QUARTERLY REPORT
For
Contract No.: NAS5-11542

(1 September, 1970 - 31 December, 1970)

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For

Goddard Space Flight Center
Greenbelt, Maryland

Contracting Officer: Mr. Newchy Mignone
Technical Minitor : Mr. William Bandeen

SUMMARY

This report on contract NAS5-11542 covers the period September 1 - December 31, 1970. Major reporting areas include:

1. Miniaturizing the balloon borne radio altimeter,
2. Application of ATS data:
    a. correlating the cloud brightness with meso to sub synoptic scale rainfall intensity and amount in the mid-latitude as well as in the tropical disturbance regime
    b. on the feasibility of an inexpensive real-time communication of ATS enhanced pictures to data sparse remote places in the tropics.
3. Some applications of satellite data on the study of atmospheric dynamics.
4. A feasibility study on the ATS time domain data access systems.

CONTENTS

I. INTRODUCTION AND DISCUSSION

A. Radio Altimetry

During the period September 1 - December 31, 1970 most of the activity in this portion of the effort for contract NAS5-11542 was directed toward miniaturizing the balloon borne radio altimeter. The progress in this area can be easily understood by comparing the enclosed figures 1 and 2. Primary differences are listed below:

	Original Version	New Version
1. Weight of electronic	130 gms	40 gms
2. Power	1 watt plus filament of RF tube	1 watt transistor introduced in the RF stage
3. Electronic circuitry	hand wiring	printed circuit
4. RF circuit	RF circuit had coils and adjustable capacitances	printed circuit as main RF component

Work is continuing to make all inductors by using printed circuit techniques. Preliminary results look very promising.

In addition we have: (a) Modified the altimeter to fit ghost balloons, (b) Delivered one unit to Dr. Lally (NCAR). Four more will be sent next quarter. (c) Abandoned 1680 RF circuit as requested by IRLS program, (c) Completed studies of shape of return pulse. Modifications to remove ambiquity are being studied presently. A report on the shape-of-return-pulse study will be communicated separately.

Three papers on meteorological applications of the balloon-borne radio altimeter will appear in the NASA Annual Report 1969 - 1970, scheduled for publication this summer.

SSEC Investigating Team

Development


Dr. Nadav Levanon


Charles Blair

Principal Investigators


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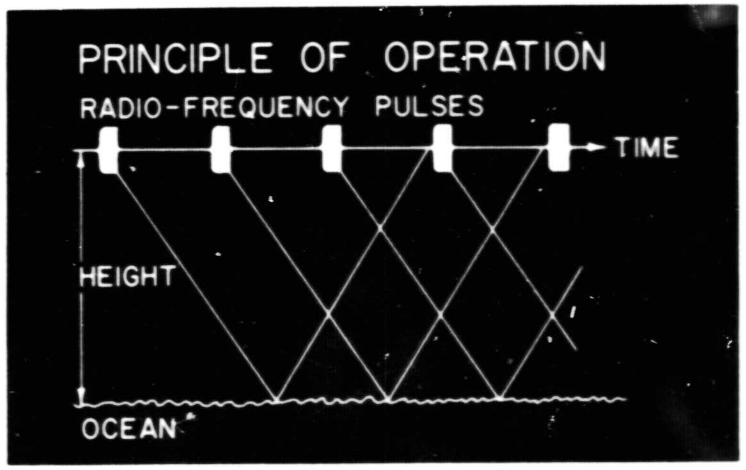
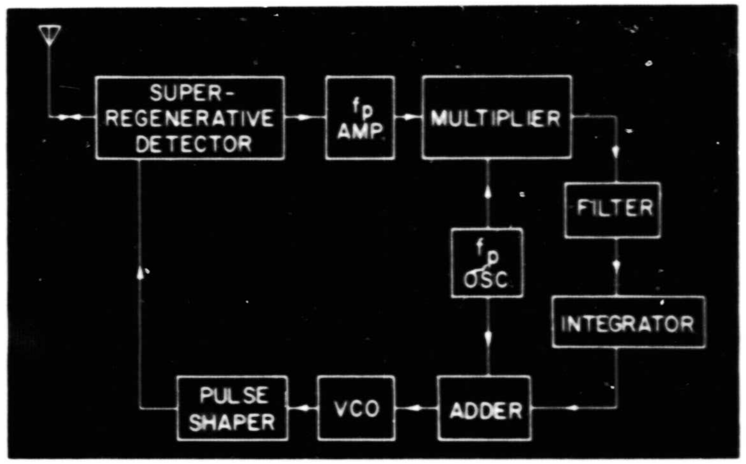
Radioaltimeter Development

