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REENTRY FLIGHT DEMONSTRATION NUMBER TWO (RFD-2): SPECTROGRAPHS, PHOTOMETERS, AND EVENT CAMERAS DEVELOPED FOR SNAP REENTRY STUDIES

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ABSTRACT

Spectrographs, photometers, and event cameras have been developed for use in attempting to record the disassembly of an inert nuclear power supply and the complete ablation of inert fuel rods during an actual reentry operation, RFD-2, to be conducted off the island of Bermuda.

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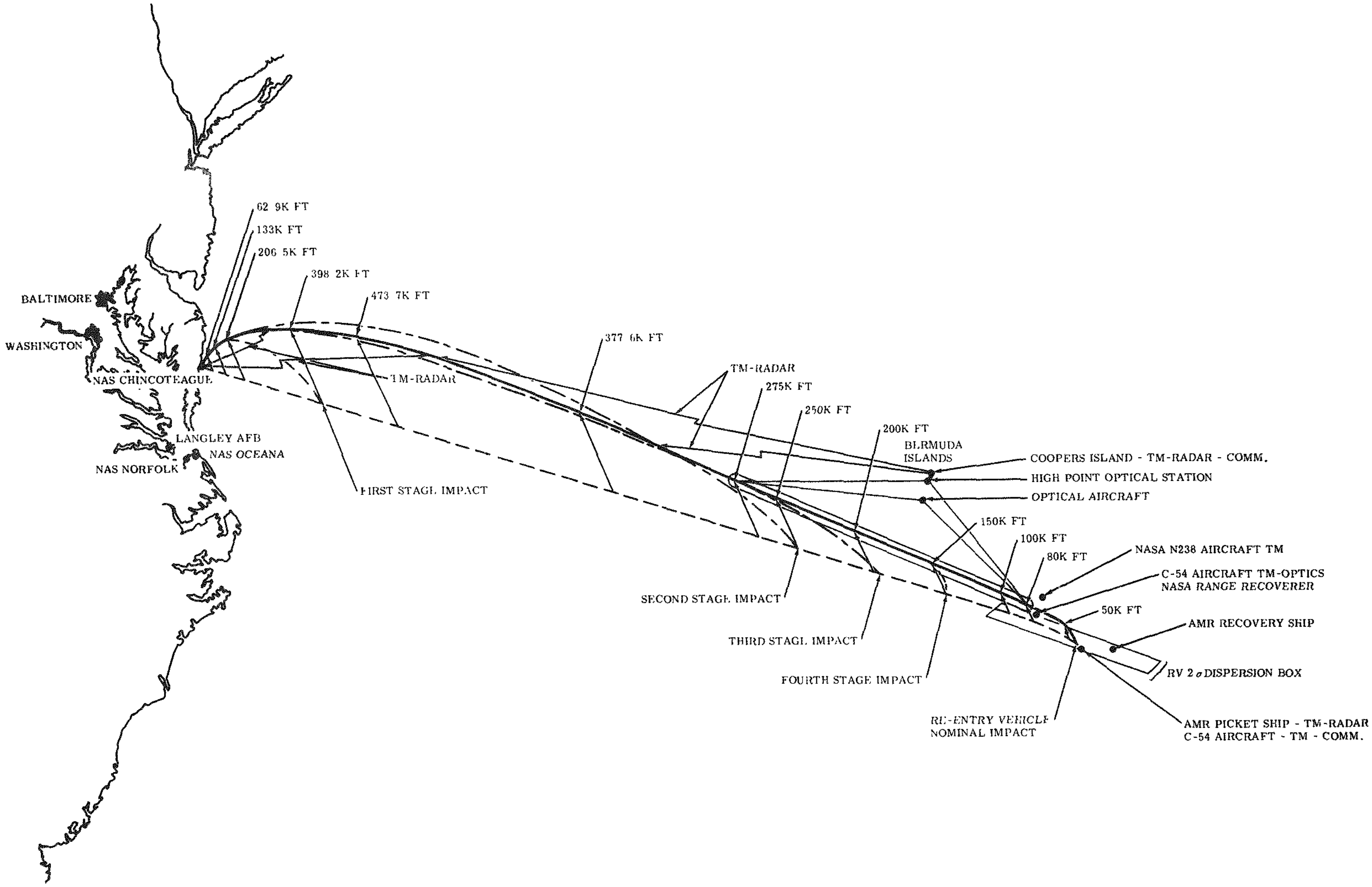

