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INITIAL PROPOSAL

to

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

for an

ATS TECHNOLOGICAL EXPERIMENT

Submitted for

UNIVERSITY OF WISCONSIN

MADISON, WISCONSIN

by

Professor V. E. Suomi, Department of Meteorology

Professor R. J. Parent, Department of Electrical Engineering

28 September 1964

INITIAL TECHNICAL PROPOSAL FOR A "STORM PATROL" METEOROLOGICAL EXPERIMENT ON AN ATS SPACECRAFT

by

V. E. Suomi and R. J. Parent
University of Wisconsin

I. OBJECT

The object of this experiment is to continuously monitor the weather motions over a large fraction of the earth's surface. Even though near earth weather satellites have provided an impressive array of visual and infrared observations of the earth's weather on a nearly operational basis, the synchronous satellite affords another opportunity to gain a better understanding of the global weather circulation, the key to better weather prediction.

II. DISCUSSION

The view from a near earth satellite is so fleeting that it is not possible to obtain any real measure of the weather motions. For example, in the TIROS series of satellites, the life history of a model storm had to be derived from a number of different storms, at different times, at different places, and in different stages of development.

In the tropics the weather motions have a shorter time scale than the motions at higher latitudes. The tropics, between $\pm 30^{\circ}$ latitude covers half the earth's area which is 80% ocean. Here the surface observations are very sparse and polar orbiting satellites have the greatest gaps in their data.

The tropical region is the "boiler" of the giant atmospheric heat engine. Convective activity plays an all important role in the heat transfer process, yet its short time scale prevents its being observed adequately by near earth satellites.

We propose a simplified version of the "Aeros" satellite which has many of its benefits, yet takes advantage of the simple spin stabilized system already proved in "Syncom". The experiment can also be adapted to a gravity gradient stabilized spacecraft, but loses some of its simplicity in the process.

III. IMPLEMENTATION

This experiment utilizes a spin stabilized spacecraft as designated by F-2 and F-3 of the ATS series. Stated simply the experiment will yield a high resolution "television" picture of the earth's disc.

With a synchronous orbit it is possible to take a "time exposure" of the earth about the subsatellite point. This feature allows a surprisingly simple optical and electronic system to generate a high resolution photograph. A six mile resolution at the subsatellite point appears to be within the state of the art.

Fig. 1 shows the geometry of the experiment. Some of the parameters are tabulated below.

1. Approximate diameter of disc to be scanned is ($\pm$ 50° Latitude) 5300 Na. Mi.

2. Number of scan lines ≅ 1000

3. Resolution at the subsatellite point = 6 Na. Mi.

4. Time to scan disc = 1000 lines/100 RPM = 10 minutes

5. Scan time for earth's disc = 28.92 MS.

6. Time to scan 6 miles at subsatellite point = 29.52 μS

7. Fundamental signal frequency at subsatellite point = 16.9 KC

8. Duty cycle, earth scan to total time = 4.44%

A rough sketch of the basic scanning system is shown in Fig. 2. Operation is as follows: The spacecraft is in the cartwheel made with the spin axis parallel to the earth's axis. In this configuration, the image of the earth formed by the optical system moves rapidly across the image plane. If an aperture is placed in the image plane the light passing through the aperture generates a single line scan across the earth's disc, sun's disc, and possibly the moon's disc if they are included in the field of view. The time to scan the earth's disc is very much longer than for the sun or moon.

If the energy passing through the aperture is enough to generate a signal of high signal-to-noise ratio in the photo-detector (probably a photomultiplier) a video signal of a single line can be generated.

Preliminary calculations indicate that it is quite feasible to generate a video signal with high signal-to-noise ratio when observing bright clouds. The signal-to-noise ratio when observing the clear ocean (albedo approximately 4%) will be less, but should be adequate.

It is necessary to "move" the aperture position in the image plane for the next scan line, the next, and so on. The time for this "motion" is approximately 10 minutes for a 1000 line raster at a spacecraft spin rate of 100 RPM. The weather motion on a 10 minute time scale is essentially zero. Even if it were not, each scan could be considered a "snap shot".

In principal it is possible to mechanically move the aperture across the image plane, or move the image past the aperture (rocking mirror, etc.), normal to the motion of the earth's image in the image plane.

A more satisfactory method of effectively moving the aperture appears to be possible with the image dissector tube, Fig. 3. In this case an electron image is actually scanned past a fixed aperture by means of an electronically controlled scanning field. A scan line across the earth's disc is still provided by spacecraft spin, with the lines now being displaced by electronic displacement of the image perpendicular to the scan lines. Preliminary calculations indicate that a typical image dissector will yield a signal with satisfactory signal-to-noise ratio, but further study is needed in this area.