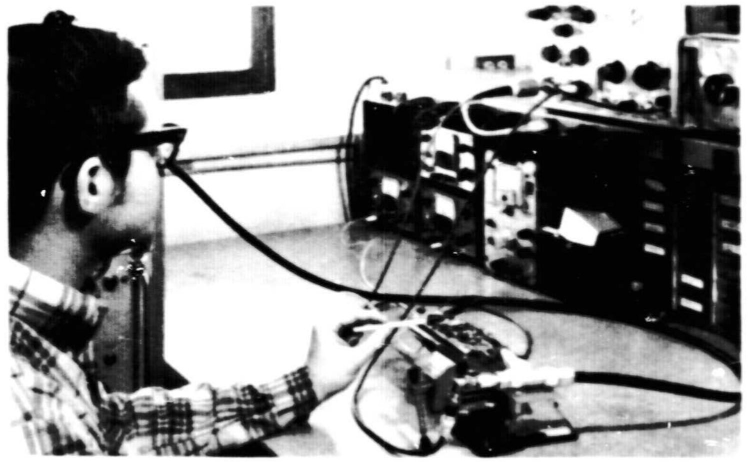
Since the speed at which radio waves travel is known very precisely, it is possible to calculate accurate distance measurements from measurements of the time it takes a radio wave to travel a given distance. The radioaltimeter works on this principle. It transmits a radio frequency pulse from a balloon (or satellite) platform downward to the ocean surface where a portion of the pulse is reflected back to a radio receiver on the platform. A number of pulses may be transmitted before the first pulse is received at the platform.



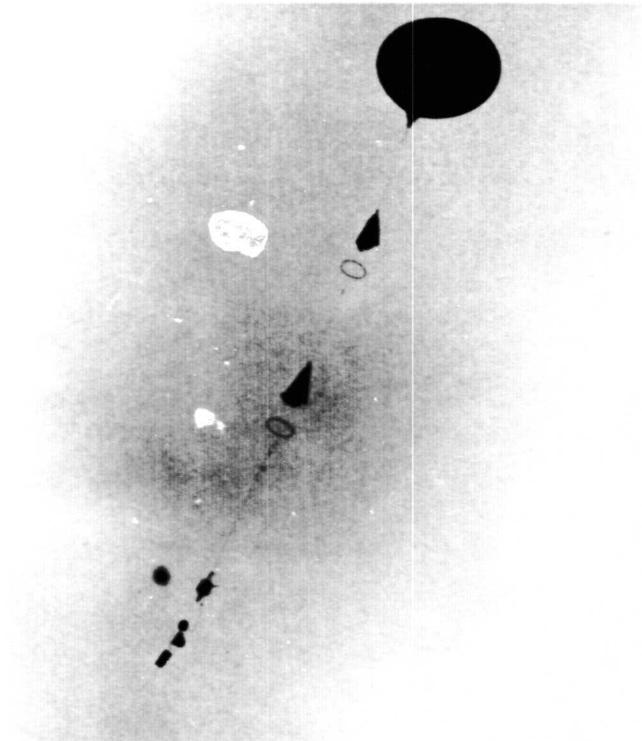
The radioaltimeter is a pulsed radar system which transmits 30,000 pulses per second. The returned signal is averaged for approximately one second for each altitude measurement. A phase-locked loop system is employed in which an error signal locks a VCO to the peak of the returning pulses.



The development work was carried out at the Space Science and Engineering Center, The University of Wisconsin. Further development of this instrument is continuing for future satellite applications.

