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GROUND OPERATING EQUIPMENT

For the

ORBITING ASTRONOMICAL OBSERVATORY

by

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[redacted] OPERATING EQUIPMENT FOR THE ORBITING ASTRONOMICAL OBSERVATORY

(100 Word Abstract)

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The Orbiting Astronomical Observatory is a precisely stabilized National Aeronautics and Space Administration satellite which is capable of being pointed to an accuracy of seconds of arc and designed for a useful orbiting lifetime in excess of one year. Ground Operating Equipment to be located at NASA minitrack stations is designed to transmit operating commands which have been simulated on a large scale digital computer and to provide an auxiliary real time control mode. Suitable safeguards are incorporated to prevent irreversible commands to be transmitted by the remote control operator. A central control station to be located at Goddard Space Flight Center provides "quick look" capability for evaluating spacecraft status by means of a novel "credit card" type system. The operational philosophy of the proposed design and the unique features are applicable not only to control of the Orbiting Astronomical Observatory, but to other controlled satellites.

GROUND OPERATING EQUIPMENT FOR THE ORBITING ASTRONOMICAL OBSERVATORY
(500 Word Abstract)

The Orbiting Astronomical Observatory is a scientific satellite funded by the National Aeronautics and Space Administration to provide a precisely stabilized orientable vehicle. The spacecraft will be made available to make those scientific measurements requiring control and equipment orientation to the precision implied by a system stabilized to seconds of arc. The information telemetered to and from the satellite is of two general types - the spacecraft data and the experimenter's data. The Ground Operating Equipment (GOE) described is designed to receive, record and display information concerning the spacecraft and experiments status and to provide controls to send commands to the spacecraft. The actual experimenter's information will be decoded and displayed on other equipment.

In order to efficiently control the Orbiting Astronomical Observatory, two types of Ground Operating Equipment are provided. The central control station, linked to the Blossom Point remote station by microwave station, provides "quick-look" capability to examining status data and will be located at the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. The remote control stations ~~will~~ may be located at Quito, Ecuador - Santiago, Chili - and Blossom Point, Maryland. The system concept is shown in the block diagram of Figure 1. Common to each of these types of stations is a digital computer which is used to process the data from the satellite and to convert it into signals which can be displayed as actual analog and digital status, together with an indication of the deviation of the actual status from the predicted status.

The predicted status is generated by a second digital computer (IBM 7090) simulation of the satellite's operating characteristics. This computer is not the computer that is part of the Ground Operating Equipment. Tolerance limits are set on each of the items to be displayed upon the operating console of the central control station and warning lights are used to indicate to the operator that certain status items are out of tolerance. These status items are presented together with their tolerance lights in a library or index on the turrets of the operating console. In a file slot opposite each light, an index card with suitable coding is filed so that in the event of an item of status showing out of tolerance, the associated card can be removed and inserted in a display panel which will call forth from the computer and display the actual value of the status item and its deviation from the predicted value.

The remote control station displays are considerably simpler, since the diagnostic displays of the central station are eliminated. The fundamental design philosophy of the remote control station is to provide to the operator only that data and those controls which he needs to accomplish the control of the satellite. The premise on which the Ground Operating Equipment is designed is that normal operation permits no commands to the satellite unless these commands have been previously programmed on a simulator. The simulation is to establish that none of these commands will drive the satellite into a physical position which is such as to cause sun damage to the telescope or excessive use of the gas in the stabilization jet system.

The commands that are generated for transmission to the satellite are teletyped to the remote control stations from the control at Goddard by a standard simplex teletype link. One of the constraints that is placed upon the design and operation of the remote control station is the limited data handling capacity of the teletype link.

Although the period of contact with the OAO is short, as shown by the typical contact times of Figure 2, the amount of data which can be telemetered down from the spacecraft is large. In the event of malfunction of the spacecraft equipment, the remote control station operator must place the spacecraft in a hold mode and teletype to Goddard the pertinent portions of spacecraft status data for analysis. Figure 3 is a time analysis of a typical contact based upon the minimum contact time of Figure 2.

This abstract has summarized the principal problems and features of the Ground Operating Equipment, designed to solve the problem of control of a precision orbiting experimental vehicle such as the Orbiting Astronomical Observatory. The approach used will be applicable to the control of many satellites of the type similar to the Orbiting Astronomical Observatory and Orbiting Geophysical Observatory. The paper will detail further the specific realization of the requirements resulting from the short time period available for contact time, the low data rate of the teletype link, and the large quantity of data which can be spread out by the spacecraft over the telemetry link. Block diagrams of the system will be provided and discussion of the detailed operational flow diagrams will provide further understanding of the system.

