



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON 25, D.C.

IN REPLY REFER TO: ATSS-AC

MEMORANDUM

AUG 2 1965

TO : SFF/m. Garbacz

FROM : ATSS-AC/Contractor Reports Unit  
Scientific and Technical Information Division

SUBJECT: Request for document release

The Scientific and Technical Information Division recognizes NASA Headquarters Program Offices' responsibility to recommend processing and distribution limitations on documents prepared under their auspices. In this regard, attached for your information and appropriate action is a "Document Release Form" for a NASA-sponsored document which we believe was prepared under your responsibility. It would be appreciated if you would complete the Document Release Form and return the original copy together with the document, if attached, to Code ATSS-AC so that we may process the document in accordance with your desires. In addition, you may feel this report is worthy of printing under NASA covers and being automatically distributed to the same distribution list as a NASA Technical Note in a similar subject area. If so, please note "under NASA covers" above your signature.

It is the desire of the Scientific and Technical Information Division to receive classified and unclassified scientific and technical documents generated by NASA activities automatically in order that we may place them under a centralized bibliographic control for subsequent retrieval and use as expeditiously as possible. In this regard, you may wish to consider granting a comprehensive authority to process on a routine basis any or all documents emanating from a specific program, project, or contract for which you are responsible. This office will be pleased to prepare, with your guidance, a memorandum of understanding containing your instructions regarding the release and processing, on a routine basis, reports prepared as a result of your contracts or projects. As a result of such an agreement the reports could be received and made available without our contacting your office on a recurring basis. We will be pleased to discuss such an arrangement with you at any time you so desire.

Thank you for your consideration in the release of the information attached, as well as your consideration to granting a "blanket" authorization. If you have any questions or comments regarding our contractor reports program, please let us know.

Attachment

FACILITY FORM 802

N65-30564	(THRU)
31	1
(PAGES)	(CODE)
CR 64269	31
(NASA OR TMX OR AD NUMBER)	(CATEGORY)
TMX-56696	

ROBERT L. MURPHY

## TIROS: THE SYSTEM AND ITS EVOLUTION

### INTRODUCTION

TIROS is the name given to the meteorological satellite program of the National Aeronautics and Space Administration (NASA). TIROS I is the first U. S. satellite to carry a television camera on board. The initials stand for Television (and) Infra-Red Observation Satellite, since both types of sensors are employed. The objective of this satellite program is to give the meteorologist a pictorial view of the weather from a vantage point well above the weather.

The basic system consists of (1) the satellite with sensors, recorders, transmitters, receivers, attitude indicator, solar cell power supply, and control circuitry; and (2) the primary command and data acquisition stations. The supporting elements of the system are the tracking network (for orbit determination as contrasted to data acquisition), the data analysis center, the control center, the communications network to tie these elements into a coherent operational system, and the pre-launch check-out facilities.

It is the intent of this paper to give an indication, from a management point of view, of some of the problems and factors which vitally affect the course of a development program -- particularly a highly-complicated program such as a satellite system. Since a satellite system is such a complex mechanism, a sufficient amount of design and operational information is given so that the workings of the TIROS system and its main elements can be well understood.

GPO PRICE \$ \_\_\_\_\_

1 CFSTI PRICE(S) \$ \_\_\_\_\_

Hard copy (HC) 2.00

Microfiche (MF) .50

## EVOLUTION AND HISTORY OF THE TIROS PROJECT

A brief history of the TIROS Project is included primarily to help place in proper perspective the design considerations and changes which took place in the satellite configurations. This history was shaped by a series of management decisions based on timing, equipment priorities, economics, and assignment of organizational responsibilities.

TIROS evolved from a relatively modest start in life as a first try at the problem of viewing the earth's surface by means of a TV camera installed in a satellite. It had its roots in a study conducted by the Radio Corporation of America for the Rand Corporation under an Air Force contract initiated in 1951. The objective at this stage was to evaluate the general reconnaissance potential of a TV satellite. The results of the study were generally quite favorable, and several projects evolved leading toward the development of flight-type equipment.

As a result of an unsolicited proposal, the Army Ballistic Missile Agency (ABMA) in 1956 awarded a contract to RCA to reduce to practice an early feasibility television satellite, using the Army's Jupiter C missile system with a Redstone booster. This missile system later placed into orbit Explorer I, the United States' first artificial earth satellite. The program was later expanded, upon decision of the Department of Defense and the Army Ballistic Missile Division, and redirected toward a more specific mission -- that of target acquisition and location.

A contract again was awarded to RCA covering the initial phases of a program which included the design and construction of a satellite to be launched by a Juno II missile system using the Army's Jupiter IRBM ballistic missile as the booster. Included in the contract was the requirement for a complete system design of the satellite structure, power supply, stabilization, environmental control, orbital dynamics, and electronic instrumentation. In addition, the contract required development of the associated ground systems equipment necessary for the proper

operation of the satellite system. Responsibility for the vehicle system remained with ABMA; responsibility for the payload and ground complex was subsequently assigned to the Signal Corps.

In mid-1958, it was determined that this project came within the purview of the Advanced Research Projects Agency (ARPA). This agency, after reviewing the existing program, decided that it was well suited to meet a very high priority and urgent requirement for a meteorological satellite and as a result work on the television satellite was directed toward the development of a meteorological system. An Ad Hoc Committee on Meteorology was created by ARPA to help formulate the design objectives for a satellite program with particular emphasis on the initial payload which was to be of an exploratory nature. This committee included representation from ARPA, ABMA, Office of Naval Research, National Advisory Committee for Aeronautics, Air Force Cambridge Research Center, U. S. Weather Bureau, University of Wisconsin, Rand Corporation, U. S. Army Signal Research and Development Laboratory, and the Astro-Electronic Products Division of RCA. The Committee recommended the inclusion of a number of design objectives (described later in this paper) which in addition to TV cloud-cover observation using high, medium, and low resolution cameras, proposed a series of measurements in the infra-red and in the ultra-violet and x-ray regions. It was possible to include most of these in the specifications for TIROS.

At about this time, further work on the Juno II missile program was discontinued and the available vehicles were reassigned to the Explorer series for satellite cosmic ray exploration. As a result of this decision and of others related to the over-all problems of missile advancement, the Juno IV program was conceived and initiated by ABMA. This program consisted of the Jupiter booster plus new liquid-fuel upper stages. The physical design characteristics of size, form factor, and weight of the

TIROS satellite were based on the Juno IV system. However, as a result of a realignment of the national space program, it was necessary to shift the TIROS Project from the Jupiter to the Thor, and with this, the responsibility for the vehicle system was transferred from AFMIA to the Air Force Ballistic Missile Division and its subcontractors: Space Technology Labs and the Douglas Aircraft Corporation.

In April 1959, as a result of the apportioning of project responsibilities between ARPA and the newly-formed civilian space administration, the TIROS project was transferred (from ARPA) to the National Aeronautics and Space Administration (NASA). In its role as overall system manager, NASA is coordinating the efforts of the Ballistic Missile Division of the Air Force, and those of the Signal Corps with the NASA Goddard Space Flight Center, the Minitrack network, the NASA Computing Center and the U. S. Weather Bureau Meteorological Satellite Center.

#### DESIGN OF THE TIROS SYSTEM

The TIROS system evolved as a result of a series of management decisions and their historical results. The earliest feasibility television satellite (Project Janus) weight of 20 pounds was specified by the capability of the Jupiter C missile system. The payload consisted of a television camera (using a  $\frac{3}{8}$ -inch vidicon) with a frame rate of 1 per second, powered from chemical batteries. The slow-speed scan rate produced a video bandwidth of 125 kc which could be transmitted through the standard existing telemetry band at 240 mc. The receiving stations were those that existed "down range" at Cape Canaveral for receiving missile test data. A dove prism optically immobilized the image within the 750 rpm spinning frame.

Stabilization of the optical axis in space was accomplished by using the spin momentum generated during the launch phase. The Jupiter C satellite was required to be a rod-shaped body with a diameter of approximately 5 inches. In a spinning, picture-taking satellite, it is extremely important for successful operation that the optical axis remain parallel to the spin axis. Such alignment is difficult to maintain when it is necessary to point the optical axis along the longitudinal axis of a rod-shaped body. A disc-shaped body has its maximum moment of inertia around the figure axis, and will spin stably around that axis. However, a rod-shaped body prefers to spin about a stable axis which is perpendicular to the (longitudinal) figure axis of the rod, since that is the line around which the mass of the body has its maximum moment of inertia.