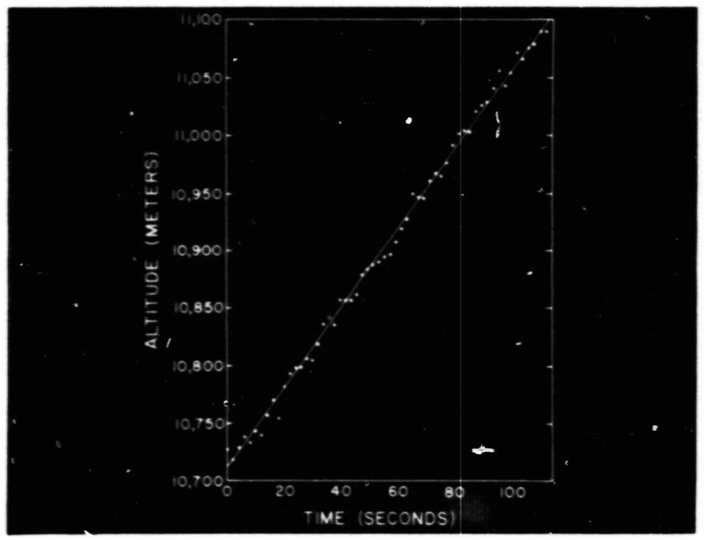


Test Flights

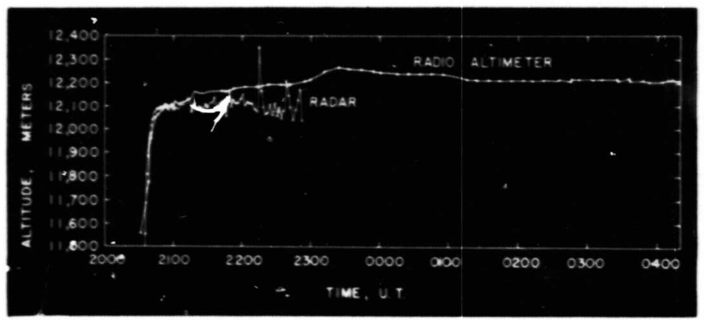


The radioaltimeter has been flight tested on aircraft, radiosonde balloons, and GHOST balloons. The electronics weigh 130 grams and the 2-element Yogi antenna for radiosonde use weighs 40 grams. The electronics are battery powered. The altimeter pulse repetition rate has been used to modulate the radiosonde 1680 MHz signal without disturbing normal radiosonde operation. The power consumption is 1 watt.

Flight tests by radiosonde were carried out at Sturgeon Bay, Wisconsin, in March, 1969. Data were obtained on a trajectory across Lake Michigan. The high precision of the radioaltimeter is seen in data obtained at an altitude of 11,000 meters which show that the height is accurate to within 7 meters.

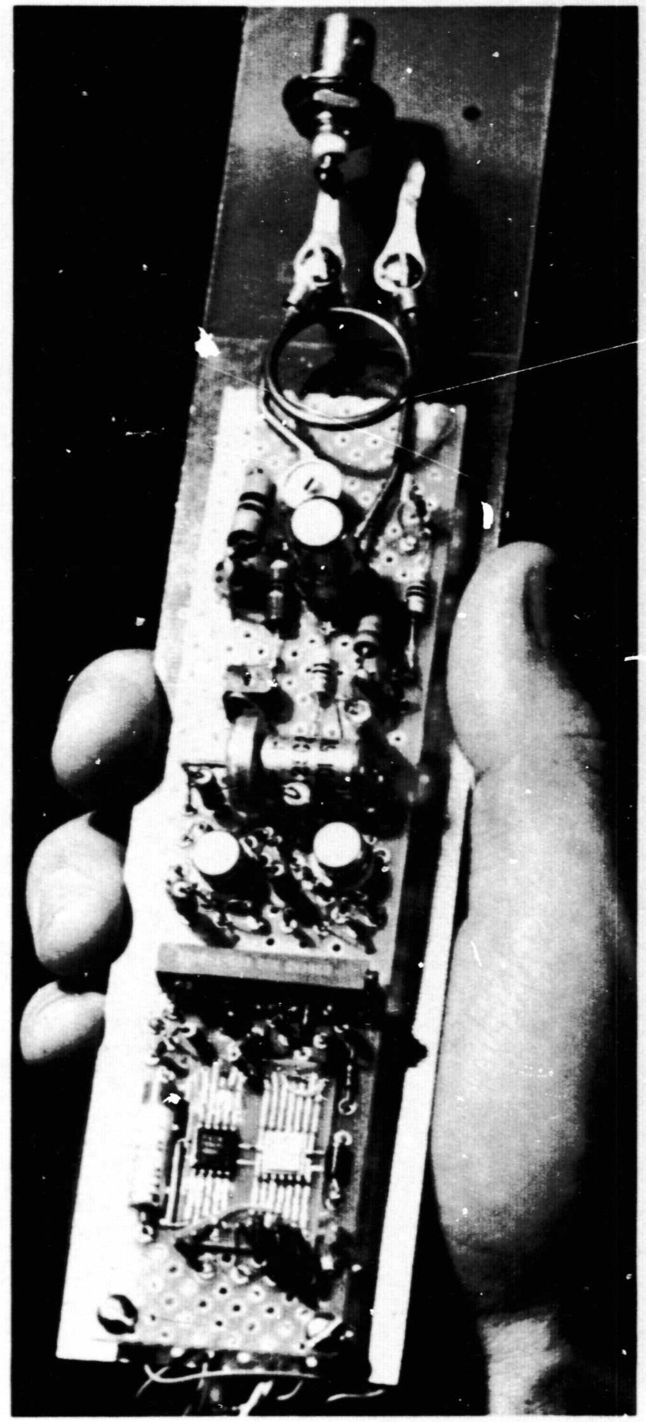


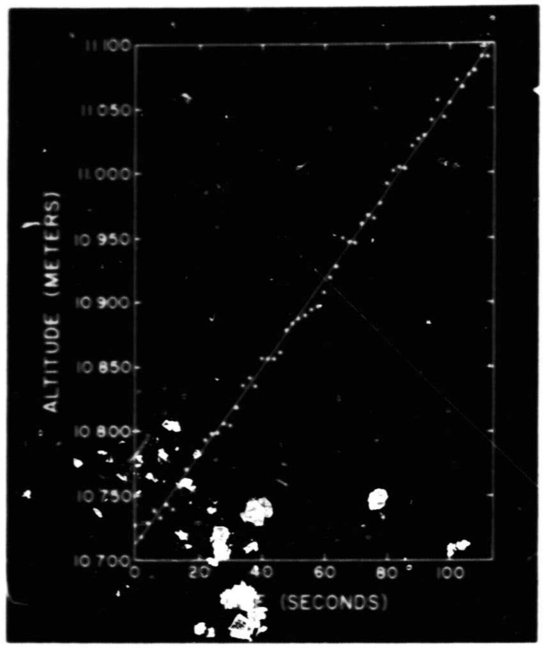
Two test flights were obtained on GHOST balloon platforms which were launched from Christchurch, New Zealand, in the fall of 1969. These balloons are designed to rise to a specified altitude and float there for extended periods. The radioaltimeter height determination was found to be more accurate than the ground radar which tracked the balloon.

