. This network is set to have a characteristic that is the exact inverse of that of the signal reproduced from the tape. The equalized signal is then fed to one input of a three-transistor video adder stage.

The 600-kc signal from the low-frequency track is also amplified by a two-transistor low-noise transistor preamplifier. The amplified carrier plus sidebands is then coupled to an equalizer which provides an overall flat response from 150 kc to 1.3 Mc. This band is equalized to insure that the FM carrier and its sideband components have a constant amplitude characteristic to prevent the following limiter stages from introducing unwanted phase distortions into the signal. The output from the equalizer is coupled to a four-stage diode-type limiter and the limited signal is coupled to a two-transistor multivibrator-type frequency doubler.

The frequency doubler elevates the carrier and its sidebands above the 10-cps-to-300-kc modulation band to

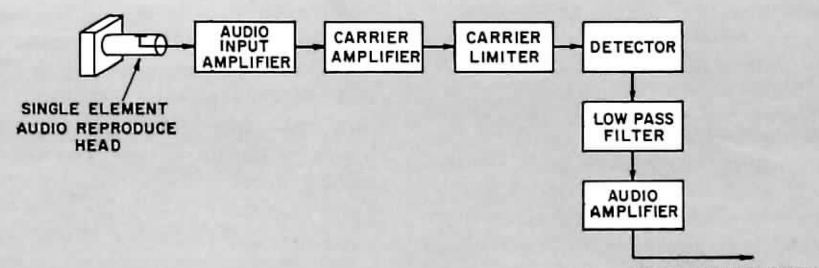
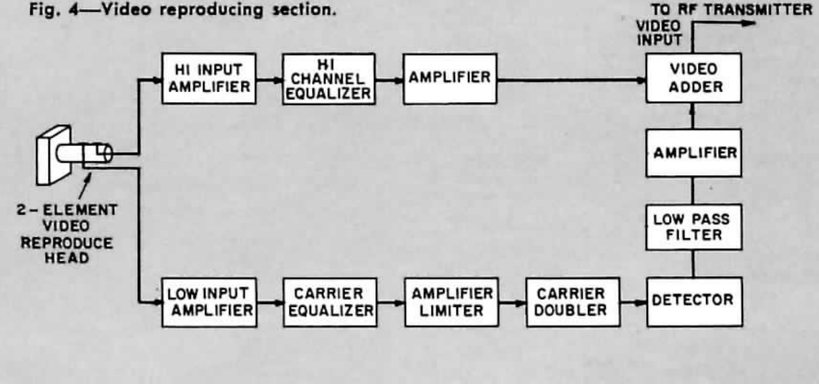


Fig. 3—Audio reproducing section.

Fig. 4—Video reproducing section.



WILLIAM D. HOUGHTON joined the Research and Advanced Development group of RCA Communications, Inc. in 1940 and was transferred to the RCA Laboratories in 1942. From 1940 to 1942, he was assigned to a Television microwave relay research project and from 1942 until 1950, he specialized in time dimension multiplex communications system research at the Rocky Point, New York Laboratory. In 1950 he was transferred to RCA Laboratories, Princeton. Since 1952, he has been a group leader responsible for research on home type video tape systems. Mr. Houghton holds 39 U. S. patents, and has received two individual and two group RCA Laboratories "Achievement Awards." He is the author of several published articles on time dimension multiplex and video tape recording systems. Mr. Houghton is a member of the IEEE, Sigma Xi, and the Acoustical Society of America. He has been active in IEEE activities serving as treasurer, vice chairman, and chairman of the Princeton Section.

SEYMOUR NAROFF joined the Terminal Facilities Laboratory at RCA Communications, New York in 1941, and transferred to the Laboratories Division Communications Section at the same location in 1943. Here, he was responsible for the design and development of numerous electromechanical devices. Besides the work in communications systems, he also designed devices for special projects such as TV Film scanning systems, the RCA BIZMAC, and military systems such as the VOFLAG, TYPHOON and KILLER contracts. In 1956 he was transferred to the RCA Laboratories. He took part in the development of the JANUS II satellite demonstration equipment, and designed the mechanical portion of a radar recorder for the WADC PRESSAR system. From 1959 to the present he has been a member of the video tape group of the Acoustical and Electromechanical Research Laboratory. Here, he has designed and built various tape transport mechanisms for home type video recording systems.