Frontispiece. Proposed Trajectory of RFD-2.

INTRODUCTION

This is a preliminary report outlining briefly the purpose and development of optical instrumentation to be used to cover the Reentry Flight Demonstration Number Two off the island of Bermuda late in the summer, 1964 (see Frontispiece). After the operation, a more detailed report on the instrumentation and the results obtained will be published.

The photo-optical instrumentation for RFD-2 is divided into ground-based and airborne stations and can further be classified as tracking and fixed-axis instrumentation. All the ground-based optical instrumentation is installed at High Point on Bermuda and all the Sandia airborne optical instrumentation is installed in a leased DC-7B aircraft flown and maintained by AVCO Corporation.

The primary purpose of the optical instrumentation covering RFD-2 is to prove disassembly of the inert nuclear power supply carried on the nose of the reentry vehicle. The secondary purpose is to record the heating and ablation of external inert fuel rods that are ejected from the reentry vehicle early in the reentry phase of the trajectory. Position in space and time of these occurrences is of utmost importance in correlating theoretical data with measured data from the actual reentry.

The primary technique to determine disassembly of the inert nuclear power supply and ablation of the external rods will be identification of spectral lines of tracer materials packed inside the internal and external rods. As the rods ablate from the frictional heat of reentry, the walls of the rods will finally be gone, exposing the tracer materials which will themselves be heated to a high temperature. Very shortly after exposure, the tracer material should flare and thus be recorded by the spectrographs, photometers, and event cameras.

The internal rods are carried inside the inert nuclear power supply and will be thrown clear when it disassembles. Calculations show that the internal rods should flare several hundred feet behind the reentry vehicle, thus indicating disassembly of the inert nuclear power supply.

Several types of spectrographs have been constructed; namely:

1. Plate spectrographs
2. Framing plate spectrographs
3. Cinespectrograph
4. Time-resolved streak spectrographs

To provide better time resolution, more sensitivity, and correlation of the spectrographic data, two sampling photometers will be used, one on each of the LA-24 tracking telescopes. Trajectory information will be provided by a bank of chopped plate cameras with star backgrounds exposed on the operational plates.

As a backup and interpretative aid to the trajectory cameras, unchopped event plate cameras, varying in focal length from 12 to 36 inches, will also be operated.

As a final correlation aid to the spectrographic and photometric instrumentation, framing event cameras will be mounted on the three powered tracking mounts utilizing optical systems with focal lengths from 12 to 120 inches and apertures up to 16 inches. The use of color film will provide possible identification of the various tracer materials because of their particular color when they burn.

Optical instrumentation in the aircraft utilizes the same designs as the ground-based instrumentation except for the mounting systems. For maximum flexibility and minimum costs, the mounting design allows the instrumentation to be installed in any passenger DC-7B aircraft in a matter of 2 or 3 weeks without major modifications to the aircraft.

The main body of the report contains a detailed listing of all the optical instrumentation, with brief descriptions of the purpose, design, and development of the instruments. However, a summary list of the instruments that will be used in the RFD-2 is presented here, grouped according to responsibility assignments.

