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THE U.S. ARMY SEQUENTIAL COLLATION OF RANGE GEODETIC SATELLITE SYSTEM

Technical paper sent by the Government of the United States of America

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THE U. S. ARMY SEQUENTIAL COLLATION OF RANGE GEODETIC SATELLITE SYSTEM

A. GENERAL

The Sequential Collation of Range System (SECOR) was developed by the United States Army Corps of Engineers as an all-weather, mobile geodetic tool designed to provide ranging data through phase comparison, to determine the geodetic position of ground points located up to 1500 miles from known geodetic positions. The SECOR system is being used to accomplish intercontinental, interdatum and inter-island geodetic ties utilizing a satellite-borne transponder and four ground stations.

B. GROUND STATIONS

1. Description: Figure 1 is a picture of a SECOR Ground Station. The SECOR ground stations are part of the Geodetic SECOR system used to establish geodetic positions. A station consists of an RF shelter, data shelter, storage shelter, and support equipment which includes generators, air conditioners, ranging antenna, communications antenna, single side band communication equipment and GOAT transporter. Each shelter weighs approximately 3800 pounds and has 6½' x 6½' x 13' dimensions. The RF shelter contains frequency synthesizer, servos, processor, tuning and sequencing control and recorder. The storage shelter contains ground communications and test equipment and working space. A complete ground station with all support equipment weighs approximately 35,000 pounds. This overall weight is being reduced considerably by repackaging.

2. Principles of Operation: Distance measurements are made to a satellite-borne transponder by determining the phase shift of a series of modulated signals transmitted by the ground station. A RF signal is transmitted by the ground station to the transponder where phase information is demodulated and retransmitted to the ground station on two off-set carrier frequencies. The shift of phase between the outgoing and returned signals is measured by a servo mechanism and range measurements are recorded on magnetic tape. By measuring the phase delay on several related modulation frequencies and a pulse, unambiguous measurements are obtained.

Inospheric correction data is obtained from the two frequencies returned by the satellite.

C. TRANSPONDER

Figure 2 is the picture of a SECOR Transponder, the spaceborne portion of the Geodetic SECOR system. It may be mounted in its own separable satellite or installed as an integral part of a larger satellite.

1. Description: The SECOR Transponder, as shown, weighs 8 pounds and has no dimension over 6" in length. It consists of a closed loop transponder and power supply. The transponder sub-assembly consists of a receiver, phase modulation detector, ranging signal amplifier, phase modulator, high frequency transmitter and select call circuitry. The power supply sub-assembly converts the satellite battery voltage into voltages required by the transponder.

2. Principles of Operation: In operation the transponder remains in a standby condition until activated by a select call signal generated at a ground station. Upon activation, the transponder receives and detects four ranging frequencies and a master station command tone that have been phase modulated on the carrier frequency. The receiver ranging frequencies are then remodulated on two offset carrier frequencies and retransmitted without a phase delay to the ground station. This sequence is repeated as one complete cycle from four ground stations every 50 milliseconds. It is in this manner the transponder receives and retransmits the ranging phase information required to make range measurements from the ground to the satellite.

D. SATELLITE

1. Description: Plate 3 is a picture of a SECOR Type II Satellite. The SECOR Type II Satellite weighs 40 pounds and has 10" x 13" x 9" dimensions. It contains the SECOR Transponder and its support systems. These systems are:

a. An electrical system consisting of solar cells, nickel cadmium batteries, voltage regulator and connecting wiring.

b. A telemetry system to transmit housekeeping data (i.e., battery temperatures, battery voltage, shell temperature, etc.) from the satellite to monitoring stations.

c. An antenna system consisting of a telemetry dipole and 8 transponder antennas, 4 for each carrier frequency, configured as a turnstile.

2. Principles of Operation: When in orbit, the solar cells convert solar energy to electrical energy to charge the batteries. This stored electrical energy, with voltage regulated, continuously operates the telemetry transmitter and the transponder receiver, and intermittently operates the transponder transmitter when the ground stations are interrogating the transponder.

E. OPERATIONAL MODES

Plate 4A represents the schemes of operation of the SECOR system in its two primary modes, simultaneous and orbital. The simultaneous mode is being used operationally. The orbital mode is still in the test and analyses phase.