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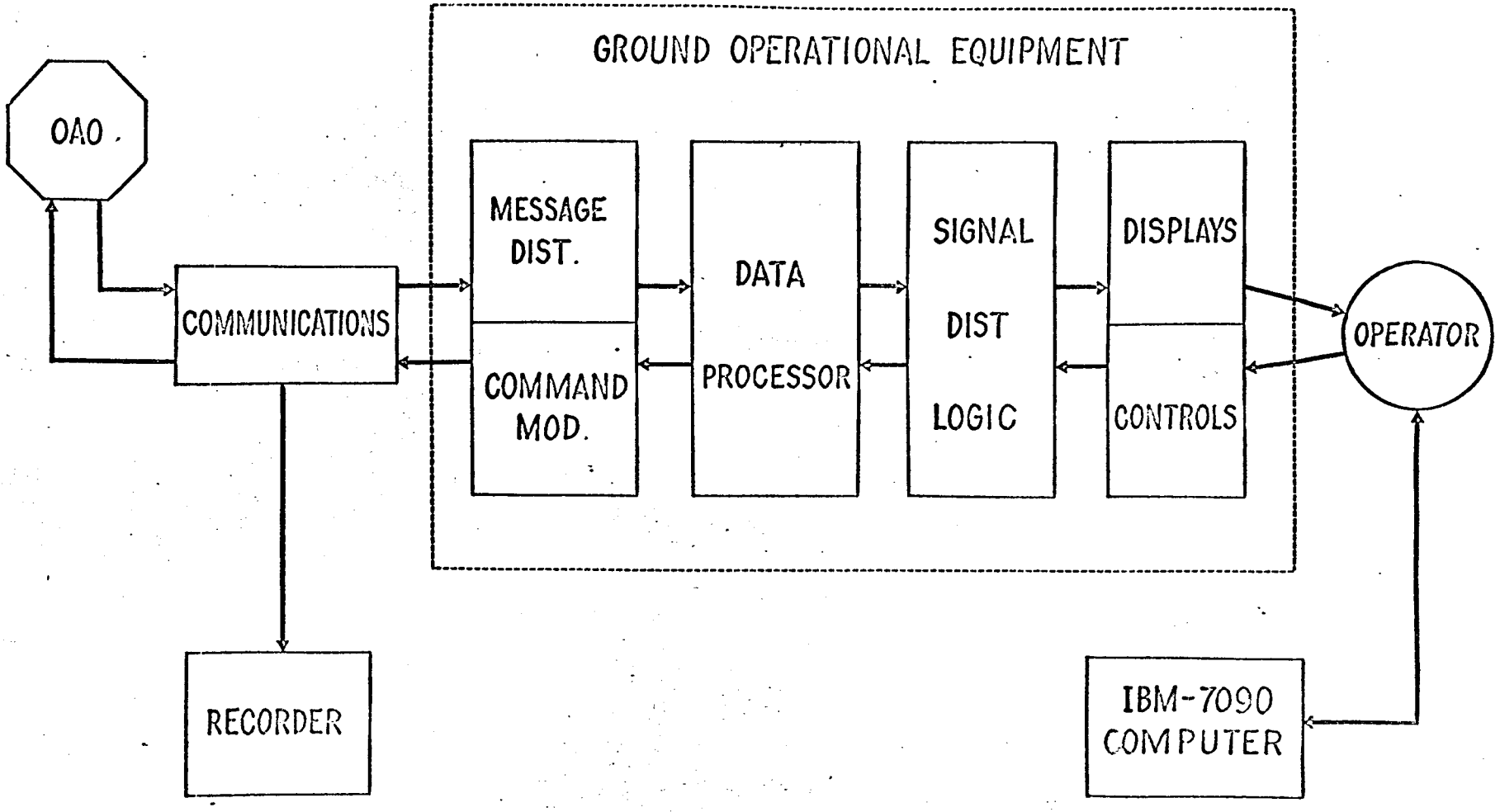
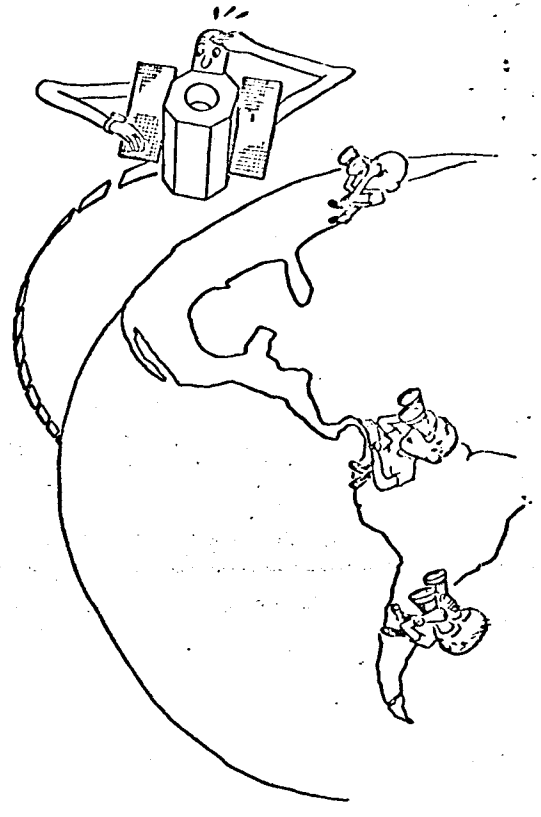
SYSTEM CONCEPT



CONTROL STATION CONTACT TIMES

ALTITUDE = 400 MI

ORBIT NUMBER	BLOSSOM POINT MARYLAND	QUITO ECUADOR	SANTIAGO CHILE
1	9.2		
2	10.2		
3	8.6		
4			
5		9.2	
6		8.4	
7			8.7
8			11.2
9			11.0
10			9.4
11		4.1	
12		9.7	
13		7.1	
NO. OF CONTACTS	3	5	4



ALTITUDE = 600 MI

NO. OF CONTACTS	4	7	6

DATA FROM GAEC, OAO COMMUNICATION SUBSYSTEM PHASE I REPORT

TYPICAL CONTACT SEQUENCE