Still another means of moving the aperture is available. Glass fibre optics can be used to bring a line of apertures (1000 in number) oriented perpendicular to the scan line in the image plane to the image dissector as a "bundle". This bundle can now be scanned electronically in the image dissector by moving the electron image in two directions with two slow scans. The advantage of this arrangement is that only 1000 rather than 1,000,000 elements need be resolved by the image dissector.

IV. SYSTEM

A simple system block diagram is included in Figs. 2 and 3. In addition to the sensor and scanner the system will include electronics for signal conditioning and control of scanning. The telemetry will be included as part of the system or use may be made of the spacecraft telemetry. This can be resolved at a later date.

No data storage is required on board the spacecraft.

V. TELEMETRY

The bandwidth of the telemetry channel is reasonable (fundamental signal frequency at sub satellite point is approximately 17 KC). The form of the signal and its timing and duty cycle suggest an intermittent duty cycle on a transmitter if practical. Since data need by transmitted to earth during only about 5% of a rotation while the optical system is scanning the earth it would be quite feasible to use a directive antenna which is aligned with the optical axis (may best be offset to point at receiving station). The directivity and gain thus obtained should substantially lower transmitter power requirements.

VI. DISPLAY

The image of the earth's disc which is dissected aboard the spacecraft must be reassembled on the ground. Some form of synchronization will be needed and a display system must be provided. There are several methods for doing this, none of which appear to present any serious problems. No specific method is proposed at this time.

VII. PREVIOUS EXPERIENCE

The University of Wisconsin has participated in several meteorological experiments (Vanguard, Explorer VII, TIROS III, IV and VII) and is preparing an experiment for the TOS series. A competent group has been built up under the direction of Professors V. E. Suomi and R. J. Parent. Much of the flight hardware used to date has been prepared at the University.

VIII. SUMMARY

In this rather hastily prepared proposal we have outlined a simple method of exploiting the spin stabilized synchronous satellite for obtaining a look at the earth's cloud patterns over a substantial portion of the earth.

It appears possible to provide a high resolution picture of the daytime illuminated portion of the earth's disc. This would represent an impressive step forward in the means for obtaining a picture and understanding of how the weather changes on a global scale. One can obtain a complete view of the weather every ten minutes - a "movie" of the weather's motion. Less frequent observation would provide "time-lapse" pictures.