LIST OF INSTRUMENTS

Ground

A. Powered Tracking Mounts
   1. One ME-16 Tracking Telescope
      a. 70mm framing camera, 120" fl, f/7.3 lens
      b. 35mm framing camera, 24" fl, f/3.5 lens
      c. 35mm framing camera, 18" fl, f/3.0 lens
      d. 35mm framing camera, 12" fl, f/2.5 lens
      e. 35mm streak camera, 12" fl, f/2.5 lens
   2. LA-24 No. 1 Tracking Telescope
      a. streak spectrograph 9 1/2" film, 120" f l, f/5.0 lens
      b. photometer, 240 samples/sec, 8" dia collector lens
      c. 35mm framing camera, 40" f l, f/5.6 lens
      d. 35mm framing camera, 12" f l, f/2.5 lens
      e. 35mm streak camera, 12" f l, f/2.5 lens
   3. LA-24 No. 2 Tracking Telescope
      a. streak spectrograph, 9 1/2" film, 120 f l, f/5.0 lens
      b. photometer, 240 samples/sec, 8" dia collector lens
      c. 35mm framing camera, 60" f l, f/5.0 lens
      d. 35mm framing camera, 12" f l, f/2.5 lens
      e. 35mm streak camera, 12" f l, f/2.5 lens

B. Fixed-Axis Cameras
   1. Five chopped trajectory cameras, 12" f l, f/2.5 lens
   2. Four plate cameras, 12" f l, f/2.5 lens
   3. Eight plate spectrographs, 600 lines/mm grating, 12" f l, f/2.5 lens
   4. Five framing cameras, 9 1/2" film, 12" f l, f/2.5 lens
   5. Three color plate cameras, 12" f l, f/2.5 lens
   6. Four plate cameras, 24" f l, f/3.5 lens
   7. Three plate cameras, 36" f l, f/4.0 lens

C. Photometers
   1. Two sampling photometers, 240 samples/sec, 8" dia collector lens

D. Ultraviolet Cameras
   1. Three ultraviolet cameras, 12" f l, f/4.0 lens, 20° field, 3000-4000 Å range

E. Hand-Tracked Mounts
   1. One 70mm cinespectrograph, 12" f l, f/2.5 lens
   2. Four time-resolved streak spectrographs, 12" f l, f/2.5 lens
   3. Two 16mm framing cameras, 7" f l, f/2.5 lens

F. Electronics
   1. Communications
   2. Recording
   3. Timing
   4. Parallax computers
   5. Mount controls
   6. Camera power

Airborne

A. Fixed-Axis Cameras
   1. Four chopped trajectory, 12" f l, f/2.5 lens
   2. Six framing cameras, 9 1/2" film, 12" f l, f/2.5 lens
   3. Six framing spectrographs, 9 1/2" film, 12" f l, f/2.5 lens
   4. Four plate spectrographs, 12" f l, f/2.5 lens
   5. Three ultraviolet plate spectrographs, 12" f l, f/4.0 lens

B. Tracking Cameras
   1. Two 35mm framing cameras, 12" f l, f/2.5 lens, hand-tracked

C. Electronics
   1. Communications
   2. Recording
   3. Timing
   4. Camera power

Note: The ultraviolet cameras listed under ground instrumentation will actually be used on the aircraft as shown above and were listed previously because of the responsibility assignment.

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PART ONE: GROUND-BASED INSTRUMENTATION

Powered Tracking Mounts

When photographing a moving target, large-aperture, long-focal-length narrow-field optical systems must be supported and smoothly tracked on target by a powered tracking mount. The time-resolved streak spectrographs, the sampling photometers, and the long-focal-length event cameras must be accurately tracked and, therefore, are mounted on the Sandia field-proven ME-16 and LA-24 tracking platform (Figure 1).

Figure 1. LA-24 and ME-16 Tracking Mounts at Bermuda. The LA-24 is shown on the left.

