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FEASIBILITY STUDY FINAL REPORT

GEODETIC ORBITAL PHOTOGRAPHIC SATELLITE SYSTEM

VOLUME 5 PROGRAM PLAN, PHASES 2 THROUGH 5

JUNE 1966

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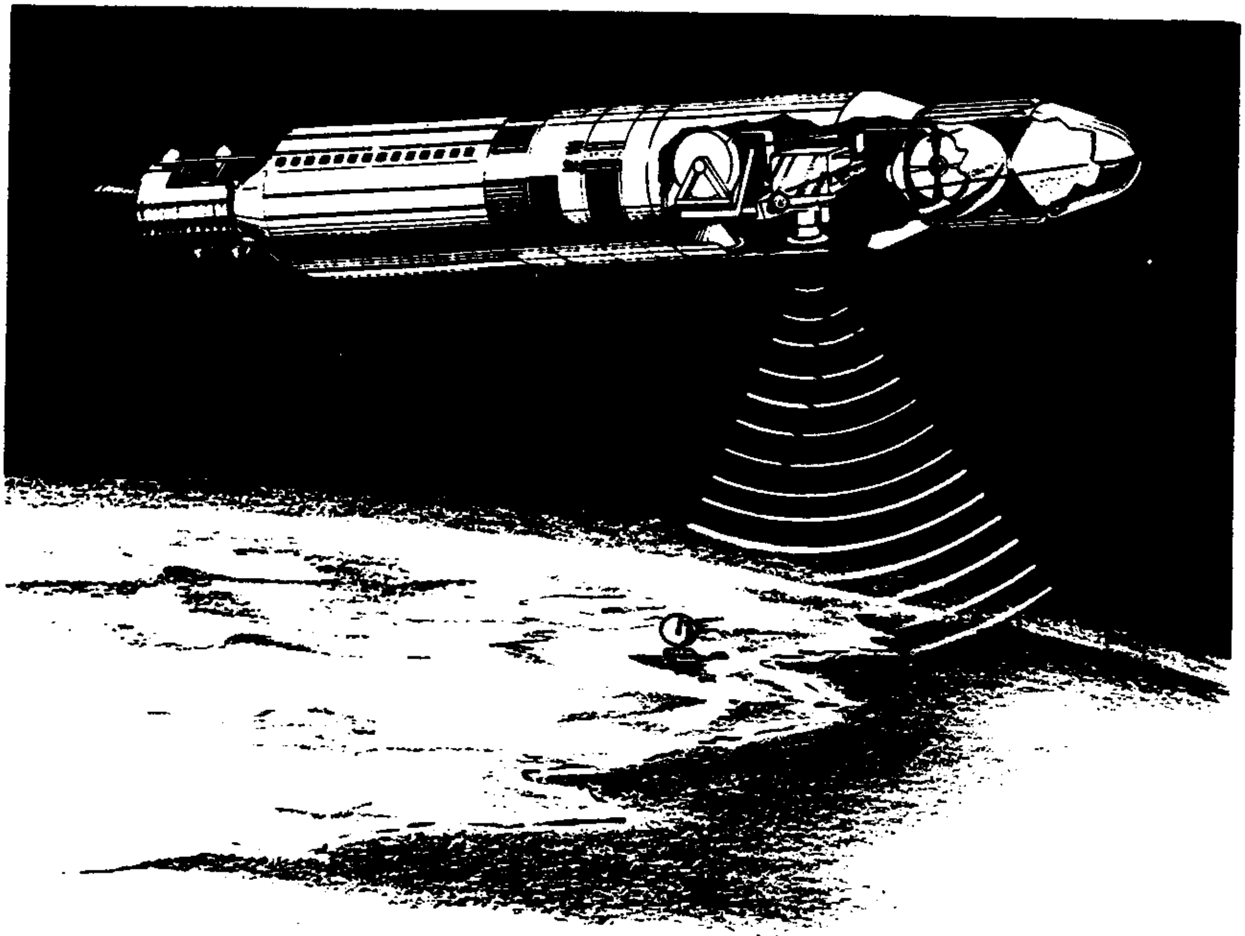

Geodetic Orbital Photographic Satellite System

PREFACE

The objective of the Geodetic Orbital Photographic Satellite System (GOPSS) is to accurately determine the location of landmarks widely distributed over the earth's surface and provide better information concerning the geophysical parameters which affect this system and other systems operating at similar altitudes. The means chosen to accomplish this objective is to orbit a series of data acquisition systems supported by ground-based instrumentation. The data gathered by this system is incorporated into a sophisticated data reduction scheme which determines the geodynamic parameters and landmark locations.

Detailed studies were conducted to determine the feasibility of the GOPSS. The study period was designated as Phase I, and the results of these studies have been compiled into five volumes for reader convenience.

This volume describes the planning activity as it has been programmed through Phases II to V for the engineering, fabrication, and operational support for the delivery of five systems. Continuing studies which are required are also defined in this volume.

The division of the remaining volumes and their content are now briefly described for information and reference purposes.

Volume 1, Program Compendium and Conclusions, was prepared to provide briefly the details essential to a comprehensive understanding of the effort conducted during Phase I of the GOPSS feasibility study. System concept and objectives are described plus conclusions which concern the attainment or modification of the initial objectives, along with recommendations for a system configuration and a solution of the attendant data handling problems.

Volume 2, Data Collection Systems, describes the effort for implementation of the data acquisition requirements for the GOPSS program. This volume presents the preliminary design which defines and describes the various sensors, considers their functional interdependencies, and shows their evolvement into an integrated GOPSS.

Volume 3, Data Processing, Part 1, considers the photogrammetric data subject to constraints imposed by orbital and auxiliary data, the mapping capabilities of the system, and ground handling of mission photography.

Volume 4, Data Processing, Part 2, discusses orbital considerations affecting the feasibility of the GOPSS. Physical models and computational procedures are reviewed and error studies involving typical sensor and model inaccuracies are described. Based on these studies, recommendations are made for tracking networks, auxiliary on-board sensors, and detailed orbit plans. In addition, the data reduction procedure, whereby the acquired data are simultaneously located to yield geodynamic parameters and landmark locations, is considered.

SUMMARY

Phases II through V describe the implementation of the results of the Phase I feasibility study into an operational Geodetic Orbital Photographic Satellite System (GOPSS) payload configuration. The following phases are defined separately to permit efficient program management and control funding allocations. Although separately defined, many program requirements are interwoven among the phases to ensure total program accomplishment.

Phase II of the program plan develops the final design of the photosensor and auxiliary sensors, the data collection module, and the general design requirements of the recovery section. Tasks performed during this phase are system engineering and design, design of tooling and test equipment, breadboarding and test of critical assemblies, generation of design specifications for AGE, auxiliary equipments, and the recovery section.

Phase III consists of four primary tasks: production, testing, and qualification of the first photosensor; final design of the recovery section; fabrication of tooling associated with Phase III; and design of AGE and MAB specifications.

During Phase IV, the second photosensor and the first recovery section are produced; in addition, auxiliary sensor equipments are procured. The photosensor and auxiliary sensors are integrated as a system, and the system is subjected to a qualification test program. After completion of the qualification tests, the system is refurbished for delivery as one of the operational systems.

Three new flight systems will be produced during Phase V. Acceptance tests will then be performed on these three plus the two from previous phases which will be refurbished. The five systems will be delivered at two-month intervals. Also auxiliary ground equipment will be produced, missile assembly building construction will be monitored, and field service operations will be initiated.

Extensive functional or baseline, environmental, and calibration testing which is required to ascertain the suitability of the system for launch will be conducted. Also described are equipments required to perform these tests.

Strict and efficient management is required to implement a program of this nature. A detail management phase which discusses scheduling, project organization and control manpower requirements, and the facilities required to implement the GOPSS program is therefore provided.

5.1 INTRODUCTION

The study to establish the feasibility of locating landmarks over the earth's surface to high accuracies from data collected by an orbiting vehicle has been successfully completed. The analyses concluded that the TRANSIT tracking network, supplemented by selective photogrammetric and other inputs, would adequately describe the orbit from the accumulation of data from five missions, and that once the subsequent vehicle positions were determined, photogrammetric techniques would then permit landmark locations to the specified accuracies of 200 feet in the horizontal and 40 feet in the vertical direction.

In addition, to ensure compatibility with the prescribed operational environment, a preliminary design study was conducted, illustrating the employment of the various data collection systems that the systems analysis determined to be necessary. This task, in addition to generating the specifics of individual sensors, fully considered the functional interdependencies of these sensors and evolved an integrated payload concept, the implementation of which is described in the body of the program plan for the continuing phases of the GOPSS.

Within this integrated concept, a payload system responsibility in which all equipment forward of the Agena has been considered a single assembly has been developed. This assembly, composed of the section containing the data collection sensors and a dual recovery section, is shown in Figure 5-1. This volume described a four-phase plan which fully designs, manufactures, integrates, tests, and assumes field responsibility for this integrated payload. It implies the availability of recovery vehicles and TRANSIT transmitters as GFE. As part of the initial design phase, substantial breadboarding of critical elements is contemplated. This breadboarding is followed first by a qualification model of the critical photo-optical sensor and then by a qualification model of the entire payload as herein described. Finally, a manufacturing and qualification model refurbishment program is developed to produce a total of five operational payload systems, and a field engineering activity is programmed.

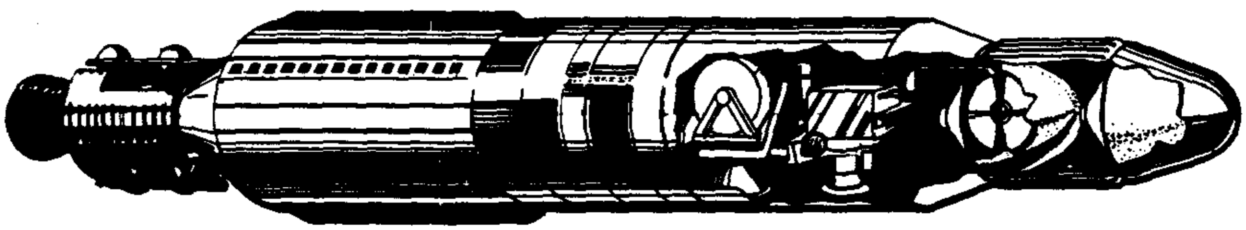

Fig. 5-1 — Geodetic orbiting photographic satellite system

5.2 PROGRAM DESCRIPTION

The Phase II through V Program Plan describes the implementation of the results of the Phase I software feasibility study into an operational payload configuration to accomplish the objectives of the GOPSS program. Figure 5-2 is a family tree of the payload configurations. The various segments encompassed in this task are design, breadboarding, fabrication, integration, testing, and field service, all of which are woven into an efficient flow by strict management control. Best engineering practices are reflected in this plan to (1) design and take all necessary steps through to actual operation, and (2) to construct the advanced equipment necessary to gather the required data. Design tasks are strengthened by breadboarding during the design phase. Test procedures have been developed for comprehensive debugging during fabrication and assembly. Integration test programs facilitate orderly system integration with formal qualification and acceptance tests programmed to make the most economical use of test facilities during the short schedule. In general, all program events follow a sequential order which permits design modifications that result from testing to be implemented without schedule slippages. This order is reflected in the division of the program into four phases following the presently concluded feasibility phase. Although these phases are separately defined, many requirements are interwoven among the phases to ensure total program accomplishment. However, these four phases have the necessary separation of effort to permit efficient program management and control of funding allocations. A Phase II through V schedule is shown in Figure 5-3.

Phase II is devoted primarily to the design of the GOPSS payload and the breadboarding of critical designs. Figure 5-4 is a schedule of Phase II effort. Included are designs for the cameras, DCM structure, and film transport system, generation of auxiliary sensor specifications, and a general design of the recovery section. Support to this design function includes a configuration control effort, necessary interface liaison, construction of a mockup, design of Phase III special tooling, formal test program specifications, and the initiation of the reliability program. Breadboarding is started immediately using Phase I design information. Sufficient notification of the choice of recovery vehicle will permit design of the recovery section during the 10 months of Phase II. All design tasks during this phase terminate in complete drawings and specifications for all of the GOPSS except the recovery section.

Procurement of glass blanks for lens manufacture is an initial requirement of Phase III, which is primarily devoted to the fabrication, assembly, and qualification testing of a complete photosensor system. Phase III effort is actually initiated during Phase II to allow immediate fabrication of photosensor parts. During Phase III, tooling and test equipment are fabricated, the final recovery section design is completed, and AGE design and MAB layout are accomplished.

Phase IV, which runs concurrently with Phase III, requires the fabrication, assembly, integration, and qualification testing of one complete GOPSS payload. The phase is scheduled so that system qualification testing follows Phase III qualification testing to permit design modifications, if needed, and judicious use of test facilities.

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FIGURES

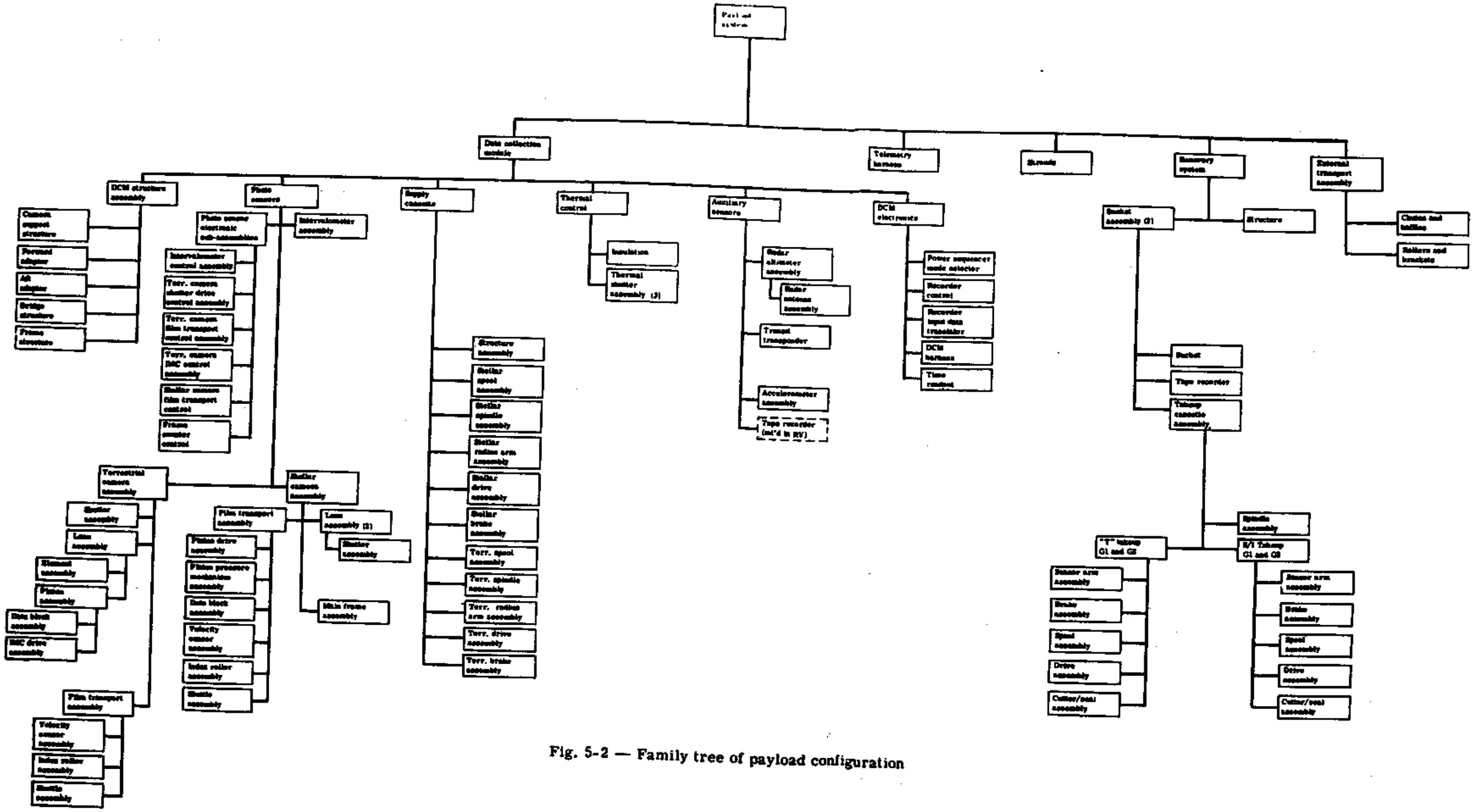

Fig. 5-2 — Family tree of payload configuration

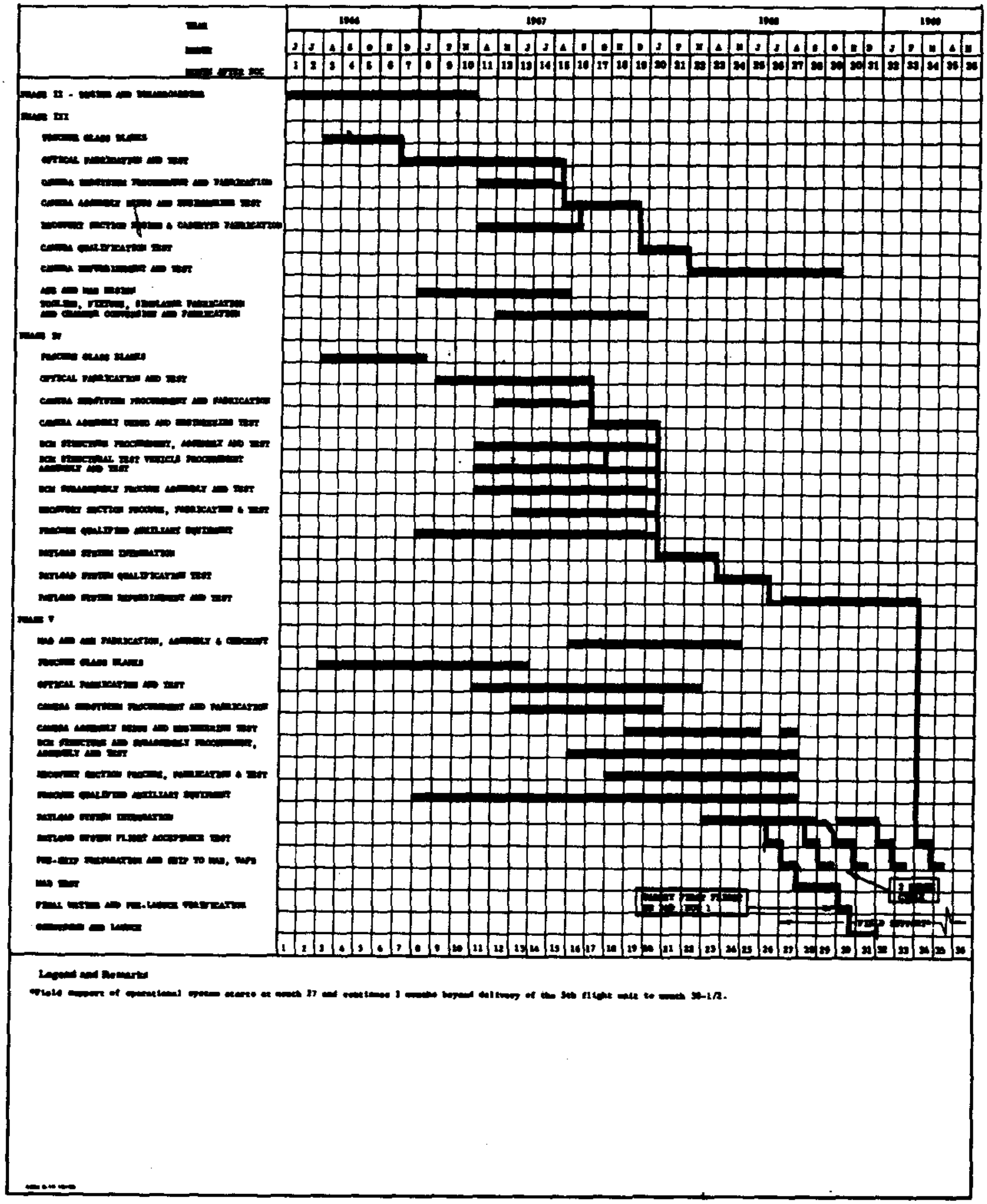

Fig. 5-3 — Phase II through V schedule bar chart

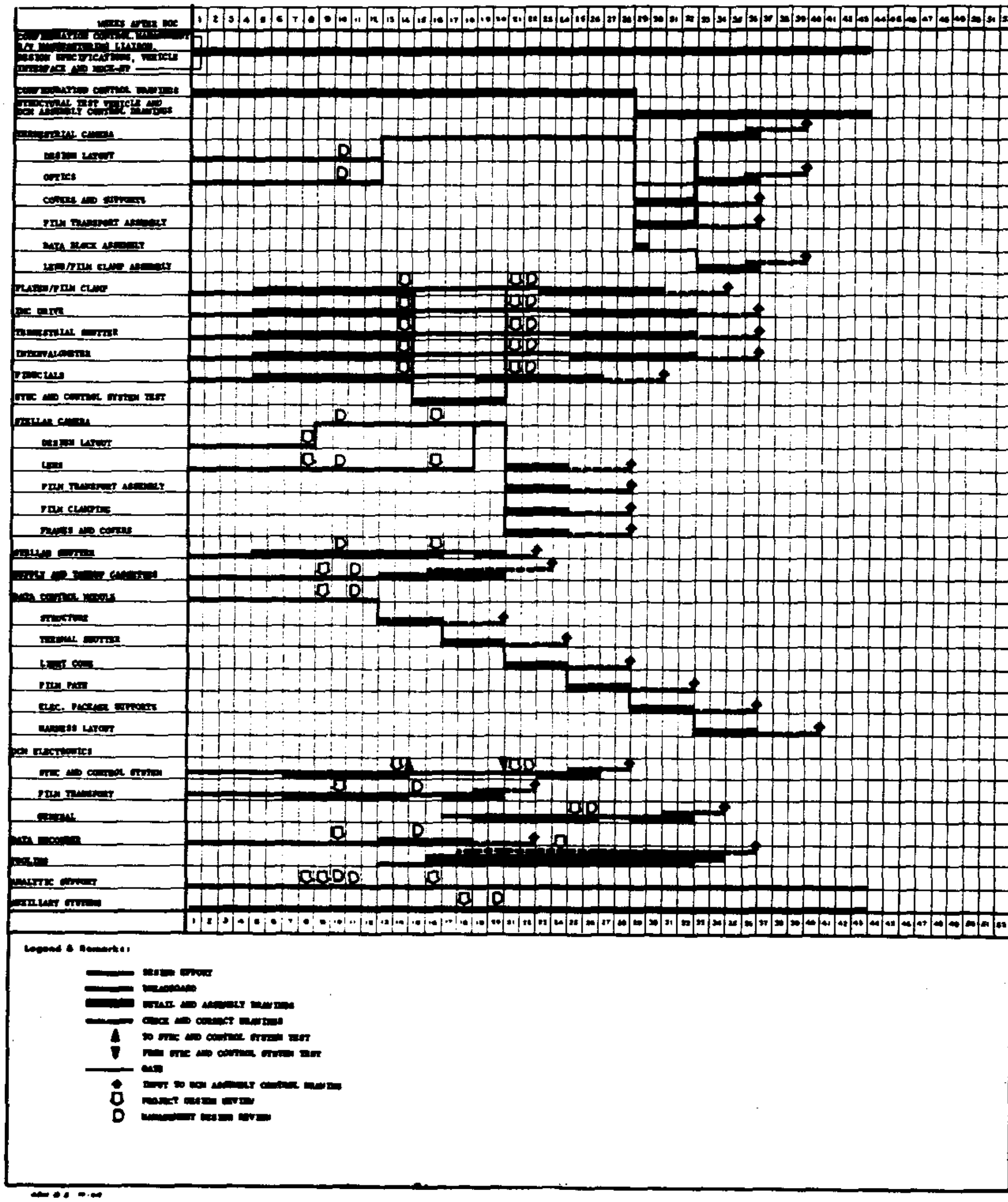

Fig. 5-4 — Phase II schedule bar chart

Phase V effort consists of the fabrication of three complete GOPSS payloads, the fabrication of a fourth to mate with the refurbished "qual" photosensor system, and acceptance testing of these four systems plus the refurbished "qual" system as the fifth deliverable flight system. Fabrication and test of AGE, MAB, construction liaison, and field support of launch site efforts are additional tasks under Phase V.

5.3 PHASE II DESCRIPTION

This section describes in detail the work which will be performed during Phase II. Major tasks performed during this phase are system engineering and design, design of Phase III tooling and test equipment, breadboarding and test of critical assemblies, generation of design specifications for AGE, auxiliary equipments, and the recovery section, and the construction of a DCM mock-up. A separate section has been accorded to this particular phase since it is the next step in implementing the GOPSS.

5.3.1 Scope

Phase II of this program will develop the final design for the Data Collection Module of the Geodetic Orbital Photographic Satellite System (GOPSS) and the general design requirements for the recovery section which were established in preliminary form in Phase I. To ensure proper work flow, maximum utilization of allotted time, and total program coordination, Phase II has been charted as shown in a summary PERT network, Figure 5-5. All critical assemblies will be breadboarded and integrated to determine design compatibility and eventual performance with respect to system requirements. After completion of the design effort and approval, both by Itek project and management personnel, detail and assembly drawings will be completed under a strict drawing configuration control. The final drawings will be an input to the DCM assembly control drawing for the procurement and fabrication of the GOPSS. Structural and thermal analytic support will be furnished throughout this phase.

Strict management configuration control will be administered to ensure the following activities: proper liaison between customer, vehicle manufacturer, and RV manufacturer; review and evaluation of system control and design specifications; completion of preliminary vehicle interface requirements; and generation of vehicle interface specifications. During the course of the program, a full scale DCM mockup will be built as an aid to the design effort and to provide proper interface between the various subsystems.

Major design areas which comprise the Phase II effort are as follows:

1. Terrestrial camera
2. Stellar camera
3. Supply cassette
4. Data collection module
5. DCM electronics design
6. Data recorder
7. Auxiliary systems

In addition, Phase III tooling and test equipment design as described in Section 5.3.1.2 will be required.

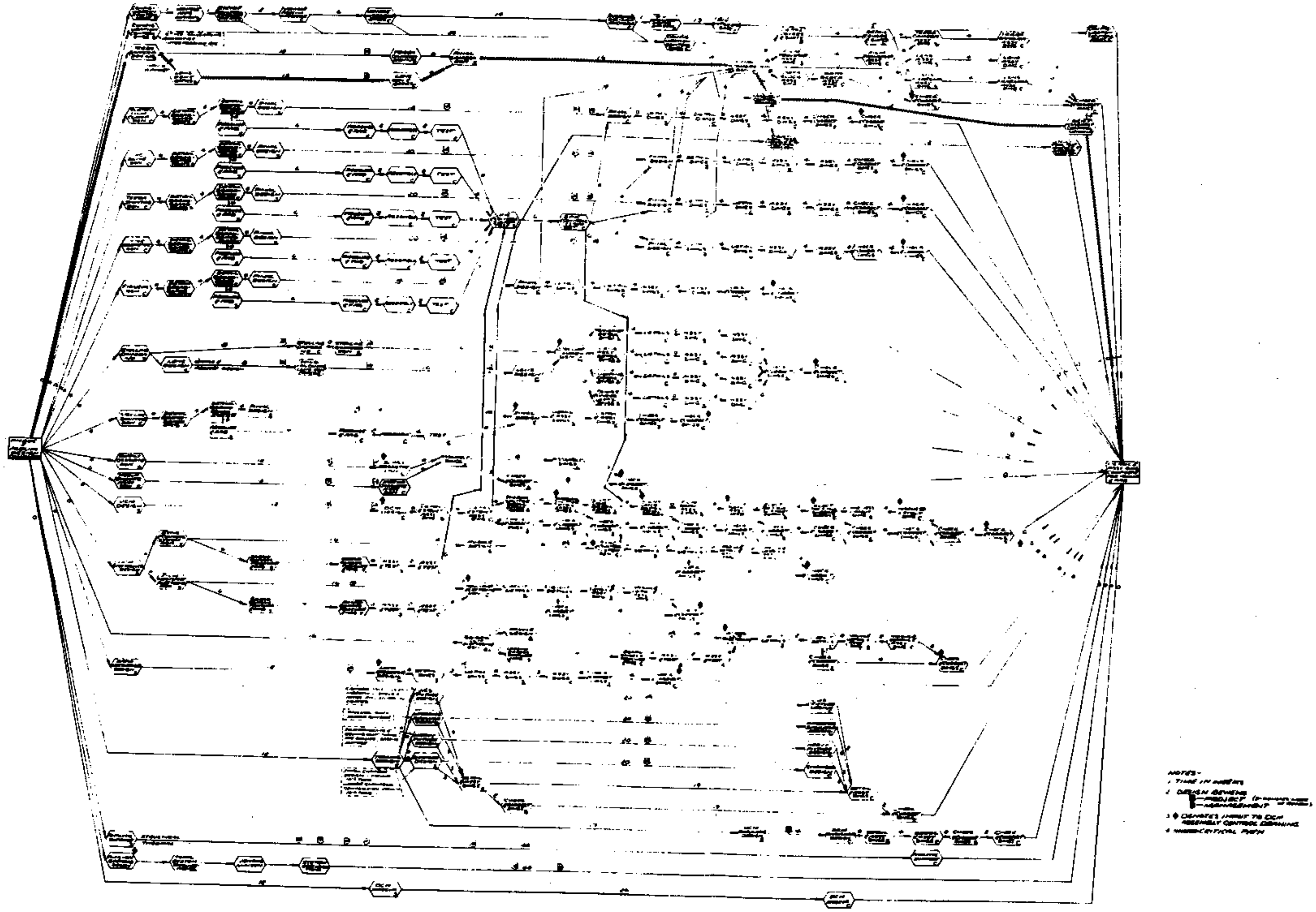

Fig. 5-5 — Phase II summary network

5.3.1.1 System Engineering and Design

5.3.1.1.1 Terrestrial Camera Design

Terrestrial camera layout, including lens design and optics, will form the basis for the final camera design.

Individual design subtasks within the terrestrial camera structure include the platen film clamp, IMC drive, shutter, intervalometer and fiducials. These subtasks will all be breadboarded and integrated into a synchronization and control system test generated during the DCM electronics design effort. After completion of this test, any changes deemed necessary within the various subtasks will be incorporated into the final design; all subtasks will then be fitted into the final camera design. Once the final design is approved, detail and assembly drawings will be completed.