ROBERT F. SANFORD received his BSEE from the University of Arkansas in 1954. From 1952 to 1954 he assisted at the University Research Center as an associate engineer. In June 1954 he joined the RCA Laboratories in Princeton. After his training program, his permanent assignment was with the Special Systems group on color TV. In March of 1958, he transferred to the Acoustical and Electromechanical Research Laboratory where he has been assigned to video tape systems research. During 1961 he developed the heterodyne demodulator for use in testing the quadruplex color tape machine (for which he received an RCA Laboratories "Achievement Award"). Since that time he has been active in the development of transistorized circuits for small compact video tape machines. Mr. Sanford is a member of the IEEE and is presently Business Manager of the local IEEE Publication "P.S.".

prevent undesired beats between the lower carrier components and the higher modulation frequencies at the detector output. The 10-cps-to-300-kc band from the counter-type detector is then selected by a four-element low-pass filter network, and the output from the filter is coupled to the second input on the transistor adder by a single-transistor video amplifier stage. The output from the adder, which covers the video band from 10 cps to 2.5 Mc, is coupled to the video input of the RF transmitter.

RF Transmitter

Fig. 5 shows the elements in the miniature four-transistor VHF television transmitter. As shown, the audio frequency modulates an oscillator with a 4.5-Mc center frequency. The frequency modulated 4.5-Mc carrier is then added to the 10-cps-to-2-Mc video band in a video adding network. The output from the video adder is used to amplitude modulate the output from a crystal oscillator which oscillates at a frequency equal to half the desired channel frequency. The output from the amplitude modulator is then doubled to produce the RF television signal.

The output from the transmitter is coupled to a coaxial connector so that a shielded line may be connected between the tape reproducer and the antenna terminals of any number of standard television receivers. Satisfactory RF tests have been made when the reproducer was connected to the television receiver by means of a pair of rabbit ear antennas.

Power Supply

The power supply (Fig. 6) is a silicon-diode bridge rectifier followed by a transistor regulator set to maintain the voltage at 20 volts-DC. The ripple voltage is 2 mv and the regulation is within 0.2 volts from zero current to 200 ma. The total current drain of the entire electronic unit is 160 ma, and the total power input to the unit is 150 watts.

TAPE TRANSPORT

Fig. 7 shows the elements in the tape transport mechanism. The 1/20-hp hysteresis synchronous motor is used to drive both the capstan and the take-up reel. The capstan and its flywheel are

Fig. 5—RF transmitter section.

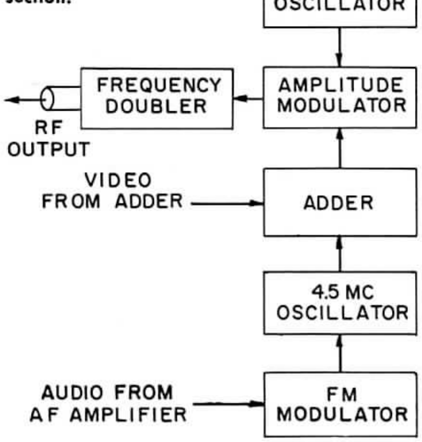
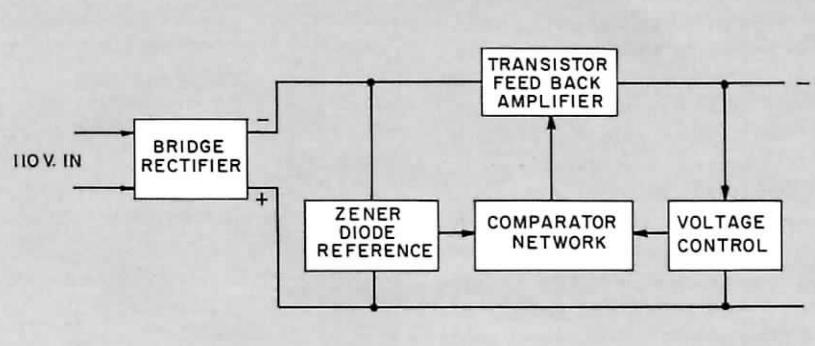


Fig. 6—Power supply.



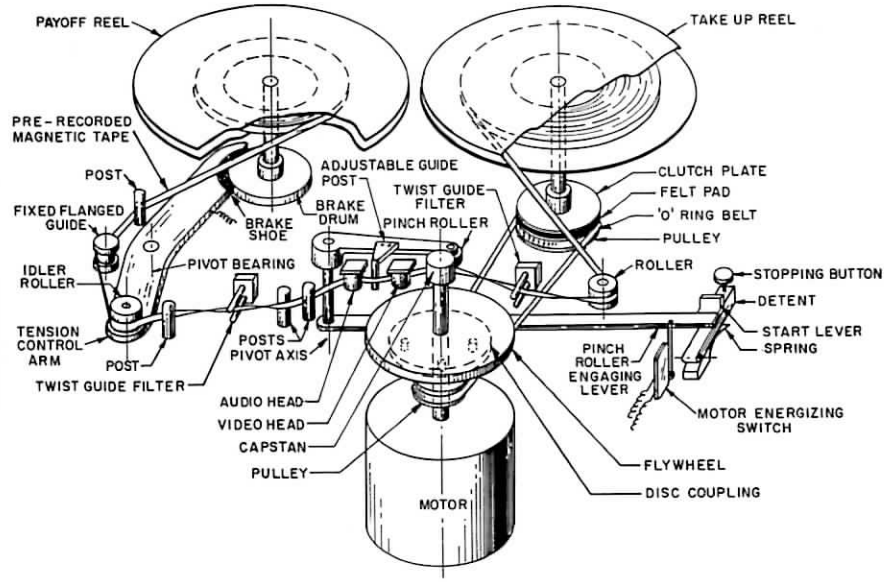


Fig. 7—Tape transport mechanism.

