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Sputnik's Doppler Shift Measured and Recorded with -*hp*- Counter and Digital Recorder

The curve reproduced in Fig. 1 is a high-resolution frequency record made of the 40-megacycle transmission from the Russian earth satellite as it passed over the western United States on Wednesday, October 10. The record was made by the engineering staff of the Stanford Research

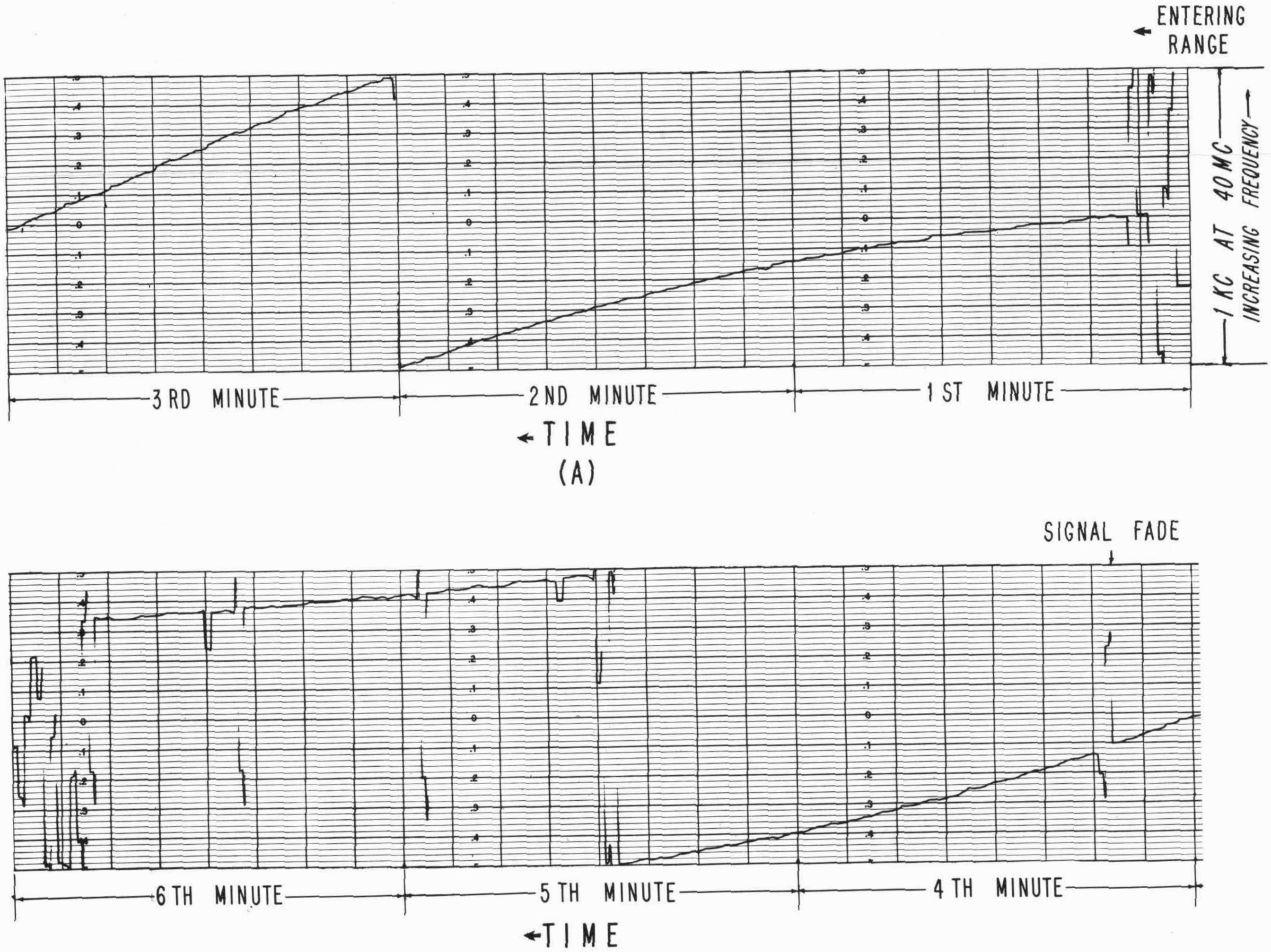

Fig. 1. *Record of doppler shift in 40-megacycle transmission from Russian earth satellite made by Stanford Research Institute, Menlo Park, California.*