5.3.1.1.2 Stellar Camera Design

Stellar camera design will follow a design phase similar to that for the terrestrial camera. A layout will be initiated, and the Wild Falconar lens design modified to meet the requirements of the stellar camera. A subtask for the design of the stellar shutter will be performed, and the design will be breadboarded.

5.3.1.1.3 Supply Cassette Design

The supply cassette will be designed, and assembly drawings detailing the structure, spool, spindle radius arm, drive, and brake will be completed.

5.3.1.1.4 DCM Design

Initial effort during DCM design will result in detail and structural assembly drawings. During the course of this design task, detail and assembly drawings will be made for the thermal shutter, light cone, film path assemblies, electronic packaging supports, and harness layouts.

5.3.1.1.5 DCM Electronics Design

The DCM electronics design effort is basically divided into two areas: (1) the synchronization and control system, and (2) the film transport electronics. Both are concerned with the electronics required for the photosensor operation.

Electronics included under the synchronization and control systems are the shutter, IMC drive, and intervalometer servos, plus a matrix which uses the V/h and t_e signals to govern the speed ratios of these servos.

Electronics included under the film electronic transport design are the spool servos, shuttle servo and relay controls for speed regulation, and the calibration film sensor.

The synchronization and control system will be breadboarded and integrated with the other breadboards to perform the synchronization and control tests. During these tests, modular design will be implemented for the electronic circuits. After the test, circuit details will be completed, and module and detail assembly drawings provided.

General DCM electronic design will be initiated in the sixteenth week of Phase II. This effort will be concerned with the electronics which join the photosensors, radar altimeter, accelerometer, and TRANSIT transponder. Also included are the mode control circuits which tie into the system power and control lines to provide proper operational sequencing. A data readout electronic system will also be designed to transfer individual component readouts to the film data block or to the recorder.

5.3.1.1.6 Data Recorder Design

A mission recorder design will be initiated since available hardware does not meet system power requirements at the present time. This will be a design of a film recorder utilizing a light diode array.

5.3.1.1.7 Auxiliary Systems

Auxiliary systems design is concerned with those systems required for operational suuport: the radar altimeter, clock, TRANSIT, accelerometers, data recorder, and signal conditioner. Evaluation of total system requirements, vendor liaison, and generation of specifications will be accomplished during this design effort period.

The effort is largely one of liaison with the end product a set of procurement, technical, and test specifications for each system. It is expected that vendors for these auxiliary systems will not be required to engage in an actual design effort during this phase, but instead will perform the engineering work necessary to support the specification and control drawing generation.

5.3.1.2 Design of Phase III Tooling and Test Equipment

Tooling design will be initiated during the twelfth week of the program. Design items will include manufacturing jigs, assembly and environmental test fixtures, a payload/photosensor interface simulator, heavy fixtures, and environmental chamber design and conversion.

Jigs and fixtures are required for the assembly of both the terrestrial and stellar cameras; also required are vibration fixtures for the shock and acceleration tests, and shipping crates for the spools and system.

The payload/photosensor interface simulator will be a console which will provide an electrical interface with other payload systems.

Heavier fixtures to be designed are a film handling and rewind unit, handling dollies for the cameras and takeup spools, and a photosystem spatial fixture. A commercial film processor will be converted to handle the system spool sizes.

The following are descriptions of some of the key Phase III tools and test equipment used from assembly through qualification testing. They are referred to extensively in the sections which describe Phases III, IV, and V when their use is required.

5.3.1.2.1 Assembly Fixtures

The film supply cassette assembly fixture and dolly permits assembly of the cassette at a convenient working height. The dolly is equipped with casters for transporation of the supply cassette to other assembly areas (see Figure 5-6). It is a pipe and flange construction with a plywood top. The cassette frame may be fastened to brackets on the top and the assembly built up from this point.

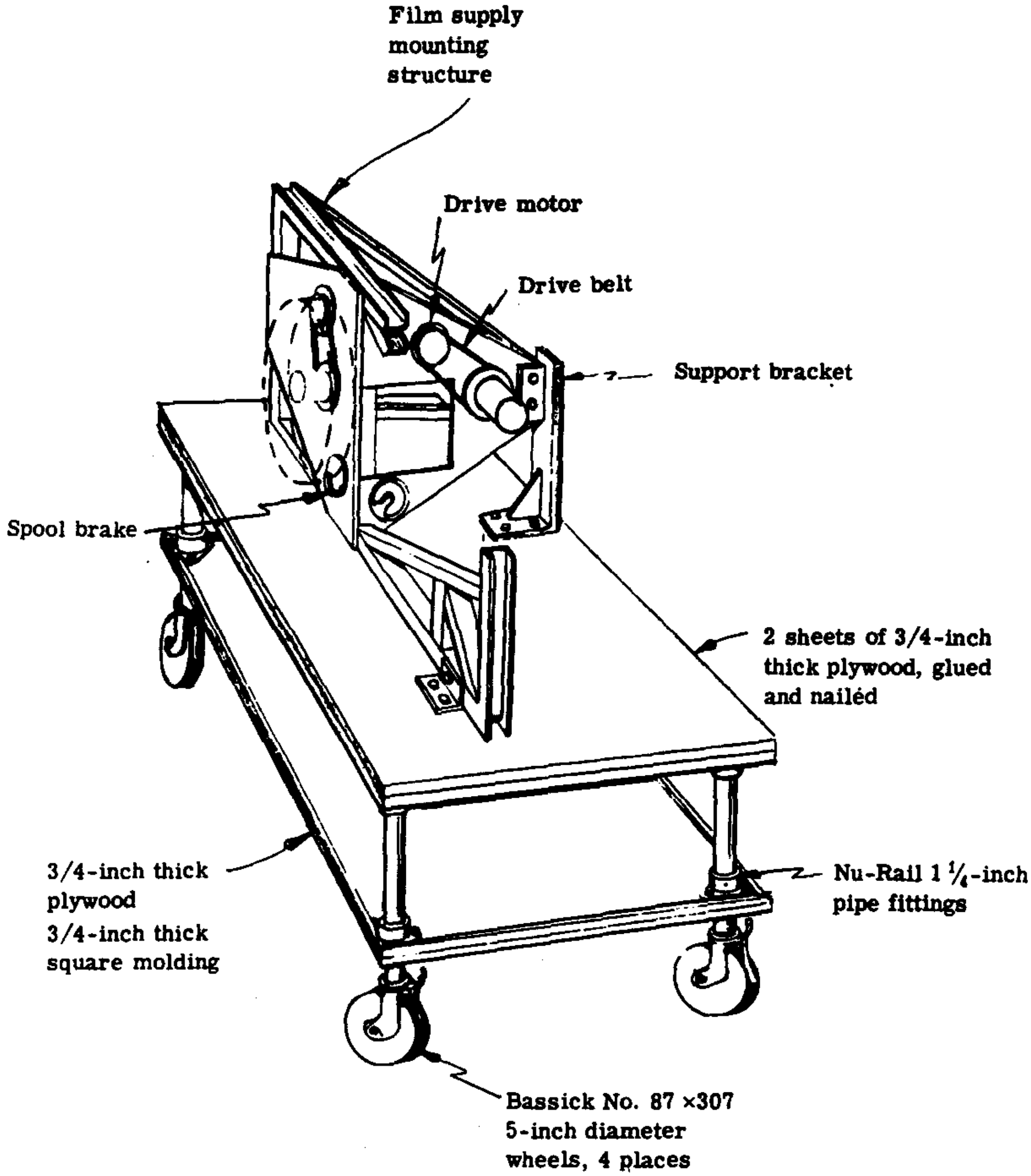

Fig. 5-6 — Film supply cassette assembly fixture and dolly

The terrestrial camera assembly fixture and dolly (Figure 5-7) permits mounting of the terrestrial camera during assembly at a convenient working height. It has a single gimbal mounting frame for rotation of the camera to permit easy access. It is also equipped with casters for mobility.

5.3.1.2.2 Spatial Frame

This device is a framework on which the cameras, cassettes, shutters, and electronic modules may be mounted to simulate the spatial arrangement of these components in the payload structure (Figure 5-8). This simulation will permit the establishment of a film path. The unit will have a harness similar to that of the payload and will be made a collimator with a target drive. The collimator will be used to provide an image for the IMC verification. The design of the spatial fixture will be such that the photosensor system can be checked in the assembly areas while in a horizontal position, and will also fit within the environmental chamber in a vertical position.

5.3.1.2.3 Collimator and Target Drive Assembly

This device consists of a 24-inch focal length, f/8, (3-inch aperture), collimator with a target drive (Figure 5-9). It is a single unit construction, i.e., the drive and collimator are housed in a single assembly. The target drive subassembly consists of a servo-driven wheel approximately 7.60 inches in diameter and a velocity pick-off to provide V/h signals through the photosensor/payload simulator or the AGE to the photosensor system. A series of standard Air Force resolution targets are placed on the surface of the wheel, which is located tangent to the focal plane of the collimator. When illuminated and moving, the targets provide a moving image to the terrestrial camera to verify IMC.

5.3.1.2.4 Erecting Dolly

The erecting dolly is used in the environmental test area for rotating the complete satellite system from a horizontal to a vertical position prior to mounting in the large chamber (see Figure 5-10).

5.3.1.2.5 Payload/Photosensor Interface Simulator

This device provides an electrical and control interface for the photosensor system similar to that of the operational installation. The following inputs are provided to the photosensor system from this console.

a. 28 vdc power
b. V/h signal
c. Exposure signal
d. Time signal
e. Altitude signal
f. Mode selection

The interface simulator is presently envisioned as a two-rack console. Although the V/h is generated within the console, the signal will control the rate of the target wheel in the target-collimator assembly, and a signal from its tachometer will provide the V/h rate for the photosensor system.

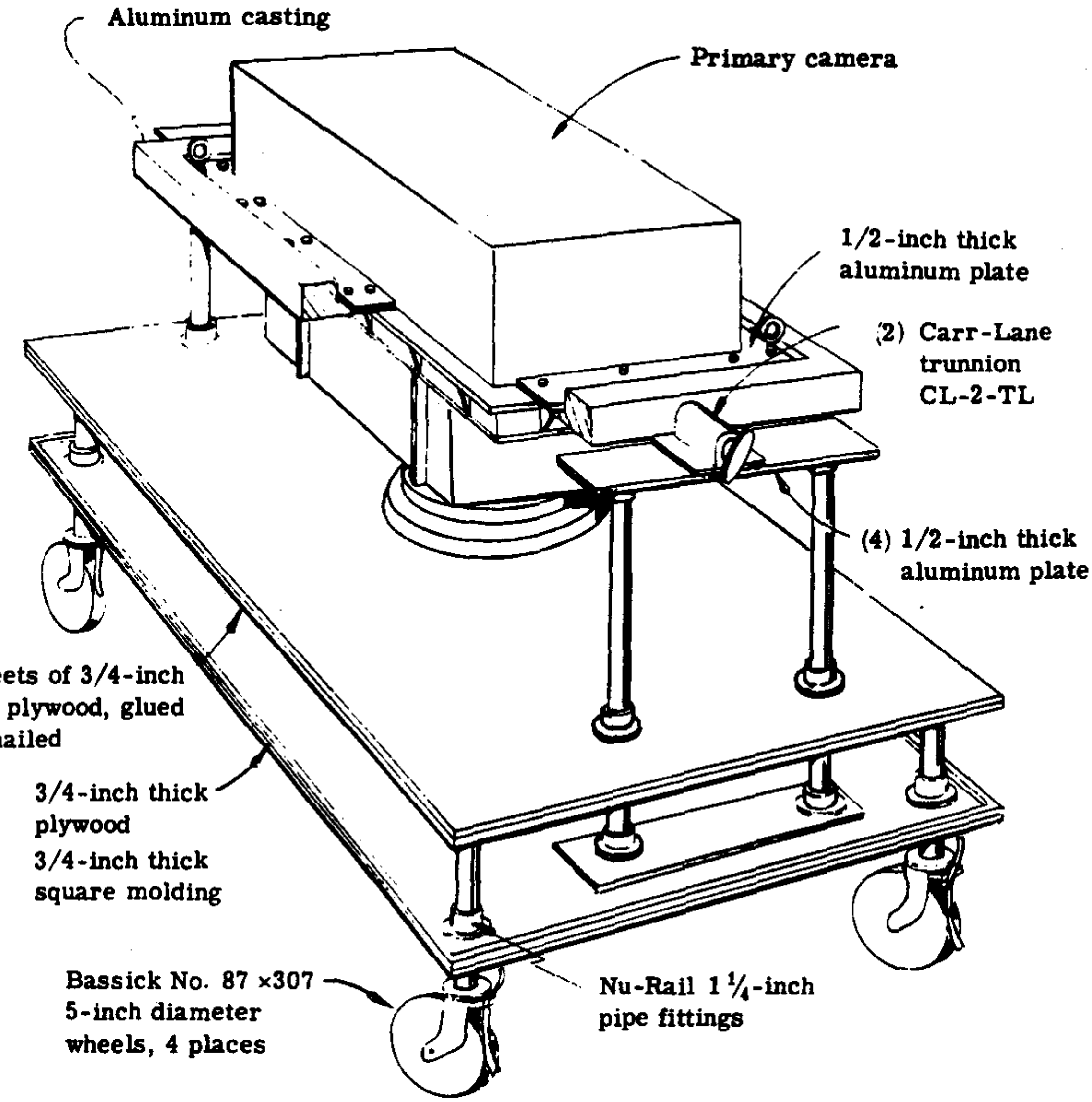

Fig. 5-7 — Terrestrial camera assembly fixture and dolly

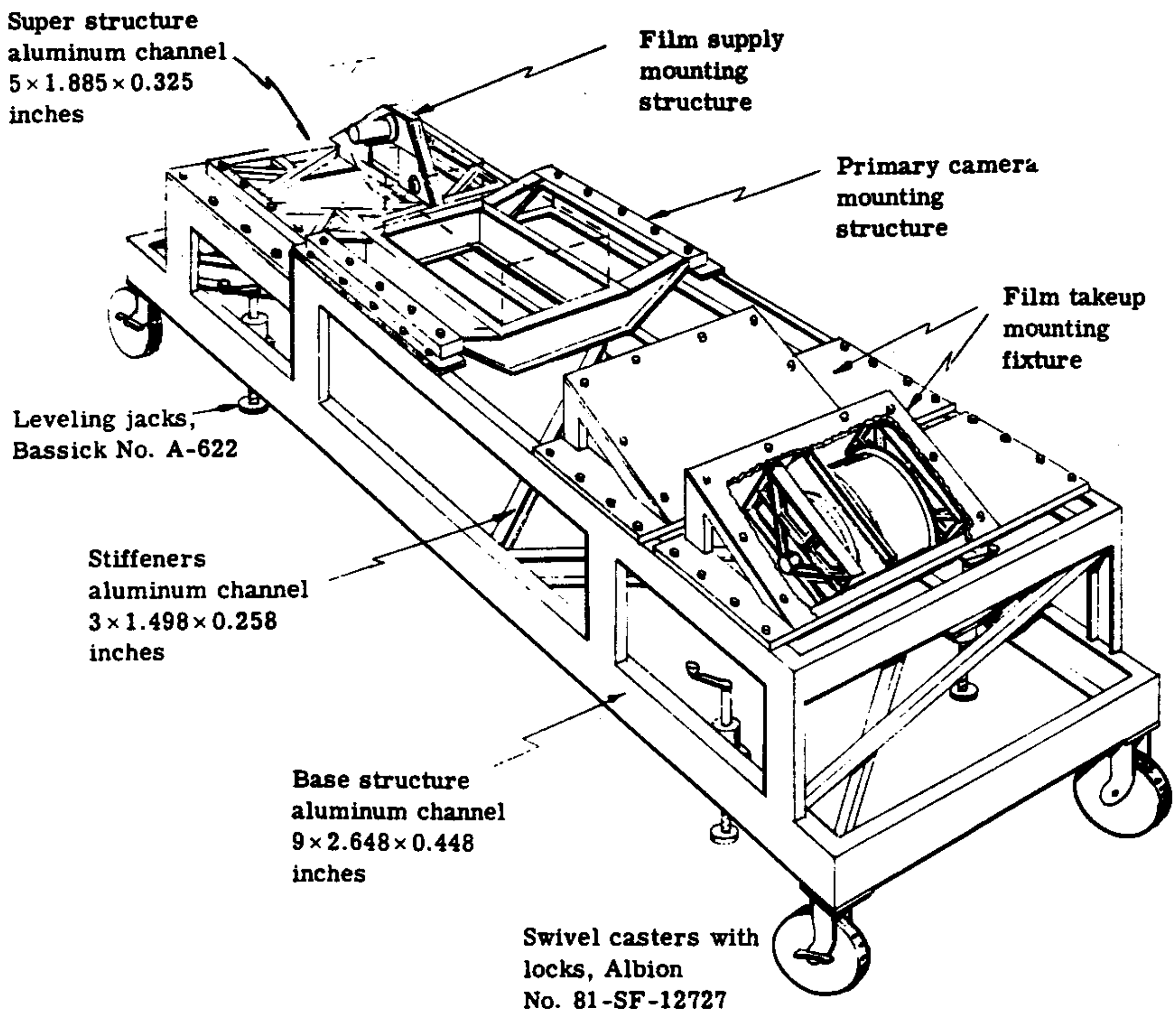

Fig. 5-8 — Spatial fixture

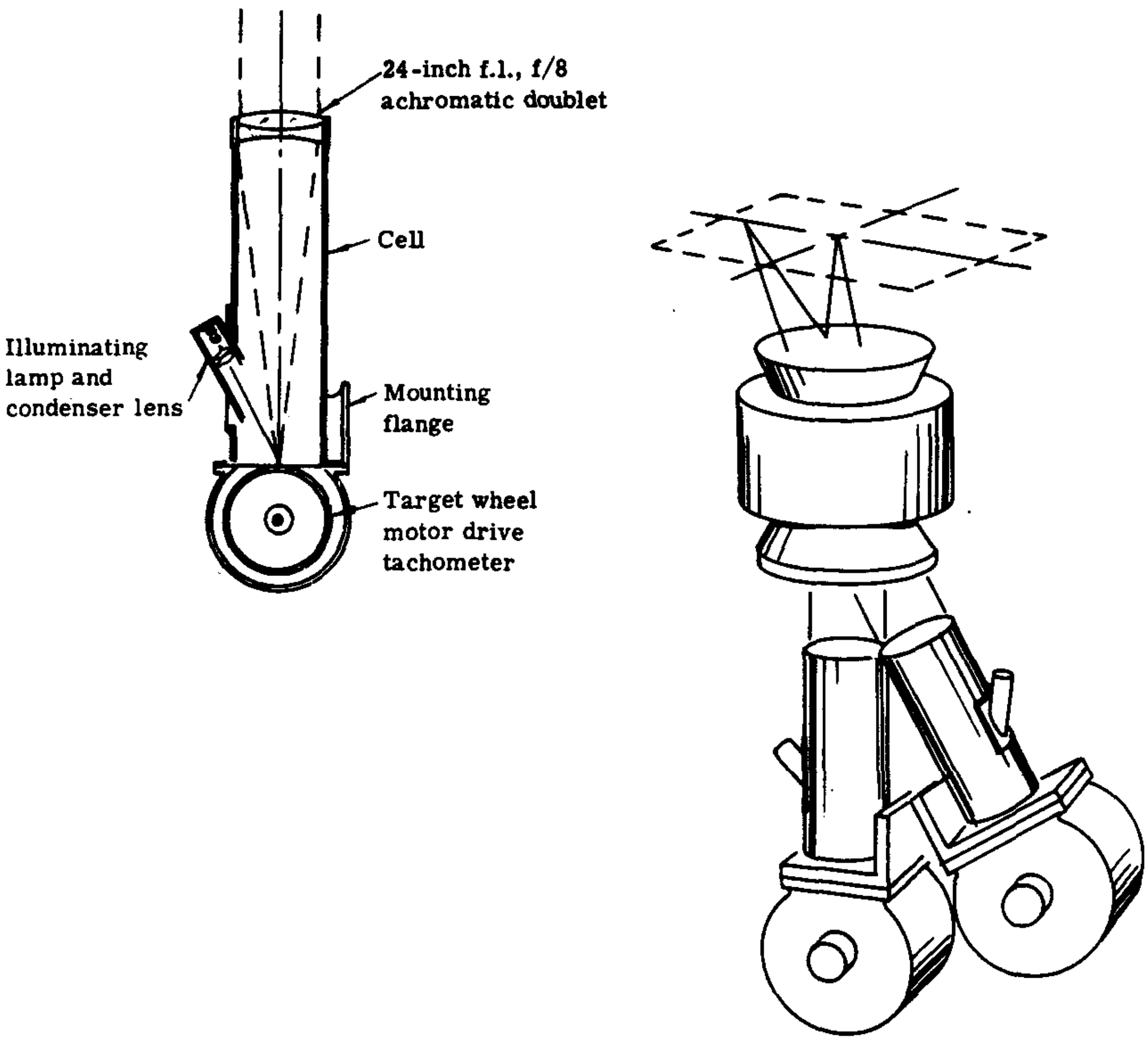

Fig. 5-9 — Collimator/target drive assembly

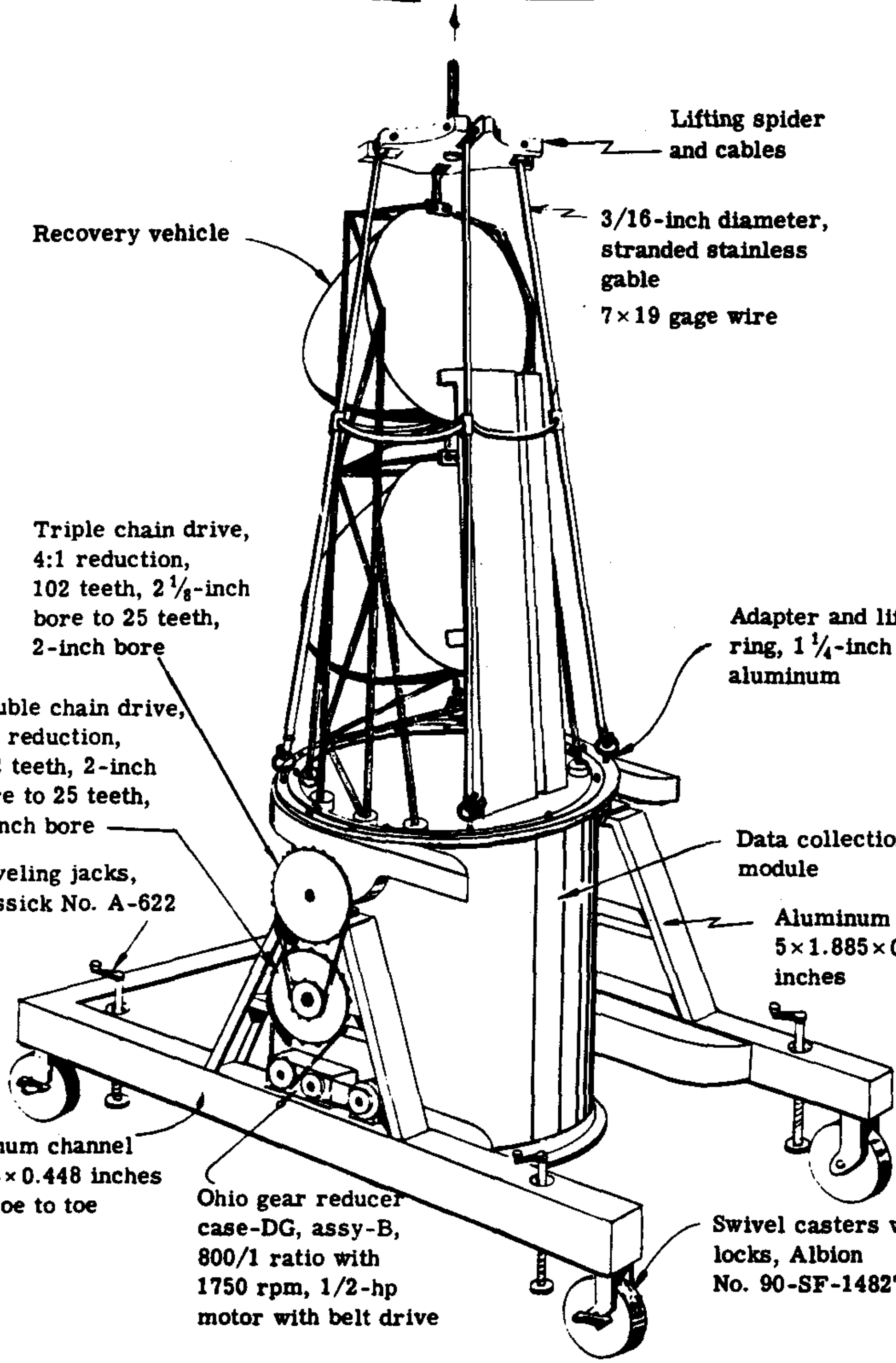

Fig. 5-10 — Erecting dolly

5.3.1.2.6 Shipping Containers

Shipping containers for the supply spools loaded with film (Figure 5-11), for the DCM, and for the RS (Figures 5-12 and 5-13), will be designed during Phase II. The supply spool containers will be constructed of plywood and light-tight; the DCM and RS containers will be aluminum, pressure sealed, humidity-controlled, and equipped with isolators.

5.3.1.2.7 Chamber Design and Conversion

Two chambers which will be designed during Phase II are required for the later phases of the program. One small chamber, basically a bell jar system, will be used for calibration of film distortion and the terrestrial-stellar camera knee angle. Vacuum requirements are 10^{-3} Torr. This unit will be approximately 6 feet in diameter and 6 feet high.

A large chamber is required for environmental testing and is presently available, but must be modified to meet the vacuum requirement of 10^{-6} Torr. It is a 50-foot vertical chamber, 9 feet in diameter. Its pump apparatus and fittings will be modified, and provision will be made to accommodate two small collimators external to the chamber.

5.3.1.3 Breadboarding and Test

Phase II breadboarding and breadboard testing will be undertaken primarily to evaluate the designs of critical hardware generated during Phase I. The assemblies which will be breadboarded are:

1. Terrestrial camera shutter
2. Terrestrial camera IMC drive
3. Intervalometer
4. Synchronization and control system electronics
5. Fiducial assembly
6. Platen and pressure mechanism
7. Stellar camera shutter

In addition, the electronics for the photosensor system will be breadboarded, not because these assemblies are critical but because this approach is common practice in electrical design. The breadboard approach consists of: (1) rough circuit layout, (2) breadboard, (3) test, (4) evaluation, and (5) final circuit design. The assemblies that will be breadboarded are as follows:

1. Film transport electronics and servos
2. General control electronics
3. Data recording system electronics

Where assemblies are to be breadboarded, the breadboarding and test efforts will run parallel with the design efforts. As knowledge is gained from testing, it will be reflected immediately in the formal design efforts.

5.3.1.4 Software Efforts

Special consideration will be given during Phase II to the generation of controlling specifications for auxiliary equipments, AGE design and manufacture, and to recovery section design scheduled during Phase III interface and configuration.