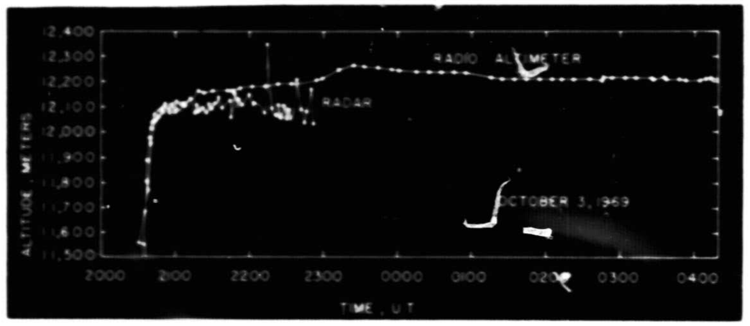


UW–NASA Research

Balloon-Borne Radioaltimeter





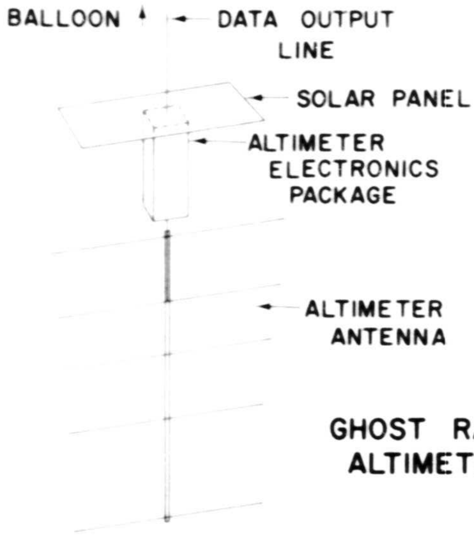


Specifications and Test Flights

The radioaltimeter has been flight tested on aircraft, radiosonde balloons, and GHOST balloons. The electronics require one watt of power (± 12v., ± 10%) from batteries or a solar panel. The radio frequency of operation is 403 MHz. The altimeter pulse repetition rate has been used to modulate a standard radiosonde signal at 1680 MHz without disturbing normal radiosonde operation.

Flight tests using standard weather balloons and radiosondes were carried out at Sturgeon Bay, Wisconsin, in March, 1969. Data for two flights were obtained on a trajectory across Lake Michigan. The rms error of the radioaltimeter at an altitude of 11,000 meters was within 7 meters.

Two test flights were obtained on GHOST balloon platforms launched from Christchurch, New Zealand, in the fall of 1969. These balloons are designed to rise to a specified altitude and float there for extended periods. The radioaltimeter height determination was found to be more accurate than the ground radar which tracked the balloon.



GHOST RADIO ALTIMETER

Early altimeter models used a vacuum tube transmitter and hand-wired electronics. In 1970 the altimeter was redesigned using the latest advances in solid-state circuitry and printed circuit layout. Presently the electronics weigh 40 grams and the 5-element Yagi antenna for high-altitude use weighs 40 grams. The minimum range of this altimeter is 500 meters and the maximum range is 35,000 meters over water.

A test flight of the new altimeter model was begun on a GHOST balloon platform launched from Christchurch, New Zealand, in October 1970. Two days of very good data have been obtained. Further tests are being planned for January, 1971.