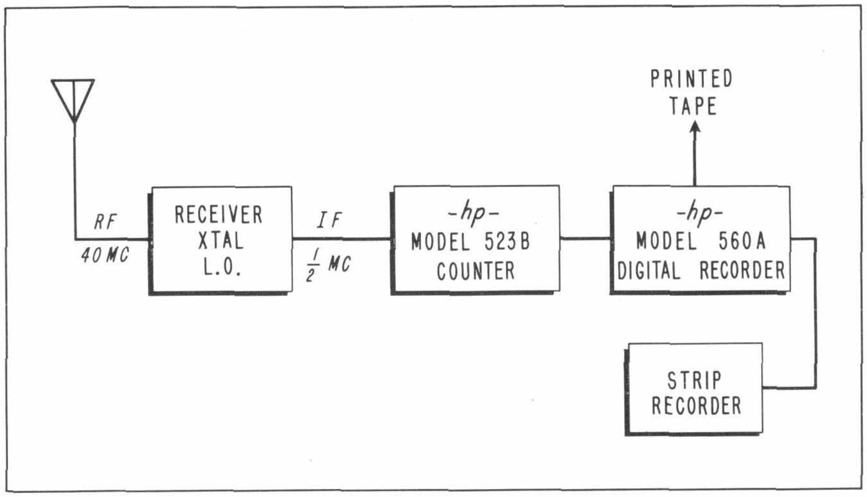

Fig. 2. *Equipment arrangement used to make record in Fig. 1.*

Institute, Menlo Park, Calif., under the direction of Dr. Allen Peterson, who assembled the system described below and other equipment and established an extensive tracking program shortly after first announcement of the satellite launching.

The record covers a period of some six minutes, during which time the signal happened to be "on" continuously, rather than being keyed. The time scale begins at the right side of the record. Irregular initial readings were caused by low signal strength as the satellite first came into range. The recorded change in frequency after the signal level increased above the noise level is the doppler shift in the received signal. The detailed knowledge of this shift provided by the counter-recorder system enables information to be calculated about the minimum slant range of the satellite with respect to the receiving point as well as about the velocity. At about 3.2 minutes, the signal faded momentarily. After about 4½ minutes occasional fades occurred as the signal level decreased with increasing range. At about 5½ minutes the signal was quite noisy and was lost shortly thereafter as the satellite passed from range.

The measurement was made with the equipment arrangement shown in Fig. 2. The r-f signal was applied to a receiver with a crystal-controlled local oscillator. The i-f output of the receiver at about 0.5 megacycles was applied to an -hp- Model 523B 1 megacycle frequency counter which in turn operated an -hp- Model 560A Digital Recorder (see *Hewlett-Packard Journal,* Vol. 8, No. 7, March 1957). This instrument both prints counter readings in digital form on paper tape at high speed and provides an analog output for operating a recorder. Although a 1-second gate would give 10 times higher resolution if the signal could be relied upon in advance to be continuous, the counter was operated at a 0.1-second gate in the record of Fig. 1 to insure that readings would be obtained during whatever times the signal were on in the event the signal became keyed or intermittent. The digital recorder was operated so that its analog output was proportional to the final two digits of the measured frequency. The full-scale value of the record is thus equal to 100 cycles/0.1 second or 1 kc. The resolution of the record then becomes about 10 cycles (½ of a minor chart division) in 40 megacycles or 0.25 part per million.

The record is actually continuous despite the steps that occur when end of scale is reached. These steps are automatically provided by the Model 560A so that the record will always be on scale even though the curve exceeds full-scale value.

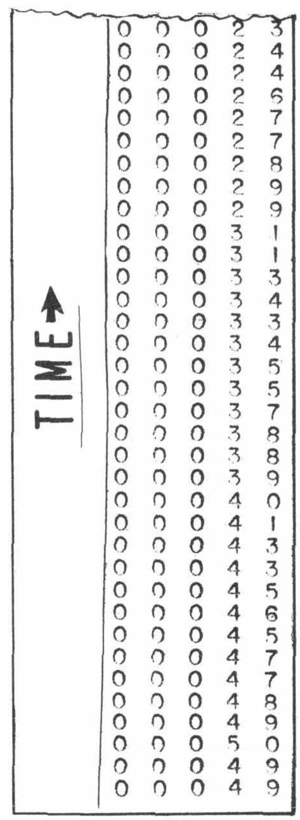

Fig. 3. *Portion of printed tape similar to that provided by -hp- Model 560A during measurement of satellite transmission.*

A printed digital record similar to that shown in Fig. 3 was also provided by the Model 560A for detailed analysis.

Appreciation is expressed to Dr. Peterson and the Stanford Research Institute for permission to reproduce the record shown in Fig. 1.