1. Simultaneous Mode: Each ground station and the satellite transponder comprise an electronic distance measuring unit. Range measurements (by means of multiple frequency, phase comparison techniques) are made to the satellite in rapid sequence (essentially simultaneous) from each ground station when the satellite is above the radio horizon of the ground stations. Three (3) of the ground stations are located on known geodetic positions with the fourth ground station located where geodetic coordinates are desired. The simultaneous range measurements permit the determination of the desired geodetic coordinates independent of the satellite's orbital parameters.

2. Orbital Mode: If the satellite can be viewed simultaneously only by the three (3) known stations with the unknown station able to view the satellite very shortly before or after on the same pass, the orbital mode can be used. An arc of the satellite orbit will be extrapolated from the ephemeris of the satellite determined by the three (3)

known stations. This permits the determination of the desired geodetic coordinates dependent on the satellite's orbital parameters. Tests are now being conducted on this method.

F. RESULTS

Results of operational measurements show probable errors of as little as ± 3 meters in position.

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SECOR GROUND STATION

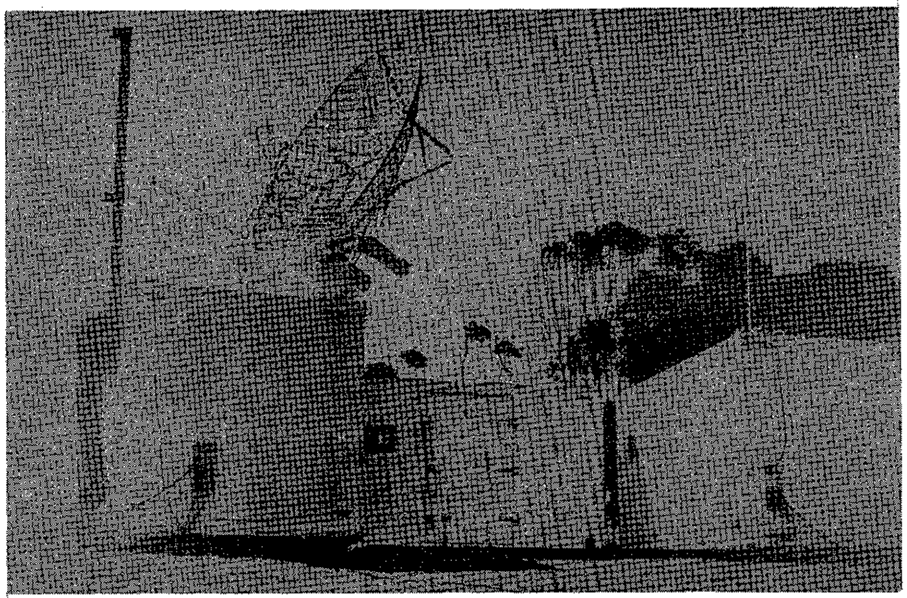

FIGURE 1

SECOR TRANSPONDER

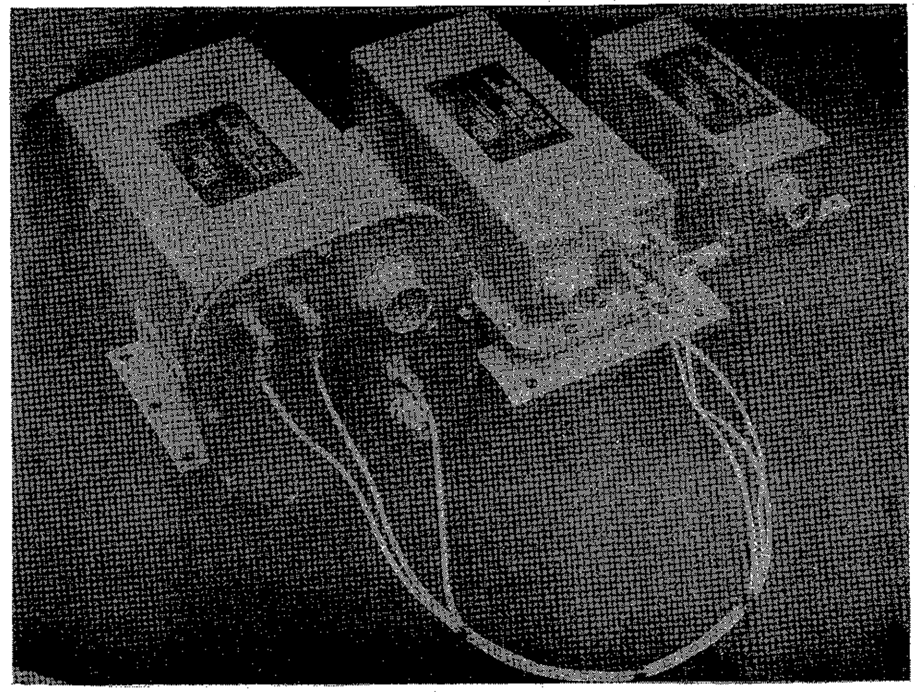

FIGURE 2

SECOR TYPE II SATELLITE

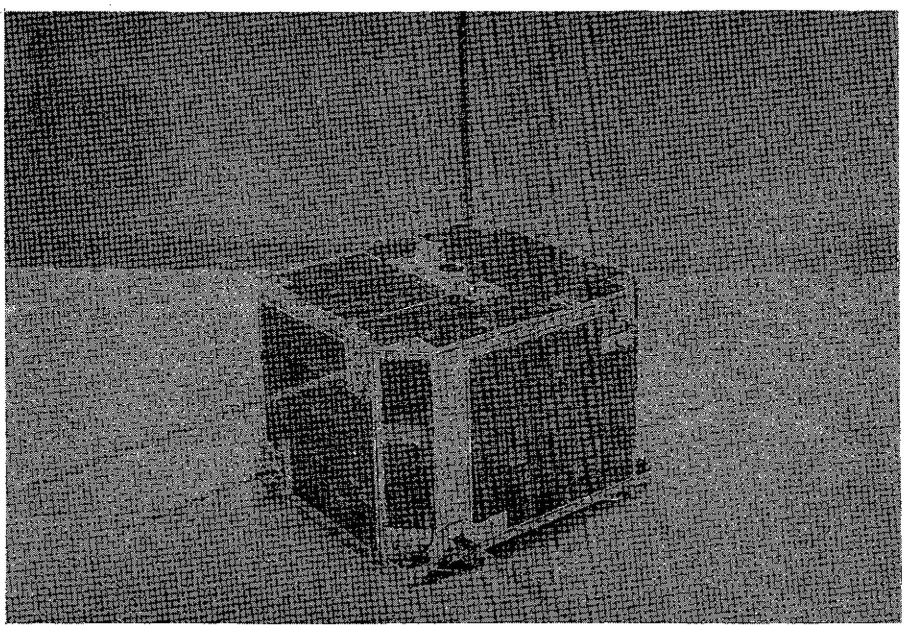

FIGURE 3

SIMULTANEOUS & ORBITAL TRACKING MODES

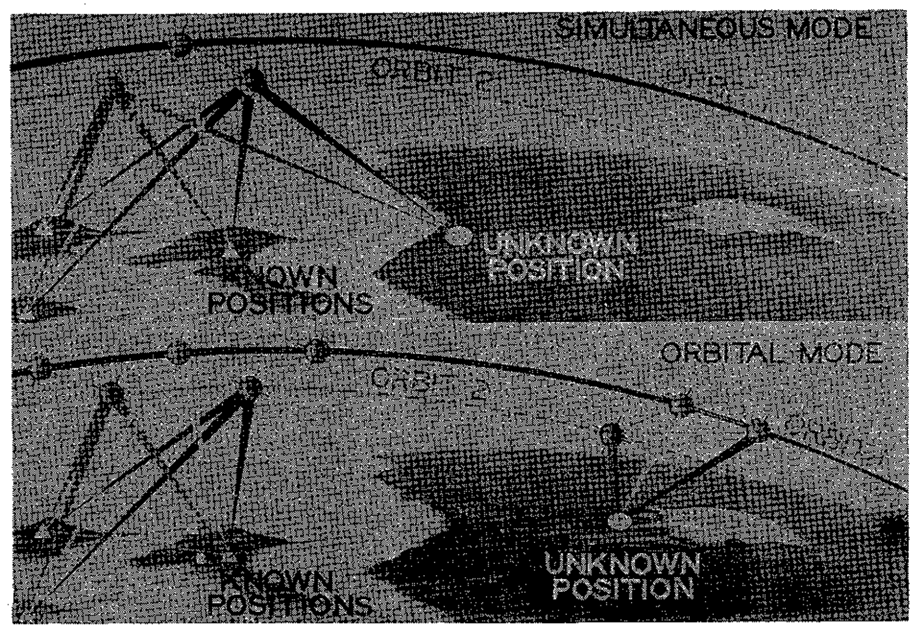

FIGURE 4