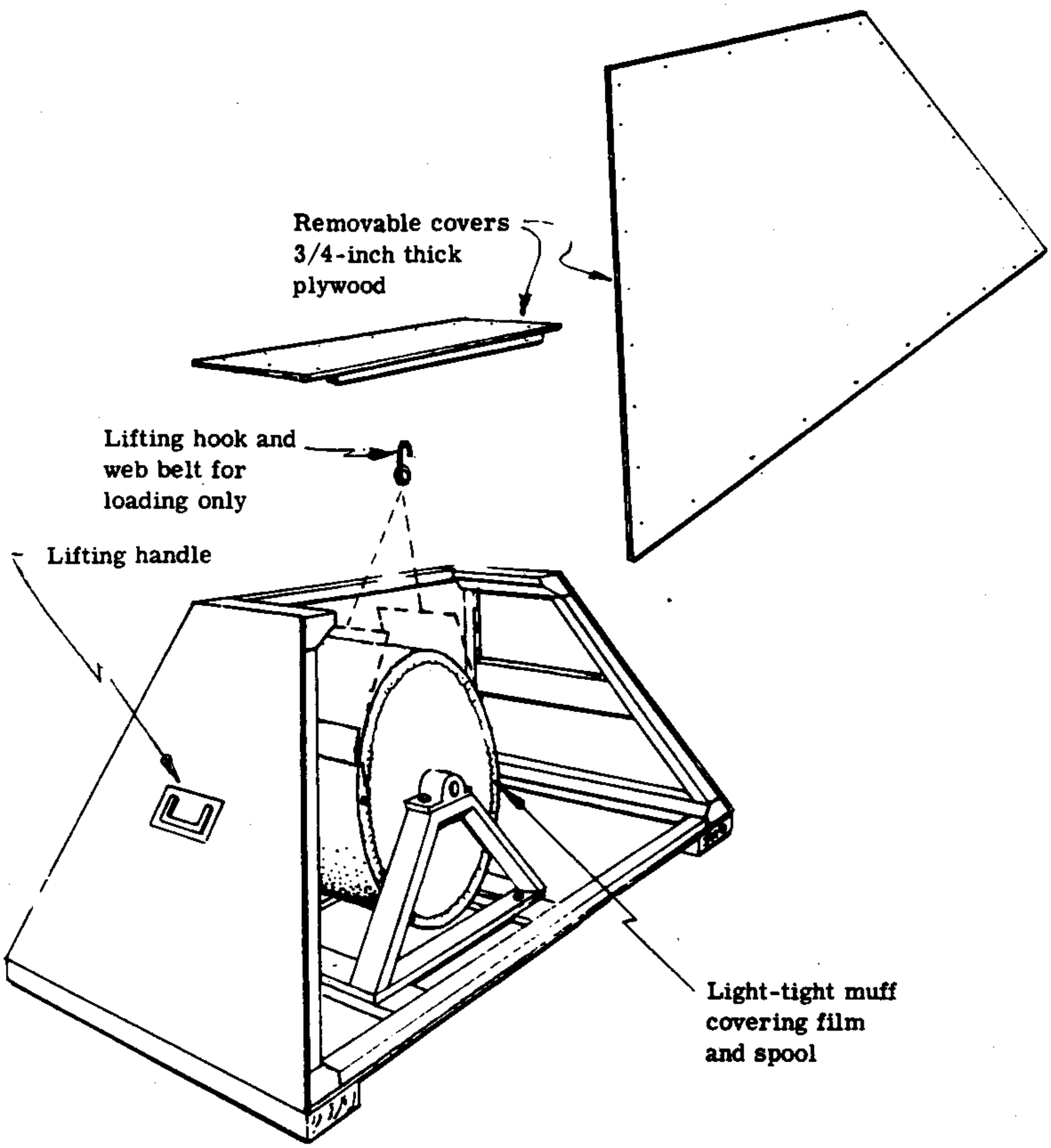

Fig. 5-11 — Film shipping container

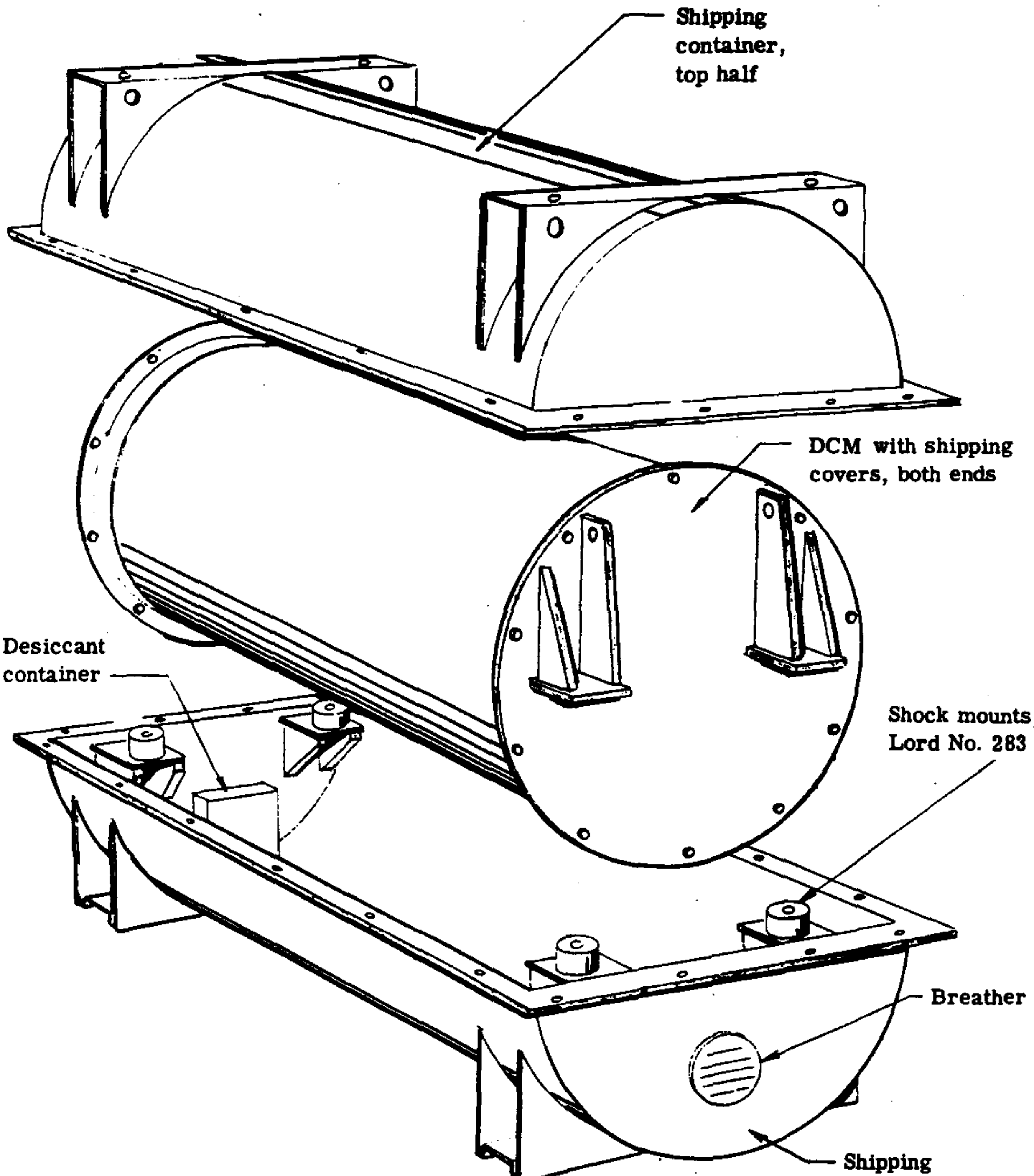

Fig. 5-12 — Data Collection Module shipping container

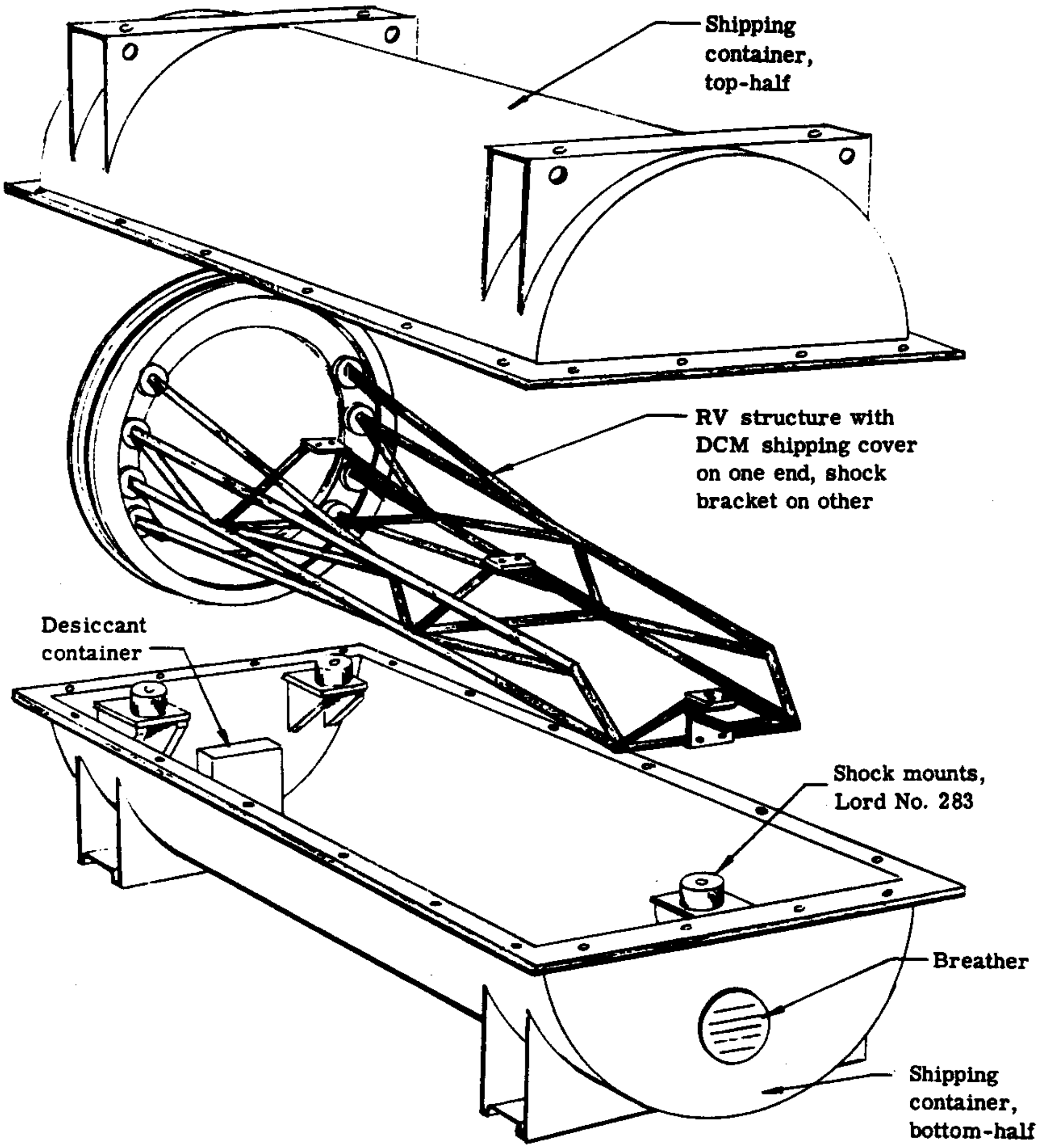

Fig. 5-13 — Recovery Section structure shipping container

The AGE specification effort during Phase II will develop design specifications to delineate functions to be controlled and monitored, by the vehicle-payload interface simulator console. Requirements for payload handling follies, photographic processing, viewing equipment, etc., will also be formally specified.

The recovery section design requirements will be documented as part of the system configuration control. It will be the prime responsibility of configuration control to document and maintain liaison on vehicle and other GFE interfaces, and to main an overall configuration drawing of the DCM. These interface problems include mechanical and electrical mating, control, assembly, and flight line integration, and all must be well defined by the end of Phase II. This configuration control group will also be responsible for developing and maintaining the weight and balance and power profiles for the entire payload system.

5.3.1.5 DCM Mockup

During the latter portions of Phase II and prior to completion of the major drawings, a DCM mockup will be constructed. This will be a full size nonfunctioning model fabricated of wood and metal. It will serve as a reference for the designers, for checking interferences, and as an aid in wiring and harness layouts.

5.4 DESCRIPTION OF PHASES III, IV, AND V

5.4.1 Scope

During Phases III, IV, and V, five payload systems are fabricated, assembled, integrated, qualification tested, acceptance tested, and delivered ready for mating with the Agena and booster. Each of these three phases serve different purposes leading to the eventual delivery of the five flight systems.

In Phase III, one photosensor system consisting of the terrestrial and stellar cameras' supply cassette, two takeup cassettes, and an electrical control system is fabricated, assembled, qualification tested, and refurbished for use in the fourth flight system. From the eleventh through seventeenth month, final design of the recovery section is completed, test tooling fabricated, and formal AGE design and MAB specification completed.

The first complete satellite system will be fabricated, assembled, integrated, and qualification tested in Phase IV. Each of the four major subsystems—photosensor, DCM structure, recovery section, and auxiliary equipment—will be run through acceptance testing prior to integration as a complete system. After qualification testing, this system will be refurbished as the fifth flight system. This phase starts in the 11th month and ends with refurbishment in the 33rd month. In addition, the AGE sets are fabricated during this phase, and the first set is discussed in the 20th month.

Phase V involves the fabrication, assembly, integration, and acceptance testing of five flight systems, starting in the 12th month and ending in the 36th month. MAB construction is completed during this phase in the 25th month just prior to delivery of the first flight system at Vandenburg AFB.

These three phases are functionally separate and are kept so for accounting purposes but in reality, they are run concurrently in an attempt to meet a November 1968 launch date. The schedule has been designed to meet the following milestones in serial order to maintain continuity despite the overlap.

1. Photosensor system qualification complete
2. Payload qualification complete
3. Delivery of five flight systems

A brief description of the functional baseline tests used during Phases III through V are described at this point, since an understanding of them is required before the following sections become meaningful to the reader. The details of these baseline tests are provided in Section 5.5.

The functional baseline tests are used as follows: (1) during assembly to perform debugging; (2) prior to qualification or acceptance testing to verify in-tolerance operation before testing; (3) after qualification and acceptance testing to determine if the hardware has deviated from specifications as a result of such testing; and (4) as a preflight check. There are two types of baseline tests for the GOPSS program; the first is called the Photosensor System Baseline Tests (PSSBT), and the second is called the Integrated System Baseline Tests (ISBT). During Phase III, only the PSSBT are used, since the photosensor is being fabricated and qualified during this phase. Both types of tests are used during Phases IV and V.

5.4.2 Phase III

Phase III consists of the following four primary tasks: (1) production, testing, and qualification of the first photosensor; (2) the final design of the recovery section; (3) the fabrication of tooling associated with Phase III; and (4) the design of AGE and MAB specifications.

5.4.2.1 Production, Testing, and Qualification of the First Photosensor

This task comprises the fabrication, procurement, assembly, and debugging of the terrestrial camera and the stellar cameras. The unit is then given a comprehensive engineering test; following this, a qualification test program is performed, and the qualified photosensor is subsequently refurbished. Since the manufacture of the optical components is in the initial critical path portion of the PERT analysis, a detail description of the optical manufacture is included after the discussion of terrestrial camera production.

5.4.2.1.1 Production

1. Terrestrial Camera

The terrestrial camera assembly comprises four major subassemblies and a number of supplementary components.

Initial effort concerns the production of the lens assembly. This is combined with additional elements to form the lens/film assembly. The lens assembly task is a combined project/optics section effort.

The several lens elements, the reseau grid platen, the lens cell, and various miscellaneous items such as the desiccator assemblies, and aperture plate, are procured and/or fabricated during optical manufacture. The bezel, the flexures, support guide posts, the light cone, etc., which are camera parts, are procured separately.

The lens elements are assembled into two sub-groups (forward and rear) and prior to final assembly, optical tests are required to assure optimum alignment. The two element groups are assembled into the central cell along with the desiccator assemblies and the aperture plate. The reseau grid is etched on the glass platen and measured, and the coordinate locations of the grid intersections are recorded. Glass contact photo-duplicates of the reseau pattern are also made as a permanent record.

After the glass platen has been completed, measured, and photo-copied, the glass and bezel are combined and the guide posts and flexures are added to form the platen/bezel subassembly. This completed lens assembly is given a series of optical tests to assure proper location of all elements and lens performance within specifications. The terrestrial camera shutter assembly is completed independently of the lens assembly.

The IMC drive and servo are assembled and debugged, and then assembled to the lens assembly with the platen pressure mechanism to form the lens/film clamping assembly. This assembly is placed on the distortion bench for final optical testing.

During this test program, the location of the focal plane is established at the correct distance and attitude relative to the lens nodal points for best photo-optical lens performance. Bench tests (both visual and photographic) establish the platen center dimension, and determine the EFL, BFL, resolution capabilities, and inherent distortions. During the test program, adjustments and alignments are made as required for optimum performance. All test data are recorded for future reference.

The film transport assembly consists of about fourteen hardware items including springs, dancers, switches, guide rollers, index roller, index drive, side plates, the shuttle subassembly, etc. In addition, the calibration film sensor, and the film velocity sensor assembly are components of the overall transport assembly. A special holding fixture (produced under the tooling sub-phase) is used in conjunction with the completed supply and takeup cassettes to test and debug the film transport.

After completion of the lens/clamping assembly test program, and test and debugging of the shutter and transport assemblies, the three units are combined with the main support, the covers, and the terrestrial camera cable harness to form the terrestrial camera assembly.

2. Optical Fabrication Procedure

As a part of the Phase I feasibility program, a feasibility lens system (described in Vol. II) is scheduled for completion in February 1967. At the time of this report, fabrication of this system was proceeding well; all elements were fine ground; spherical surfaces were polished; aspheric polishing had started, and special aspheric measuring machinery was available. In addition, lens system test facilities and apparatus are proceeding in pace with the optical element fabrication. It is anticipated that this experience and equipment will be directly applicable to the fabrication program herein described.

a. Glass Procurement and Element Generation

Glass blanks are received from the vendor and subjected to a rigid pre-acceptance inspection program wherein they are checked for bi-refingence strain, bubbles and homogeneity. If the glass meets or exceeds the specifications, it is accepted; if not, it is rejected and arrangements are made with the vendor to replace it with satisfactory material on a high priority basis. In addition to the physical inspection program, the melt data sheets, which contain pertinent lens design data such as index of refraction and dispersion, are analyzed for completeness and satisfactory characteristics.

When both glass and melt data have been found acceptable, the data are forwarded to the Lens Design Department for initiation of a procedure entitled "melt design." This consists of a redesign of the lens based on the actual glass data instead of the catalog (or theoretical) data. Often there is considerable variation between these two types of data, requiring design modifications to the optical system.

Completion of the "melt design" culminates in the production of final lens element drawings which serve to define the actual element configurations from which the elements are generated.

Element generation is a physical process whereby large amounts of glass are removed from the blank in a relatively short time. The generating machines, while rapid in action, do not produce the exact curvatures necessary for precision elements; therefore, the generating procedure is applied to "rough out" the elements to a general approximation of the final configuration, leaving the dimensions somewhat oversize so that the individual elements can be shaped to size by subsequent equipment and operations.

After completion of the generation task, the elements are ground, using grinding equipment and various size grit particles, to a very close approximation of the final configuration. Again this is oversize and is generally within 0.0005-inch sag accuracy as measured with a mechanical spherometer.

When the elements have been ground to an optimum configuration, they are lapped by hand and machine-lapping techniques, and are constantly checked against their test plates until they match the plates within the number of fringes specified by the lens designer's tolerance analysis.

After satisfactory completion of generation, grinding, and lapping, and when all physical inspection criteria have been satisfied, the elements are centered and edged down to their final outside diameters. After this, they are surface coated as indicated by lens design specifications.

b. Large Element Fabrication

Fabrication of the large elements (I, II, IX, X) for the GOPSS lens design will vary slightly from the normal Itek procedure.

Acceptance inspection and "melt design" will be performed on a regular basis and generation will be initiated. The generated configuration will be 0.030 inch greater than final center thickness (C_t), and 0.100 inch greater than the final outside diameter.

When generation is completed to the above specifications, the blanks will be transferred to Itek's optical shop where they will be ground, lapped, and polished to the specified regularity and power, and then edged to final OD. Final sag-to-flat dimensions will be accomplished when these dimensions have been established so that final calculation of the glass sag-to-flats will assure glass-to-metal cell contact; then the elements (with the exception of element II) will be coated with an anti-reflective film. In the case of element II, a spectral transmission filter is applied instead of the anti-reflective material.

c. Small Element Fabrication

Fabrication of the six small elements (III, IV, V, VI, VII, VIII) will vary more from the normal Itek procedure than the fabrication of the large elements. This is because the small elements are combined into two cemented triplets each having an aspheric surface ground into one face.

Acceptance inspection, melt design, and generation procedures will proceed normally with the generated configurations meeting the previously mentioned plus 0.030 inch C_t and plus 0.100 inch OD specifications.

Upon completion of the generating cycle, elements III, IV, VII, and VIII will be ground and polished in the small optics shop to specification power and regularity. This will be followed by edging to the specified OD, but sag-to-flats will be deferred until sufficient cell information is available for precise definition.

The generated elements V and VI will be initially polished to the aspheric "best fit" sphere, and then edged to the final OD. The lens will be aspherized in the small shop and the aspheric configuration will be verified by the aspheric measurement machine.

Upon completion of the aspherizing procedure, the spherical sides will be configured to the final C_t.

When all the configuration fabrication procedures have been completed, the six elements will be transferred to the cementing area. Here elements IV and V will be cemented together to form the front doublet and elements VI and VII cemented into the rear doublet. After this, element III will be cemented to the front doublet and element VIII will be cemented to the rear doublet, resulting in completed front and rear triplets.

d. Reseau Plate Fabrication

The complete fabrication of the reseau plate can be divided into eight different operations as follows:

1. Grinding of the aspheric contour by a vendor in Massachusetts
2. Polishing and figuring of the aspheric by Itek
3. Testing of the final figure by Itek
4. Final polishing and figuring of the flat side by Itek
5. Cutting and shaping of the disc into a rectangle by a vendor in Massachusetts
6. Grid application by a vendor in Philadelphia
7. Grid measurement and calibration at Itek's Washington Data Center.
8. Application of the anti-vignetting filter by Itek

The first three operations approach state-of-the-art tasks. There may be a number of cycles required between operation 2 and 3 before a satisfactory aspheric is obtained. All possible precautions will be taken to ensure that regrinding will not be necessary. Operations 4 to 8 are relatively straightforward, but handling must be kept to a minimum so that the finished aspheric surface is not defaced.

e. Final Assembly of Optical Elements

The production of the two internal aspherics will be the most difficult optical problem in the optical fabrication cycle.

A unique electro-mechanical measuring device (described in Volume 2) will accurately measure aspheric contours. The opticians then will make local corrections on an element which has been ground and polished to the nearest sphere. They will check the contour they have obtained on the measuring machine, reworking and remeasuring until the desired aspheric shape is attained.

The elements which have been edged, contoured, and cemented will then be assembled into the cell (fabricated to very tight concentricity tolerances) using standard Itek shimming techniques.

The final aspheric figuring (tuning) will be done after the lens has been tested and debugged on the resolution test bench. A number of cycles between the test bench and the aspherizing table may be necessary until the required lens performance is attained.

The resolution test bench is an instrument designed specifically for this contract (described in detail in Volume 2). In general, this instrument consists of a bank of 17 collimators located at 5-degree increments. A moving light source illuminates each of the collimators sequentially. The lens is mounted horizontally in a cylindrical drum such that the collimated light is presented at the lens entrance pupil.

A 360-degree rotational capability of the lens drum is provided so that the lens may be rotated about the optical centerline during test. A traveling microscope and a film pack assembly are provided for visual and photographic evaluation of image quality and vibration isolation. In addition, an axial reference autocollimator and an angular rotation autocollimator are provided to enhance evaluation of test results.

f. Lens/Cell Assembly Procedure

When optical fabrication procedures and pre-assembly testing have been completed, the optical elements are combined with the lens cell, the shutter assembly, and the platen bezel to form the lens/cell assembly.

After this unit has been completed and mechanically checked out, it is subjected to a program of optical testing which must be successfully completed before proceeding with the subsequent assembly tasks.

The optical test tasks are described in Section 5.5.

3. Stellar Camera

The stellar camera consists of a main frame assembly, film transport assembly, and lens assemblies. Each of these consists of fabricated and/or purchased components and minor subassemblies.

The stellar camera has two lens assemblies, each consisting of a lens, a lens mounting plate, a platen with a reseau grid and miscellaneous hardware items.

The lenses are a Wild Falconar lens design modified to adapt the lens for performance in accordance with the system requirements. The project will furnish modification specifications to the lens manufacturer and procure the modified lenses. Upon delivery, optics personnel will perform optical bench testing to ensure that the lenses meet all design criteria.

Upon delivery, the reseau plates will be measured, coordinates of the grid intersections will be recorded, and contact duplicates will be made.

The platens will then be mated with the lens cones and the shutter assembly, the lens, the platen/cone subassembly and the lens mounting plate will be combined into the lens assembly. A series of tests will be performed to check out the lenses and shutters.

The main frame assembly comprises a basic structure, a movable frame, and several covers.

The film transport assembly consists of a framework, roller assembly, velocity sensor assembly, platen pressure assembly, shuttle assembly, and data block assembly. All of the assembly components are fabricated or procured by the project, and fabrication and assembly are performed in project facilities. The completed subassemblies are given functional checks and debugged, and then combined to form the transport aseembly. In turn, the completed and tested stellar camera subassemblies are combined to form the stellar camera which is then checked out functionally and photographically. After debugging and the successful completion of testing the stellar camera is combined with the terrestrial camera to form the complete photosensor unit.

4. Supply Cassette Assembly

Assembly of the supply cassette, which contains both terrestrial and stellar camera film, is carried on along with the assembly of the other films transport elements to allow functional testing of the entire film transport system.

Priority is assigned to the assembly of the supply spools so that they may be shipped to the film manufacturer, loaded with film, and returned to Itek facilities in time to perform the scheduled functional and photographic tests and checks.

Spool assembly consists of mating the flanges with the core; checking and adjustment to preclude all misalignment, runout, and essentricity, and installation into the film TRANSIT case.

Technicians complete the subassembly of the terrestrial and stellar camera spindles, radius arms, drives, and brakes which are in turn, added to the cassette structure. These subassemblies are checked and tested to ensure that they function properly as an assembled unit.

After the supply cassette has been assembled and debugged, the loaded supply spools are assembled into the cassette.

5. Takeup Cassette Assembly

The assembly of the takeup cassette is similar to that of the supply cassette, however, overall assembly of the takeup cassette must, of necessity, be delayed until completion of the recovery section design and production or procurement of the RV's.

When the RV's have been received, the cassette structures are mated to them and the preassembled spools, spindles, radius arms, drives and brakes are added in proper order. During this sequence, the subassemblies are tested and debugged in place and as required.

5.4.2.1.2 Confidence Testing

Strictly speaking, the engineering confidence test program begins when the first subassemblies become operational and are subjected to unit test and debug procedures; however, the formal confidence program begins after the completion of the mating assembly and cassette assembly tasks.

Prior to formal confidence testing of the photosensor system, the following tasks must be performed in Phase III.

1. The empty spools must be transported in their containers to the film manufacturer for loading, sealing, and return to the project.
2. The payload/photosensor system interface simulator must be assembled and debugged.
3. The spatial frame must be assembled with a mating harness system.
4. The collimator and target wheel assemblies must be assembled and mated to the spatial frame
5. The PSSBT set (i.e., payload/photosensor simulator, spatial frame, and collimator/target wheel assemblies) must be integrated and debugged.

The photosensor assembly, supply cassette assembly, and two takeup cassette assemblies are bolted to the spatial frame and mated to the harness connectors. The first test series checks electrical continuity and operation of the subsystems. The second series of tests comprise a baseline, the PSSBT series, which checks total system performance by operating the photosensor system in all four modes. The confidence testing of the first photosensor system is a three month effort.

5.4.2.1.3 Qualification Testing

The Phase III qualification test program for the first photosensor system consists of a vibration, a shock, an acceleration, and an environmental soak test. Following each of the first three tests (vibration, shock, and acceleration), the photosensor is given a photo/functional baseline test to determine what effect the physical stresses, strains, and loadings have on the system. Following the third baseline test, the sensor is again subjected to the calibration test program. The calibration program is repeated after completion of the environmental soak.

If breakdowns and damage occur during the test phases, or if the baseline tests show functional or photographic degradation, the defect or malfunction is corrected (or in extreme cases design changes are made) and the sensor is again subjected to that portion of the test in which the incident occurred. Test phases are rerun as many times as required for the sensor to pass the test without breakdown, damage, or degradation.

The test series begins with an in-vacuum calibration test on the goniometer to provide a record of the actual distortions and scale of the lens prior to the mechanical environmental test.

The photosensor, cassettes, and electronics are vibrated on an Itek shaker through the range of frequencies and g-levels indicated in Section 5.5, Test Program. Vibration will be applied along the three major axes (roll, pitch, and yaw). Fixtures required for the three-axis shake are fabricated under the tooling subphase in Phase III.

During the vibration cycles, the photosensor and other assemblies are equipped with accelerometers located to indicate the strains, stresses and loadings felt by the sensor. The accelerometers are connected to a graphic recorder having sufficient channels to gather all acceleration data.

While vibration is in progress, project personnel visually monitor the sensor, and test personnel monitor the shaker console instrumentation to detect the first sign of destructive resonance and to shut off the equipment before damage occurs.

After vibration testing, a PSSBT series is conducted to evaluate the photographic and functional capabilities of the sensor and point up any gross adverse effects caused by testing.

The sensor is set up on the spatial fixture, which is used in the engineering confidence program, and operated both in room light and darkroom conditions. In the darkroom portion of the test, the three lenses are focused on lighted, collimated targets and a series of exposures are made.

The room-light portion is for visual observation of the functional operation of the instrument. Malfunctions and/or apparent visual damage are observed and corrected. Photographic results of the darkroom tests are evaluated for resolution and for differences attributable to the qualification tests.

Shock tests are performed on an Itek drop machine. The photosensor assemblies are mounted on a fixture (or fixtures) produced under the tooling tasks of the project. The fixtures and assemblies are equipped with accelerometers and are drop tested in three axes to the acceleration and g levels indicated by the qualification test specification (Section 5.5). After completion of the shock test, the photosensor is again run through the PSSBT series described in Section 5.5.

The photosensor and cassettes, mounted on an acceleration fixture produced under the tooling subphase, are subjected to accelerations at the levels called out by the test specification.

The photosensor is equipped with accelerometers and gauges strategically located and connected to recording instrumentation so that the effects of the acceleration spin may be evaluated later.

After completion of the acceleration program, the photosensor is run through a third PSSBT program followed by a calibration test program. Procedures for these programs are described in Section 5.5.

The environmental soak test is performed in the large vertical environmental chamber that has been modified to meet the physical and operational requirements of this program. The photosensor is mounted on a test fixture, loaded with film, equipped with thermocouples and other detecting devices, and then installed in the chamber.

After installation, the photosensor is connected to the external payload/photosensor simulator, and the detection instrumentation is connected to external recording and indicating instruments. The sensor is then physically aligned so that each of the three lenses is focused on target/collimator units mounted to the chamber. When these tasks have been completed, the photosensor is operated, for a short period, at ambient temperature/pressure conditions to check out its functions. After this, the chamber is sealed and the internal pressure and temperature are adjusted in accordance with the test specifications.

The chamber remains sealed for 11 to 15 days. During this period, the pressure and temperature are maintained in accordance with the test specification schedule, and photo/functional runs are made at various pressure/temperature levels.

After completion of the soak program, the photosensor is subjected to a final calibration test as defined in Section 5.5.

5.4.2.1.4 Refurbishment

After the qualification test program has been completed and the first photosensor system has been qualified, the refurbishment cycle begins. All assemblies and subassemblies of the camera system are disassembled and examined for wear or fatigue. Such parts will be replaced and items, such as all bearings and semi-conductors, will be replaced without examinations. The subassemblies and assemblies will then be reassembled and debugged. The camera system will then be given a complete confidence test series, using the PSSBT series, prior to acceptance testing as part of the fourth flight system on Phase V.

5.4.2.2 Recovery Section Design

While the RS design task could logically be included in Phase II, the short time period allotted for Phase II combined with the need to choose a recovery vehicle, would result in the development of only a very general RS design concept. However, the overall program plan permits the RS design to be performed in Phase III with subsequent production of the first takeup cassettes in Phase III and the first RS in Phase IV.

However, the general design concept will be formulated in Phase II. When the operational RV has been selected, this concept will be modified and refined for compatibility with the selected unit.

The design task consists of designing an RS that will mate with the DCM; support the RV's during launch and flight; allow the takeup cassettes, film transports, recorders, and cutters to operate satisfactorily; protect the exposed film from incidental radiation; and permit the RV's to be separated from the parent structure for re-entry after completion of the mission.

The most important aspect of this task is the design of a structure that will always support the RV's in the precise physical relationship to the DCM regardless of the stresses and strains of varying g-loadings due to terrestrial environment, launch dynamics, and orbital conditions. This precise relationship is necessary to assure proper film tracking. Combined with this requirement is the limitation of the mass of the unit to a reasonable percentage of the total payload mass.

The structure configuration will be established by analyzing several tentative configurations on a digital computer which will use standard programs and programs written especially for the task. The computed data will be evaluated, and advanced design concepts will be synthesized as a result of the evaluation. These will be fed back into the computer, and results will be evaluated again. The computer/evaluation/synthesis sequence will be continued until an optimum structure design has been developed.

The selected design will establish the structure configuration; configuration and location of the RV's; configuration and location of the film transport tracks, material, configuration, and location of radiation shielding, re-entry component configuration and function; the configuration and location of the control/power harness; and the basic design concept of the recorders and other auxilaries.