During launch, the Jupiter C satellite received a spin rate of 750 rpm around its longitudinal axis for stabilization. Due to unbalance impulses (which are impossible to avoid) the vehicle precesses. This oscillation builds up if there is any energy dissipated (such as heat due to mechanical bending) in phase with the precession oscillation. The system finally ends up spinning about its axis of maximum moment of inertia, and appears to be tumbling. This was recognized by RCA early in the Janus program and was later proven by Explorer I, which actually did tumble due to the whipping of the crossed dipole antennas which were used for the 108 mc beacon. To counteract this problem, an "active" damping system was invented (shown in Figure 1) to produce mechanical friction out of phase with the precession oscillation. This required that there be a net power gain by the system derived, in this case, from the chemical batteries. With such a device the system would spin true about its longitudinal (rod) axis.

The laboratory model of the 20 pound system (shown in Figure 2) was demonstrated immediately after Sputnik I, and was scheduled for launch in the Spring of 1958.

The expansion of the program in early spring of 1958 changed the design of the TV satellite in order to meet the requirements of a reconnaissance mission and a different missile system: Janus II. A new optical system (shown in Figure 3<sup>3A</sup>) was required to meet the specifications for increased picture resolution. Perkin-Elmer Corporation, under subcontract to RCA, designed a cassegranian-type optical system with an 8" aperture and an 8" focal length. A dove prism for image immobilization could no longer be used; the spinning satellite had to be slowed down from an initial 450 rpm speed to as slow a speed as would still maintain enough angular momentum for stabilization -- about 7 rpm. Although an increase in weight to 85 pounds was possible in the new system; it was still impossible, due to limitation of form factor, to achieve a ratio of moments of inertia which would provide a disc-shaped system. A design was conceived, however, which would solve both problems of speed slow-down and conversion from rod to disc characteristics while the satellite was in orbit. Weights at the ends of four wires would be slowly paid out to a distance of six feet. In the process of increasing the moment of inertia this would -- in a momentum conservation system -- slow down the angular speed. By keeping the extended weights and wires, now under tension from centrifugal force, as part of the overall mechanical system, the total satellite system would effectively be converted from a rod to a disc shaped body. The dissipation of energy released from the flexing of the wires due to any precession would cause the oscillation to damp out, as in a stable disc shaped system, keeping the figure axis, spin axis, and optical axis properly aligned. This system was demonstrated on a tester built at RCA and shown in Figure 4.

Development of a light-weight, rugged, low power drain magnetic tape recorder was initiated in order to store pictures taken at remote locations in the orbit. Video bandwidth of 125 kc compatible with the vidicon scan rate was provided. Nickel cadmium storage batteries with a solar-cell (charging) power supply were substituted for the limited-life chemical batteries. A picture of a full-size model of this satellite is shown in Figure 5.

The initiation of the new Juno IV missile system replaced the Juno II for the TV Reconnaissance Satellite. Now, a third stage that would accommodate a disc-shaped satellite was available. A housing 42 inches in diameter and 17 inches in height was designed. Since the upper stage was liquid and equipped with guidance control, no spin was needed for stabilization during the launch phase. Consequently, the satellite could be placed into orbit at the spin rate needed for orbital attitude stabilization, consistent with picture taking requirements (i.e., 7 rpm). The despin weights and wires were thereby eliminated, resulting in a much simpler system. Reliability was served by the new simplicity and the redundancy now possible due to the increased orbital lifting weight capability of the Juno IV.

As previously mentioned, in mid-1958 it was determined that the Project came within the purview of the Advanced Research Projects Agency (ARPA). At the same time the mission requirement was directed toward meteorology and away from reconnaissance. The new requirement permitted a drastic change in optics. Rather simple off-the-shelf refractive optical systems were found adequate to fulfill the much coarser resolution specification for cloud observation. The heavier and more complicated cassagranian optics was abandoned. Three complete and independent TV camera and magnetic recording systems were to be provided for three steps of resolution and coverage. A two-second frame was selected for picture readout, reducing the video bandwidth requirements to 62.5 kc.

A "scanning" infra-red observation system covering five selected bands in the I-R spectrum was added. This subsystem was assigned to U. S. Army Signal Corps (later transferred to NASA) for development, and was to be installed in the satellite by RCA. The introduction of this new system required that an increase in spin speed (to 12 rpm) be provided and maintained during orbit. Since the I-R sensor system tied to the spinning



vehicle provided for a spot scan of the earth, a specific scanning speed was necessary to assure overlapping lines as well as full utilization of the resolution capability of the system. It was realized that without some on-board power for control of spin speed, the magnetic field would slow down the satellite in a relatively short period of time rendering the I-R scanning useless. A number of small "spin-up" rockets, whose firing was controlled from the ground, were equi-spaced around the periphery of the satellite to compensate for spin slowdown. In order to power the increase in payload, additional solar cells were required; finally reaching a total of 10,000 individual silicon 1 x 2 cm cells.

At this point in its genealogy, the TIROS satellite was very close to its final system design. The shift from the Jupiter-Juno IV missile system to the Thor involved the transfer of missile system responsibility to the Ballistic Missile Division of the Air Force. A former problem was again introduced: the final stage of the missile system used solid fuel, and was spin-stabilized (at 120 rpm). Therefore, it would be necessary to slow down the spin rate of the satellite in orbit from 120 rpm to 12 rpm. Once again, the weight and cable despin system was considered. However, this time, the complication of maintaining the extended weights as part of the satellite system was found not to be necessary, since no conversion of the ratio of moments of inertia from rod to disc was required. A simpler system was installed, in which weights and cables wrapped around the satellite are allowed to fly out under the influence of centrifugal force at the initial angular velocity, and then are released to continue into space, carrying with them sufficient momentum to slow down the spin rate to 12 rpm.

The final shift in management responsibility from ARPA to NASA in April of 1959 did not entail any major redesign in the TIROS system. The policy rather was to endeavor to assure that no further changes or additions be made in the TIROS satellite. The final form of the satellite structure (and antennas) is shown in Figure 6. The component layout in the interior is shown in Figure 6A.

The above discussion has attempted to point out the very strong influence of management decisions on the design configuration of the TIROS satellite.

It should not go unnoticed that, as changes were necessitated in the satellite, complementary and equally important changes had to be made in the ground equipment. However, these are not covered in the present paper.

#### DESCRIPTION OF THE TIROS I SATELLITE

The main elements of interest of the TIROS I satellite are the television and infrared sensor subsystems, the ground station command and control system, the data acquisition system and the prelaunch check-out system.

In the television subsystem, two cameras are employed. One, equipped with a wide angle lens, will provide coarse, large-area coverage; the other, equipped with a longer focal-length lens, will provide relatively fine information on cloud structure. The cameras are miniaturized units, designed around a ruggedized 1/2-inch vidicon picture tube. The "sticky" (high-persistence) characteristics of the vidicon makes it possible to achieve appreciable bandwidth compression by using a low read-out rate. Exposure is set for approximately two milliseconds and readout has been extended to approximately two seconds. Although several modes of operation are possible, the principle mode will be one in which a series of "coarse" pictures which overlap approximately 50 percent are taken simultaneously with a series of high-resolution pictures, one of which falls in the center of each coarse picture.

The area on the surface of the earth which can be observed by the cameras is limited mainly by two factors: presence of sunlight and orientation of the satellite. Since the satellite is spin stabilized (that is, the spin axis is fixed in inertial space) the surface bearing the cameras faces the earth for only part of each orbit. At the point where proper camera orientation and adequate sunlight coincide, a series of exposures is made. Each picture taken by the cameras is read out and stored on magnetic tape, and then subsequently is read out when the satellite passes over a primary ground-data station. At those times when the orientation and sunlight coincide and the satellite is within range of one of the ground stations, it is possible to read out the cameras in "real time"; that is, to bypass the tape recorders and transmit the picture information directly. If the satellite is passing overhead, the ground station is photographing itself!

With the importance of reliability constantly in mind, it was decided to make the two camera systems completely independent of each other, except for the synchronization of exposures previously mentioned. Each camera feeds into its own recorder, recorder electronics, and picture transmitter. To carry this philosophy through to its logical conclusion, independent, function-control "clock" assemblies and command receivers were provided in the satellite as well.