Like fixed-axis cameras, tracking mounts have their advantages and disadvantages. From an operational standpoint, their only real problem is in acquiring and tracking the proper target. On a free-fall bomb drop test such as those conducted at the Tonopah Test Range, this presents little or no problem. On a high-acceleration rocket test, acquiring is no problem but tracking is. On an operation such as Reentry Flight Demonstration Number Two (RFD-2), the problems are somewhere in between. Initial acquisition was not a problem on RFD-1 because the reentry vehicle appeared visually as scheduled and both tracking mounts were slaved to the FPS 16 radar which was tracking the reentry vehicle. It is expected that the same will hold true on RFD-2. Tracking the proper object or objects is another story. The ME-16 tracking telescope (Figure 2) and one LA-24 tracking mount (Figure 3) will track the reentry vehicle, and no real trouble is expected here.

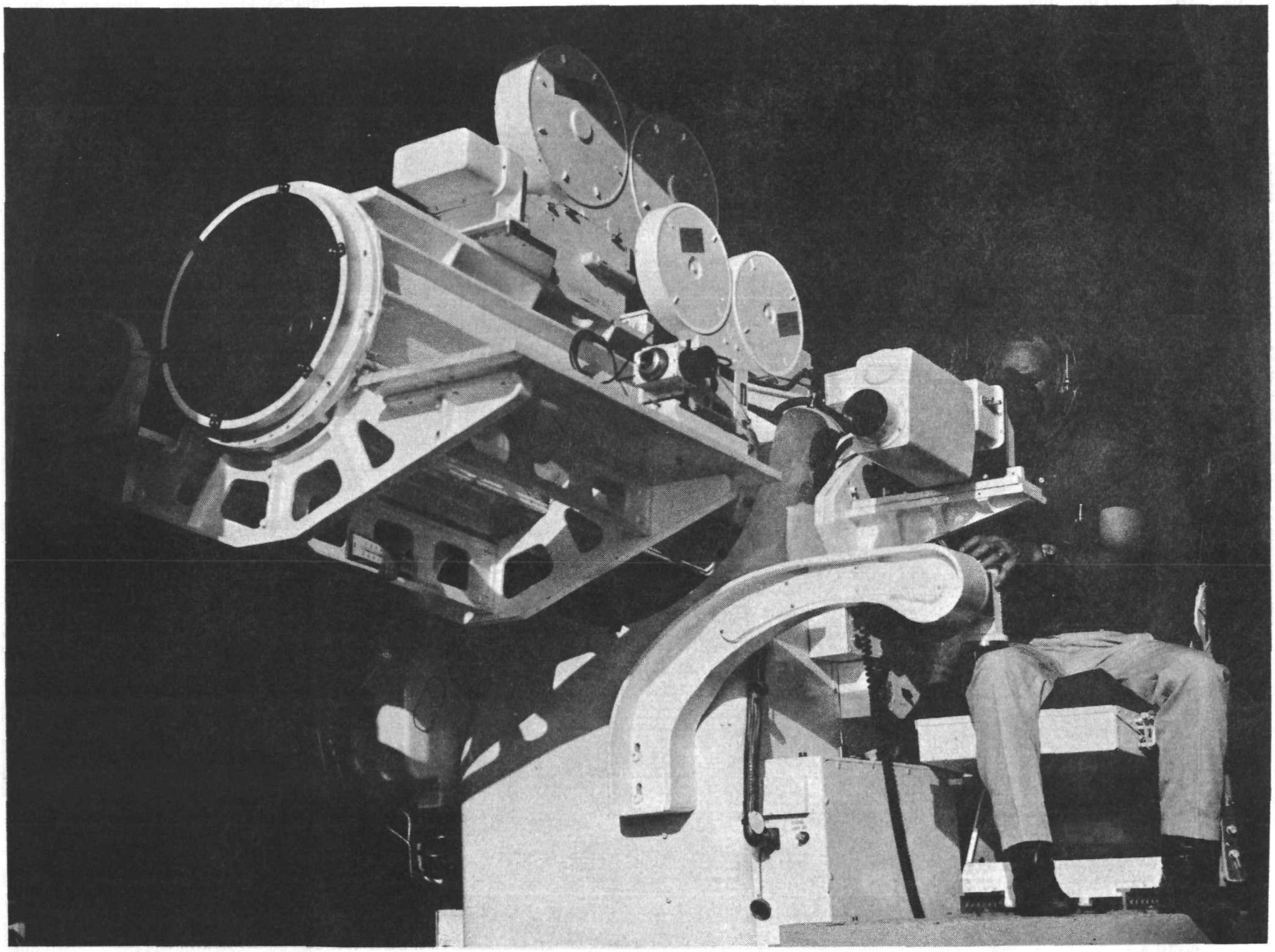

Figure 2. Closeup of ME-16. Shown at Bermuda as equipped for the RFD-1 operation. Two additional cameras have been mounted under the main tube for RFD-2.

The second LA-24 will track the external inert fuel rods, and it is here that the odds are not so good. These rods are only 6 inches long and 1 inch in diameter and are at least 100 miles from the instrumentation; therefore, they will not show up very clearly before they flare. Since the radar cannot track the ejected rods, the mount tracker must acquire the rods and then stay with them until they flare. Experience from RFD-1 shows that even though this is a difficult task, well-seasoned trackers have a reasonable chance of success in the acquisition and tracking. The advantage that a tracking mount has in bringing large and sensitive time-resolved spectrographic instrumentation to bear on small, dim reentry objects makes its use worth the difficulties and the risk of an occasional complete loss of information due to miss-track.