In addition to the primary design effort, a parallel task will be performed to develop a general takeup cassette design which will be compatible with the selected RV's. This includes the design of suitable film cutting and sealing mechanisms, layout and location of the RV control/power harness, and location of the film recorders. This second design task will be governed by the basic requirement of distributing the mass within the RV so that it does not adversely affect the ballistics of re-entry.

5.4.2.3 Auxiliary Ground Equipment (AGE) Design

The second major design task under Phase III is the design of the auxiliary ground equipment (AGE). The AGE will be designed at Vidya, an Itek facility at Palo Alto, California, which has extensive experience in and is specifically organized and staffed for such tasks. The items of AGE hardware that must be designed for the GOPSS include handling dollies, the GOPSS Control Console, and the Camera S/S test and checkout console.

The AGE design task will be initiated simultaneously with the initiation of photosensor production, and will be completed in approximately six months.

The AGE design phase includes the development of equipments, and the procurement of standard commercial items to be used "as is" or modified to meet specific requirements for testing of the integrated system.

In addition to a goniometer and the vacuum tank apparatus which will be required at the Itek facility, a second goniometer and vacuum tank apparatus will be located at the Missile Assemblies Building (MAB) for field calibration of the cameras. The following is a list of AGE which must be specified on Phase III and purchased for use in the acceptance test facility on the east coast or the MAB.

1. Electric hoists
2. Monorail assemblies
3. Microscopes
4. Densitometers
5. Film processors and supporting auxiliaries

6. Sensitometers
7. Sanborn recorders
8. Theodolites
9. Temperature/humidity recorders
10. Viewing tables

Two handling dollies have to be designed, one to accommodate the DCM and the other to accommodate the Recovery Section. In addition, an erecting fixture/dolly is required; it will be designed simultaneously with the basic handling dollies.

The present concept of the DCM dolly design is that of a low silhouette framework equipped with a cradle type mounting into which the DCM can be mounted in a horizontal attitude (see Figure 5-14). Swivel wheels, with mechanical brakes, will be provided. In addition, the basic frame will be provided with leveling jacks so that the DCM can be precisely leveled for assembly and/or testing.

The DCM will be held in the cradle mounting by gravity and the cradle/DCM interface will contain rollers so that the DCM may be rotated manually about its axis to allow access to various areas during assembly and alignment operations.

A basic design criterion for all handling dollies is that their structures and/or components do not interfere with access to any area or component of the supported unit in order to facilitate operations.

The RS dolly design will be similar to that of the DCM dolly, and will accommodate the RS in a horizontal attitude.

A semi-circular cradle equipped with rollers will support the aft end of the RS, and a trunnion device will support the forward end. This unit will allow 360-degree rotation of the supported RS around its roll axis and will be designed so that it does not interfere with assembly/alignment tasks. Its basic design criterion is that it support the RS at the same height above the ground as the mounted DCM, so that physical integration of the two payload elements may be performed without difficulty or misalignment. In addition, after integration has been effected, the two dollies must become, in effect, a single unit.

As a supplement to the DCM and RS dollies, it is necessary that an adapter/lifting ring be designed. This ring serves as an interim coupling between the DCM and the RS, and furnishes the necessary strength and rigidity to the assembly for lifting, handling, etc., during the qualification/acceptance test tasks.

The GOPSS console and the camera S/S test and checkout console comprise the complete electronics required for operation and monitoring of the GOPSS payload while on the ground. Design of this equipment will be performed at Vidya under the close supervision of those field service personnel who will eventually operate it. The Camera S/S test and checkout console will be a modified version of the payload/photosensor system interface simulator more suitable for field operations and compatible with the GOPSS control console. It will have the capability of operating the photosensor systems on a subsystem basis, as a system separate from the remainder of the GOPSS hardware, or in conjunction with the GOPSS control console. In the first two of these functions it will be similar to the P/PSSIS; for the latter application, V/h, t_e, power and mode control commands are received from the GOPSS control console. The design will be conducted from specified functions set down during Phase II. The GOPSS control console will provide a full electrical command, control signal, and power interface simulating that of the Agena. The monitoring or T/M functions of the Agena will also be simulated. The two console system will be designed as a four-bay unit with casters.

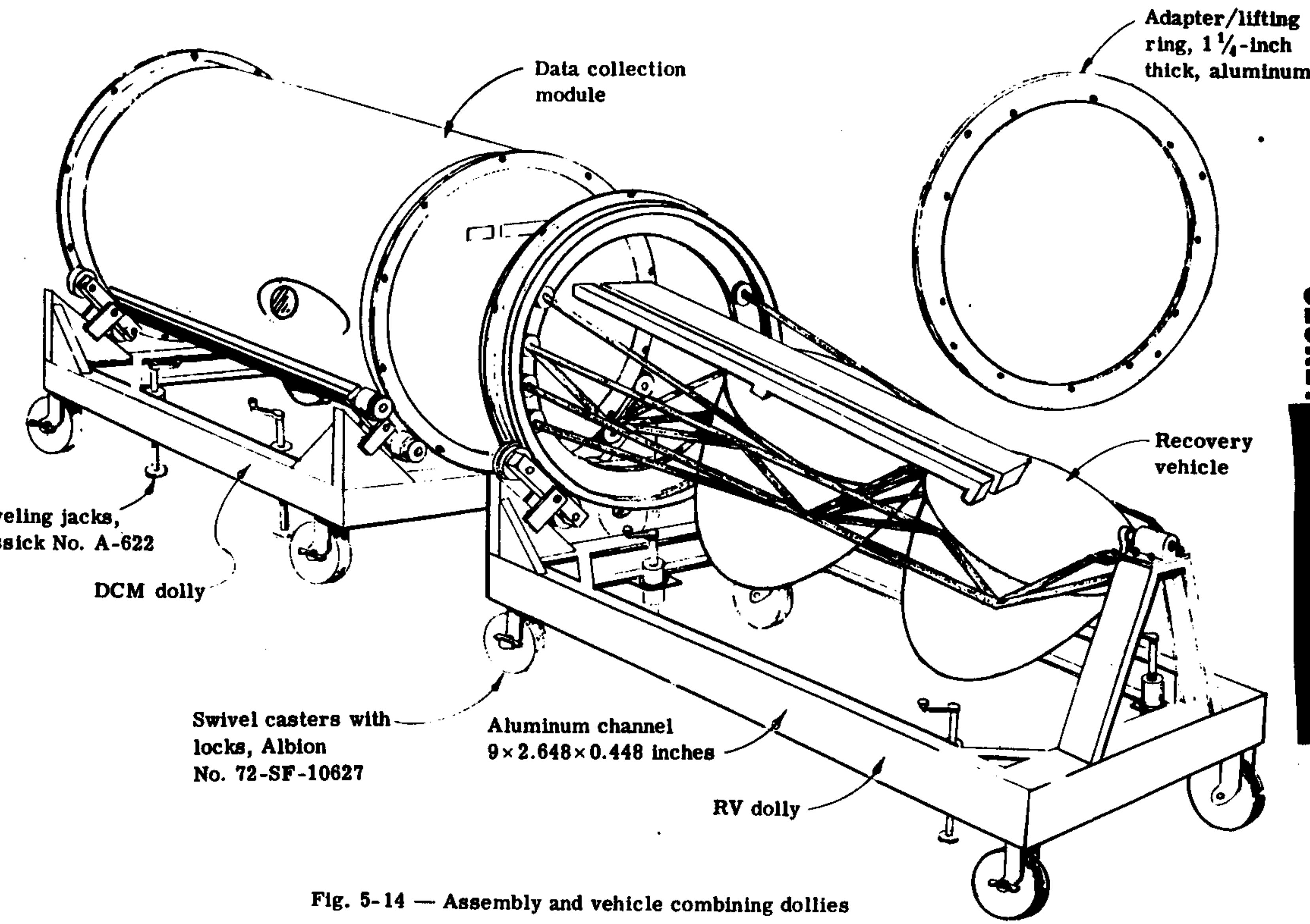

Fig. 5-14 — Assembly and vehicle combining dollies

Vidya design personnel will analyze the several ground handling tasks with respect to the procurement of necessary equipment and will, as a part of the AGE design task, specify those commercial equipments (previously defined in general) which are best suited for their particular uses. In addition to selection, those modifications to standard units which will improve or enhance their functions relative to the tasks at hand will be defined.

The AGE design task will be documented with formalized drawings and reports.

5.4.2.4 Tooling and Fixtures Fabrication

Fabrication and procurement of tools and fixtures will be started during Phase III so that they can be used in the fabrication, assembly, and test of an operational system.

In general, the design of tools and fixtures will be completed in Phase II, with time alotted during the first part of Phase III to modify these designs for compatibility with any modifications of system design that result from actual fabrication experience.

The tools and fixtures to be fabricated during Phase III are as follows:

1. Assembly/fabrication jigs and fixtures
2. Photosensor/payload interface simulator
3. Camera calibration equipment
4. Chamber conversion
5. Spatial fixture

Jigs and fixtures are required for both fabrication and assembly. Those jigs and fixtures that are relatively small and do not require sophisticated welding techniques during manufacture will be produced in the Itek shops. Large items which require heavy machinery, large manufacturing areas, and specialized welding techniques and equipment will be subcontracted to a manufacturer who specializes in this field.

5.4.3 Phase IV

Phase IV starts during Phase III to permit the timely completion of "in progress" design changes resulting from the Phase III task. During this phase, the second photosensor and the first recovery section are produced. In addition, system auxiliary sensor equipments are procured. After the aforementioned units have been fabricated and/or procured and subjected to unit acceptance tests (where required), they are integrated and the system is subjected to a qualification test program.

After completion of the qualification program, the system is refurbished for subsequent delivery as one of the operational systems.

5.4.3.1 Fabrication and Assembly

The procedure for producing the second photosensor is the same as that described for producing the first unit under Phase III, except for minor differences. The differences are that, during the engineering confidence program, the photosensor is mated with the DCM to detect and correct physical interface problems; after completion of the engineering confidence test, the sensor is subjected to a unit acceptance test. This test consists essentially of a mild vibration cycle followed by a photo/function baseline test.

While the second photosensor is in production, the first DCM is produced as a parallel effort.

The tasks consist of fabrication of the framework and supporting structure, fabrication of miscellaneous DCM components, procurement of components, and assembly of the various components and elements into the DCM unit. After completion of the assembly task, the DCM is mated temporarily with the photosensor. When the mating task has corrected and eliminated all interface problems, the DCM is subjected to an acceptance test during which dummy loads are attached to simulate operational loading conditions. A second DCM structure is procured with specified structural integrity for use in a preliminary structural test, but less such items as finish, etc.

The first recovery section is also produced in parallel with the production of the second photosensor and the first DCM.

The task consists of fabrication and procurement of section components, procurement of qualified RV's, and assembly of the components and elements into the recovery section unit. After completion of the assembly task, a second recovery section structure is run through a qualification test, with dummy loads, in the same manner as the DCM.

The auxiliary equipment, that is, the mission data recorders, radar altimeter, transponder, accelerometer and clock, are produced for use in the system during Phase IV. All of these items are purchased as qualified units that meet or exceed component and system specifications.

Because the auxiliaries are operational as purchased, the procurement period extends somewhat beyond the integration start date.

During this phase, the auxiliary sensor vendors will qualify one of these subsystems to the vibration, shock, acceleration, and vacuum conditions outlined previously. They will test the second system to the acceptance test levels (vibration and vacuum only) under Itek QA supervision, and deliver that system to Itek by the 20th month for integration into the first payload system.

5.4.3.2 Integration and Test

When acceptancetests for the photosensor, the DCM, and the recovery section have been completed, the integration task is initiated.

Integration consists of combining all of the units mentioned previously, plus the auxiliary equipment, into a cohesive system and performing the alignments, design changes, machining operations, et cetera, that are required to assure a satisfactory operational system. Among the several aspects of integration are film path alignment, component interface, and electrical continuity.

Testing to acceptance test levels will have been conducted on the photosensor system, DCM, and recovery sections prior to integration to ensure that these subsystems do not contain loose fastenings, connections or other minor troubles which could impair progress of the more significant qualification testing. Structural test structures (full size DCM and RS structures) are dummy loaded and subjected to qualification vibration shock and acceleration prior to integration. This ensures less chance of failure during the system qualification testing.

The integration of this first complete system commences with the mechanical mating of the subsystems to the DCM and RS structures and to each other. This is followed by a combined electrical continuity and RFI test. One of the bays in the assembly area will be converted to a screen room. The control consoles will be external to the room. The electrical continuity checks of the system will be conducted first, followed by the first EMI test which will check for spurious signals on the control lines. The signal source will emanate from an antenna located in the screen room but external to the system structure.

Functional baseline testing is started next (approximately 8 weeks into this cycle), combined with EMI testing. The ISBT series is used, the first step of which consist of the four mode tests of the photosensor system. During one portion of each of these mode tests, the system control lines will be monitored for spurious signals which are generated within the system, a cross couple with other subsystem lines to cause malfunctions. Basically this is the second EMI test required. This procedure is also followed when checking the auxiliary equipment performances.

At the end of each of the subsystem tests during the ISBT series, an antenna will be used to monitor the spurious radiation from the complete system while in operation. This is the third and last EMI test. The integration cycle is programmed to take 3 months and, after that, the system is subjected to final qualification testing.

5.4.3.3 Qualification Testing

The qualification test program on Phase IV, for the first integrated system, is scheduled to commence in the 23rd month, one month after completing the qualification of the first photosensor system. This allows final modifications to the camera system to be completed during the integration cycle, so that a system may be qualified containing a previously qualified camera system.

The effort starts with calibration of the photosensors, which are then remounted for environmental testing. The first vibration is that of the DCM subsection which will be run at the qual levels mentioned in Section 5.5. The DCM is then tested for shock and acceleration. The acceleration test involves shipping the DCM in its shipping container to an outside facility for testing. For reasons of security, the DCM will be tested in its shipping container with the DCM hard-mounted to the container (that is, the shipping isolators are removed). The DCM will be shipped on an isolated pallet and, after the test at Itek, the container will be opened to allow examination for damage during test. The shock test will be accomplished at Itek using the vibration shaker to pulse it in the desired shock profile. The Recovery Section testing will be handled in the same manner, utilizing the same test equipment but will be performed immediately following each of the DCM tests.

Unlike Phase III qualification testing, only one baseline test will be conducted, and this will follow acceleration testing since it is felt that enough confidence will be obtained during qual of all the subsystems and make additional testing between environmental tests unnecessary. This baseline test will comprise an ISBT series.

The complete system will then be given a vacuum and thermal test (i.e., thermal soak) in the large vertical chamber. The test duration will be from 11 to 15 days and the heat inputs to the system for the thermal simulator within the chamber will be cycled according to a realistic program under vacuum conditions of 10^{-5} to 10^{-6} Torr. All system functions will be monitored during testing using the AGE consoles. After the test, exposed film will be developed and checked on a sampling basis to check camera performance during this simulated mission.

Upon completion of thermal soak testing, the cameras will again be removed and calibrated under the same vacuum and temperature conditions of the pre-environmental calibration test. The results will be checked for unreasonable changes in distortion and scale. Qual testing will end in the 26th month.

5.4.3.4 Refurbishment

After qualification, the entire system is refurbished to eliminate defects found during the qualification program, including replacement of any worn critical components.

After refurbishment, the system is acceptance tested and then delivered as the fifth operational flight system.

5.4.4 Phase V

The purpose of Phase V is to produce three flight systems, and with the two refurbished systems, conduct acceptance testing delivering five flight systems at a two-months interval. In addition, three AGE sets will be fabricated, assembled, and debugged; the construction of the MAB will be monitored, and field service operations will start. The production of flight systems involves fabrication, assembly, system integration, acceptance testing, and delivery to the MAB.

The initial portion of the field service effort will be devoted to monitoring the MAB construction which will be completed in time for delivery of the first flight system. Then field service operations will start the task of readying flight systems for launch.

5.4.4.1 Flight System Fabrication and Assembly

Flight system production procedures encompass the production of photosensors, DCM's, and recovery sections in sufficient quantity to make three complete flight payload systems and part of a fourth. This breaks down to a requirement to produce three photosensors, four DCM's, and four recovery sections, and to procure four sets of qualified auxiliary equipments. The total complement of the five required systems results from the use of refurbished hardware that was produced in preceding phases of the program. The first photosensor produced in Phase III is integrated with a Phase V DCM, recovery section, and auxiliary complex to become the fourth flight system. The first (qualification) payload system produced in Phase IV becomes the fifth flight system.

The production cycle consists of the following tasks:

1. Fabrication and test of three sets of photosensor optics. Fabrication of the first set is initiated at the start of Phase V, with the other sets following at two-month intervals.

2. Procurement, fabrication, and assembly of three photosensors, with initiation and completion of each unit spaced at two-month intervals. As each of the sensors is completed, it is subjected to an engineering confidence test program and followed by a unit acceptance test.

While the photosensors are being produced, procurement, fabrication, and assembly of four DCM's proceeds with one-month intervals between completion of each unit. Acceptance tests are run on each DCM after completion of assembly and debug.

During the same period, procurement of four sets of qualified recovery vehicles, and procurement, fabrication, and assembly of four recovery sections proceeds in the manner defined in the description of the Phase IV production procedure. Recovery sections are completed at one-month intervals, with a unit acceptance test being performed on RS/RV units as they are completed.

The procurement cycle of the acceptance-tested auxiliary equipment coincides with the production tasks. Delivery intervals of the auxiliary sensors coincide with the production of the functional units.

As the major system components (photosensor, DCM, recovery section, and auxiliary equipments) complete their individual acceptance vibration tests and/or are delivered, they are integrated into payload systems. The integration tasks are scheduled so that the systems complete integration at two-month intervals.

5.4.4.2 Flight System Integration and Acceptance Testing

The integration cycle of each flight system is similar to that conducted on Phase IV for the first system. After each subsystem receives a "low g" (19) vibration sweep to assure the absence of loose fastenings and electrical connections, etc., mechanical mating begins. Upon completion of mechanical mating, electrical continuity checks are performed to complete the actual integration. However, the integration cycle is not complete until baseline tests have been run. The ISBT series is conducted on the system to verify the specified performance of all subsystems. Each system is run through the equilvalent of a full mission profile in terms of the number of test photographs taken and the total operating time. After completion of integration baseline testing, the system is moved to the environmental test area for flight acceptance tests.

The flight acceptance test consists of a vibration test and a vacuum/thermal or soak test. The vibration test in the three major axes is conducted on the completely assembled payload (DCM bolted to the Recovery Section) at the low g level. The system is driven at the base of the DCM (at the Agena/DCM interface) in all three axes. During the y and z axis sweeps, the system is mounted on a fixture which rests on a series of slip pads similar in function to a slip table. After completion of this test, an Integrated System Baseline Test (ISBT series) is conducted to check system functional performance.

The system is then placed in the large vertical chamber for an 11 to 15 day thermal/vacuum soak test. During the test, the payload will receive thermal inputs to the system skin, simulating the magnitude and cyclical nature of solar, earthshine and orbital albedo fluxes. The systems will be run through a complete mission profile exposing all frames at a simulated altitude of 10^{-5} to 10^{-6} Torr. Of particular concern during testing will be the effects of electrostatic discharge on photography. During an actual flight, the payload would be given a partial pressure by the release of nitrogen within the DCM. This partial pressure will preclude electrostatic discharge effects on orbit, however, this system will not operate during flight acceptance test, only as a backup against unforeseen trouble and not a necessary item.

After the completion of the soak test, the test data will be evaluated and the photosensor removed for calibration testing. During the qualification testing, confidence will be developed assuring that only a post-acceptance test calibration of the photosensor is necessary. In the event that permanent changes in scale occur during testing, the complete pre- and post-flight acceptance test and "on orbit" calibration will have to be reviewed.

When post-flight acceptance test evaluations are complete, the flight system is delivered to the MAB at VAFB. This delivery will occur on a two-month cycle with delivery in the 27th, 29th, 31st, 33rd and 35th months of the program.

5.4.4.3 AGE Fabrication and Test

The fabrication and debugging of AGE sets is a Phase V task. During Phase III, design will be conducted by Vidya personnel, and as a continuation effort they will fabricate, assemble, and debug three sets of AGE. AGE designs will be completed by the 14th month and fabrication will start in month 16 with the delivery of the first AGE set for the 20th month, and prior to integration of the qualification system during Phase IV. Delivery of the second AGE set prior to integration of the first flight system occurs in the 22nd month, and delivery of the third set will be made to the MAB during or after the 24th month. The first two sets are delivered to Itek, Lexington, and when the second flight system is delivered to the MAB, it will be accompanied by the second set of AGE. Therefore, after the 29th month, there will be one set at Itek, Lexington, and two sets at the MAB. This is possible because flight system integration and testing is conducted in serial order after 29th month.

Each set consists of one pair of handling dollies, a GOPSS control console, and a Camera S/S Test Console.

5.4.4.4 Field Service

The following is a listing based on receipt of an accepted, integrated system at the Missile Assembly Building (MAB), VAFB. It indicates the involvement of field operations in the pre-ship function at Boston at which time a transfer of responsibility or condition and release for transfer (CART) procedure will be exercised. This sequence requires a minimum of three months between MAB delivery and countdown.

1. Pre-ship preparations (Boston)
   a. Subsystem cleaning and lubrication
   b. Environmental test review and audit
   c. System assembly and pre-ship confidence run
   d. Document review and audit
   e. CART meeting
2. Ship to MAB, VAFB
3. MAB Receiving Inspection
   a. Visual inspection of the system for damage that may have occurred in transit
   b. Operate each subsystem to reconfirm functional integrity and electro-mechanical calibration. Upon successful completion, the system is tested through the entire range of operational modes and inputs
   c. Test all in-flight and ground test instrumentation for presentation and calibration
4. SRV Weight and Balance
5. Pad Run Preparations

   Load the camera system with flight film and prepare all sensors for pad run.
6. Pad Run

   Vehicle mating and compatibility tests to confirm total system integrity and verify command system.

7. Readiness Evaluation and Verification

   Evaluation of pad run and previous tests to verify suitability for flight.

8. Flight Preparations

   a. Subsystem cleaning and lubrication

   b. Final operational adjustments or settings on all sensors

   c. Pyro loading

   d. Load flight payload in camera subsystem

   e. Final system assembly and confidence run

9. Final Mating

   Move system to launch pad for vehicle mating.

10. Pre-Launch Verification Tests

    This is a modified ISBT series.

11. Countdown

12. Launch

5.5 TEST PROGRAM

In order to ascertain the suitability of a satellite system, such as the GOPSS for launch, many types of tests are required. The testing comprises functional or baseline testing, environmental testing (vibration, shock, acceleration, vacuum, and thermal) and calibration testing. All these tests have been designed into this program, and a general description of each follows.

5.5.1 Photosensor and Integrated System Baseline Tests

5.5.1.1 Photosensor System Baseline Tests (PSSBT)

In reality these tests comprise a series of separate tests to check the electrical and photo-optical performance of the camera system. The following subsystems are being checked.

1. Terrestrial camera
   a. Shutter
   b. IMC drive
   c. Sync and control system
   d. Data block and fiducials
2. Stellar camera
   a. Shutters
   b. Data block
3. Film transport systems
   a. Supply cassette
   b. Takeup cassettes
   c. Camera transport assemblies
   d. Control servos
4. Intervalometer and camera electronic modules
5. Thermal shutters

The following are the test equipments required to implement this test.

1. Payload/photosensor interface simulator
2. Spatial frame
3. Collimator and target drive assembly

The PSSBT series is comprised of the following tests.

Mode I Verification Test

1. Apparatus: payload/photosensor interface simulator, spatial frame, and collimator and target drive
2. Purpose: to check the functions of the photosensor system in the normal photographic mode (stellar and terrestrial photography)
3. Procedure:
   a. Mount photosensor components on spatial frame
   b. Couple console, and collimator and target drive electrically
   c. Energize target drive and console
   d. Operate in Mode I
4. Checks:
   a. Monitoring of the photosensor system diagnostic points during the test will verify the on or off state of the system components during test
   b. A check of the processed terrestrial film after test will verify IMC, correct shutter exposure, platen/shutter position synchronization, data block operation, on- and off-axis dynamic resolution, opening of thermal shutter, correct framing
   c. A check of the stellar film will verify the fogging of the reseau, data block operation, operation of the shutter, and film framing

Mode II Verification Test

1. Apparatus: payload/photosensor interface simulator and spatial frame
2. Purpose: to check the functioning of the system in shutdown of the forward cassette and starting of the aft cassette
3. Procedure:
   a. Mount photosensor system to the spatial frame and operate it from the payload/photosensor simulator console
   b. Film cut is made by a recycling cutter attached to the spatial frame (not an operational cutter and sealer)
4. Checks: monitoring of the photosensor system diagnostic points will verify the correct sequential order and completion of all events

Mode III Verification Test

This test checks the system shutdown mode in the same fashion as the Mode VI verification test.

Mode IV Verification Test

1. Apparatus: same as the Mode I Verification Test
2. Purpose: to check verification of the camera calibration mode (Mode IV)

3. Procedure:

   a. Mount the photosensor system to the spatial frame
   b. Couple the console, collimators, and target drives electrically
   c. Target drives are not energized but are stationary during test

4. Checks:

   a. Monitoring of photosensor system diagnostic points during the test will verify the on and off state of the system components and the sequential order of the events

   b. A check of the processed terrestrial camera film after the test will verify platen/lens position, exposure, opening and operation of all shutters, reseau fogging, data block operation, and film framing

   c. A check of the stellar film will verify similar operational functions

The aforementioned tests may be run in any desired order or for any duration at the discretion of the test engineer, depending on whether it is a part of debugging or part of the photosensor system qualification test program.

5.5.1.2 Integrated System Baseline Tests (ISBT)

In general, these tests are designed to check and verify the electrical and photo-optical performance of the complete GOPSS and, in particular, the following systems:

1. Photosensor system
2. Radar altimeter
3. TRANSIT transponder
4. Accelerometer
5. Clock
6. Mission recorder
7. Recovery vehicles

The test equipments needed to conduct this baseline test series are described in the following paragraphs.

5.5.1.2.1 Auxiliary Ground Equipment (AGE)

The AGE console is required to fulfill baseline test requirements of a complete system. The payload/photosensor simulator is designed only to operate the photosensor system. The AGE console supplies the following simulated inputs to the payload system.

1. Power 28 vdc
2. V/h and exposure signals
3. All OCV programmer inputs including cut and seal commands

In addition, it is coupled to the OCV/payload TM interface and, through built-in oscillographs, is able to perform complete diagnostic recording of the performance of all GOPSS.

5.5.1.2.2 Handling Dollies

Two handling dollies are required during assembly of the two major sections of the satellite, the DCM, and the Recovery Section. (See Figure 5-12.) The ISBT is performed when the satellite sections are mounted on these dollies. The dollies are designed to cradle and to align the two sections with separation between the sections for easier internal access. Both dollies are mounted on casters for maneuverability or they may be jacked to remain stationary. The collimator target drive assemblies can be mounted to the dollies.

5.5.1.2.3 Collimator/Target Drive Assembly

The same collimator/target drive assemblies described in the previous section are used in this test series.

In the ISBT series the following tests are performed:

1. Mode I Verification Test
2. Mode II Verification Test
3. Mode III Verification Test
4. Mode IV Verification Test

(These tests are the same as those run during the PSSBT series with the AGE console and dollies used in place of the payload/photosensor interface simulator and spatial frame.)

Testing of the auxiliary equipments during this series will be conducted through tests designed by the vendors of these equipments. The problems associated with complete testing of the radiating auxiliaries (radar and TRANSIT transponder) are generated by the enclosed space (assembly area and environmental tank). Functional tests will be performed on the transponder and altimeter, however, this will require that the associated antennas be disconnected and the signals be fed to simulators in the AGE and return signals fed back. The accelerometer will be functionally tested, but in a biased 1-g field, therefore the tests designed for this apparatus can only reflect an analogous "on orbit performance." Throughout this test series, the mission data recorder will continuously monitor outputs from the clock, altimeter, and accelerometer (when operating). Examination of the recorder material at the end of the series will verify the performance of the recorder and other equipment. During testing, the recorder transport system operation will be monitored through the channels. The system clock will be turned on throughout the series and will be monitored at the AGE console. In addition, it will supply time signals to the photosensor system and the mission recorder, and a check of their outputs will also reveal clock performance.

The recovery vehicle cannot be checked functionally during this ISBT series because, for safety reasons, pyrotechnic and similiar devices will be either disarmed or absent. Therefore, only electrical continuity checks of mating connectors will be performed.

5.5.1.3 Environmental Tests

5.5.1.3.1 Vibration Tests

Vibration tests will be performed in Phases III, IV, and V; the individual vibration tests will vary extensively both as to severity of test levels and as to the equipment tested.

A number of vibration fixtures are required to accomplish the total program; these will be designed and fabricated under the tooling/fixture program in Phase II.

Itek is equipped with vibration test equipment having sufficient capacity to accommodate all of the proposed equipment which will be subjected to vibration tests, thereby precluding the requirement to contract for the use of outside facilities. The tests described here are sine waveform tests, but in the near future most of the Itek equipment will have a random capability and the tests could be respecified as random waveform tests. The vibration test program is divided into two broad categories, qualification tests and acceptance tests.

Qualification tests are quite severe and may be considered as at least partially destructive. Equipment subjected to qualification vibration will either be discarded or will be completely refurbished prior to being put into operational use.

Acceptance test g-levels are relatively mild and units so tested can and will be put into operational use with an enhanced degree of reliability.

During the qualification tests, physical failure or damage to any element or component will cause the test to be halted at that point. The failed unit will be analyzed to determine the cause of failure, and the unit will be replaced and/or modified to preclude the same type failure. Then the portion of the test which caused the failure will be rerun. Replacement/modification/retest sequences will be performed as often as necessary to completely qualify the test subjects.

The several vibration test sub-phases are described in the following paragraphs.

1. Phase III Qualification Vibration

During Phase III, selected individual photosensor components will be subjected to vibration for component qualification. On completion of the component qualification program, the camera assembly and each of the film cassettes will be vibrated (using dummy film loads) to qualify them as assemblies.

a. Component Qualification Vibration

Each of the electronic units and the several system auxiliaries will be vibration tested in accordance with the following specification:

Axis	Sweep Time, minutes	Levels	Limits
x, y, z	30 (log sweep)	5 to 14 cps, 0.5 in. (da) 14 to 400 cps, 5 g (peak) 400 to 2000 cps, 7.5 g	None

2. Assembly Qualification Vibration

The assembled cameras and supply cassette will be tested as a single unit as will the takeup cassette. Each of these units will be vibration tested in accordance with the following specification.