The design of the system provides for two types of infrared observation. One of these, identified as the Scanning I-R subsystem, is an expanded version of the Vanguard Cloud Cover experiment wherein the rotation or spin of the satellite provided the equivalent of the horizontal scan of a raster, and the orbital motion of the satellite provided the equivalent of the vertical scan. Actually, the raster pattern is much more complex, since the I-R sensors "look" simultaneously "up" and "down" at 45° to the spin axis. The shape of the scan line varies as a function of the changing attitude of the scanning cone as it intersects with the spherical earth. This technique results in a much broader coverage over the surface of the earth than the TV system, and takes advantage of the fact that infra-red observation is not restricted to sunlit areas.

The spectrum ranges selected for the scanning I-R subsystem are:

- (1) 0.2 to 5.0 microns; to provide a measurement of the earth's albedo or reflected energy from the sun.
- (2) 7.0 to 30 microns; to measure the total radiated energy of the earth and its atmosphere.
- (3) 8.0 to 11 microns; to measure, through a "window" in the atmosphere, the temperature of the earth's surface, or the "bottom" of the atmosphere.
- (4) 5.9 to 7.0 microns; to measure, in effect, the temperature of the "top" of the atmosphere. This is the wavelength range at which the water vapor in the atmosphere absorbs the radiated energy from the earth.
- (5) 0.55 to 0.74 microns (the visible spectrum); to provide a reference for the preceding four measurements, and for comparison with the TV pictures.

The second infrared subsystem utilizes two relatively simple non-scanning sensors with the same response approximately, as (1) and (2) above. These are aimed parallel to the TV cameras, and cover approximately the same area as the coarse resolution camera. These measurements will permit an estimate to be made of the heat budget of each area observed, and to correlate this with the cloud cover.

The recording and transmitting equipment for the I-R subsystems are contained in a common package which is independent of the TV equipment. The scanning system is designed for continuous operation and makes use of a magnetic tape recorder with an endless loop of tape. Sufficient tape is provided for a nominal orbit of 100 minutes duration and, upon interrogation by one of the ground stations, the tape speed is increased by approximately 30:1 for playback. A different transmission frequency is used

by the I-R transmitter, permitting both the I-R and the TV information to be telemetered simultaneously. While the tape is playing back the recorded data, the output of the sensors modulates a separate channel of the transmitter to provide direct data readout in "real time", bypassing the tape recorder.

It is reasonable to assume that the spin axis of the satellite is not likely to lie in the plane of the orbit. Any one of several effects such as uneven burning of the third carrier-rocket stage, precession, or even slight tip-off upon separation from the third stage can shift the axis by an appreciable amount. Since both of the sensors (TV and I-R) are aimed with respect to the spin axis, it was necessary to include a system for determining the attitude of the spin axis in space. This system employs a separate infra-red sensor which scans the earth as the satellite rotates and detects, essentially, the horizons. The data is telemetered continuously through 108 mc beacon transmitters to the ground stations, from which it is relayed to the computing center where it is processed with the orbit elements to give the spin-axis attitude. In addition to the primary stations, attitude-axis data recorders will be installed in Minitrack stations at Lima, Peru; Santiago, Chile; the Ascension Islands; and Goldstone, California.

The purpose of the primary command and data-acquisition stations is to transmit instructions to the satellite and to receive observed-information from the satellite. The primary ground stations are equipped with a 60-foot diameter, self-tracking parabolic antenna and the electronic equipment for programming, transmitting, receiving and data recording.

A programming console at each primary ground station is designed to permit a considerable flexibility in control of the satellite functions. Control may be exercised manually or by automatic sequence, and the satellite may be programmed for remote operation or direct response. The automatic mode

requires less time and reduces the likelihood of operator error. The total time that the satellite is in range varies from pass to pass (from) approximately 6 to 14 minutes), and this period must be divided among the three functions -- stored data read-out, direct data read-out, and the transmission of instructions for remote camera operation. Hence, pre-programming permits most efficient use to be made of the time that the satellite is within range, thus retaining the maximum time for direct camera readout.

It should be noted that programming is complicated by the problem that, with only two primary stations, there are several passes in a 24-hour day that are not within range of either station. However, the satellite can be programmed in advance (as far ahead as 3 passes) for read-out on a subsequent pass. In all likelihood, the meteorologists will require this more complicated mode of operation.

The receiving and recording equipment consists of independent subsystems for handling the TV and I-R data. To preclude the possibility of having "holes" or nulls in the received signal as the satellite rotates, the satellite was equipped with a circular polarized transmitting array. On the 60-foot receiving antenna both horizontal and vertical dipoles are employed, and these feed separate receivers connected to diversity combiners. Two high-quality multi-track tape recorders are employed. The basic TV and I-R outputs are recorded on both machines to provide backup, and the remaining channels are used for reference data such as sun angle, synchronization pulses, indexing, time, etc. The handling of the TV picture is illustrated in Figure 7.

The TV picture signal, in addition to being recorded on tape, is displayed on a video monitor. Since the scan rate is the same low rate at which the picture was recorded in the satellite, a picture can be seen only when a high persistence cathode ray tube is employed. However, good photographic copy can be obtained from a short persistence, high ultra-violet cathode

ray tube. The picture is built up line by line and is photographed by a 35 mm camera, mounted opposite the CRT screen. The camera is automatically advanced frame by frame until playback from the satellite is completed. To provide additional film strips quickly, the signal recorded on the ground station tape recorder can be played back through the monitor as many times as is needed. Each frame is indexed and contains a coded reference of the position of the satellite with respect to the sun, from which the relation to North can be determined.

For use in the check-out of the satellite through all of the many prelaunch operations at Cape Canaveral (see Figure 7A), a compressed (rather than simplified) version of a command control and data acquisition station was devised. This equipment permitted rapid interrogation of the satellite in all of its modes and reduced the evaluation of performance to GO,NO-GO type of criteria.

The entire operational phase of the program is directed from the Space Operations Control Center of NASA, at which location the actual sequence of operations for each satellite orbit is prepared and specific instructions transmitted to the primary ground stations at Kaena Point (operated by Lockheed Missile and Space Division for the Ballistic Missile Division of the Air Force) and at Fort Monmouth (operated by the U. S. Signal Corps). These instructions are (primarily) from three sources of information: the NASA Computing Center, the Weather Bureau Meteorology Satellite Center, and the primary ground stations themselves. The computing center, in turn, bases its calculations on tracking data and attitude axis data received from the Minitrack Network and also from the primary ground stations. The satellite tracking complex is illustrated in Figure 8. The meteorology center analyzes all data, and when a choice exists as to where data may be acquired by the satellite, recommends those areas which are of greater meteorological significance. This control complex is illustrated in Figure 9.

At both Kaena Point and at Fort Monmouth, teams of meteorologists will be stationed with representation from the Weather Bureau, Air Force Cambridge Research Center, Air Weather Service, Navy Research Weather Facility, and the U. S. Army Signal Corps Research and Development Laboratory to conduct real time analysis of the data. The results of the picture interpretation will be transmitted to the Meteorology Satellite Center for use in planning subsequent instructions to the satellite and for correlation with weather data from other sources. In support of this operation, weather radars and sky cameras will be employed to provide data "looking up" which may be correlated with that of the satellite "looking down".

In order to extract the maximum amount of information from the pictures, one untouched set of film exposures from each satellite pass will be forwarded to the Naval Photo Interpretation Center for precision development and photogrametric processing.

The integration of the satellite payload with a Thor Able rocket vehicle, presented many problems requiring coordinated effort for their solution and many compromises had to be worked out between the contractors and government agencies involved, namely: the Air Force Ballistic Missile Division, Space Technology Labs, Douglas Aircraft Corporation, the RCA Astro-Electronic Products Division and the Signal Corps. A scientific payload such as TIROS imposes many restrictions on the vehicle system and the vehicle, of course, imposes many restrictions on the payload.

TIROS presented a number of problems during the course of its development, of which the following are some of the more interesting.