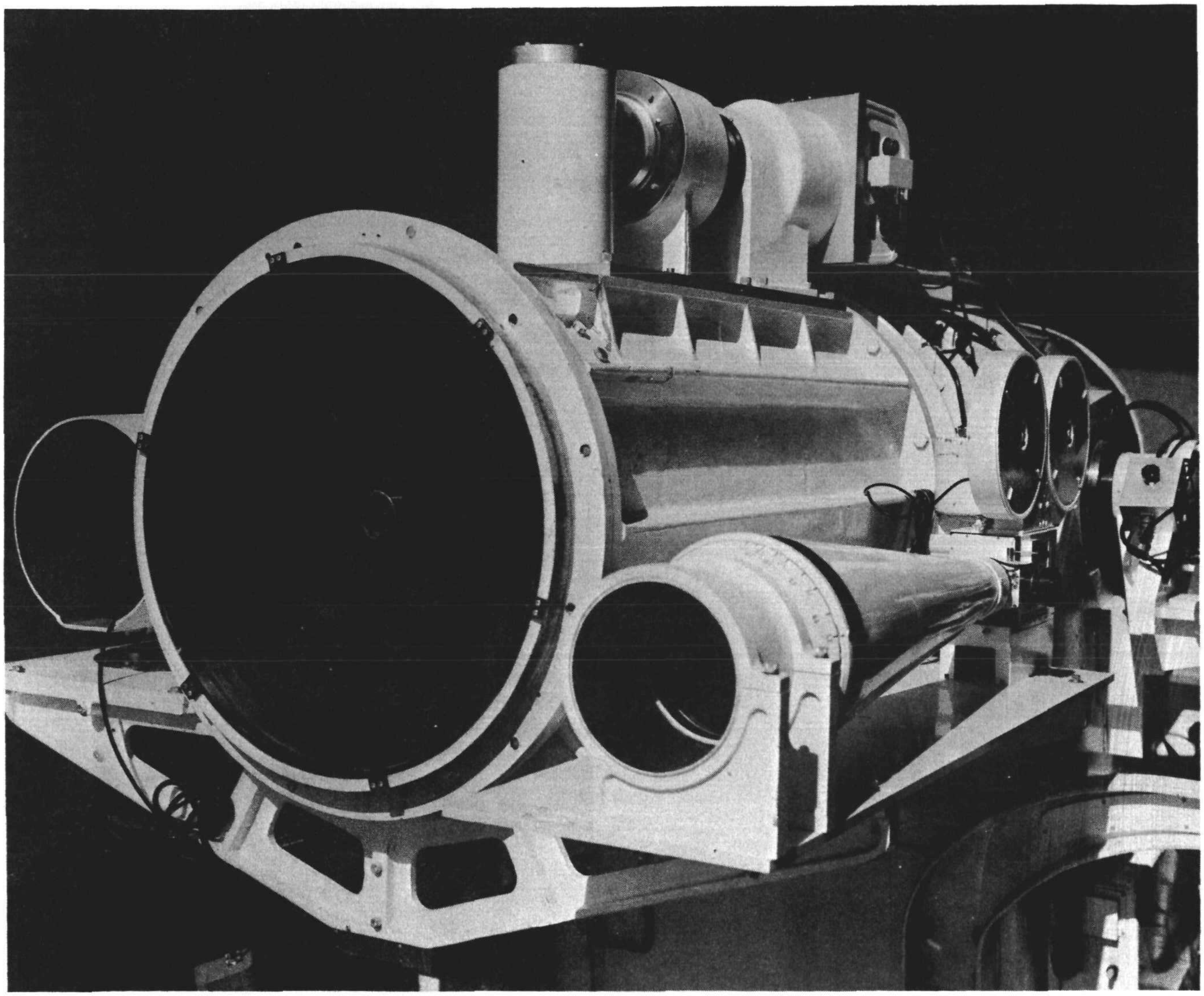

Figure 3. Closeup of LA-24

Time-Resolved Streak Spectrograph

To provide a spectrographic record of the reentry with time resolution, three techniques are immediately apparent: a fixed-axis, chopped plate spectrograph; a framing or cinespectrograph; and a streak spectrograph, where the film is continuously pulled past a focal plane slot with timing marks placed along the edge of the film.

One of the main advantages of a streak spectrograph is that it is a fairly simple matter to convert a large-aperture optical system to a streak spectrograph, thus obtaining a photographically fast system. Since the basic design of a streak spectrograph requires that it track the target and since it can be simply married to a large-aperture optical system, the Sandia LA-24 tracking telescope was converted to a streak spectrograph. This is a large tracking mount (Figure 4) capable of carrying additional instrumentation; therefore, the sampling photometers and long-focal-length event cameras are also mounted on the LA-24.