Axis	Sweep Time, minutes	Levels	Limits
x (roll)	30 (log sweep)	5 to 12 cps, 0.5 in. (da) 12 to 400 cps, 3 g 400 to 2000 cps, 7.5 g	Limit to input level except 15 to 25 cps at cell and supply spool
y, z (yaw, pitch)	30 (log sweep)	5 to 9 cps, 0.5 in. (da) 9 to 250 cps, 2.0 g 250 to 400 cps, 4.0 g 400 to 2000 cps, 7.5 g	Limit to input level except 15 to 25 cps at cell and supply spool

3. Phase IV Qualification Vibration

During Phase IV, structural models of the DCM and the recovery section will be subjected to qualification vibration.

The structural models will be actual DCM and RS structures produced under the fabrication sub-phase. It is planned to use the first of each of these units which will probably have small fabrication errors and inherent "first-piece" errors and will not be carried through to completion of external finish, etc. However, they will be true structural representations of their operational counterparts. Dummy loads will be installed for the vibration test to simulate operational loading conditions.

Each of the models will be vibration tested in accordance with the following specification:

Axis	Sweep Time, minutes	Levels	Limits
x, y, z (roll, pitch, yaw)	30 (log sweep)	5 to 9 cps, 0.5 in. (da) 9 to 250 cps, 2.0 g 250 to 400 cps, 4.0 g 400 to 2000 cps, 7.5 g	None

4. Phase V Qualification Vibration

In Phase V, the integrated DCM/RS unit with all internal elements, components, and auxiliaries will be vibration tested in accordance with the following specification:

Axis	Sweep Time, minutes	Levels	Limits
x (roll)	30 (log sweep)	15 to 400 cps, 2.0 g 400 to 2000 cps, 3.0 g	Limit to input level except 15 to 20 cps at cell and supply spool
y, z (pitch, yaw)	30 (log sweep)	15 to 400 cps, 1.0 g 400 to 2000 cps, 3.0 g	Limit to input level except 15 to 20 cps at cell and supply spool

5. Phase IV Acceptance Vibration

In Phase IV, the refurbished photosensor, cassettes, electronic units, and auxiliaries will be vibration tested in accordance with the following specification:

Axis	Sweep Time, minutes	Levels	Limits
x, y, z (roll, pitch, yaw)	15 up 15 down	20 to 2000 cps, 1.0 g	None

6. Phase V Acceptance Vibration

In Phase V electronic units, cassettes, cameras and auxiliaries will be subjected to either component and/or unit vibration tests as they become ready. Each DCM/RS unit will be subjected to acceptance vibration upon completion of integration. The camera, cassettes, electronics and auxiliaries will be vibration tested in accordance with the following specification:

Axis	Sweep Time, minutes	Levels	Limits
x, y, z (roll, pitch, yaw)	15 up 15 down	20 to 2000 cps, 1.0 g	None

The integrated systems will be vibration tested in accordance with the following specification:

Axis	Sweep Time, minutes	Levels	Limits
x, y, z (roll, pitch, yaw)	15 up 15 down	20 to 2000 cps, 1.0 g	Limit to input levels except 15 to 25 cps at cell and supply spool

5.5.1.3.2 Shock Tests

The shock test program will be concerned entirely with qualification tests. Shock will not be included in the acceptance test program.

A number of test fixtures required to perform the shock program will be designed and constructed during the tooling sub-phases. Design of the fixtures and subsequent fabrication will be performed by project personnel under the technical direction of Itek environmental test engineers. Itek has test equipment and facilities with sufficient range and capacity to perform all scheduled shock tests.

Shock tests will be performed in Phases III and IV on various components, subassemblies, and major assemblies. Items tested and the several test specifications to be followed are presented in a tabular format on the following page for a half sine wave pulse shape during 6.0 milliseconds (three shocks in each direction).

Phase	Item	Direction	Acceleration, g's
III	Electronics and auxiliaries	+x, -x	15
		+y, -y	10
		+z, -z	10
III	Camera and supply cassette	+x, -x	15
		+y, -y	7.5
		+z, -z	7.5
III	Takeup cassette	+x, -x	20
		+y, -y	5
		+z, -z	5
IV	DCM/RS assembly (payload)	+x, -x	15
		+y, -y	7.5
		+z, -z	7.5

5.5.1.3.3 Acceleration Tests

As is the case with shock testing, acceleration tests will be entirely for qualification purposes. Acceleration will not be included in the acceptance test programs.

Test fixtures required for the acceleration program will be designed and constructed under the tooling design sub-phases (Phase II) of the project. Design and fabrication of the fixtures will be performed under the technical direction of Itek environmental test engineers.

There are acceleration test facilities nearby that have been satisfactorily utilized on prior programs; it is planned to contract for the use of these facilities for this program.

For security reasons, prevention of visual display of the project hardware to uncleared contractor personnel will be accomplished by enclosing the payload system in its shipping containers at Itek facilities, acceleration testing of the system without removing it from the containers, and reshipping it to Itek facilities in the unopened containers. When preparing the payload for acceleration tests, accelerometers and other data gathering instrumentation will be installed at Itek with connections fed out to the exterior of the shipping containers. This will allow contractor personnel to install the equipment on the centrifuge and connect the data instrumentation to their recording instruments without requirement to open the containers. In a similar manner, the photosensor and cassettes will be enclosed with their data gathering instruments in masking containers. Electronics packages, auxiliaries, etc., will not be shielded and will be subjected to acceleration tests in an open and straightforward manner.

The equipment to be tested will be hard mounted in the shipping containers (less the shipping isolators) and will be transported to the test facility on an isolation pallet.

Acceleration tests will be performed in Phases III and IV on various components, subassemblies, and major assemblies. Items tested and the governing test specifications are listed in the following table.

Phase	Item	Acceleration x Axis	Acceleration y, z Axis	Minimum Time, seconds
III	Electronics and auxiliaries	10.5 g ± 5 percent	1.4 g	30
III	Camera and supply cassette	10.5 g ± 5 percent	1.4 g	30
III	Takeup cassette	10.5 g ± 5 percent	1.4 g	30
IV	DCM/RS (payload)	10.5 g ± 5 percent	1.4 g	30

5.5.1.3.4 Goniometric and Calibration Testing

Goniometers have long been used to calibrate metric cameras, such as the terrestrial camera, for scale and distortion. However, these designs have generally been special purpose devices made for smaller metric cameras. Metric cameras for orbital use present a special set of problems. One problem is that they must be tested under vacuum conditions. The second problem is presented by the large size of the camera format. Star photography has usually sufficed for metric cameras to be used in air, and would be applicable for use with the terrestrial camera if the terrestrial camera could conveniently be placed in a vacuum chamber with a large calibrated window.

Stars greater than the 7th magnitude could be obtained, resulting in several hundred stars on the format close enough together to give excellent distortion and calibration figures. Weather conditions and cloud cover generally present calibration scheduling problems in star calibration with the result that goniometers have been developed to replace star calibration methods. In general, goniometers simulate star photography, but early designs do not supply enough points to conveniently cover the large format of an orbital metric camera. The early goniometers employed either banks or collimators with targets of the pin holed type to simulate stars, or employed a precision table with a horizontal circle for reading angles with an additional alignment collimator. The former has the advantage of recording the distorted target pattern from calibrated sources directly on film for quick reduction, but the apparatus becomes complicated when a great number of points is desired. The latter has the advantage of being the least complicated but, since each reseau point which aligned with the collimator must be read one at a time, the data gathering process is long and tedious for a great number of points. Therefore, Itek has proposed the following solutions to goniometer design which combine the advantages of earlier designs.

The proposed goniometer design has the same functions but differs slightly in apparatus configuration. Functionally, the principle is to flash target images from a single stationary collimator to the terrestrial camera lens, resulting in a series of target images on the camera format spaced one centimeter apart. The camera rotates on a precision rotary table of known angular displacement between images and the camera lens distortions are measured as a change or deviation from predicted spacings. The target images appear as cross-hairs imaged in a radial direction across the format, and the camera is rotated about its lens axis to image in other radial directions. The major deviation from predicted spacings along the row of images are the result of radial lens distortion and the lateral deviations, or deviations of the targets from a straight line, are the result of tangential distortion. Errors resulting from timing of flashes, runout of rotating table, and those resulting in execution of the design will be kept within the 1-micron measuring error or noise level.

The camera under test will be located on a fixture atop the rotating table such that the lens entrance pupil is located over the center of rotation. This minimizes the diameter of the collimator aperture. The table rotation rate will be on the order of 0.01 radian per second, resulting in a test duration of only a few minutes. The collimator will have the targets on axis and will be of a diffraction limited design having a relative aperture of f/6 with a focal length ranging from 24 to 36 inches, depending upon the style of goniometer. A strobe light source and circuit will be used to illuminate the target or targets for imaging them in the camera format. The table will be a precision rotating table with either air bearings or precision ball bearings. The complete goniometer device will be mounted within a small vacuum chamber and operate at an ambient pressure of 10^{-3} Torr. This pressure level is of such a low level that operation of the camera at any lower level will result in no change in lens performance. Pressure levels of lower than 10^{-3} Torr have no significant effect on the refractive index of the lens glasses. Further study during Phase II design efforts will indicate which of the following two variations of the apparatus design is the most practical.

In the first of the two variations or styles of this type of goniometer (Figure 5-15), a single target appears in the field of the collimator. This target is illuminated by a strobe light driven from a precise timing source. The oscillator of this strobe circuit will have a frequency stability of one part in 10^5 or better. The angular rate of the table rotation must be accurately known; it is measured by means of a second collimator which is autocollimated off a multifaced mirror mounted on the table. The returning light signals from the autocollimator sensor are recorded and reduced to determine the angular velocity of the camera and table plus first and second order rotational velocity variation and decay values. This rotational data combined with the flash period gives input angles between imaged targets. This scheme has fewer errors than the second of the two designs; however, it requires more computation and data reduction to get the desired results.

The second variation (Figure 5-16) has only one collimator, but up to 50 targets. The collimator is folded to image targets mounted to the rotating table. As the table rotates at a rate which does not have to be accurately controlled, the targets effectively rotate through the same angle as the camera. This provides for a fixed angle between targets that is not time or velocity dependent and can be calibrated once by placing a theodolite in place of the camera atop the table and measuring the angles. A single stationary strobe lamp illuminates all targets and is triggered by a switch actuated by cams on the table. Timing errors in this switching do not result in angular variations in the input angle but only affect target resolution. This is a result of a target being illuminated off axis in the collimator. This arrangement requires that the radius to the targets from the table axis and the collimator focal length be equal so that the angular displacement between targets is equal to that swept out through the collimator. In this second arrangement, the errors are more of a physical variation than in the first arrangement, but it has the chief advantage of one "time" calibration and less data to reduce.

5.5.1.4 Test Chambers

5.5.1.4.1 Small Test Chamber

As previously indicated, a small chamber will be used for calibration testing. In particular,

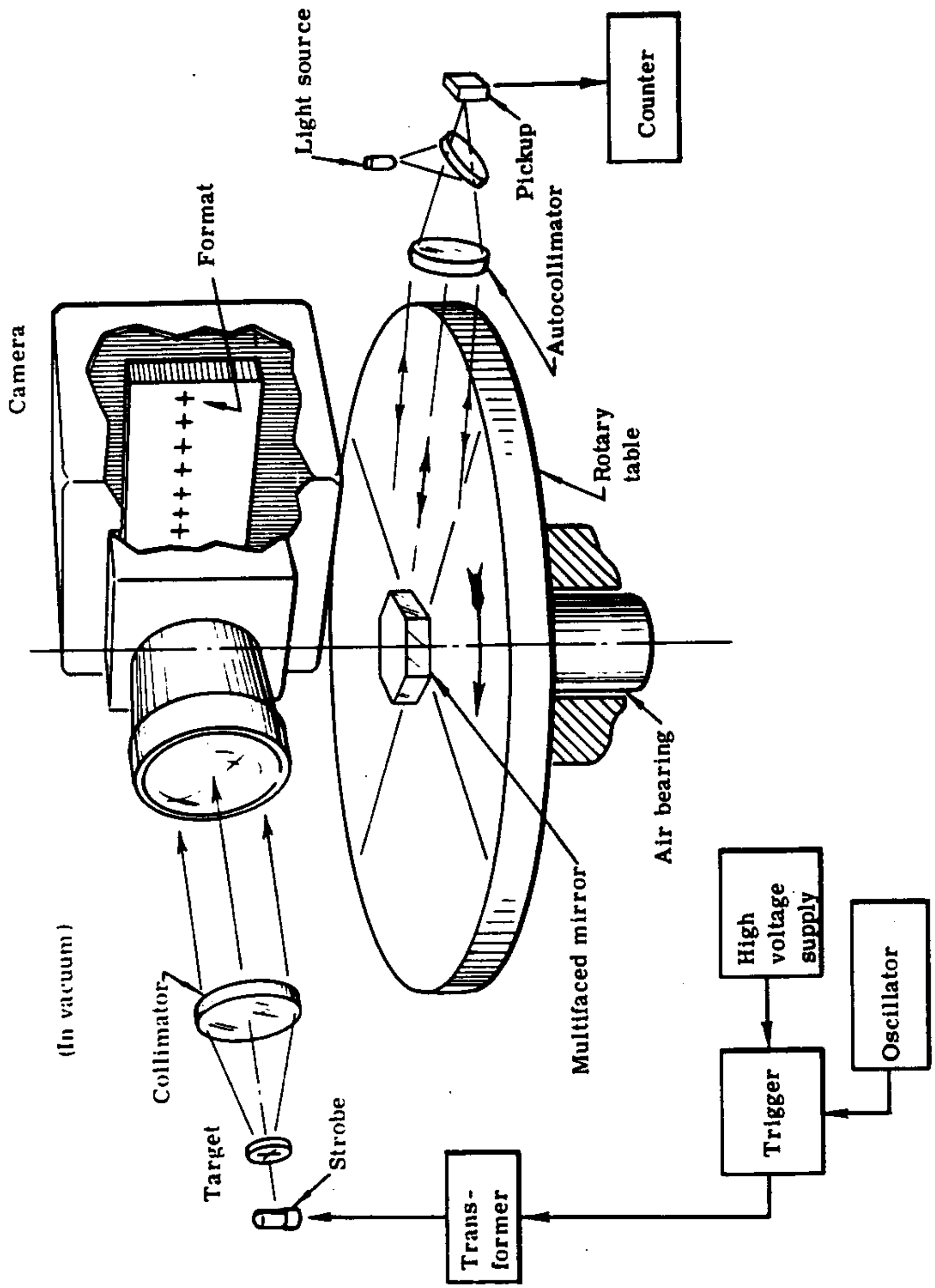

Fig. 5-15 — Goniometer calibration, arrangement 1

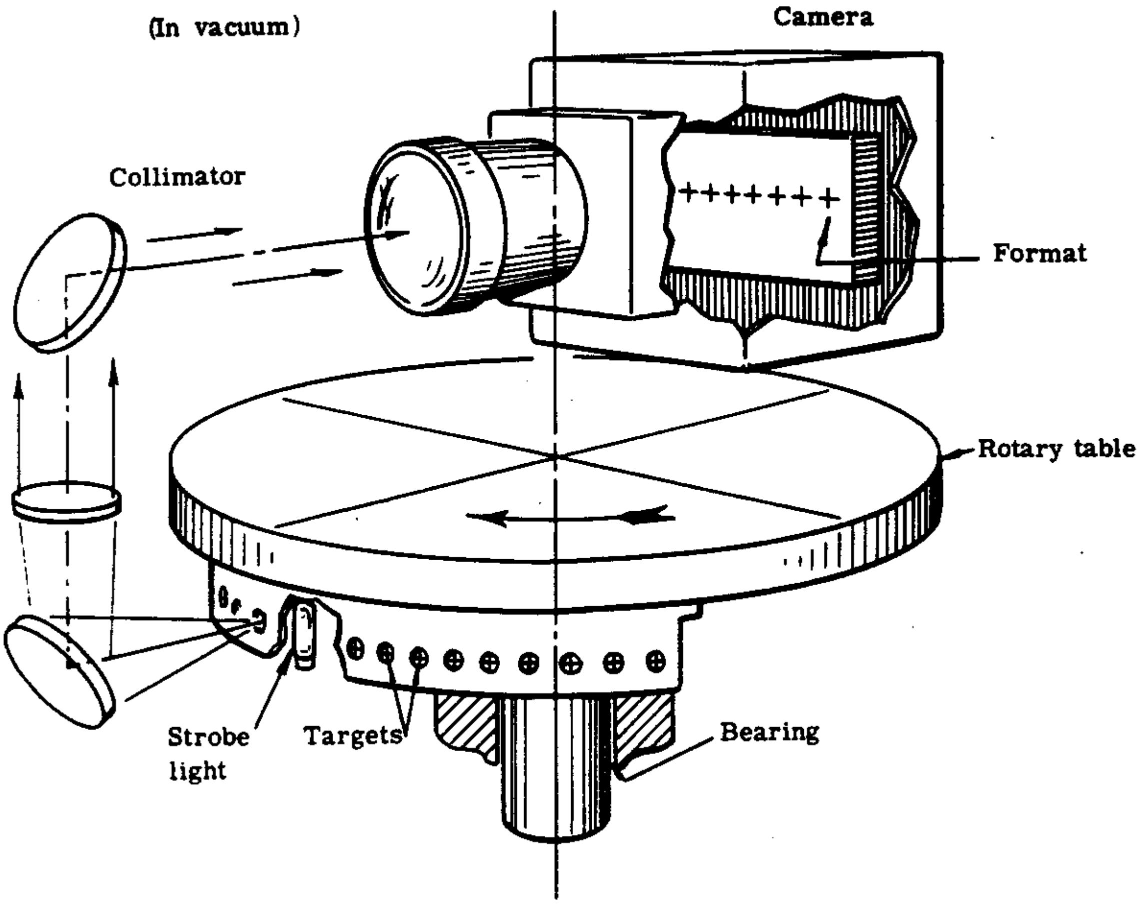

Fig. 5-16 — Goniometer calibration, arrangement 2 the tests to be performed will be primarily an optical calibration of the photosensor subassembly, and they will include calibration and distortion checks.

From the point of view of optical evaluation only, there is not a significant difference between the "high" vacuum associated with the flight condition environment and "low" vacuum conditions; therefore, this chamber will be designed to maintain only 1×10^{-3} millimeter of mercury during the test periods, thereby significantly simplifying the manufacture and construction of the test chamber.

Since the terrestrial camera represents state-of-the-art optical flight equipment, certain factors are of prime importance in the development of the test equipment to be used in the evaluation of such a precision device. With regard to the vacuum chamber, particular attention in design will be given to the subject of dynamic excitations and their effect on test equipment performance. Similarly, vacuum chamber construction and pumping system design will be considered in the test program. The problem areas associated with the development of the small test chamber aredynamic considerations, vacuum chamber construction, and pumping system and instrumentation.

The basic dynamic problem to be solved is that of minimizing the effects of dynamic excitations which tend to cause relative motion between the testing target projector systems (collimators, etc.) and the camera equipment. Basically, these excitations can originate from within the test equipment and/or the instrument being evaluated as well as from external sources, such as ground motions. Internally generated excitations will be minimized by careful design of test fixtures as well as by balancing moving components within the test apparatus and instrument.

Considering the dynamics, the environmental chamber may be considered to consist of the resilient elements and the test chamber.

The test chamber (including the photosensor and associated target projectors, collimators, test bearing support fixture, etc.) will be rigidly fastened together, and will be separated from the floor by resilient springs. (A schematic layout of the dynamic system is included in Figure 5-17.)

The vibration isolation system is more accurately described as a pneumatic servo with integral control capability, the resilient elements actually being air springs. A displacement-sensitive pickoff will be used at each resilient element, and the integrating servo will tend to maintain the same relative position between the mounting face and the isolated mass at each element. The control system has a low, narrow bandwidth, and, at higher excitation frequencies, acts as a passive filter, thereby providing excellent isolation of mounting base motions. The fundamental resonant frequency of the controller will be approximately 1 cycle per second, well below the frequency of any significant excitations measured here at any of the test facilities. An air supply (such as a standard 100 psi compressor) will be required for use with the resilient elements.

The chamber will be a cylindrical container, 7 feet in diameter and 10 feet long. The chamber will be constructed of mild steel, and the inside surface will be painted with a black epoxy paint having low outgassing properties. The chamber design will conform to the requirements of the ASME code for unfired pressure vessels, where the code does not interfere with good vacuum techniques. All surfaces exposed to vacuum conditions will be cleaned and polished prior to painting.

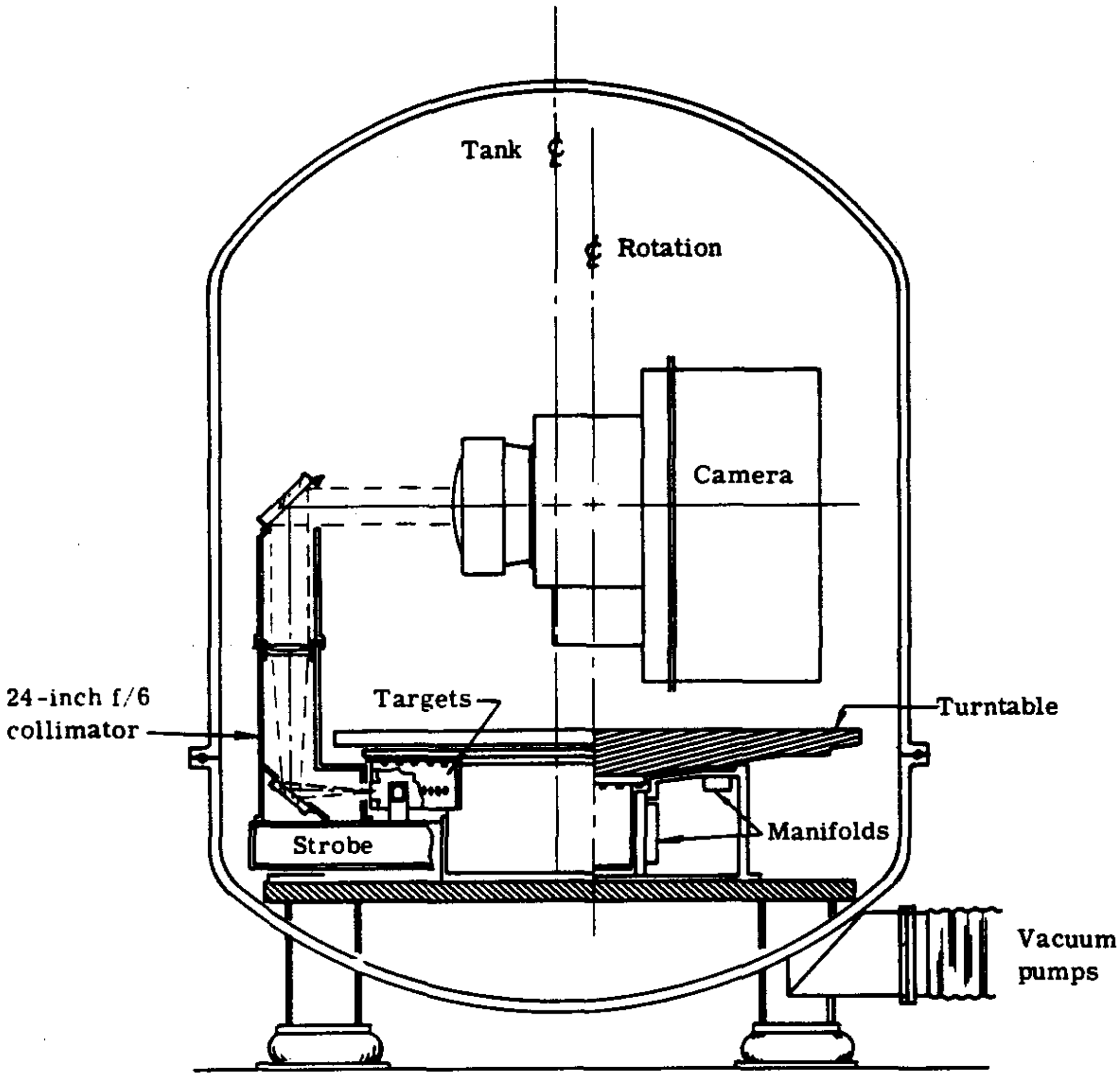

Fig. 5-17 — Small test chamber

All sealed surfaces in the chamber will be of single O-ring type construction, suitable for use in maintaining a pressure of 1×10^{-3} millimeter of mercury. All welds exposed to the vacuum will be continuous and ground to conform to the shape of the tank.

Ports will be provided in the tank to meet the electrical power feed-through requirements. Similarly, special parts will be provided, as required, for mounting test apparatus to the tank; also, special mounting pads will be provided, as required, inside the tank for general supporting purposes.

A parting flange will be included in the design of the chamber to allow the top section of the tank to be disengaged and moved out of the way for easy installation of the photosensor system and other equipment. A separate supporting structure will be provided, to which a lifting arrangement will be fastened for purposes of removing the top section of the tank.

Several different pumping techniques are presently available for use in vacuum applications, the type used being dependent upon the individual problem requirement. It is anticipated that the pumping requirements will be relatively straightforward in this particular case, and it is intended that a Roots blower backed by a mechanical pump (such as the Stokes Microvac line) be used.

As mentioned previously, vibration is a major consideration in the design of this test facility. Since mechanical pumping systems are dynamically noisy, it is intended to shut the pumps off during the test sequence, and maintain vacuum by closing a valve in the pumping line. This will be feasible, since the duration of any single calibration test in the tank will last less than 2 minutes.

It should also be pointed out that unlike the test chamber, the pumping system is not intended to be isolated from vibration. A dynamically flexible seal will be used between the pumping line and the chamber to prevent shorting out of the system during the tests. If a suitable flexible seal cannot be achieved, the pumps themselves can be isolated with the tank, but this approach must be considered as an alternate.

Presently, it is difficult to anticipate all possible problem areas in the vacuum system. Such things as an unexpected high outgassing load may require modifications to the pumping system as outlined above; however, several approaches are available, if required. For instance, Cryo pumping and sorption techniques are vibrationless and will allow pumping to proceed during tests if it is required. Also, diffusion type pumping is possible, where the tank is brought to the 1×10^{-5} level, the pumps are turned off, the system is allowed to outgass, and a pressure of at least 1×10^{-3} millimeter of mercury is maintained before the test sequence is ended. Although other techniques are available, it is not presently anticipated that they will be required.

Suitable instrumentation will be provided to continuously monitor pressure in the roughing lines and fore lines, as well as in the chamber itself. The pressure sensors needed for the vacuum levels to be encountered are standard devices and present no problem in use or delivery. An operator's console, from which all operations can be conducted, will be included. Readout and recording equipment will also be included.

The chamber and console will contain safety provisions and fail safe interlocks so that out-of-sequence console operations will not damage the equipment.

5.5.1.4.2 Large Test Chamber

In addition to the small chamber, a large environmental chamber will be used in the test program. The purpose of the large chamber is to provide an environment suitable for functional testing of the integrated system, which is made up of the mated DCM and recovery section subassemblies. A chamber having slightly less capability is presently being developed at Itek for another program. The expansion of this capability for our purposes requires modifications that can be classed as (1) structural additions to the chamber, (2) redesign of the pumping system, and (3) a new temperature/altitude environmental simulation system.

The existing chamber is a 9-foot-diameter by 46-foot-long cylindrical container. Approximately half the tank is located above floor level, and the remainder is located in a large poured-concrete pit below floor level. The chamber is supported at its midsection by six radial struts which, at one end, are tied to the tank through a structural box section, and which rest on vibration isolators located in a counter bore of the pit at the other end.

A 25-foot by 180-degree structural door is located in the section of the tank which is above floor level. The door is hydraulically operated and exposes the complete upper half of the tank when open.

The tank is centrally located in one of the end bays of a three-bay building; each bay is approximately 24 feet square. The pumping system, dehumidifier, and cold-shroud refrigeration system are located behind the tank; the vacuum system control console and hydraulic door power-control unit are located to the left of the tank (viewed from the front). (A chamber modification layout is shown in Figure 5-18.)

The tank is made of mild steel, and the vacuum construction details are the same as those of the smaller tank. The existing pumping system is a Roots blower backed by a mechanical pump, and it has the capability of attaining a pressure of 10^{-3} millimeter of mercury in 1 ½ hours when the chamber is clean and dry.

An 8-foot-diameter cold shroud is attached in the upper section of the tank, and the Freon refrigeration system will maintain the shroud temperature at -70 °F with a 20-kilowatt heat load in the chamber.

The chamber is vibration isolated by 6 pneumatic springs located under the support struts; the characteristics of the isolation system are the same as those described previously for the small tank. Also, a flexible seal is located between the pumping system and tank, enabling the pumps to be dynamically decoupled from the tank.

Standard pressure monitoring instrumentation having readout and recording capabilities similar to those described for the small chamber are used.

A 12-inch I-beam is fastened to the inside top of the upper section of the chamber, and a similar beam is used in a monorail system which spans the three bays of the building. The monorail has a swinging section directly in front of the tank which may be lined up and latched to the support beam in the tank when the tank door is opened. The monorail beam is supported on structural cross beams which, in turn, are tied to the building columns. The purpose of the monorail and tank support beam is to enable the transfer of loads from the building to the tank, using suitable trolley hoists.