In order to have the "bottom" of the satellite face the earth in the northern hemisphere under good lighting conditions for the longest period of time it was desirable to fix the time of launch with a tolerance of  $\pm 15$  minutes. To prevent sunlight from entering the I-R optics during



the launch trajectory, the payload and vehicle had to be properly oriented on the stand. A fairing or "shroud" protected the payload and third stage until it is jettisoned after the second stage burnout. This was not an unmixed blessing. Fortunately, it was of molded fiberglass construction, transparent to radio frequencies, so that the satellite could be interrogated during pre-launch check-out. However, it was only translucent to sunlight and consequently the solar cells could not keep the storage batteries charged. It was necessary, therefore, to bring power through the umbilical cord and third rocket stage to an interface contact between the third stage and the payload.

An opaque fairing also made it necessary to introduce artificial illumination for sensor checkout. However, the fairing made it possible to air-condition the payload while it was on the stand, which eliminated moisture condensation and reduced the effects of thermal shock, particularly on the optics.

#### SUMMATION

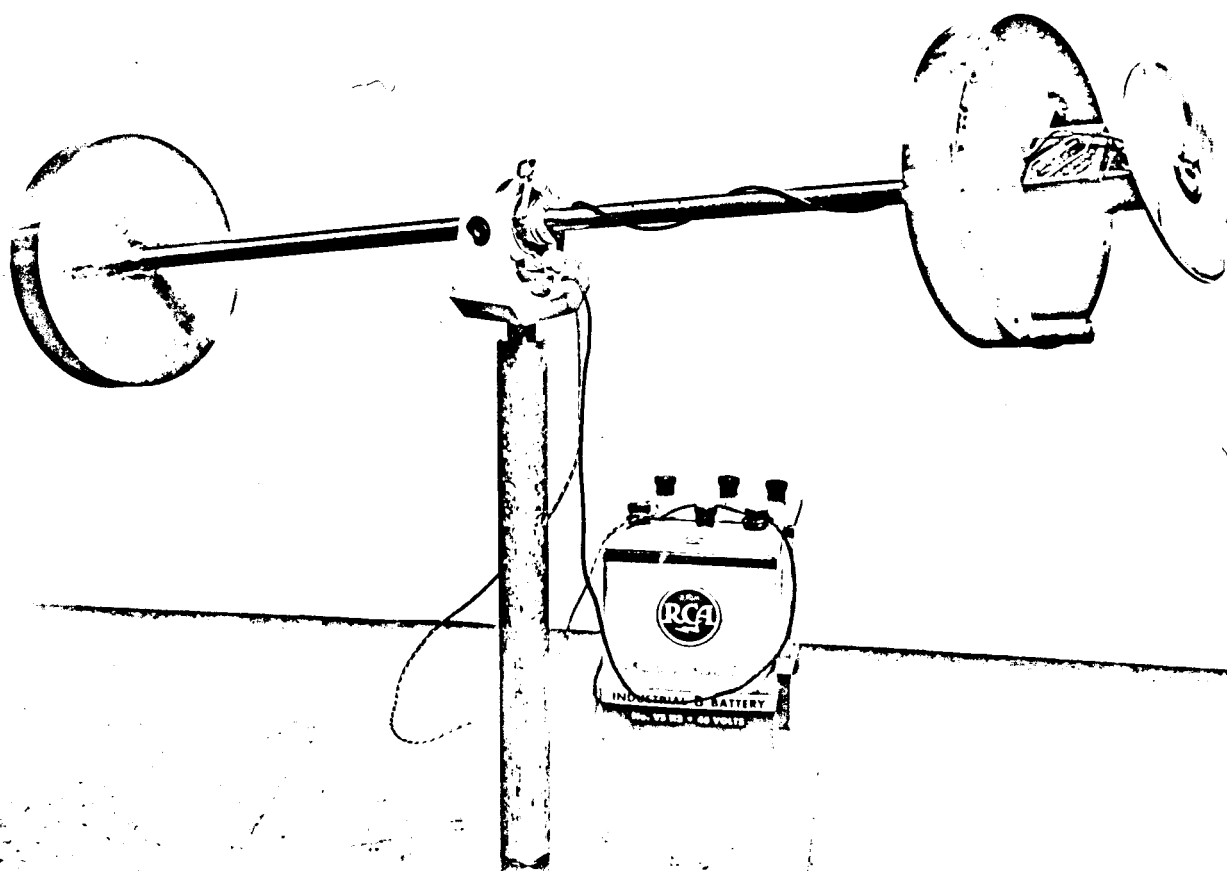
It is interesting to note that Project TIROS had its beginning before Sputnik I; lived through a period of sudden national awareness of the Space Age; and finally -- although somewhat changed in form -- emerged as a completed design. During this time, many government management decisions changed both the mission and technological requirements of the system. Many of these decisions resulted in a change of the launching missile system. This, in turn, was reflected in design changes in the TIROS satellite and ground system.

The ability of the overall space system designer to substitute missile systems and still retain the capability of a working satellite and ground system is of special interest. Missiles may be considered as "space trucks"

for the launching of satellites, and any missile system that conforms to a given payload weight versus orbital altitude dependency, and a known accuracy of guidance can be used. Small changes in these missile specifications will not appreciably modify the mission or resulting output of the total system.

However, changes in specific missile systems during the equipment design phase of the program can result in non-optimum solutions to design problems and difficulty in maintaining funding and time schedules.

If one were to look for forces which acted to smooth out the gyrations and perturbation in the program, two factors would predominate. First there was a strong requirement for a system such as TIROS. Second, continuity was maintained by having at least one organization with sufficient overall technical system responsibility, stay with the program throughout its history. The authors recognize the broad national effort involved in the TIROS program, the successful conclusion of which depended on the flexibility, determination, and skill of many people and many organizations.