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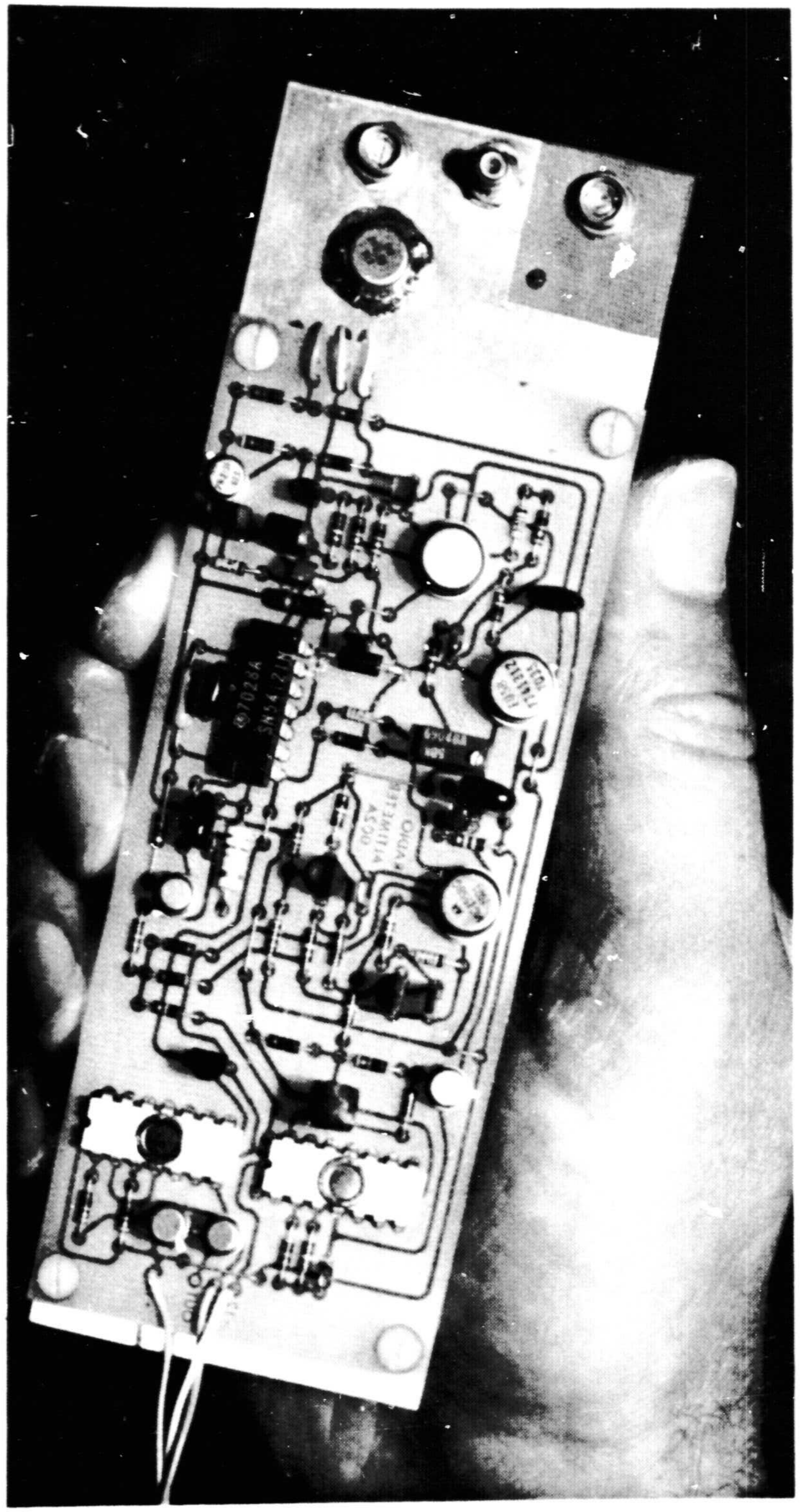
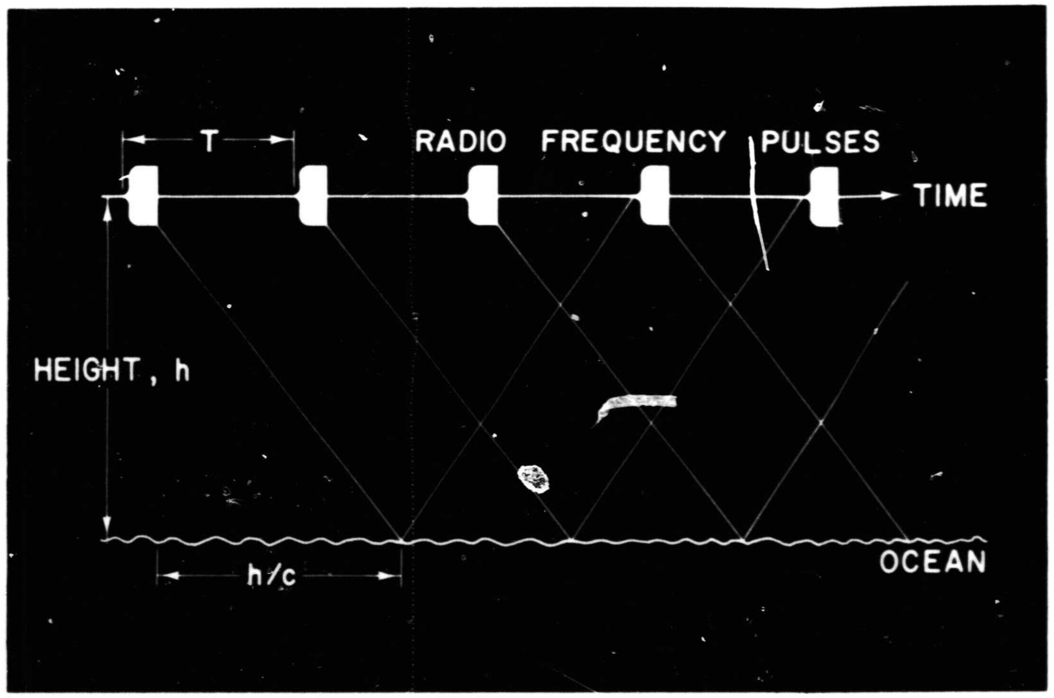
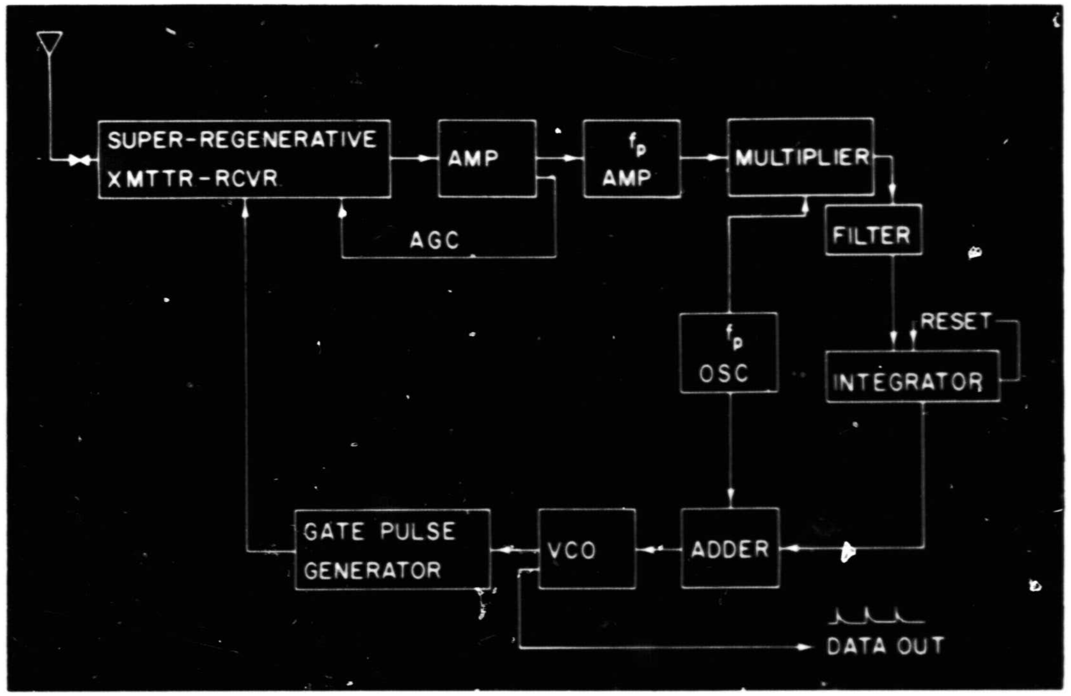