The fixture design and the procedures to be used in installing the payload into the chamber are relatively simple and straightforward. Two separate handling dollies are provided to support, horizontally, the DCM and recovery sections; each dolly has lifting jacks to vertically align the mating flanges of the respective horizontally oriented DCM and recovery sections. An adapter

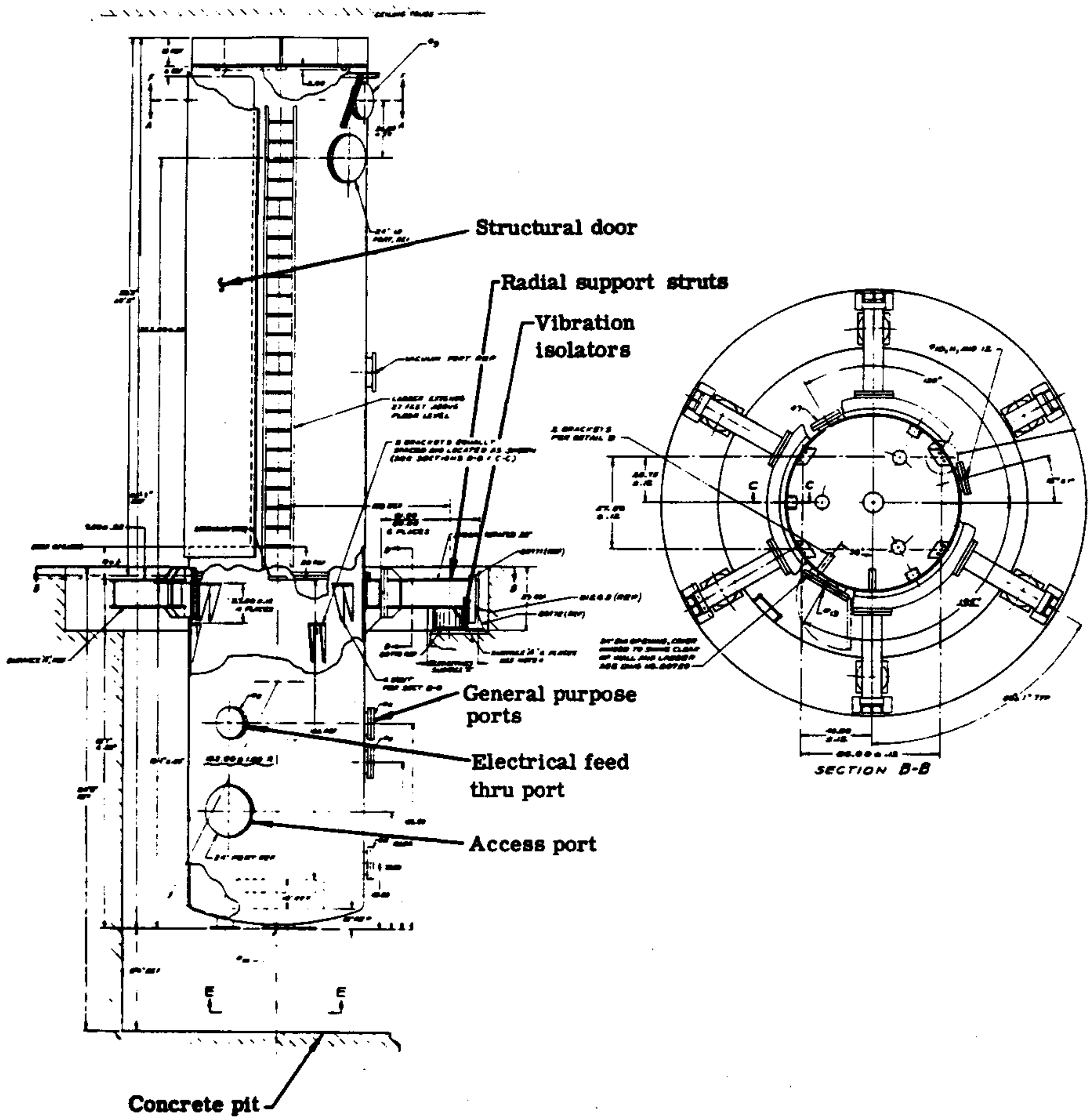

Fig. 5-18 — Large vertical vacuum chamber ring will then be placed between the flanges; the DCM and recovery section dollies, being lined up horizontally, will then be rolled together on the dollies and bolted in place with the adapter ring located between them.

A lifting sling will then pick up the mated payload in a horizontal mode and set it into the lifting dolly assembly. The lifting dolly has a large U-shaped collar for easy insertion of the payload, which will receive and mate to the adapter ring just described. The adapter ring and collar will then be bolted together.

The payload, which is on the lifting dolly in a horizontal orientation, is then rotated to a vertical position. The payload is then supported on the monorail system of the building by using appropriate spreader bars and straps; the lifting straps will be tied to the adapter ring of the payload at one end, and a lifting hoist on the monorail at the other end. The payload is unbolted from the lifting dolly and placed into the tank using the trolley hoist and monorail installation.

As previously mentioned, structural additions will be required to adapt the existing chamber to the new program requirements. The structural additions discussed in the following paragraphs pertain to the payload support problem only; those associated with pumping system redesign, and the thermal problems, are presented in their respective sections.

As indicated on the chamber layout, three support gussets exist in a plane slightly below the chamber door opening. It is intended that these gussets be used to support the mounting structure for the payload while it is in the chamber. The mounting structure will include an interface flange or ring which will duplicate the mounting configuration of the vehicle to which the payload is attached while in flight. The interface flange will be tied to a truss structure which, in turn, will attach to the three support gussets. A flat safety door will be mounted to the three gussets located just below those discussed above; the safety door will act as a working platform, and will also prevent tools and equipment from being dropped to the bottom of the tank.

The payload will be put into the tank using the overhead rail and hoist system. Once in the tank, the payload will be lowered onto, and aligned with, the support structure.

A second major modification to the test facility is the modification of the vacuum pumping system. The existing pumping arrangement comprises a blower backed by a mechanical pump, and it does not have the capacity to bring the chamber to the desired operating pressure of 1×10^{-5} millimeter of mercury. Therefore, the blowers of the existing system will be replaced with diffusion pumps which will provide the pumping capacity to reach an operating level of 1×10^{-5} millimeter of mercury. Mechanical pumping is still required to "back" the diffusion pumps, and the existing mechanical pump can be used for this purpose. Additional mechanical pumping of the same type may be required, after evaluation of pumping time requirements and outgassing loads.

The diffusion pumps will be attached directly to the tank; and the structural modifications to the tank will include enlarging the existing evacuation port, and the addition of the structural support members required for diffusion pump mounting frames.

As previously stated, vibration during optical calibration testing is a critical problem; however, for the functional tests required in the large chamber, the problem is not quite as severe. Therefore, with the mechanical backing pumps mounted to the floor and vibration isolated from the diffusion pumps by using a flexible seal in the vacuum evacuation line, a practical approach to the pumping system problem results. The diffusion pumps which are mounted to the tank directly are dynamically quiet and, therefore, present no basic vibration problem.

5.5.1.5 Thermal Testing in the Large Test Chamber

Up to this point the discussion of the test facility has been concerned with modifications to an existing vacuum chamber as well as a description of basic design parameters to be considered in the manufacture of a smaller test chamber. The final, and undoubtedly the most complex, phase of the test equipment requirements is the thermal simulation system for the payload qualification and acceptance tests.

The thermal problems of a vehicle such as the GOPSS originate with the varied types of incident radiation associated with earth satellites. Presently, it is not possible to adequately duplicate, in a single facility, all of the known forms of incident radiation; it is necessary that certain compromises, consistent with reasonable test objectives, be made in the thermal simulation area of the test program.

It is not intended to present the physics of high altitude incident radiation in this section; however, based on previous thermal studies, the thermal test sequence will be outlined, including mention of the compromises which will be made with regard to the solar simulution area.

Duplication of incident energy for test purposes involves many problems. For instance, variations in uniformity of a simulated solar beam are important since payload equilibrium temperatures will be affected accordingly. Beam uniformity is critical; nonuniformity can cause local hot spots of such a magnitude that thermal conduction in the payload may not be sufficient to average out the errors, resulting in undesirable thermal gradients. Temporal stability of the source and angular divergence of the beam are also important; such effects as shadows and vehicle shape combined with temporal instability or lack of collimation can combine to introduce large local thermal errors. Finally, spectral match is important because of the reflectance properties of the payload; deviation from the spectral distribution of the sun will obviously introduce differences in the payload thermal balance between operating environmental conditions and test periods, resulting in erroneous conclusions as to payload performance. Unfortunately, even the simplest of materials, such as aluminum, are quite spectrally selective depending on polish, oxidation, etc., which emphasizes the need for a close spectral match between test and operating environments.

Having introduced some of the problems of duplication of high altitude radiation, hardware to accomplish this effort must be considered. Various design manipulations of optical refractive and reflective elements and sources have been considered, none of which seem to satisfy the radiation duplication and economic considerations simultaneously.

Refractive element systems are difficult to combine whereby sufficient energy is obtained throughout the spectrum. A refractive collimator for a 16- to 18-foot-diameter beam (which would be required to completely soak this payload) would be expensive; even a "many modular array" configuration of the collimator is costly, along with the fact that this design suffers from nonuniformity due to boundary effects between individual modules.

Off-axis source reflective solar collimators seem to offer the best possibility; deep space background is duplicated and reflective systems are less spectrally sensitive. However, a system such as this is impractical with regard to modifying the existing test chamber, and would require a complete new environmental facility for this program.

However, thermal simulation for the payload evaluation can be compromised from the complete solar simulation facility, and still provide adequate testing. Difficulties in obtaining good simulation on a large scale arise, not only with the technical problem of determining the best simulator components, but also with the practical problems of development and manufacture of working hardware.

It is desirable, in performing a thermal test program, to completely simulate the thermal environment which the system is expected to encounter. Since this is impractical for a vehicle as large as this, an alternate approach must be used. Therefore, a two-phase thermal test program will be carried out.

The first phase of the thermal test program will be directed toward an evaluation of the DCM shell and external coating. Specifically, the parameters which will be investigated are: (1) the ratio of the absorptivity to emissivity of the coating, and (2) the temperature response of the shell structure. This portion of the program will be performed with a small scale model which is representative of the shell structure and has the same mosaic as is specified for the full scale vehicle. It will be necessary to simulate, as closely as possible, the true thermal environment, i.e., the magnitude and spectral distribution of the solar, albedo, and earthshine fluxes.

The second phase will evaluate the thermal performance of the entire system. The heat flux to which the cameras, film spools, etc., are subjected is dependent on the temperature of the DCM shell; the type of flux is immaterial. Therefore, in order to test the ability of the system to maintain the temperature of the cameras at the specified levels for the duration of the mission, it is necessary only to simulate the temperature history of the DCM shell and the energy interchange at the aperture. The temperature cycling of the shell will be based on both the results of the first phase and on analytical predictions. By running several different temperature cycles, the sensitivity of the cameras to the environment will be determined. The results obtained during this phase will also provide an important check on the validity of the analytical design techniques.

The qualification of the thermal mosaic, using a small scale model, will be conducted at an existing test facility capable of simulating the conditions of solar radiation, albedo, and earthshine. Itek will obtain the contract for the use of this test facility. The second phase of thermal testing (previously described) will be conducted during qualification testing in Itek's large chamber. The apparatus will be comprised of a cold wall operated by the existing refrigeration system, and a bank of lamps and calrod units controlled so as to provide a cycling heat flux. The configuration will consist of a circumferential cold wall 8 feet in diameter and 10 feet longer than the payload. The lamps and calrod units will be located between the payload skin and the cold wall, and will be oriented along the axis of the payload.

5.6 RELIABILITY

During the evolvement of the GOPSS program, three formal reliability reviews will be conducted. These design reviews will be held and documented to satisfy the customer that the system will be fabricated at the lowest cost commensurate with the objective of successful performances during the mission.

The reliability program may be separated into five various reliability phases as outlined in Figure 5-19. (Phases referred to in this program plan are reliability phases, unless otherwise indicated in the text.) This program will meet all requirements specified in MIL-R-27542A (USAF). The contents of the program are given in the Reliability Program Plan Outline below.

5.6.1 Reliability Program Plan Outline

Reliability Review and Analysis

Phase I

1. Specification review
2. Concept review
3. Reliability prediction

Phase II

4. Parts list review
   a. Critical components list
   b. Reliability prediction
5. Circuit review and stress analysis
   a. Procedure
   b. Forms
   c. Failure rate data sources
   d. Reliability prediction
   e. Failure modes and effects analysis
   f. Tolerance consideration

Phase III

6. Materials review or mechanical design review
   a. Dynamic environment
   b. Climatic environment
   c. Thermal environment
   d. Checklists

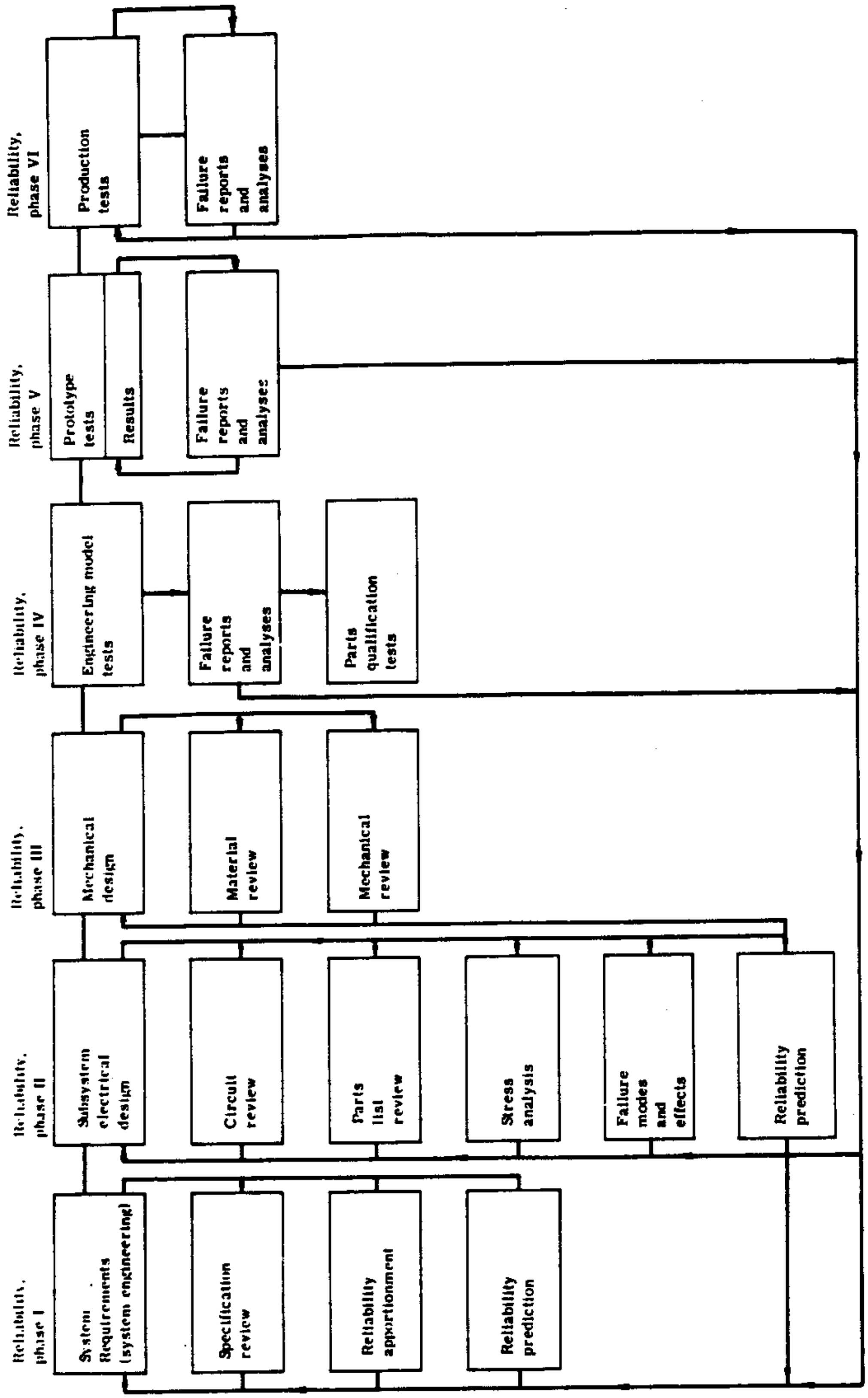

Fig. 5-19 — Reliability program

Component Parts Testing

1. Tests to specified levels
2. Tests to failure
3. Life test
4. Results and confidence level

Maintainability Review

1. Specification review
2. Concept review and establishment of a philosophy
3. Review
    a. Maintenance provisions
    b. Test points
    c. Marginal testing
    d. Prediction
4. Final review
    a. Maintenance features
    b. Maintenance instructions
    c. Logistics support
5. Maintainability testing
    a. Test on model
    b. Analysis
    c. Recommendations of design changes

Test Planning

1. Design tests
2. Qualification tests
    a. Environmental
    b. Reliability
3. Production tests
    a. Acceptance
    b. Sampling for requalification

Reliability Data System

1. Planning
2. Checkout

5.6.2 Design Review and Prediction

The three reliability reviews are outlined below.

Preliminary Review. This is a review of the overall system requirements and specifications in terms of performance, reliability, and maintainability by systems, project, and reliability engineers. This review will be held during reliability Phase I with the program manager as review chairman.

Intermediate Review. This is a review of the design subsystem (or major components) by subsystem electrical and mechanical engineers, as well as reliability, quality control, component, and thermal engineers. The design will be reviewed for the application of component parts, basic circuit selection, mechanical design features, and thermal reliability. The review chairman will be the cognizant subsystem engineer for this Phase II review.

Final Review. This meeting is primarily a review of manufacturing drawings prior to release for fabrication. Subjects to be considered will be tolerances, environmental protective features, fabrication processes, workmanship standards, and maintainability features. The meeting will be attended by subsystem design, electrical, and mechanical engineers, as well as by reliability, quality control, and test engineers. The review chairman for this Phase III meeting will be the cognizant subsystem engineer.

5.6.3 Failure Mode Analysis

As part of, or prior to, the formal design reviews, there will be a continuous series of reliability reviews and analyses conducted by the reliability groups. These reviews will control the design selections from a reliability standpoint and will later be used to control equipment modifications as required by engineering model, prototype, or production unit testing.

The reliability analysis and review procedure may be broken down into the following steps.

1. Specifications review
2. Parts list review
3. Electrical stress analysis
4. Failure modes and effects analysis
5. Materials review
6. Mechanical review
7. Failure reporting and analysis

Specifications Review

This review of all Itek-generated product or equipment specifications by the cognizant design, reliability, and quality control engineers will ensure that the tests specified are adequate for revealing potential malfunction or deterioration, and that the inspection and acceptance tests are adequate.

Parts List Review

Parts lists will be utilized to ensure that qualified parts are used wherever possible and that unqualified parts are properly evaluated and tested. These lists will also be used to update the system reliability prediction.

A critical components list will be reviewed to ensure that parts are properly derated and that the reliability goal will be met. The circuits will be further reviewed for the use of standard circuits wherever possible and to make certain that tolerances have been properly considered.

Standard forms and procedures will be utilized to transmit data on electrical and thermal stresses of parts used. These forms will be part of the permanent record and kept on file for review.

The information obtained from the stress analysis will be used for updating the reliability prediction MIL-HBK-217, and also for determining failure rates on electrical parts.

Any critical areas or parts indicated by the stress analysis will be cause for immediate action.

Failure Modes and Effects Analysis

A failure modes and effects analysis of the system will extend to the parts level.

Materials Review

Materials will be reviewed to verify that the type and quality are consistent with their end use. Special attention will be given to the characteristics of plastics adhesives and finishes ensuring compatibility with environmental conditions. Designers will use only proven materials in their designs.

Mechanical Review

Mechanical design reviews will take into consideration general mechanical features, such as

1. Environmental stresses (i.e., thermal, shock, vibration)
2. Adequacy of materials
3. Reduction of human error
4. Maintenance provisions
5. Life of moving parts
6. Tolerances, fits, locking methods

Failure Reporting and Analysis

A closed loop failure reporting system will be used from the start of engineering model testing. It will be used by Itek to monitor the program, and will provide information for required modifications to the system. It will be continued throughout the production phases to provide the same type of information. This procedure is documented in Itek procedure 014.2.

Time-Phased Elements of the Reliability Program

1. Specification review
2. Environment determination
3. Complexity studies
4. Reliability apportionment and prediction
5. Reliability documentation
6. Design reviews
7. Critical parts list
8. Component parts test
9. Test planning
10. Failure data system
11. Failure report data
12. Failure analysis
13. Engineering model tests
14. Prototype tests
15. Reliability tests
16. Quality control coordination
17. Production acceptance test
18. Field tests

5.6.4 Parts and Materials Program

All parts and materials used in the design and construction of the system will be qualified as to their suitability for use in the production units. The overall parts program is outlined in the program plan.

Parts and materials will be selected, as per program requirements, in the following order: (1) MIL items, (2) items used on previous programs where test data is available, and (3) items whose usage must be qualified through testing.

5.7 MANAGEMENT

5.7.1 Program Schedules

The summary network of Phases II through V (see Figure 5-20) shows that optical manufacture and system testing together comprise 87 percent of the length of the critical path; both of these are described in further detail in Sections 5.7.1.1 and 5.7.1.2.

Glass procurement commences in month 3 of the program and at month 7, the critical path passes into optical manufacture of the first lens. During manufacture, the critical process is the production of the aspheric reseau plate, a condition resulting from the speed of the polishing, figuring, and figure evaluation techniques, and availability of machinery. After manufacture of the elements, the critical path goes through assembly and testing. During the early stages of assembly, final "tuning" of the aspheric surfaces is done, with later stages of assembly given over to the mounting of some camera components. Final testing is then completed on the same distortion bench used during assembly; therefore, two of these benches are provided so that the second lens may be assembled and tested concurrently with the first.

The critical path then becomes the 4-month period devoted to assembly of the first photosensor system on Phase III, month 15 through month 19. This includes 3 months of camera system debugging or confidence testing.

The remainder of the critical path involves the qualification testing of the first photosensor system, acceptance testing of the first flight photosensor system, qualification testing of the first GOPSS, and acceptance testing of flight system numbers 1 through 5.

This latter part of the critical path results from test equipment availability. One item resulting in this critical path is the vibration test installation at Itek. The second is the large environmental chamber, which is the most critical.

Note that the schedule for Phases III through V has been designed so that events follow in a logical sequential order and that critical path is gated by capital equipments rather than by time necessary to complete the actual tasks. The schedule illustrates that this program has been designed to pay close attention to personnel and task support to accomplish the job in the minimum possible time.

5.7.1.1 Optical Manufacture Schedule

Manufacture of the system optical components is the initial portion of the critical path in the PERT analysis of the program. Thus, this subphase (see Figure 5-21) of the contract will be rigidly supervised, and all cognizant technical and management personnel will be alerted to take advantage of techniques and/or scheduling that might result in time savings without risk of degrading quality.

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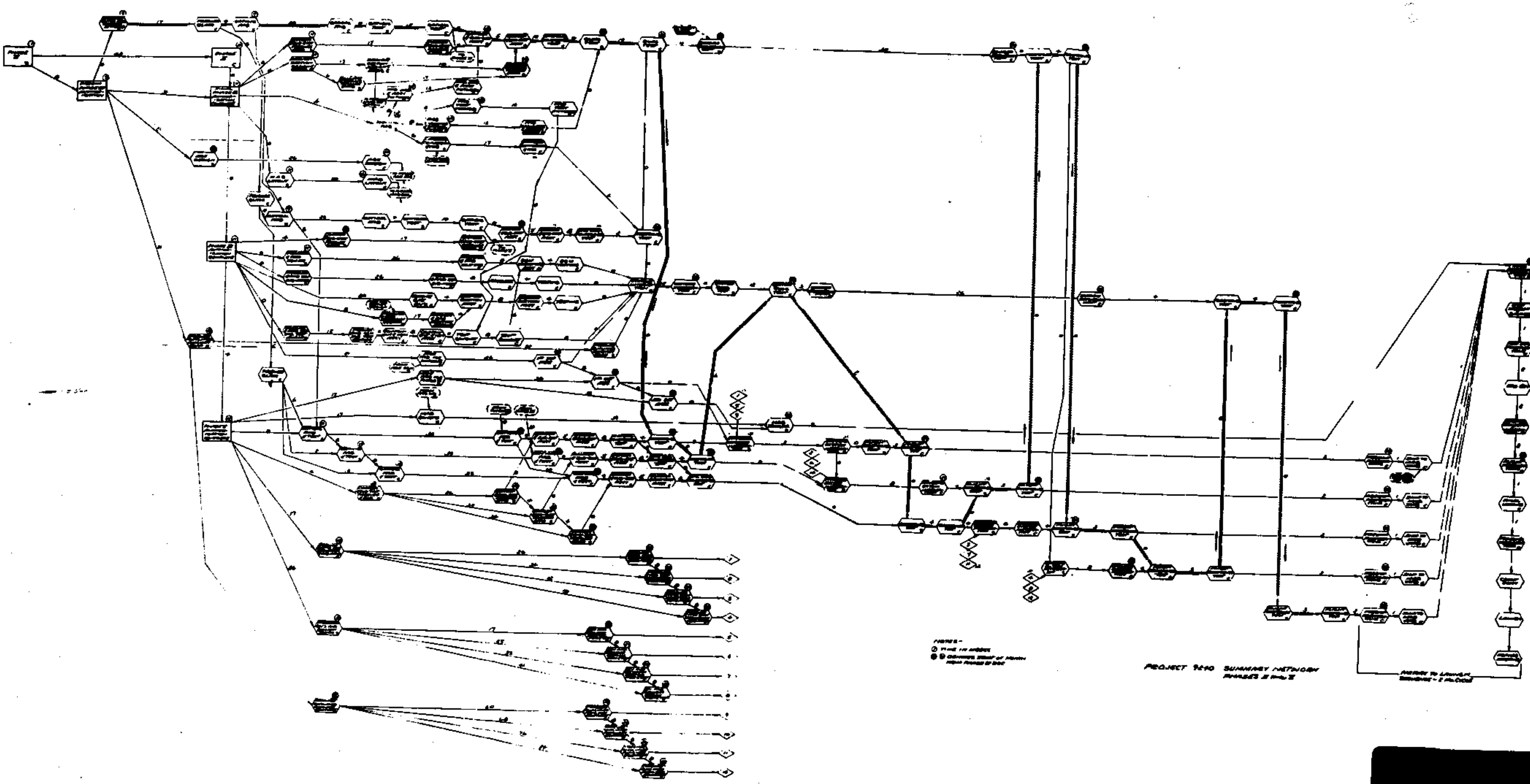


Fig. 5-20 — Phase II through V summary network

SECRET [redacted]

PHASE III THRU V - OPTICAL FABRICATION
TERRESTIAL LENS

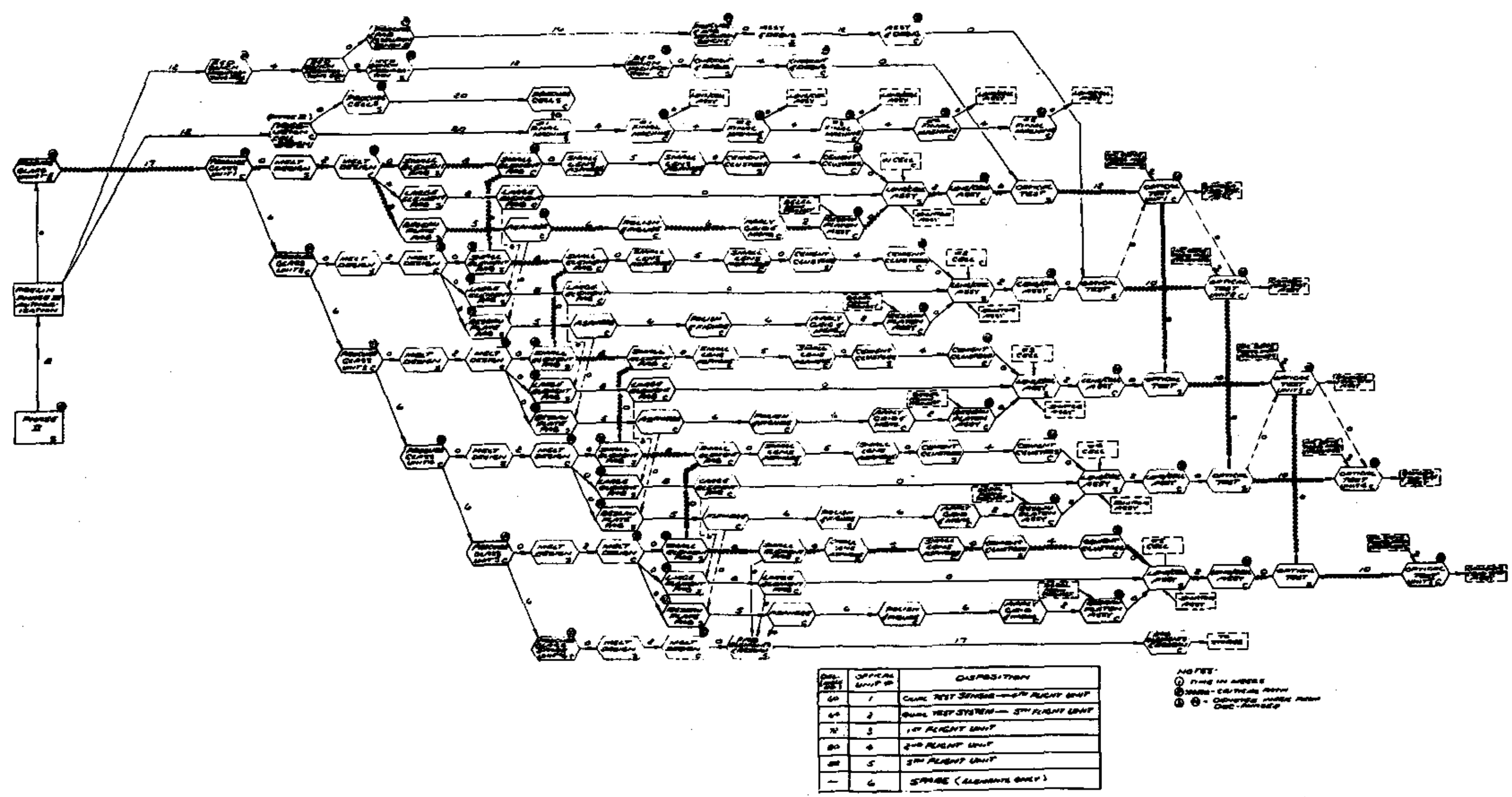


Fig. 5-21 — Optics summary network

[redacted]

Optical manufacturing starts with procurement of the raw glass stock in the third month of Phase II. After the stock has been received, its accompanying melt data is applied to the basic lens design to define design specification changes that occur due to differences between the theoretical and actual data.

When the melt design has been completed, three concurrent manufacturing paths—large element manufacture, small element manufacture, and reseau plate (platen) fabrication are initiated. The reseau plate fabrication is initially the critical item; however, small element fabrication becomes the critical item as the optics fabrication cycle progresses.

When the several discrete optical elements have been completed, they are assembled together temporarily on a test bench for final aspherizing (tuning). When the aspherizing tuneup has been satisfactorily completed, the optical elements are combined with mechanical camera components to form the lens cell assembly which is then subjected to the camera optical test program.

5.7.1.2 Test Plan Schedule

After the first sensor optics have been procured and fabricated, the qualification acceptance test program becomes the critical path for the remainder of the program. This occurs as a result of the availability of the large vacuum chamber in which a long-period soak of each sensor and/or system is required. To meet the schedule, close adherence to an established chamber usage schedule is required to prevent chamber downtime.

Although not as tight or critical as chamber usage, some fairly tight scheduling of equipment usage for the shaker, shock machine, phototest equipment, etc., is required.