C 10815

FIG 1

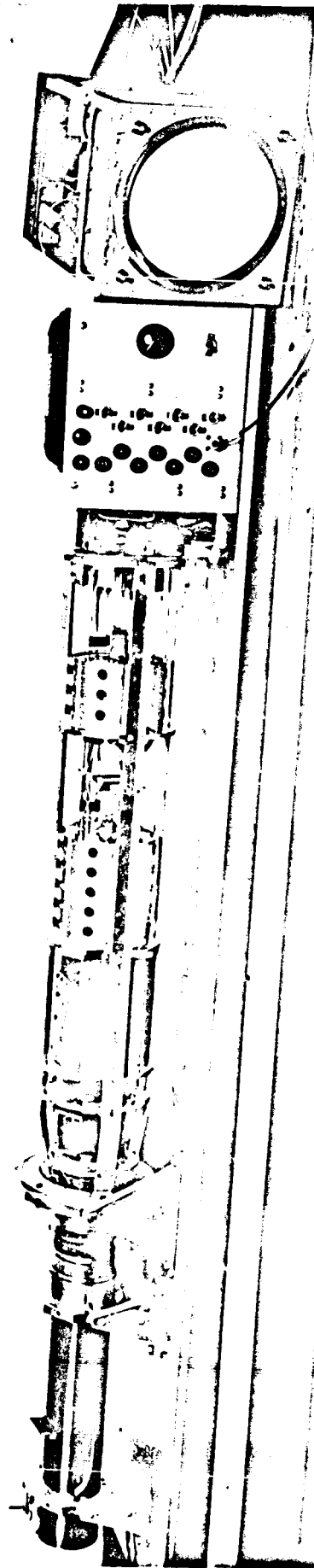


FIG 2



FIG 3

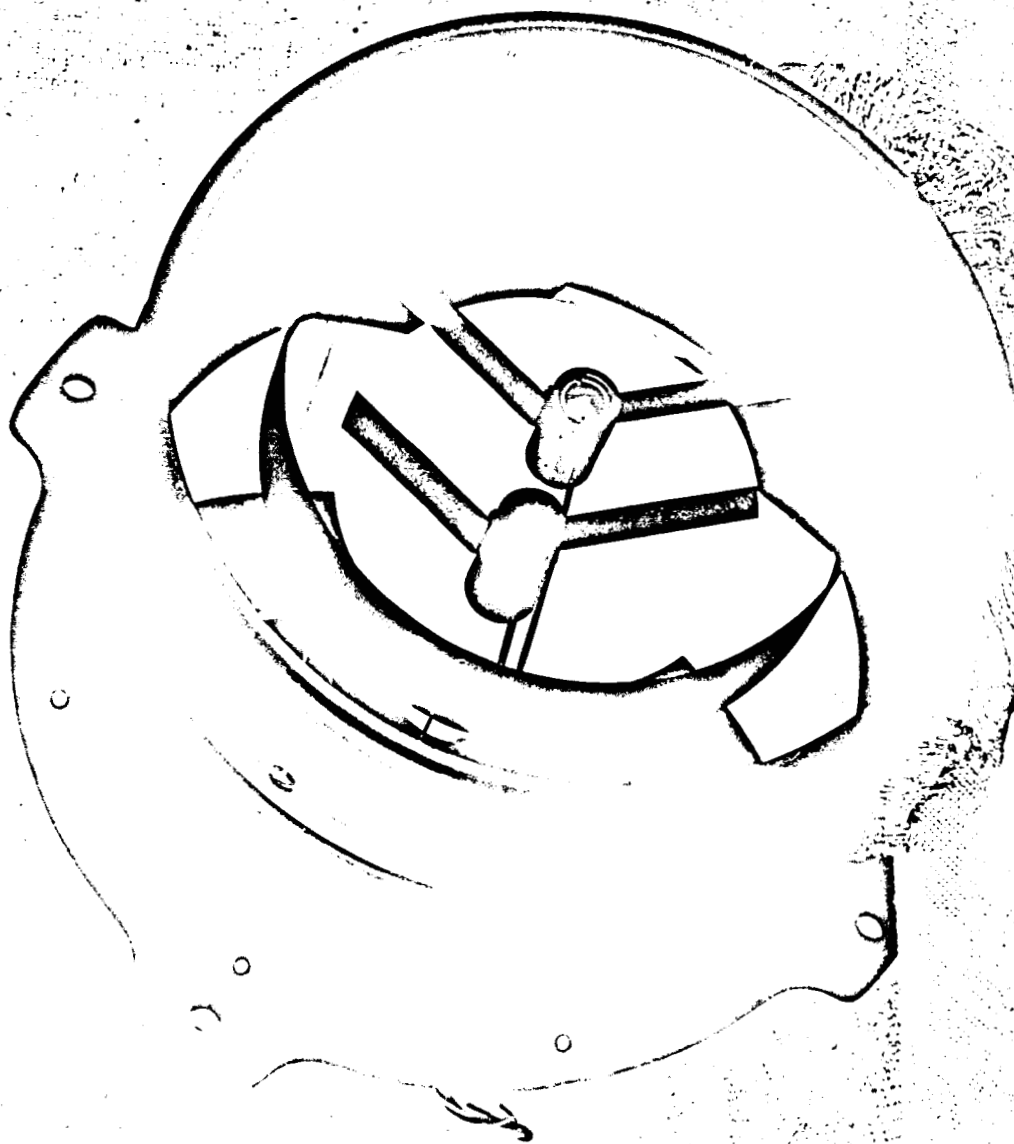


FIG3A

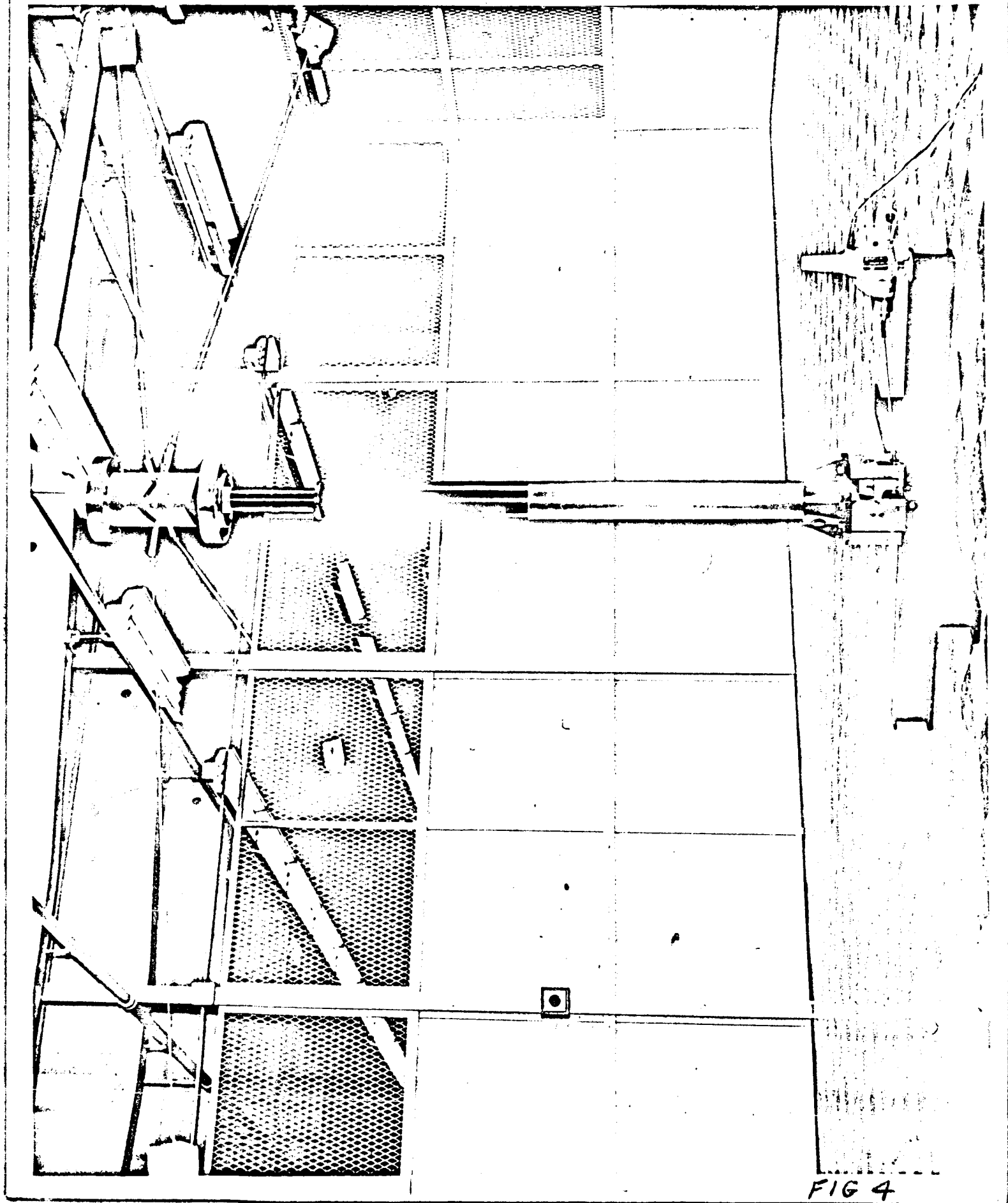