Balloon-Borne Radioaltimeter

UW-NASA Research





Principle of Operation

Since the speed at which radio waves travel is known very precisely, it is possible to calculate accurate distance measurements from measurements of the time it takes a radio wave to travel a given distance. The radioaltimeter works on this principle. It transmits a radio frequency pulse from a balloon platform downward to the surface where a portion of the pulse is reflected back to a radio receiver on the platform. A number of pulses may be transmitted before the first pulse is received at the platform.

The radioaltimeter is a pulsed radar system in which the elapsed time period between transmitted pulses is a measure of altitude. A single superregenerative transistor stage serves as both the transmitter and the receiver. This stage is an oscillatory circuit held from oscillating by a negative quench voltage. When a positive gating pulse is applied, oscillations are allowed to grow. A short burst of radio frequency (RF) energy results whose envelope area depends on the RF input signal present when the gate pulse is applied. The frequency of oscillation is carefully controlled in these units by coupling to strip lines etched on a teflon circuit board.

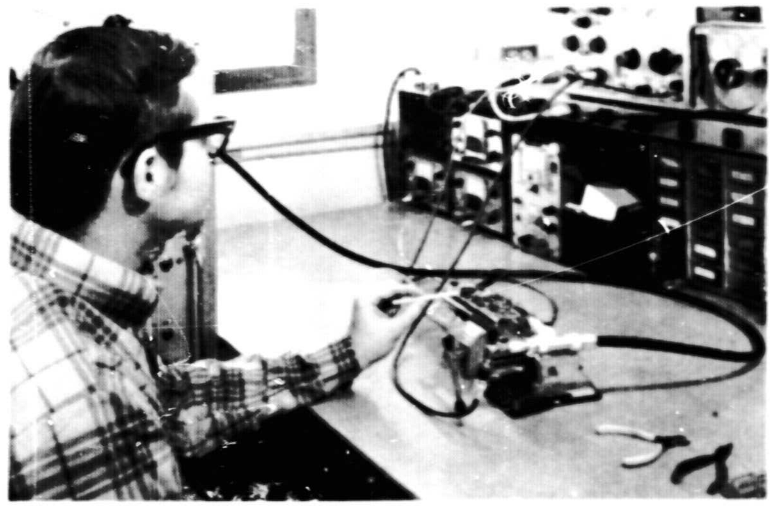
As a pulse period approaches the delay time of a previously transmitted pulse returning from the ground, the envelope of the superregenerative circuit output reaches a peak. If the RF superregenerative stage is gated on a little too early or a little too late, the envelope area decreases. The correct operating repetition period T is expressed by the equation: $nT = \frac{2h}{c} + \tau$, where n is an integer (usually known), h is the altitude, c is the velocity of light, and τ is the (fixed) delay within the altimeter itself.