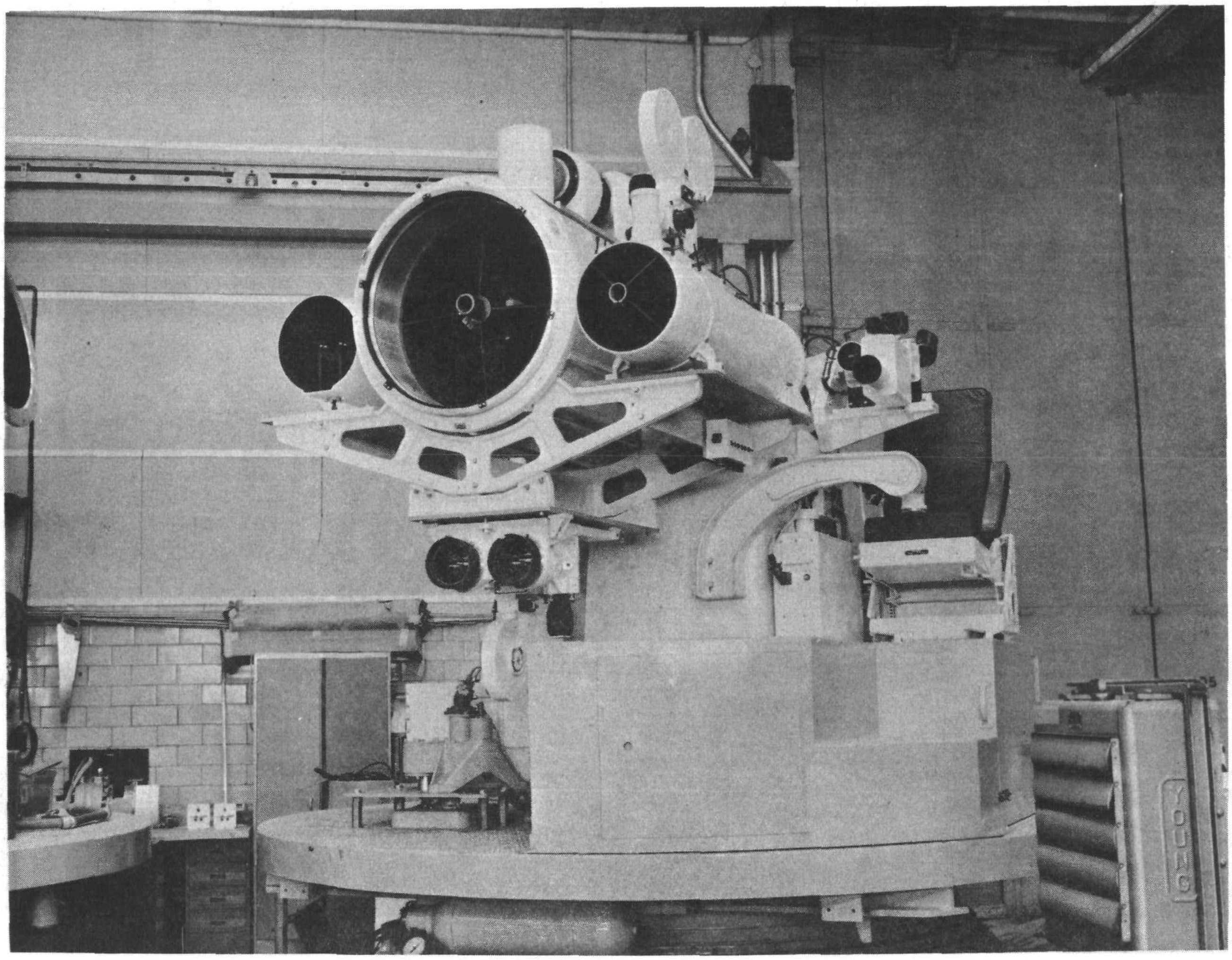

Figure 4. Shop Photo of LA-24 #2. The instrumentation carried by the LA-24 tracking mount is clearly shown in this picture. The large central tube carries the 24-inch-diameter fused-quartz Newtonian type of telescope working into a streak spectrograph mounted on top of the tube. To the right of the main tube is mounted the sampling photometer; to the left, a 35mm, 60-inch focal length, f/5.0 boresight and event framing camera. Below the main tube are two more cameras: a 35mm, 12-inch focal length, f/2.5 framing camera and a 35mm, 12-inch focal length, f/2.5 streak camera.

Two LA-24's carrying identical instrumentation will be operated at High Point. One will track the reentry vehicle and attempt to record the flaring of the internal fuel rods after reactor disassembly, and the others will track the external fuel rods which are ejected from the reentry vehicle early in the reentry.

Sampling Photometer

The modern cooled photomultiplier tube is more sensitive to light than film by several orders of magnitude, thus its use in reentry studies is thought of very early in the planning of instrumentation. Since spectral line identification is the primary method to be used to prove reactor disassembly and fuel rod ablation, an obvious photomultiplier technique would be to place a narrow bandpass filter in front of the photomultiplier tube that allows only a unique spectral line from a flare (plus continuum) to reach the tube, thus indicating that the flare did occur. This has been done with the Sandia sampling photometer (see Figure 5) but, instead of using just one filter, 24 are built into a wheel that is rotated in front of the photomultiplier tube at 10 rps, thus producing 240 samplings per second.