FIG 4

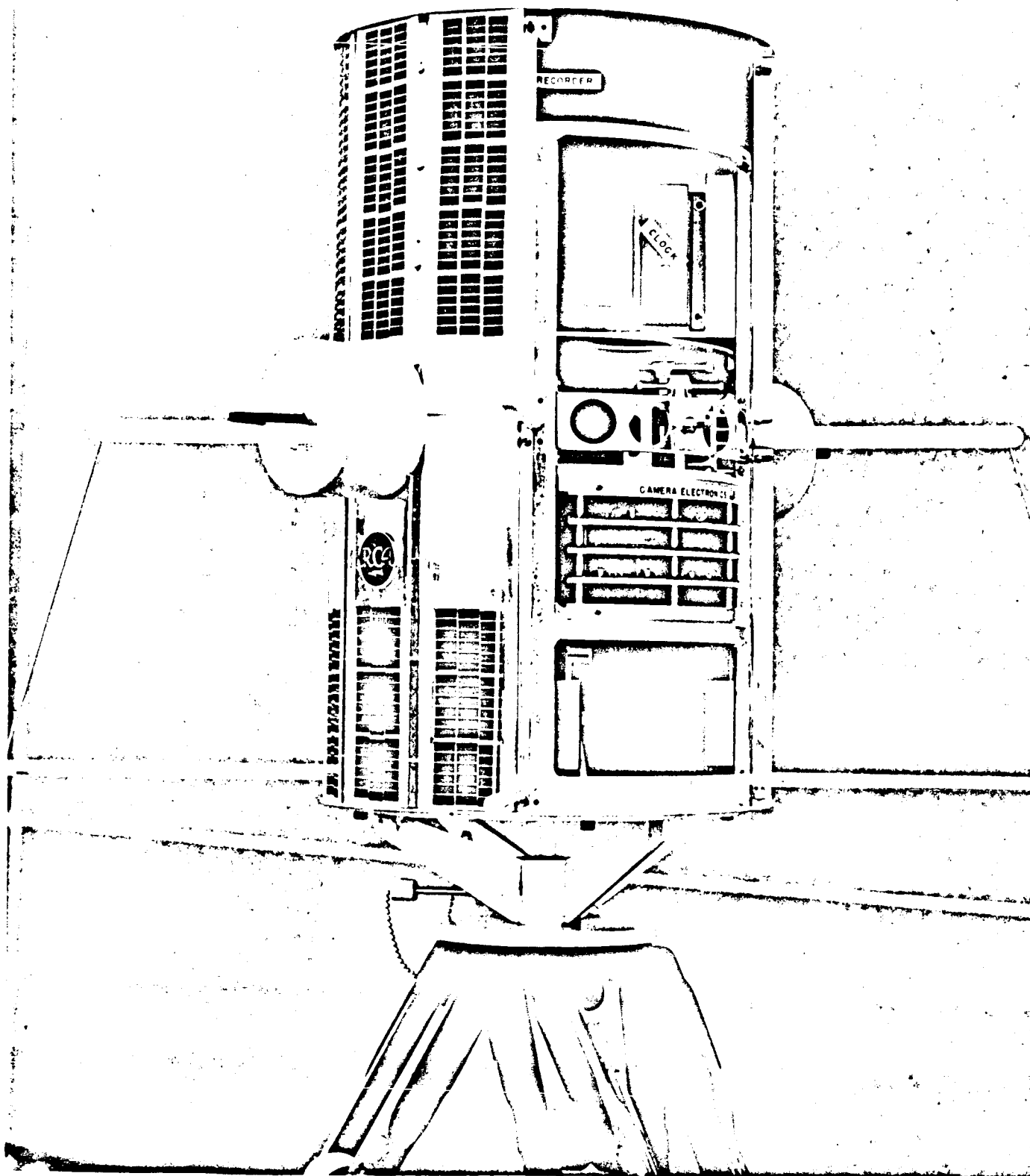


FIG 5



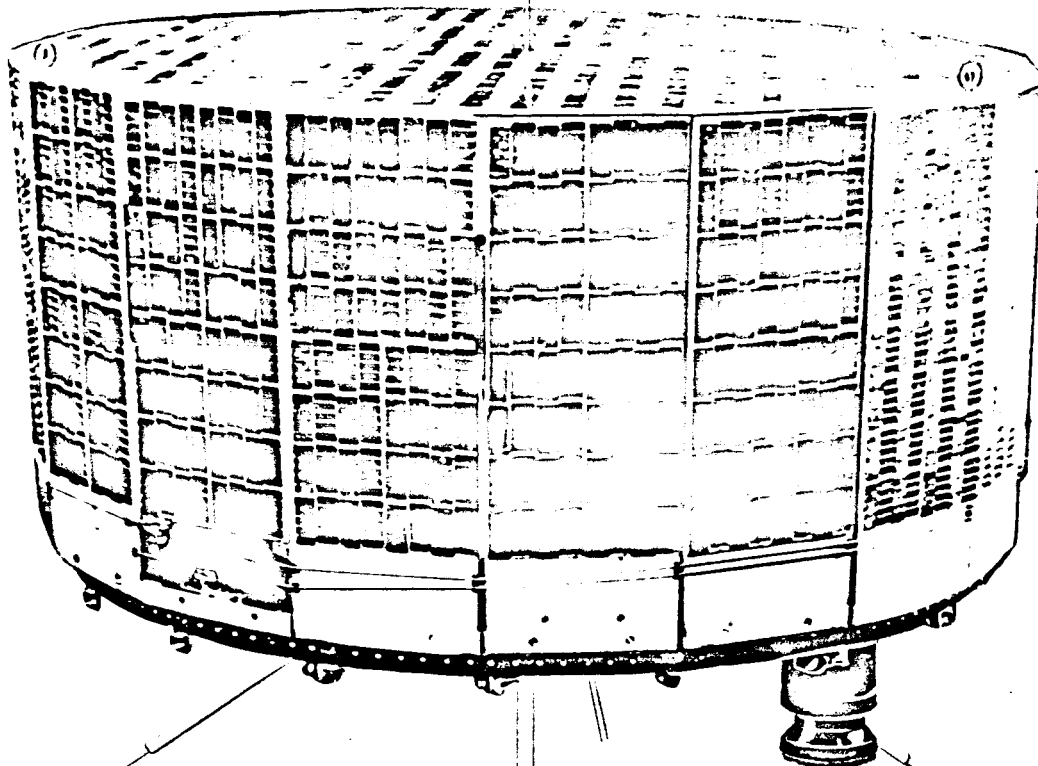


FIG 6

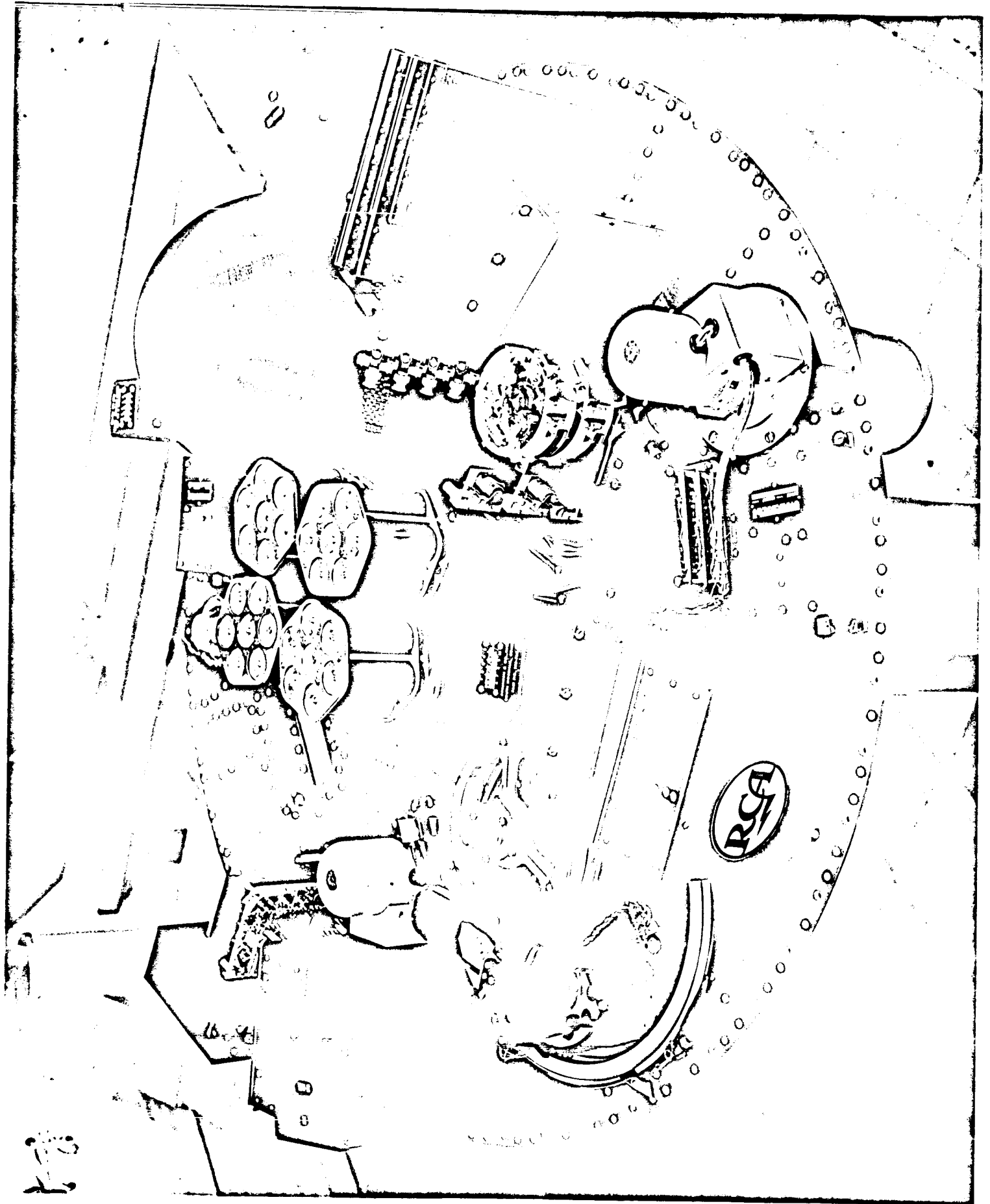