The remainder of the altimeter circuitry is needed to generate an error signal, both in magnitude and sense, to filter it, and to adjust the repetition rate accordingly to keep this error small. A modified phase-locked loop system is employed in which the error signal locks the repetition rate of the pulses determined by the voltage-controlled oscillator (VCO) to the repetition rate of the returned RF pulses. A square-wave voltage at a preset frequency, f_p, is added to the derived error signal to vary the repetition rate about the correct value. Variations at this frequency in the superregenerative detector output are amplified and then multiplied by the square-wave voltage to derive a slowly varying error voltage for controlling the repetition rate. An integrator is used to average the error voltage. Typical values are 200 Hz for f_p, a one-second time constant in the integrator, and a pulse repetition frequency of approximately 30,000 pulses per second.

Radioaltimeter Development

The development work of the radioaltimeter was carried out at the Space Science and Engineering Center, The University of Wisconsin. Analysis and design work was done by students and faculty of the Department of Electrical Engineering, UW. Improvements and modifications of this instrument are continuing for future applications and experiments.

This research is being sponsored by the Laboratory for Atmospheric and Biological Sciences, Goddard Flight Center, NASA, under Contract NAS 5-11542.



B. Application of ATS Data

(i) Studies of several cases are in progress to relate the cloud brightness parameter, as viewed from the ATS-III, to the rainfall amount and intensity. Preliminary analyses indicate a good correspondence. These investigations, are vital for now-casting in the future. In order to establish greater confidence in this possibility of rain we need better sampling in space and time of rainfall amount and intensity, and ATS-III data in the early evening hours when most of the storms occur over land. For a pilot study we intend to use data from the Illinois State water survey rain gauge network and the Oklahoma severe storm network.

Knowledge gained from these investigations will be useful for heavy precipitation warning and flood forecasting in remote, data sparse regions, especially in the tropics. To accomplish this objective one needs to develop a cheap communication system for a real-time exchange of such important information. A feasibility study on the real-time exchange of graphic data, such as a portion of the ATS-III enhanced cloud photographs indicating the location of cloud disturbances, and rainfall areas, between North and South America by means of amateur radio equipment and Telecopier has been completed. A report on this study will be included in the forthcoming NASA Annual Report, 1969 - 1970.

It appears that such a communication can be easily achieved during day-time when the amateur radio frequency band is generally free of traffic.

(ii) The scientific paper entitled "Time Variation of Tropical Energetics as Viewed from Geostationary Altitude" has been revised. It will appear in the March, 1971 issue of the J.A.S. It has been shown in this paper that the convective heat fluxes in the tropics not only pulsate with a periodicity of five days but are also tied to a westward propagating mixed-Rossby gravity type wave disturbance. This is an extension of research presented in Sikdar's thesis (published in the annual report August, 1970).

C. Satellite Observations Related to Planetary Waves

A study on the use of satellite data for understanding the atmospheric circulation in the tropics has been completed. Time series of daily areal cloud coverage over the central Pacific have been employed to determine the statistics (e.g. wave length, phase speed etc.) of cloud disturbances. Results of this study will appear in the J.A.S. in a paper entitled "Time-Spectral Characteristics of Large Scale Cloud Systems in the Tropical Pacific".

The basic difference between this study and the analysis discussed in the previous section is in the data source. The previous paper presented average daily convective cloud growth rates obtained from a number of time-lapse satellite pictures, whereas the data source for this section is once-a-day pictures.

D. Research on Data Retrieval, Processing and Storage

In this part of the research program a feasibility study is close to completion. Figure 3 presents a flow chart showing two data processing alternatives both of which appear to be feasible, but which may differ vastly in application. For example; five sources of input are possible to the time domain system. Photographs having good geometric fidelity can be used for qualitative phenomenological studies and wind observations. A Wild STK-1 (a stereo comparator) is capable of measuring displacement to an accuracy of 2 microns. With a digital readout, the STK-1 can be hooked to a typewriter, card punch or computer. Automation of x, y displacement measurement is planned as shown in the flow chart.