driven through a flexible disk-type coupling by the motor which has a speed of 3,600 rpm (or 60 rps) which coincides with the television field rate. The capstan circumference is made 2 inches in order to move the recorded tape past the magnetic pickup heads at 120 ips. The takeup reel is driven by a neoprene *O*-ring belt from a pulley on the motor shaft to a pulley on a spring loaded felt pad slip clutch mounted on the reel spindle.

The belt offers sufficient isolation so that reel vibrations are not reflected back to the capstan. The pulley ratios are such that the takeup reel tries to pull the tape slightly faster than the capstan delivers it. Thus, the clutch slips slightly at the start and this slip increases as the tape builds up and the rotational velocity of the take up reel decreases.

The guiding arrangement consists of twisting the tape 90° between pairs of guide posts set parallel to the tape deck as shown in Fig. 7. These posts guide the tape, at a fixed distance from the deck, and over the reproducing heads. The compliant nature of the twisted tape also acts as a mechanical filter which tends to absorb high-frequency tension variations.

To maintain a constant tension on the tape as it passes over the reproducing heads, a mechanical brake and feedback control unit operates to place a variable torque on the payoff reel. This is accomplished by the brake drum, the brake shoe assembly, and the tape loop around the idler roller on the tension control arm.

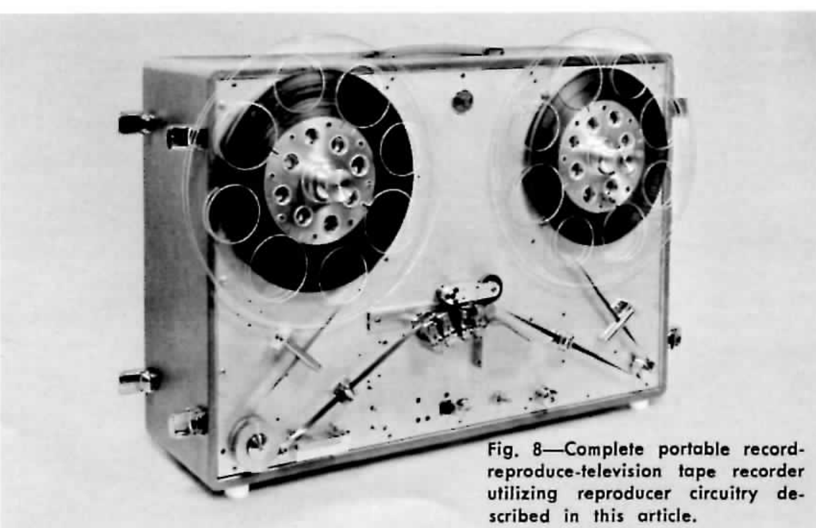


Fig. 8—Complete portable record-reproduce-television tape recorder utilizing reproducer circuitry described in this article.

The operation is as follows: if the tape tension tries to increase, the tape loop shortens thereby moving the control arm in a manner such as to reduce the brake action of the payoff reel.

In order to drive the tape, a rubber pinch roller, mounted on a lever arm, presses the tape against the capstan. The pinch roller is moved to the drive position by sliding the start lever which is manually operated and held in place by a detent. The lever also actuates a microswitch which starts the drive motor. To stop the tape, during or at the end of a run, a pushbutton is depressed which unlocks the detent, releases the lever and removes the power from the motor.

CONCLUSIONS

The objective of this development was to show that the elements for a home type video tape unit are now available. It remains to be seen if the ideas and techniques incorporated in this unit are adaptable for a mass item commercial market. Fig. 8 shows the most recent development in the form of a complete, portable recording and reproducing system. The reproducing circuitry for this unit is identical to that described above for the portable reproducer.

ACKNOWLEDGEMENTS

It should be appreciated that the developments reported here represent some results of a research and development program in magnetic recording which was initiated at the RCA Laboratories a number of years ago, and that the work is, therefore, dependent on the contributions made in various ways and at various times by our associates in this endeavor. We also gratefully acknowledge the continuing interest and support of Dr. Harry F. Olson, Director of the Acoustical and Electromechanical Research Laboratory of the RCA Laboratories.

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