FIG 6A

# TV PICTURE SYSTEM (GRD STN)

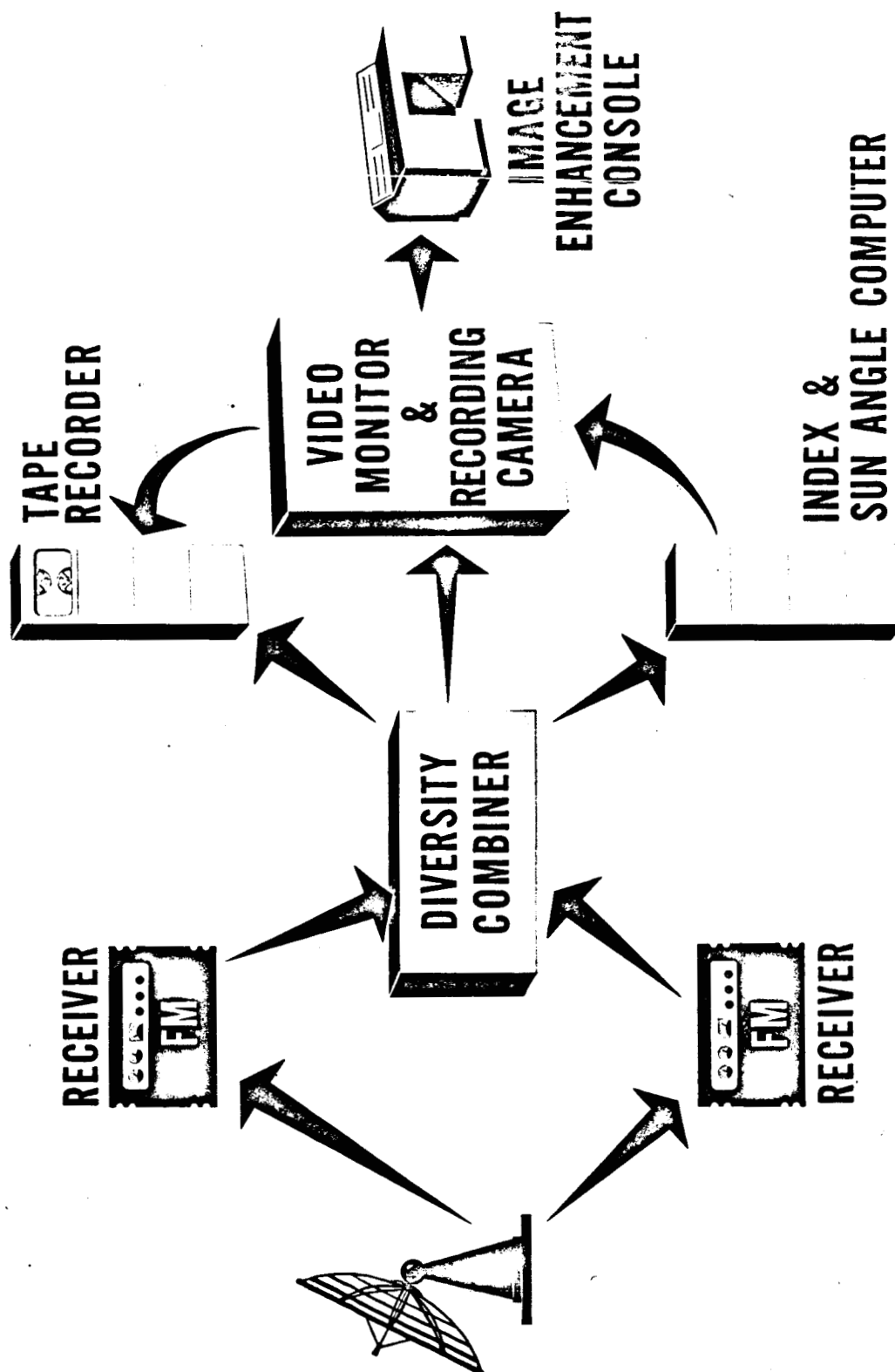


FIG 7

# LAUNCH OPERATIONS (A)

CAPE CANAVERAL, FLA.