SSEC TIME DOMAIN DATA ACCESS FACILITY

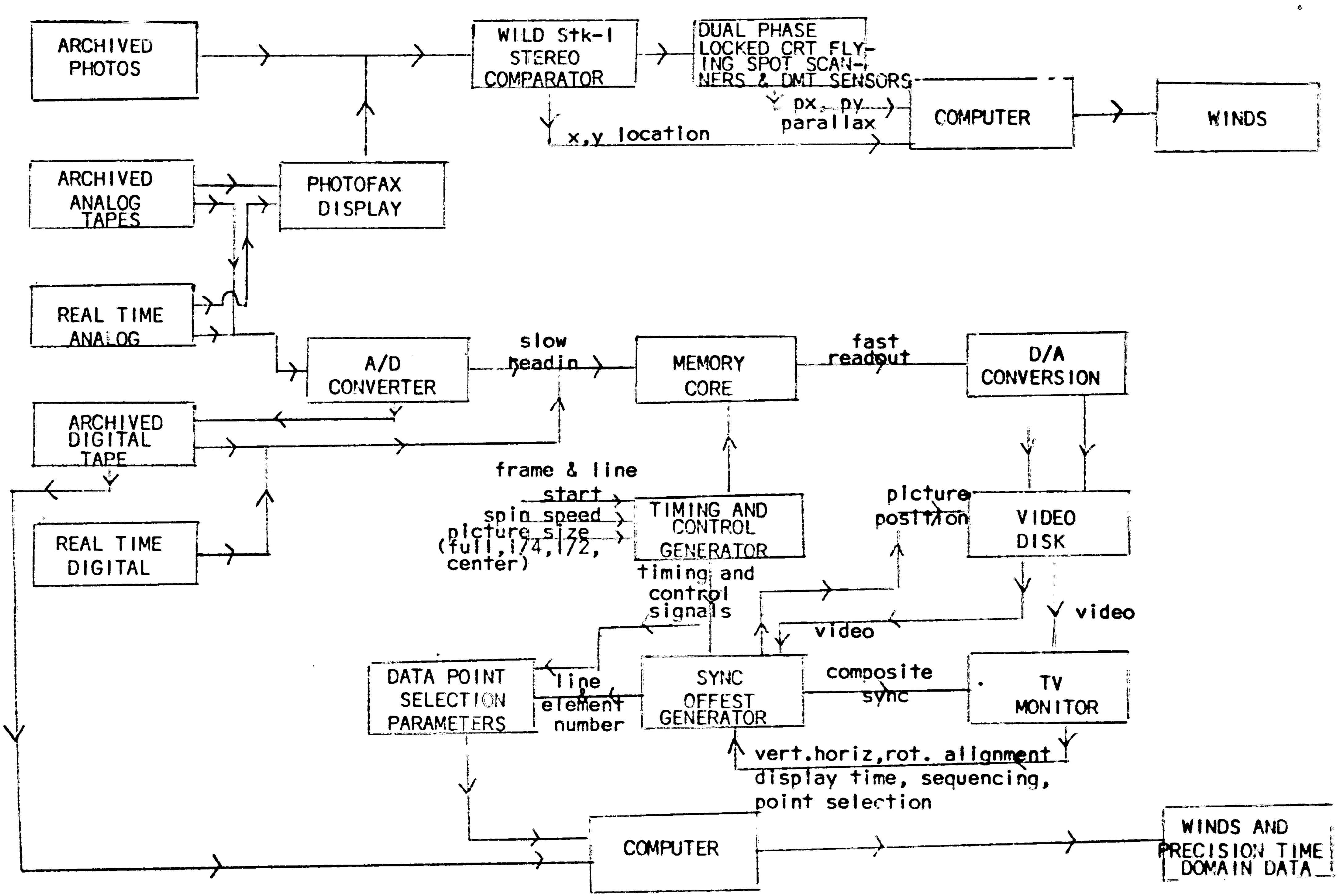


Fig 3

The second processing scheme under consideration utilizes a video disk and synchronization offset to align ATS pictures approximat[illegible] at somewhat reduced resolution. These images, which can be presented in "movie" fashion, are used to select specific areas in the original high quality digitized data. This process greatly reduces the amount of data processing without destroying its high quality. This date is then auto-correlated in a computer to obtain winds. Flowchart in Figure 3 outlines the various components in this scheme.

All of the computer programs have been written for assembling and processing the data from a sequence of ATS tapes to produce cloud displacement information. Research on improving upon the navigation accuracy and the navigation extrapolation techniques continues with good success. We expect to publish a report on this research by the end of the next quarter.

II. PROGRAM FOR NEXT REPORTING PERIOD

Same case studies on the correlation between the average cloud brightness and rainfall intensity both for the synoptic and subsynoptic scale convective systems over the U.S.A. will be completed by the end of the next quarter, and also, results on the divergence and vorticity from cloud motions around a cloud cluster, using computer and other techniques, will be documented. Additional results on the determination of wind vectors from ATS time lapse sun-glitter information will be available.