Because it is mandatory that the chamber be in operation on a virtually continuous basis, some chronological displacement in equipment flow will occur. A schedule that guarantees optimum usage of chamber time is graphically illustrated on the PERT diagram shown in Figure 5-22.

As each of the five flight systems completes its preflight acceptance program, it enters a two-month factory-to-launch cycle where it is prepared for, and subjected to, a pad run, evaluated for flight readiness, prepared for flight, run through a series of prelaunch verification tests, and launched. It is not presently foreseen that tight availability considerations will cause the two-month final cycle to become critical.

5.7.2 Project Management Concept

5.7.2.1 GOPSS Project Organization

Phases II through V of the GOPSS program will be conducted under Itek's Project Management Concept. This concept optimizes the advantages of both the centralized functional organization and the decentralized project organization. Project organization of the GOPSS Program is shown in Figure 5-23.

The project manager selected is technically qualified with respect to the key elements of that program; his administrative capabilities will ensure strong, responsible management and control of the project. He has the responsibility for successful completion of the program and its work statement within the stipulated contract period. During this period, technical and management customer representatives have direct contact at all times with the progress and status of the program through the project manager.

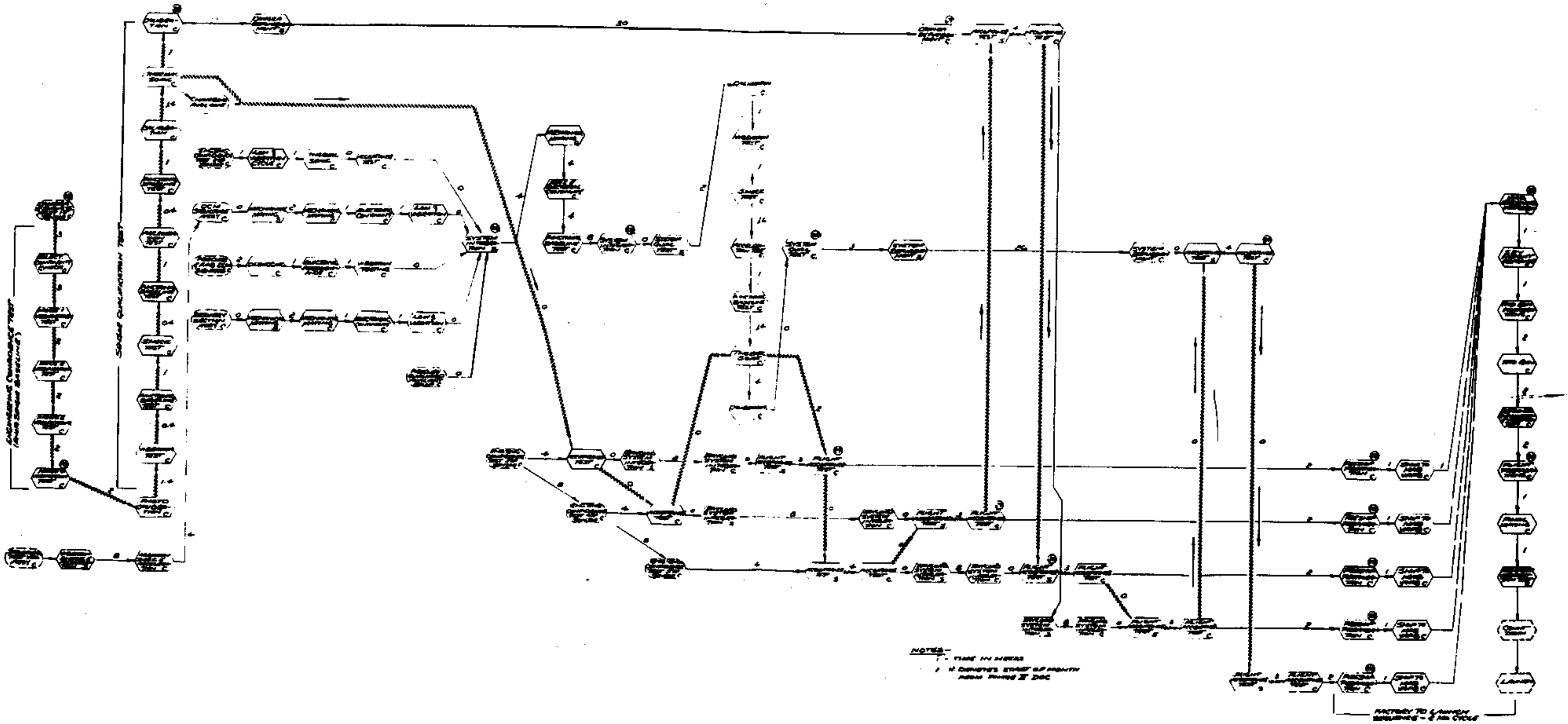


Fig. 5-22 — Test plan summary schedule

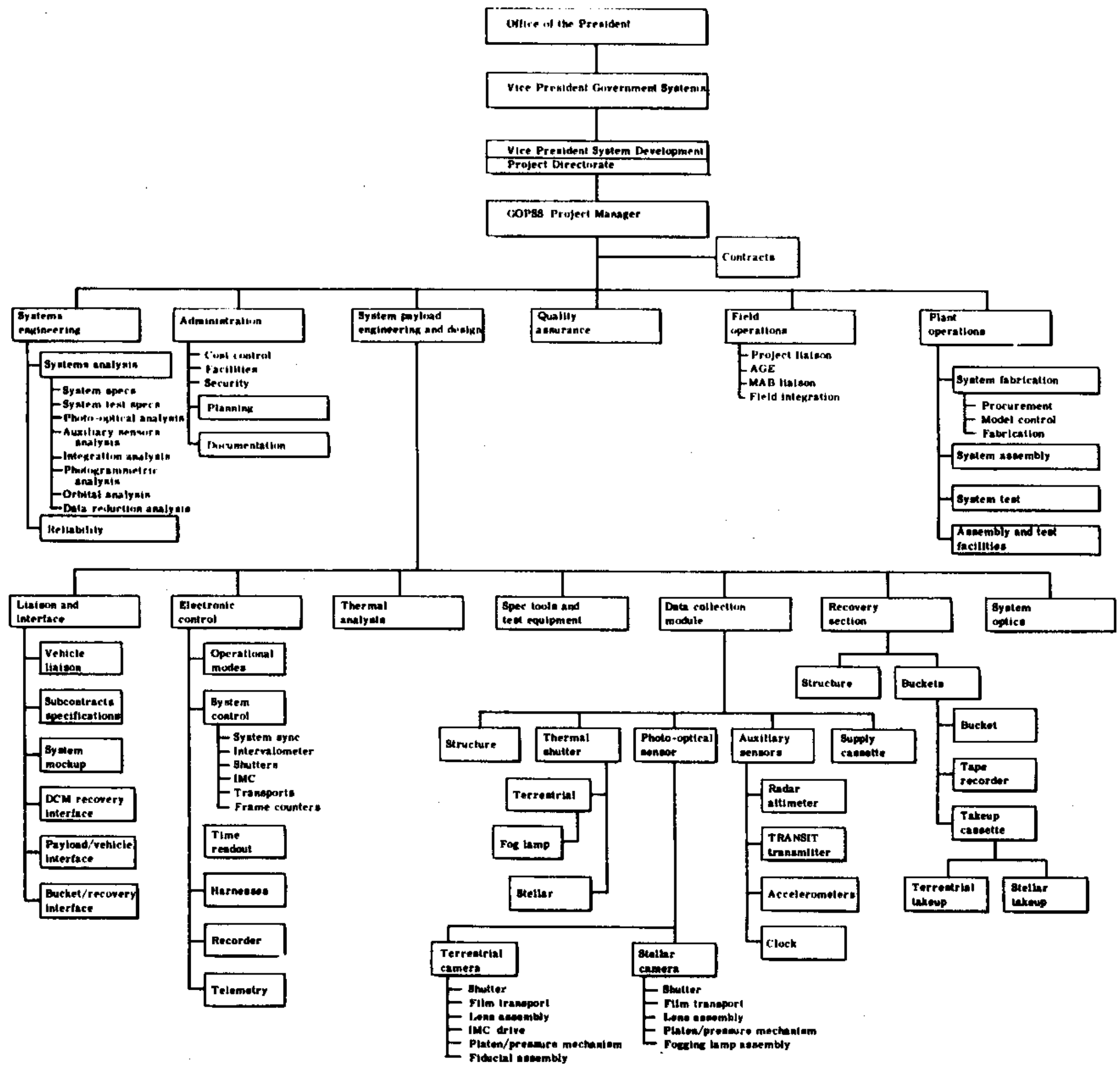


Fig. 5-23 — GOPSS program project organization

To assist in carrying out his responsibilities, the project manager has assigned to him those scientific, engineering, planning, and administrative personnel, selected from Itek's divisions and departments, who have special competence in the areas involved in successfully completing the program. Organized as a team, this group works for the project manager throughout the program, from initial planning and research through final production. Since the GOPSS optics is an important segment of the program, a separate organization chart for this function is shown in Figure 5-24.

After the project team is organized, the project planner, in conjunction with the project manager and key members of the project team, develop the program's operational plan.

During the development and evaluation of the program plan, the detailed work structure is defined, task responsibilities are assigned, and the cost control structure, project schedule, and resource requirements are established. Continuous cost and schedule monitoring and program re-evaluation against the baseline plan provide a dynamic project control system.

The project manager and his team are further supported by permanent project advisory groups and regularly scheduled technical reviews by scientific committees whose memberships are based on scientific and technical backgrounds keyed to the project area problem. These reviews subject the program to periodic evaluation and continuing guidance. Where further assistance is required, the project team may freely consult with scientists and engineers from all divisions of Itek Corporation.

In addition, frequent progress reviews are made by divisional and company administrative management, and assistance is given wherever required in order to meet the schedule and keep costs in line. Here, the Itek cost and control system allows performance measurements to be taken at each level of the organization and provides the manager with the operating information required for intelligent decisions on the conduct of the program. To provide him with the information necessary for good project control, a complete reporting system which furnishes the project manager and company management with reports covering labor analysis, commitments and expenditures, other direct charges, travel, and current overhead rates is operative.

All major projects utilize the services of a quality assurance and reliability engineer or engineers who see that specified reliability and quality assurance practices and procedures are instituted at the start of a program and upheld throughout its duration. These are administered by a quality assurance manager at the systems division engineering department. The procedures have passed the most rigid inspections by the military services and major systems managers for whom Itek has produced equipment. Their scope embraces practices and standards for (1) design and drafting, (2) component design, fabrication, and testing, (3) materials, (4) processes, and (5) workmanship. Reliability is discussed in detail in Section 5.6; quality assurance responsibilities are further defined in the next paragraph.

5.7.2.2 Project Quality Assurance

The Project Quality Assurance Manager is assigned directly to the program during the earliest practical phase of contract performance. Project quality assurance organization and Itek's overall quality assurance department and functions are shown in Figure 5-25. The manager has the responsibility for ensuring the complete integration of the quality requirements of the contract into the total program effort. He will participate on a full-time basis with full responsibility and authority for all quality assurance functions applied during the life of the program. His first step is to perform a detailed analysis of the contract and all technical exhibits in

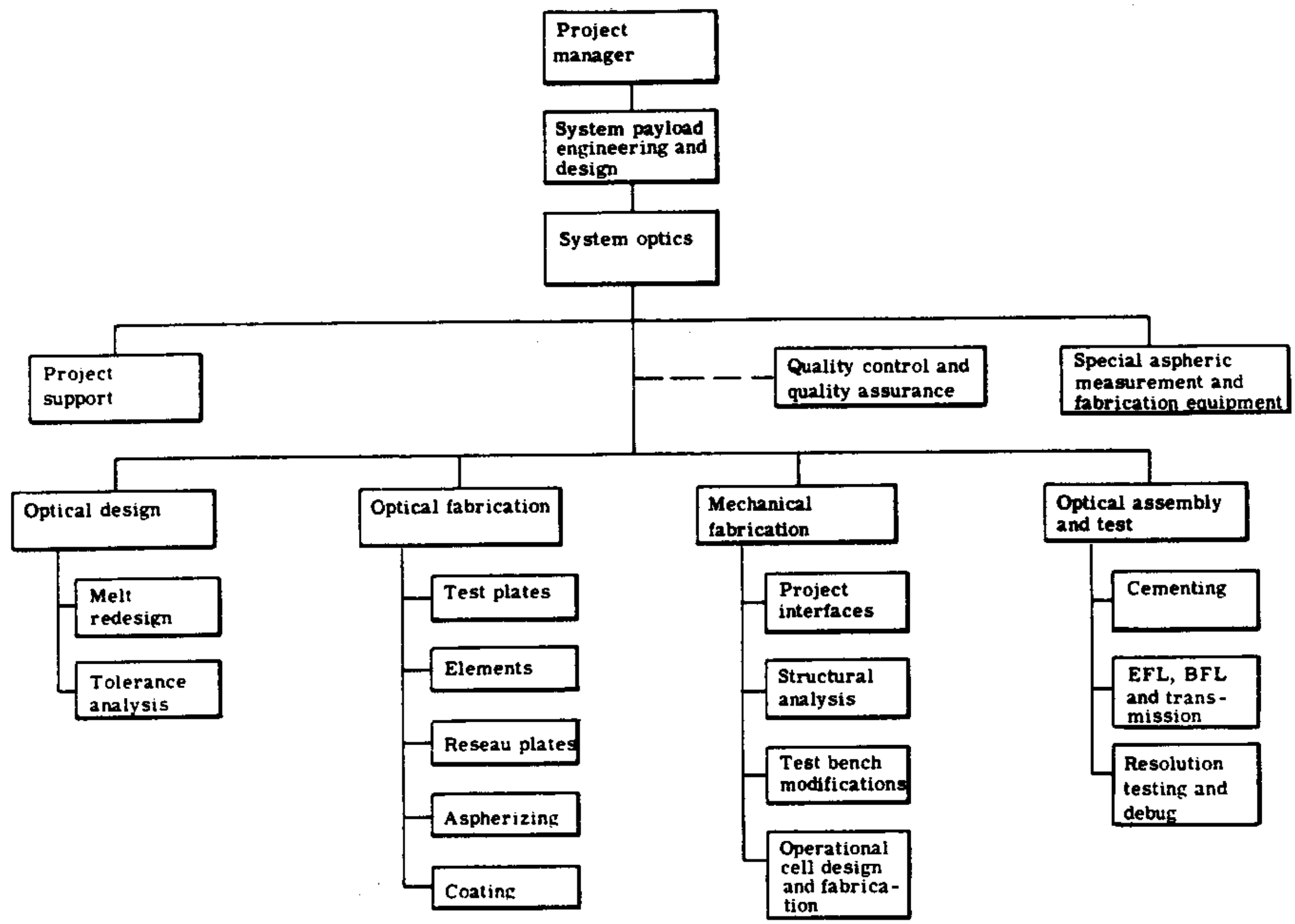


Fig. 5-24 — System optics organization chart

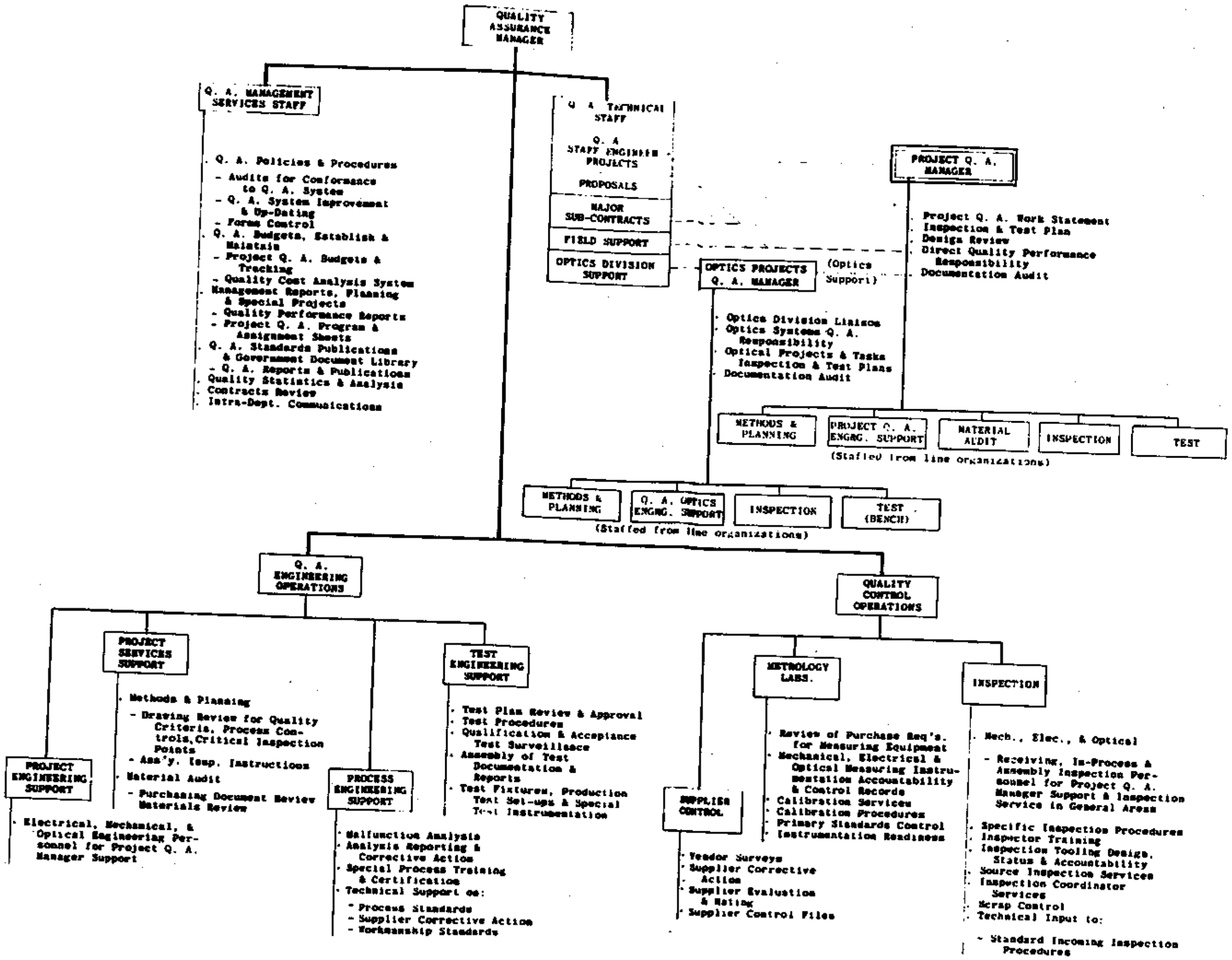


Fig. 5-25 — Q. A. Department organization preparation for the development of a formalized Quality Assurance Program Control Plan. Milestones are established and coordinated into the master plan. Special attention is paid to critical areas requiring special attention throughout the life of the program. In addition, the analysis spells out specific areas of responsibility and personnel assignments. The resulting plan defines, in detail, the nature and scope of the quality assurance tasks to be applied on the phases of the programmed.

The most important single feature of Itek's quality assurance program is the concentration on the prevention of defects. Heavy emphasis is brought to bear in this area through participation in design and drawing reviews followed by a careful monitoring of all procurements in order to determine that inspection criteria are adequately defined and adhered to. Receiving inspection functions are carefully controlled through the use of standard incoming inspection instructions supplemented by special inspection instructions for critical items. Accepted material is routed to bonded program stores under constant quality assurance surveillance. Limited shelf life and other materials are labeled carefully to prevent the use of improper and out-of-date materials. Discrepant material is bonded in material review areas and disposed of through classical material review procedures. A vigorous corrective action effort is implemented at this level in order to prevent recurrence of defects.

Feedback is maintained through the Supplier Control Group to obtain corrective action from deviating suppliers. A programmed electronic data collecting system also contributes heavily in this area. Performance limits, established through the years, automatically help sort out unsatisfactory suppliers. Foundries, processing, and welding suppliers are given extra attention.

As part of process engineering support under quality assurance engineering operations, a well staffed and equipped malfunction analysis laboratory provides fast response to malfunction reports resulting from test and field operations. Detailed analyses of component failures and establishment of the recommended corrective action to prevent malfunction recurrences are the principal responsibilities of the Malfunction Analysis Group.

Test and measuring equipment is controlled by rigid periodic maintenance and calibration surveillance directly traceable to the National Bureau of Standards. Our modern environment-controlled measurement standards laboratories and instrument repair facilities are fully equipped and staffed to perform these tasks. The Quality Control Section provides full inspection coverage during all stages of subassembly and final assembly work. As the design develops, the Quality Assurance Test Engineering Section phases into the program to assist in the development and review of all test procedures. It is the responsibility of this section to make certain that the testing will be adequate throughout all levels of systems buildup and that the results will be completely compatible with the program requirements.

All testing from subsystems through final systems test is monitored and fully documented by the quality assurance test engineers assigned to the program. Systems test log books are maintained to cover all final systems acceptance tests. After completing the acceptance test, a meeting is held (with the Customer Program Representative present, if so desired by the customer) to review the test data and discuss any open items that may exist. Agreements reached at this meeting result in the final systems acceptance. A copy of the log book, including a copy of the acceptance documentation, is forwarded to the customer for his records. Additional copies of the log are sent with the equipment for field service use.

5.7.2.3 Project Controls

Recognizing that the managerial effectiveness of a project team is directly related to the timely availability of accurate cost and schedule status data, particular emphasis has been placed on the development of cost accounting and control systems tailored to Itek's organizational concept. A central data processing facility provides for rapid accumulation and dissemination of project cost status material.

A variety of planning and scheduling techniques is available. For the GOPSS program, PERT-Time has been selected as the one most appropriate to the nature and size of this project.

Inherent in the system engineering cycles are the various reviews, inspections, tests, and demonstrations which lead to the establishment of optimum system specifications, end item performance and design specifications, and ultimately, detail design. The Itek approach follows the process of establishing and following system, design, and product configuration baselines through the use of uniform documentation, engineering reviews, and standard procedures.

The project will comply with a formal set of standard practices for proper identification, control, and accounting of engineering data and documentation.

An operations manager will be assigned during the course of the program to assume responsibility for directing the efforts of system fabrication, system assembly and test, and operating the facilities supporting their tasks. The manager will also coordinate with other project team members to ensure the successful completion of the program assembly and test. (Under system fabrication, a project procurement group and model control group will be established.) The project procurement group will be responsible for all program procurement including requesting bids, placing orders, evaluating vendors, and expediting deliveries. The model control group will control engineering, planning and scheduling, procurement, manufacturing, and assembly and test activities, in addition to providing liaison among these groups.

5.7.3 Manpower

Figures 5-26a through 5-26g show the manpower loading required for implementing the GOPSS Program. Total manpower requirements followed by individual manpower loading for project management, optics, engineering, manufacturing, design and drafting, and field service are shown.

5.7.4 Facilities

5.7.4.1 Project Facilities

Because of the nature and magnitude of the GOPSS task it is desirable that it be performed by a project group which would have its own facility completely equipped to handle all aspects of the task.

An analysis of the requirements for the project facility has been performed and has indicated a general concept of the approximate size, layout, and equipment criteria of a facility which would serve all phases of the contract.

The analysis shows that a facility capable of accommodating the personnel and equipment required for the performance of Phase II is approximately the same size as required to house the personnel and equipments required for Phases III through V. Therefore, a tentative procedure is to select a building of suitable floor area and ceiling height, develop an internal layout for Phase II operations, and, at the conclusion of Phase II, perform the internal alterations required for