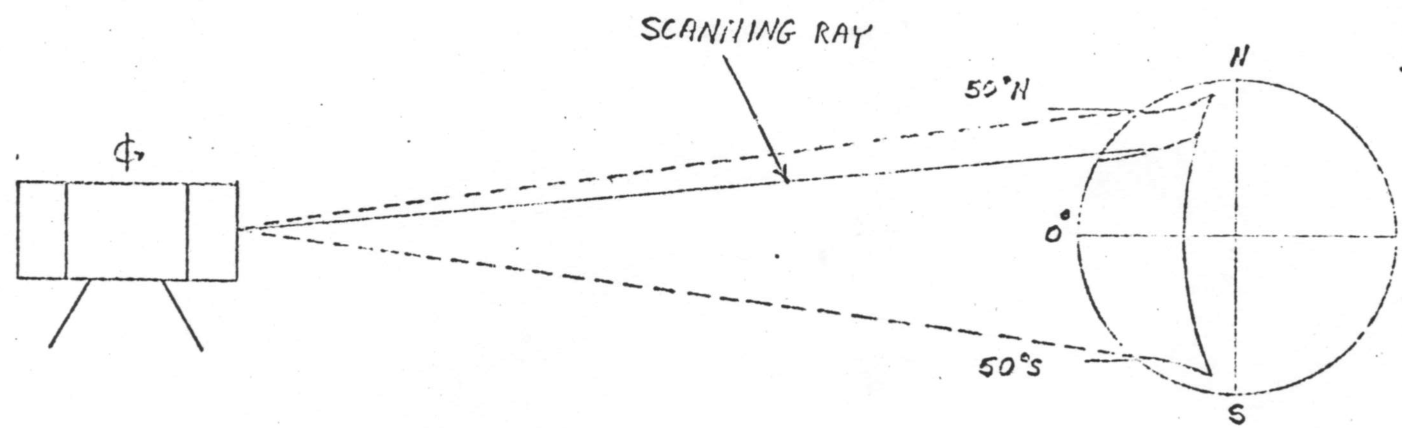

FIGURE 1 - SCANNING GEOMETRY

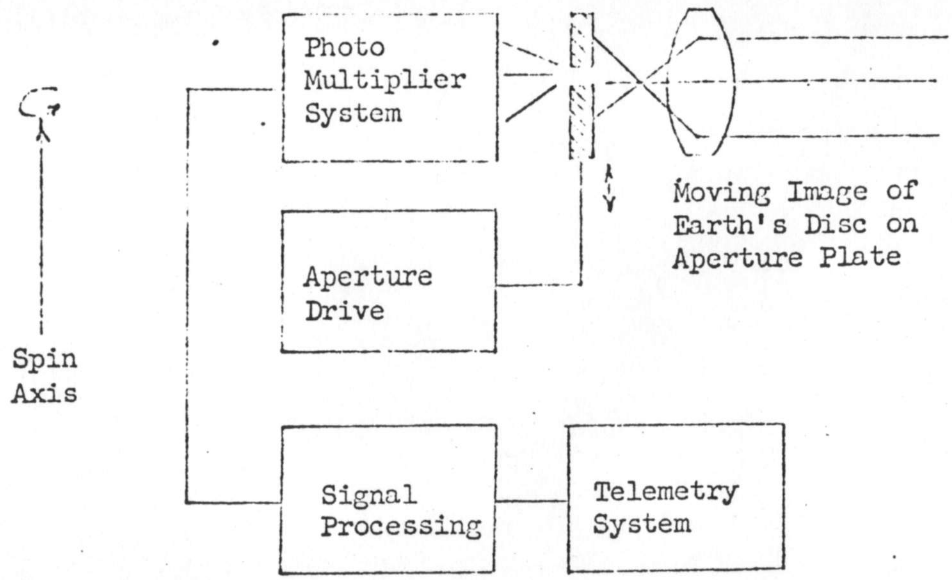
Photo
Multiplier
System
Aperture
Drive
Spin
Axis
Moving Image of
Earth's Disc on
Aperture Plate
Signal
Processing
Telemetry
System

Fig. 2

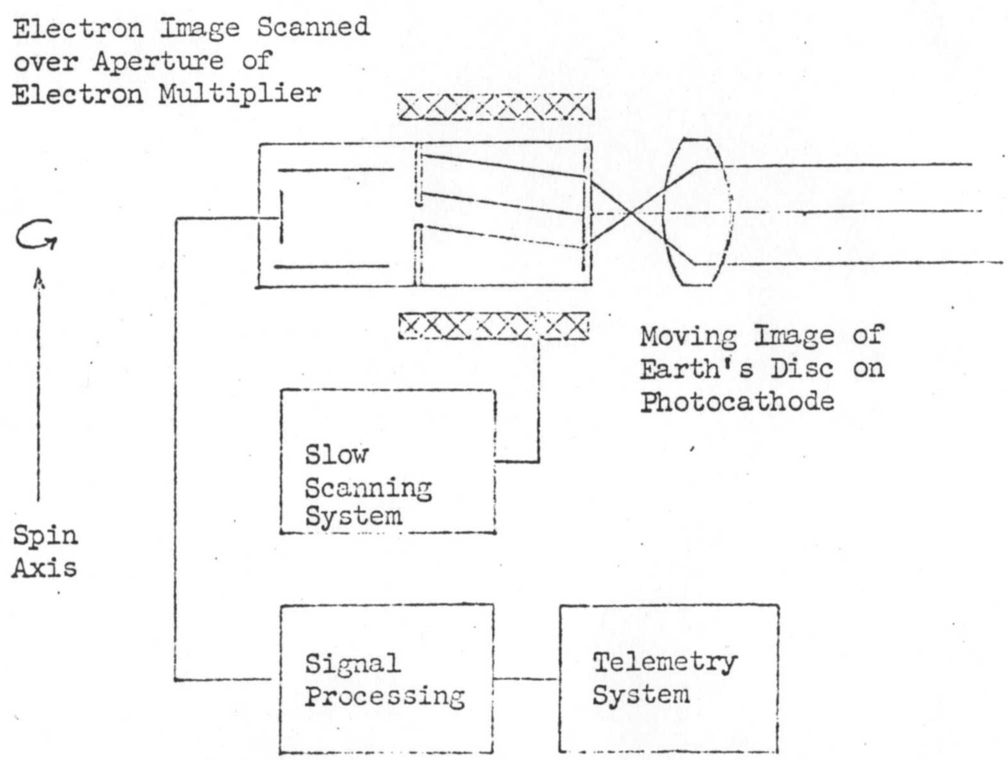
Electron Image Scanned
over Aperture of
Electron Multiplier
Moving Image of
Earth's Disc on
Photocathode
Slow
Scanning
System
Spin
Axis
Signal
Processing
Telemetry
System

Fig. 3