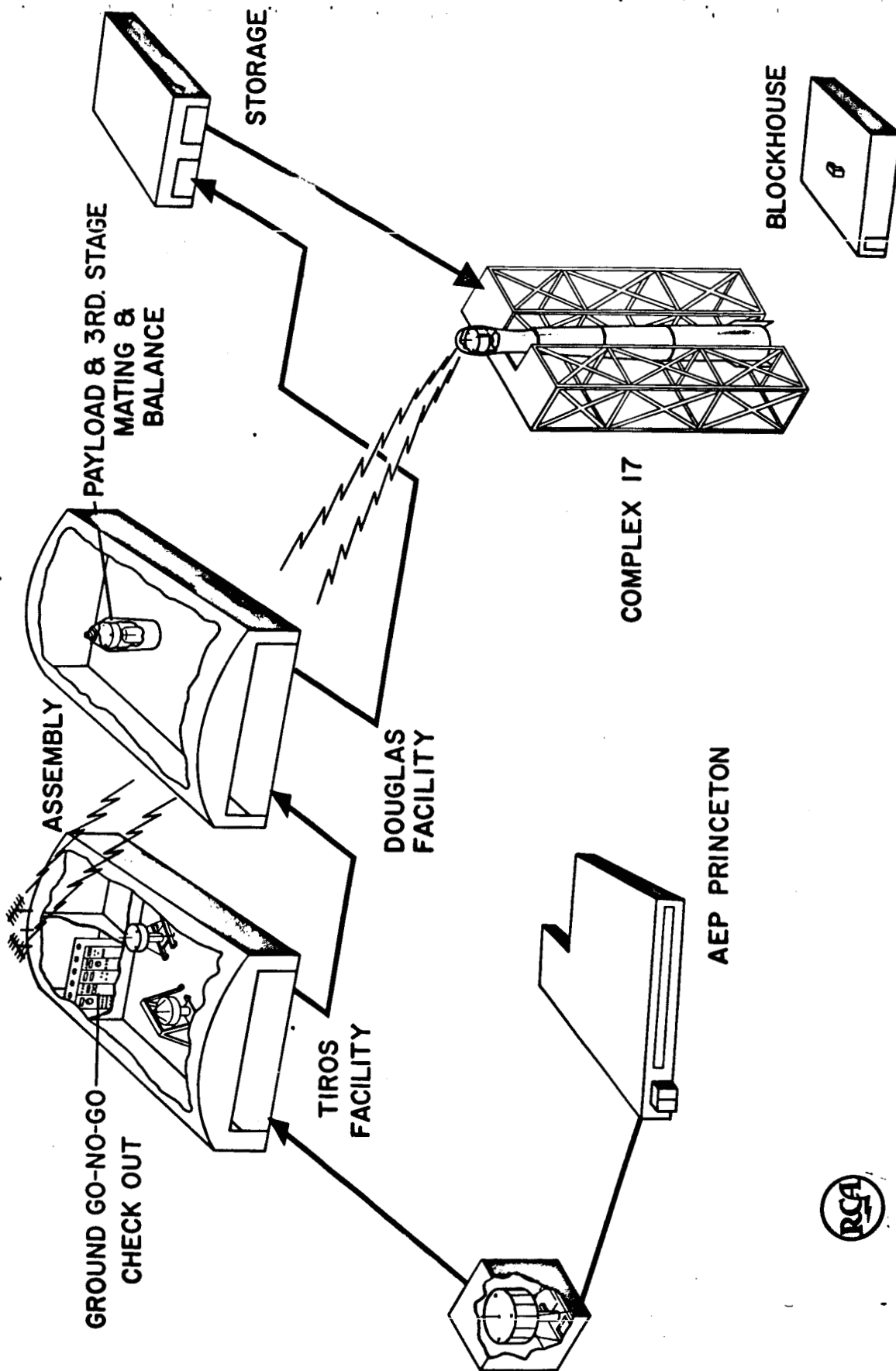


FIG 7A

# SATELLITE TRACKING LOOP

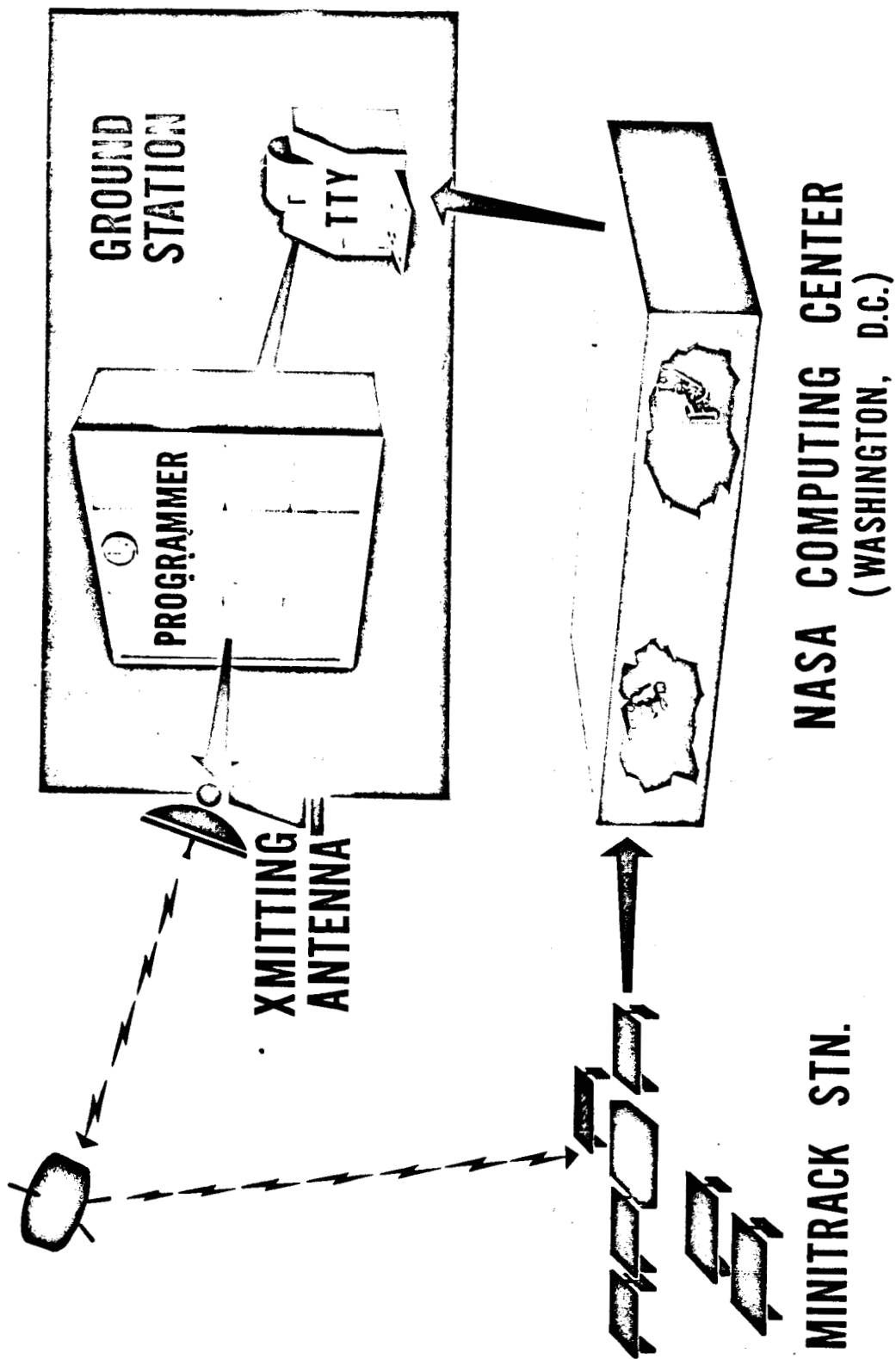
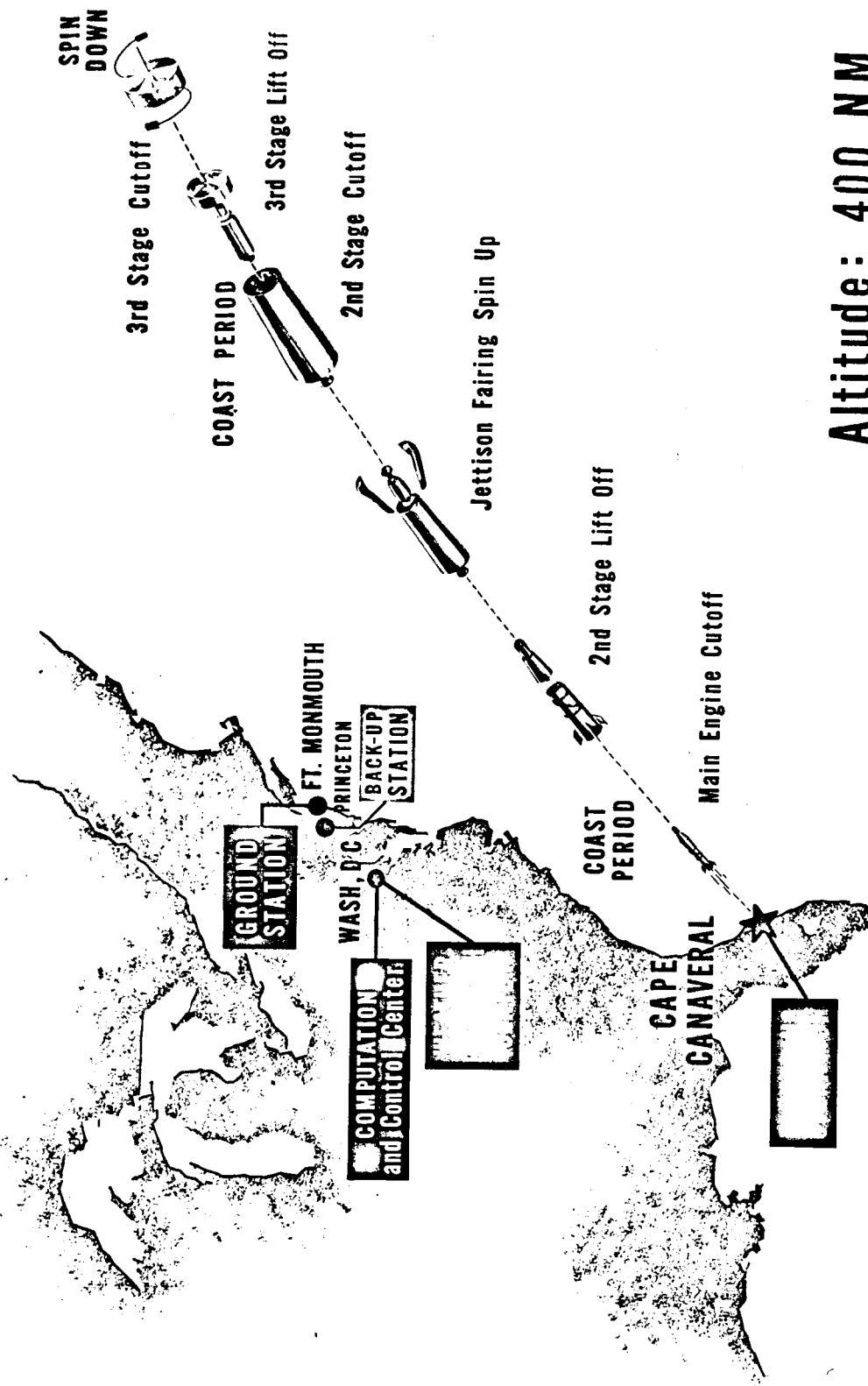


FIG. 8

# PROJECT TIROS OPERATIONS...



Altitude: 400 NM

MC 58-1671

FIG 9

## ILLUSTRATIONS

Figure	Description
1	"Active" Precession Damping Device (on Test Fixture)
2	Model of 20-lb. Janus Satellite
3 <del>3A</del>	Optical System for Reconnaissance Satellite
4	Weight and Cable Spin-Rate Reduction Device (on Test Fixture)
5	Full-size Model of Juno 85-lb. Satellite
6	The TIROS I Satellite
6A	The TIROS Satellite (Payload) Electronic Components
7	The Ground-Based TV Picture Subsystem
7A	Pre-Launch Handling of the TIROS Satellite
8	The TIROS Satellite Tracking Complex
9	The TIROS Satellite System Launch and Control Operations