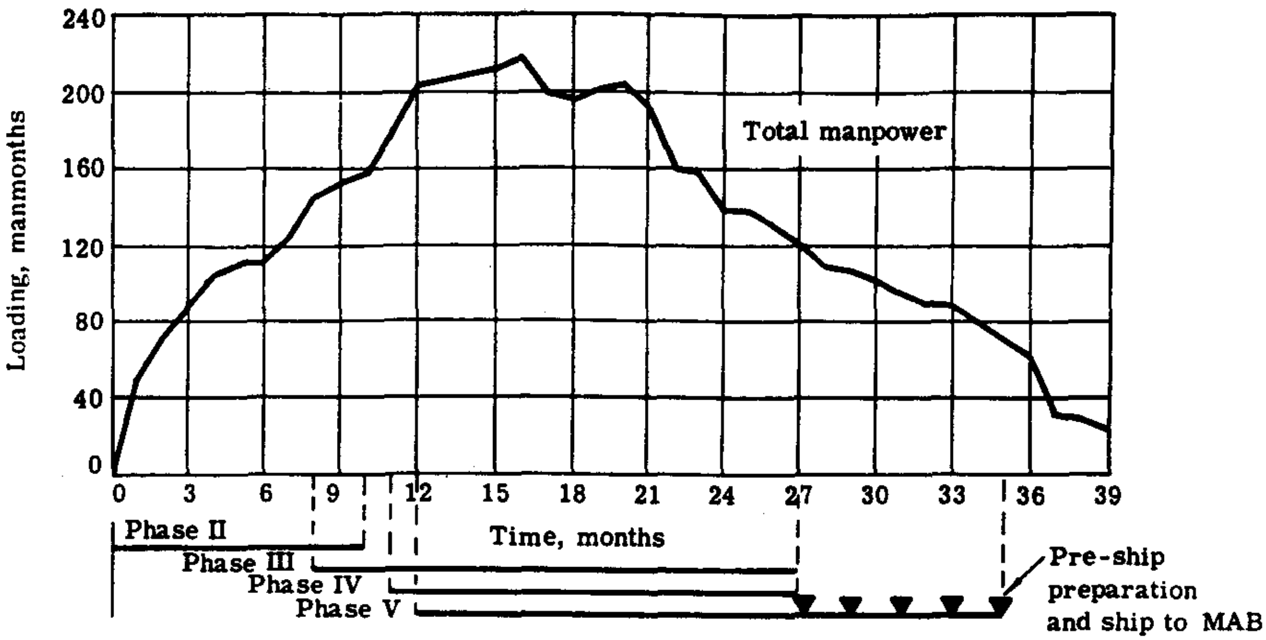


Fig. 5-26(a) — Manpower loading, total

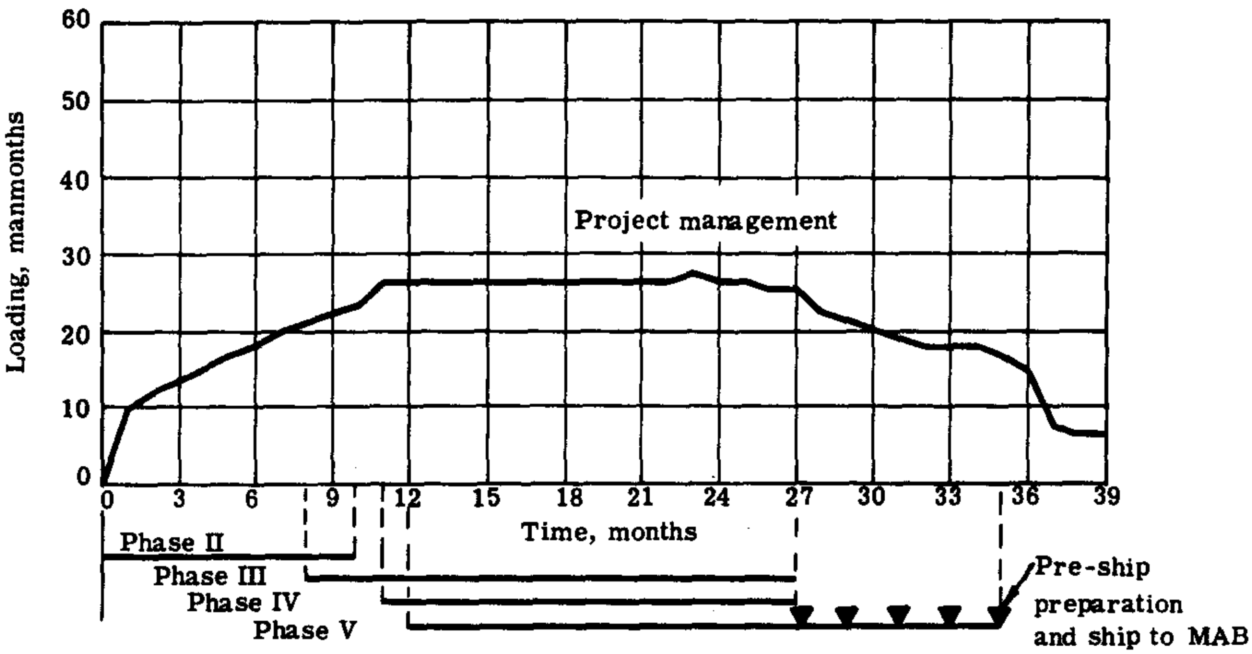


Fig. 5-26(b) — Manpower loading, project management

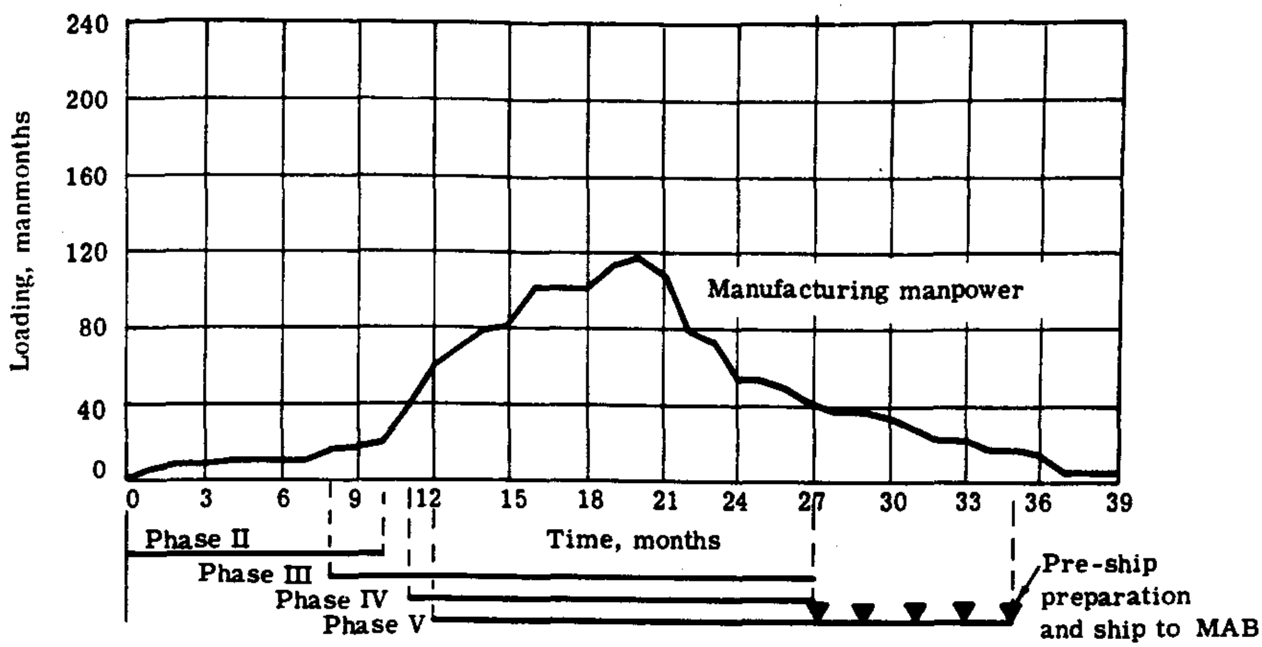


Fig. 5-26(c) — Manpower loading, optics

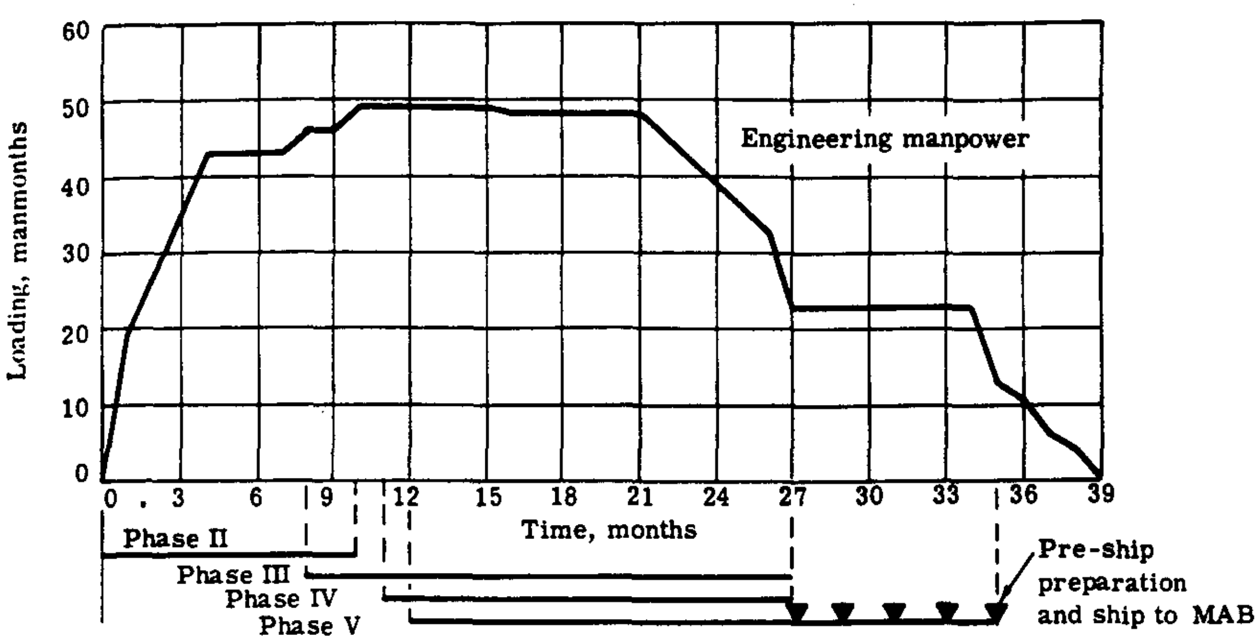


Fig. 5-26(d) — Manpower loading, engineering

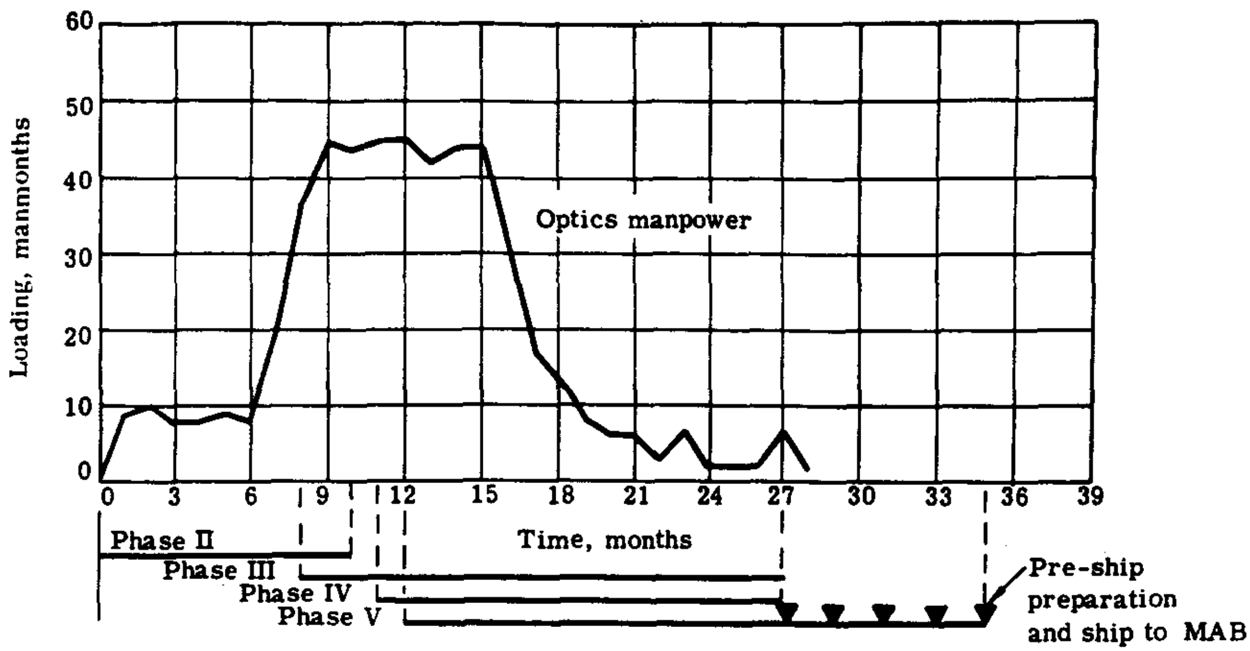


Fig. 5-26(e) — Manpower loading, manufacturing

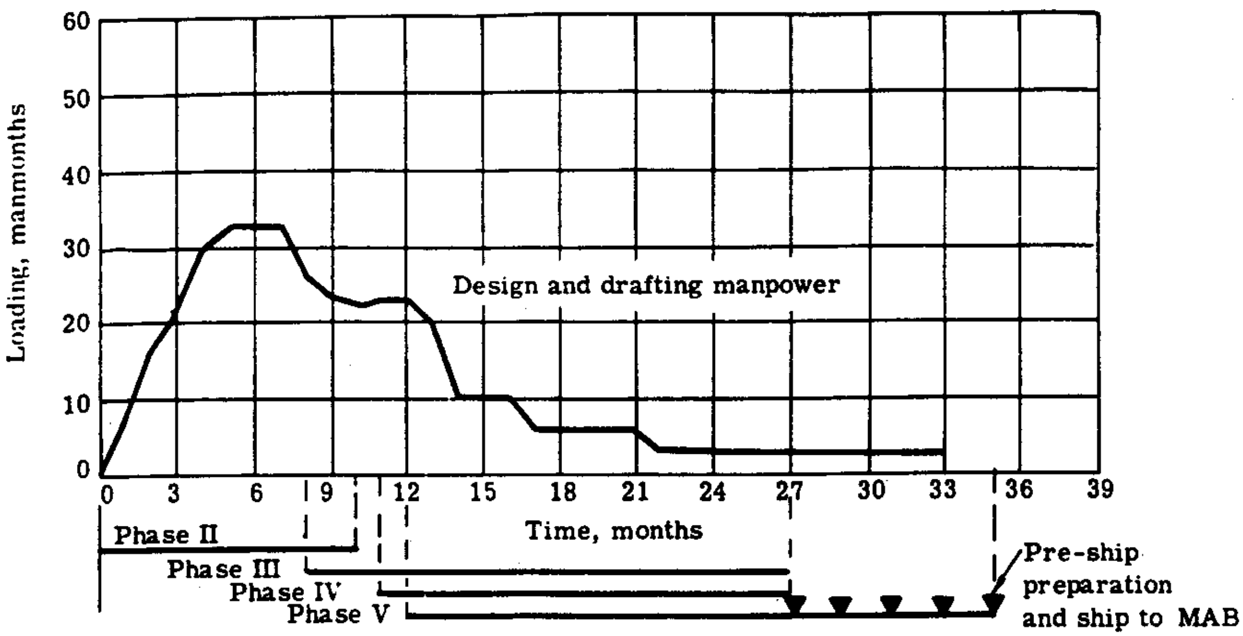


Fig. 5-26(f) — Manpower loading, design and drafting

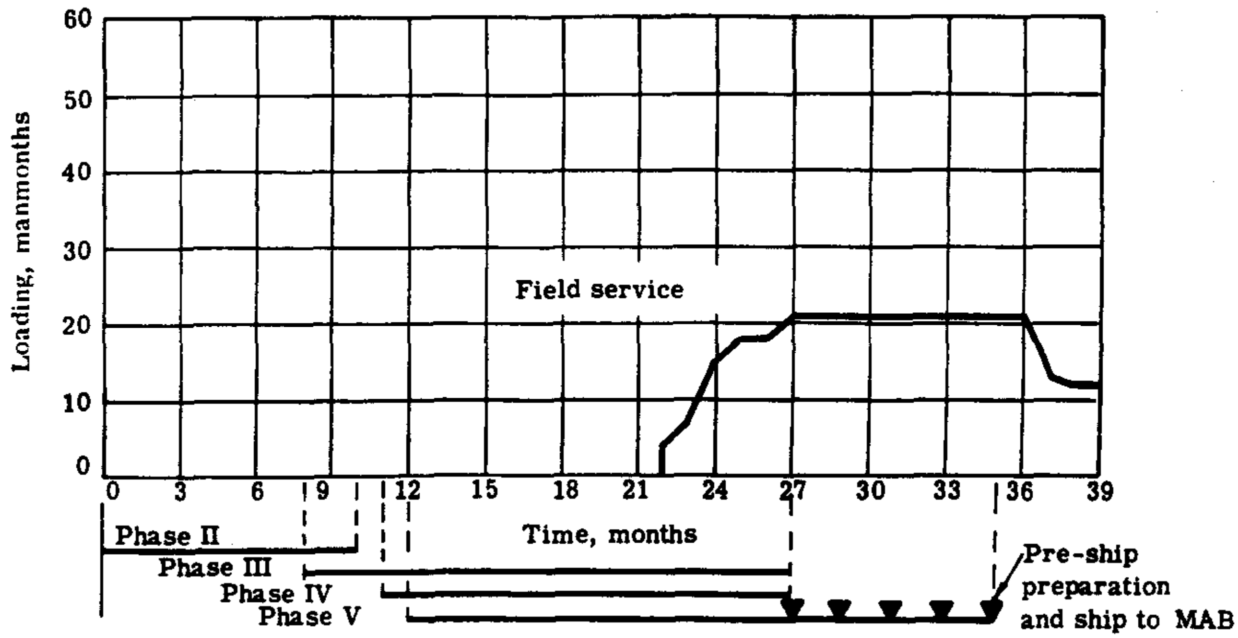


Fig. 5-26(g) — Manpower loading, field service the accommodation of the subsequent phases. Development of the Phase II layout will be governed by the requirement for the aforementioned conversion alterations.

As a basis for the initial Phase II layout, a typical Itek facility (a number of which could be made available to the project) has been selected. This is not a commitment to use this or similar facilities, but rather serves as a convenient starting point for development of an overall project facility concept.

The typical facility used as the starting point is shown in Figure 5-27. The building measures 212 by 142 feet and is a single story slab construction having a total floor area of approximately 30,000 square feet.

One of the governing layout parameters is that of having two levels of security within the building, namely "cleared" and "secret-special."

In conformity with established security requirements, the secret-special areas will be enclosed by concrete block (or equivalent) walls extending from floor to roof, and cleared areas will be enclosed by double sheet-rock walls extending either from floor to roof or from floor to seven feet two inches.

To maintain the building's security integrity, certain access procedures have been established. These are as follows:

1. Access into the building from the lobby will be given on recognition by a guard stationed there.
2. Access to secret-special areas will be gained through a two-phase procedure wherein recognition by a guard stationed outside the area and use of a "level-two" magnetic coded pass card are required. The doors to secret-special areas are shown on the layout by the symbol XX.
3. Access to cleared areas will be gained through the use of a "level-one" magnetic pass card. Doors equipped to be opened by this type card are shown on the layout by the symbol X.

In order to facilitate meetings between purchasing department personnel and vendors' representatives, a "level-one" type access door between the purchasing department work area and the visitors' lobby is provided. This door is also indicated on the layout by the symbol X.

To facilitate the internal work flow and the handling of large assemblies, large double doors will be strategically located. These will normally be locked from the inside to prevent entry and movement of unauthorized personnel.

For passive control of internal cleanliness, the building air-conditioning system will maintain a positive pressure of no less than 0.20 inch of water throughout the building except in the assembly and test areas where the positive pressure will be no less than 0.30 inch of water. As an additional means for limiting dust, all walls will be painted with a hard surfaced enamel, floors will be covered with vinyl asbestos tile, and all corners and joints will be taped prior to painting. Passive cleanliness control will be supplemented by providing all test and assembly areas with outlets from a built-in central type vacuum cleaning system.

The basic illuminating system will consist of recessed fluorescent lighting fixtures providing a minimum of 100 foot-candles on all working areas. These will be supplemented by local incandescant lamps at all points requiring high intensity light.

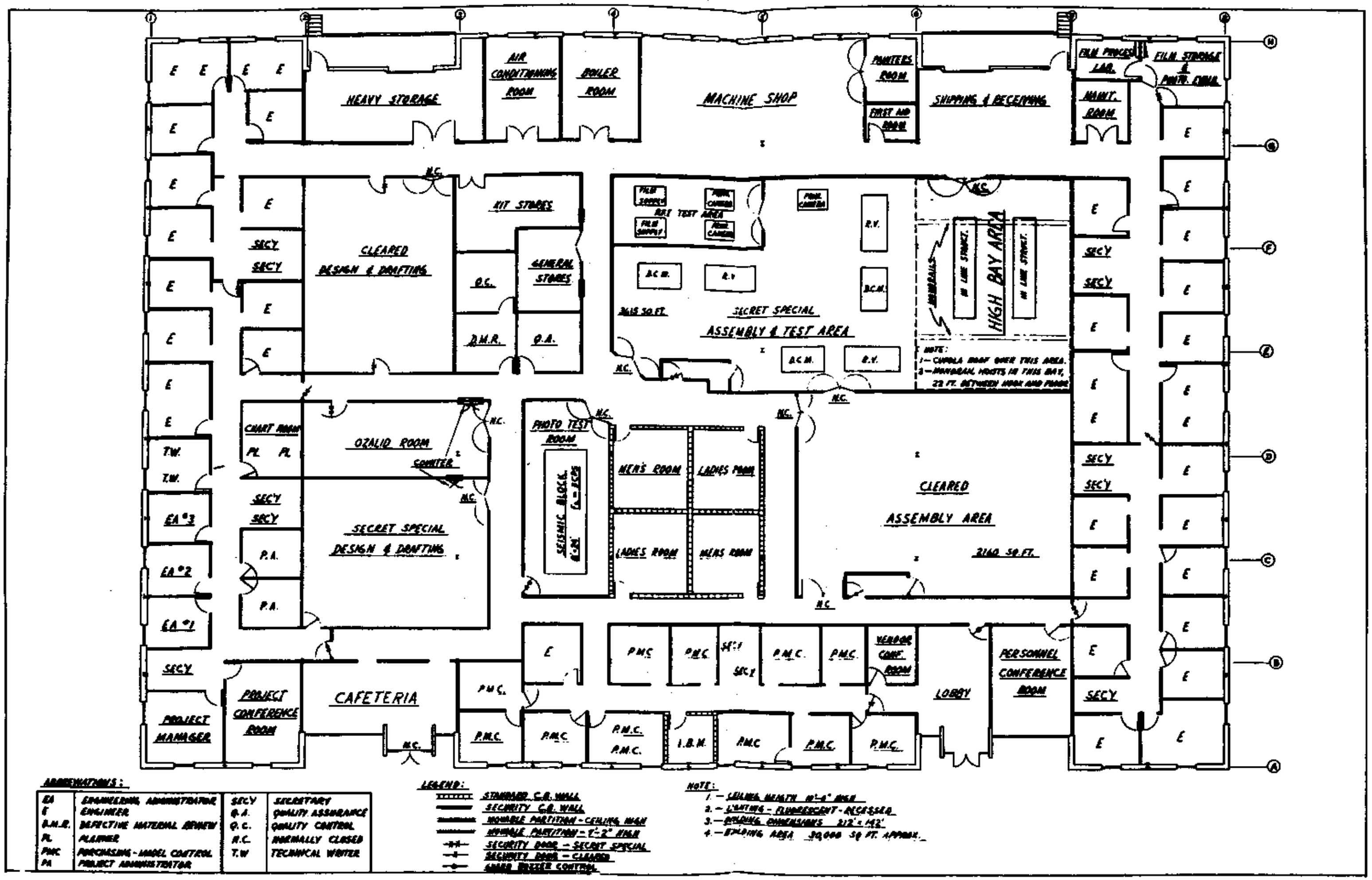


Fig. 5-27 — Typical facility

Suitable utilities as required for all anticipated tasks will be provided. These will consist of conventional 115 vac outlets in office and drafting areas, a multiple power selection in assembly and test areas, cold and tempered water in film processing laboratories, suitable plumbing and drains, and temperature-humidity control in the film storage area. The multiple power selection will consist of convenient outlets for 28 vdc, 115-volt, 60-cycle, 1-phase ac, 220-volt, 60-cycle, 3-phase ac, and 115-volt, 400-cycle, 1-phase ac.

The building selected must be modified to a certain extent in order to fulfill project requirements. These modifications are as follows:

1. Construction of a high bay area having a minimum ceiling height of 26 feet and provided with two monorail hoists of two-ton lifting capacity each. They will be installed in such a manner that when the hoists are in the uppermost limit of their travel, there will be a minimum of 22 feet between hook and floor.
2. Installation of a seismic block in the phototest room. This will be cast flush with the building floor and will "float" on servo controlled air springs. Block dimensions will be 8 feet by 24 feet and natural frequency will be 3 cps maximum.

When Phase II is completed, the character of the task will change from the production of drawings, documents, and mockups to the production of operational hardware. This will change the general personnel requirements from mostly engineering and drafting personnel to mostly technicians, assemblers, and craftsmen with a requirement for more shop and assembly areas than offices and drafting rooms. The proposed facility layout is inherently flexible so that these changes may be readily and economically accomplished.

5.7.4.2 Missile Assembly Building (MAB)

The design and layout of the Missile Assembly Building (MAB) encompasses the development of an area or separate building suitable and completely equipped for performing any and all missle assembly tasks without external or extra-facility support.

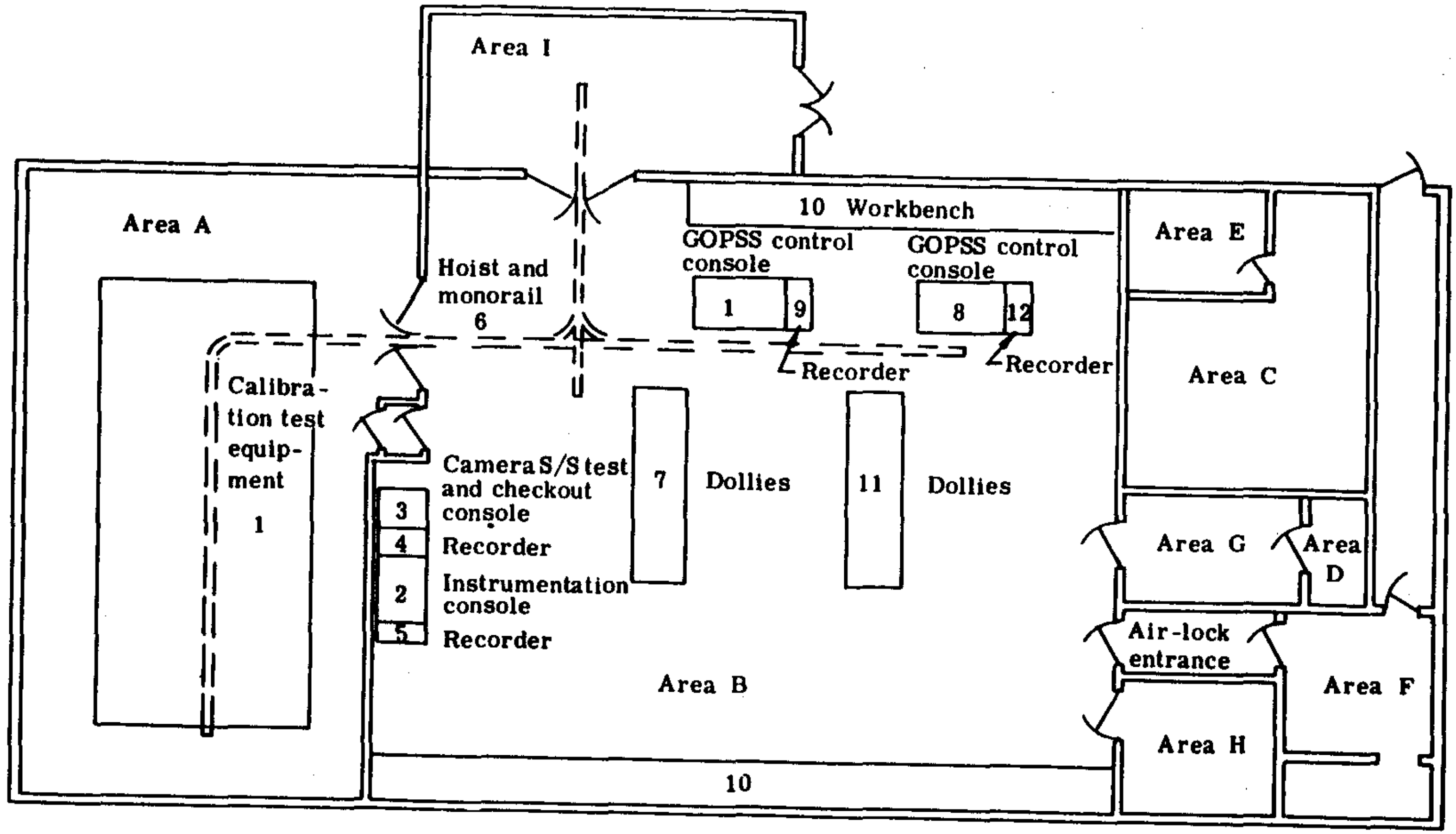
The primary design task is to specify or select an MAB area that is of sufficient size, at a convenient location, and that can properly be partitioned and furnished with the required utilities and services.

The second design task is to divide the basic MAB space so that each of the required types of areas are defined and located relative to each other to permit assembly and test operations to procede in a logical progression.

The third design task is to specify and locate the various utilities necessary for satisfactory operation of the MAB facility. These include power, water, atmospheric control (temperature and pressure), lighting, shipping and receiving facilities, and special equipments. Figure 5-28 is a preliminary layout of the MAB.

The general requirement for the MAB is for a clear floor space of approximately 6000 square feet, all at a single level. Specified portions of the floor must be seismically isolated for the performance of photo-optical test procedures.

The MAB must have (or be readily adapted to have) a shipping and receiving dock of suitable size, shape, and orientation to facilitate reception and shipment of the payload unit and the OCV, and should readily accommodate the vehicles used to transport these units.



Area A - Photo-optical test laboratory
B - Test and checkout laboratory
C - Engineering offices
D - Film storage room
E - Photo evaluation room
F - Personnel access
G - Spare parts storage
H - Film processing laboratory
I - Shipping and receiving

Fig. 5-28 — Missile assembly building (MAB)

A suitable personnel entrance must be provided, and, if the MAB shares a building with other activities, it is necessary that the layout be conveniently isolated from those others to prevent inadvertent entry by unauthorized personnel. Particular care must be exercised to prevent security breaks due to lack of soundproofing, screening, etc., between the MAB area and the group sharing the building.

The MAB will be divided into a minimum of nine separate sub-areas. These are as follows:

1. Photo-optical test laboratory
2. Test and checkout laboratory
3. Engineering offices
4. Film storage room
5. Photographic evaluation room
6. Personnel access
7. Spare parts storage area
8. Film processing laboratory
9. Shipping and receiving area

In addition to these major areas, it will be necessary to provide sufficient air-lock entrances and exits to maintain the assembly and test areas at a positive pressure of 0.30 inch of water.

Prior to establishing the several partitions that divide the MAB into the aforementioned areas, the monorail transport will be established in such location that a slung payload or OCV may be transported from the shipping and receiving area to either the photo-optical test laboratory or the test and checkout laboratory and from each of these places either back to the shipping and receiving area or to another laboratory. Partition doors will be of such dimensions and so located as to provide interference-free access to the several areas.

5.7.4.2.1 Photo-Optical Test Laboratory

The photo-optical test laboratory (Area A—the letter appearing with this subarea and those that follow are keyed to Figure 5-27) will be sufficiently large to contain the sensor calibration test equipment (AGE) and at least one sensor payload. This area will be one of the terminal stations of the overhead monorail transport. The area will be walled off from the rest of the MAB and equipped with double doors sufficiently large to permit entry and exit of the payload. Primary design will include provisions for seismic isolation of the calibration test equipment.

Design parameters for this area are as follows:

Environment

1. Temperature—70 ± 1 °F
2. Humidity—50 percent (maximum)
3. Dust particle size limit—10 microns
4. Dust particle count tolerance—50,000 particles per cubic feet
5. Positive pressure—0.30 inch of water

Floors and Room Finish

1. Vinyl floor covering coved up to walls and at corners on floor
2. Walls and ceilings to be drywall, coved up at corners and up to ceiling, sealed, primed, and painted with two coats of white high gloss enamel

Utilities and Lighting

1. Incandescent lighting—100 foot-candles at working level, flush mounted.
2. Central vacuum system complete with flexible plastic hose and basic tools. Vacuum system to be equipped with automatic closing devices.
3. Electrical requirements—110 volts, 60 cycles, 1 phase, 30 amp.
   200 volts, 60 cycles, 3 phase, 30 amp.

5.7.4.2.2 Test and Checkout Laboratory

The test and checkout laboratory (Area B) will be sufficiently large to accommodate the following equipment:

1. GOPSS control console
2. Instrumentation console
3. Camera S/S test and checkout console
4. Sanborn recorders (4)
5. Electric hoist and monorail (2-ton capacity)
6. Basic handling dollies and erecting dolly
7. Work bench and cabinet storage
8. Theodolites—Model T2 (2)
9. Instrument Stands—adjustable (2)
10. Recorders—temperature and humidity (2)

In addition, this area will provide ample working space for test and checkout operations. It will also be one of the terminal stations of the monorail.

The area will be walled off from the rest of the MAB and will be provided with entrance and exit doors for personnel and for the transport of payload units, OCV's, and other heavy equipment. Design parameters for this area are identical to those for the photo-optical laboratory.

5.7.4.2.3 Engineering Offices

The engineering offices (Area C) will serve as a general office and command center for the MAB. Like the other MAB areas, it will be partitioned off from the others. Access will be gained through a door between it and the test and checkout laboratory. In order to maintain positive pressure integrity within the MAB, there will be no direct access to the outside of the building.

The general design parameters of this area are minimal; only standard office area comfort conditioning and lighting are required.

5.7.4.2.4 Film Storage Room

The film storage room (Area D) will be partitioned off from the several other areas of the MAB, and access to it will be gained through Area G (spare parts storage). To protect the stored film from damage and/or deterioration, temperature will be controlled to within 40 to 50 °F and humidity will be controlled to within 40 to 50 percent.

5.7.4.2.5 Photographic Evaluation Room

The photographic evaluation room (Area E) serves as a work area for the evaluation of photographic test data and for the subsequent storage of test results. The area is walled off from the rest of the MAB and access is gained through the engineering office area. Area E equipment requirements are (1) a 55-inch viewing table with motor rewinds, (2) a 3-objective turret head microscope and (3) a densitometer. The general design parameters are minimal, with only standard office area comfort conditioning and lighting required.

5.7.4.2.6 Personnel Access

The personnel access area (Area F) serves as MAB access for all personnel, and as personal gear storage and general headquarters for all nonoffice MAB personnel. It is furnished with access doors to the outside of the building, and airlock type access to the interior of the MAB. To help maintain the required positive pressure in the critical assembly and test areas, the personnel access area is kept at a slight positive pressure greater than ambient but less than that of the laboratories. Equipment requirements for Area F are a shoe cleaning machine, a track mat, lockers, and restrooms. Temperature requirements are 70 ± 5 °F, with a positive pressure of 0.10 inch of water.

5.7.4.2.7 Spare Parts Storage

The spare parts storage (Area G) serves to accommodate spares, out-of-use equipment, and miscellaneous items. Access to this area is gained from the test and checkout laboratory and it, in turn, furnishes access to the film storage area which is, in effect, part of the parts storage area. No specific equipment is required for this area; the governing design parameter is standard office comfort conditioning and lighting.

5.7.4.2.8 Film Processing Laboratory

The film processing laboratory (Area H) contains the equipment and facilities for processing the MAB photographic data accruing from the various calibration and baseline tests. It is walled off so that it is completely light-tight. Equipment requirements for this area are as follows:

1. A model XR-6 automatic processor
2. Chemical mixing and storage tanks
3. Temperature controls
4. A sensitometer

The principal design parameter for Area H is standard office comfort conditioning and lighting. Required utilities and lighting are as follows:

1. Incandescent lighting: 100 foot-candles at working level
2. Darkroom safelights
3. Filtered water, 45 psi/min
   - Hot water temperature: 140 °F
   - Refrigerated water temperature: 40 °F
4. Sink and floor drains
5. Electrical requirements: 110 volts, 60 cycles, 1 phase, 30 amps

5.7.4.2.9 Shipping and Receiving Area

The shipping and receiving area (Area I) serves for the shipping, receiving, and handling oi all materials other than hand-carried items that enter or leave the MAB. It is furnished with adequate access to the exterior of the MAB and to the test and checkout laboratory, and is a terminal station of the monorail transport. An adequate dock for accommodation of trucks and other transport vehicles is provided.

Equipment requirements and design parameters are not rigidly established; rather they are the general requirements and parameters of a standard shipping and receiving area modified for the specifics of this facility.