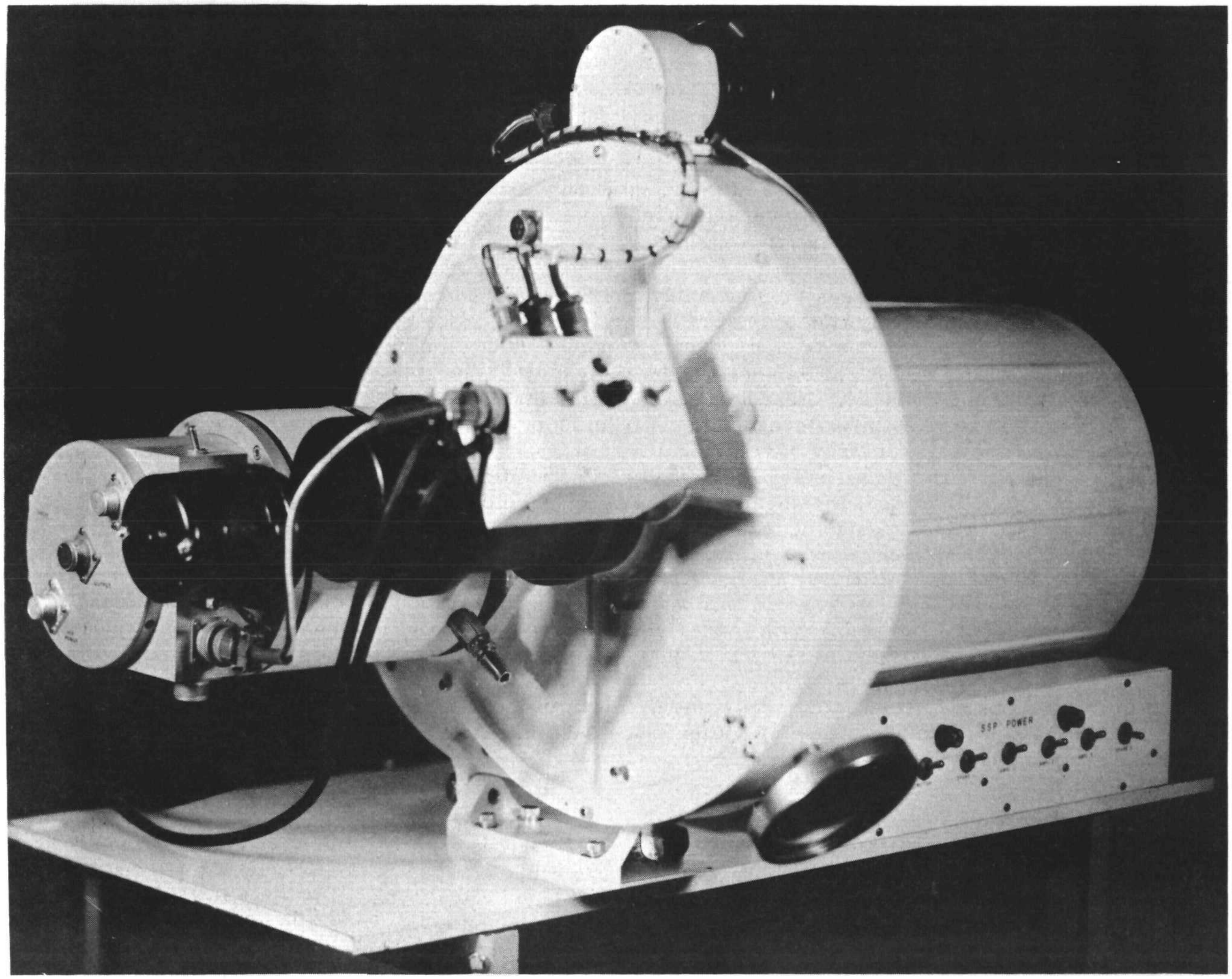

Figure 5. Sampling Photometer. The photomultiplier enclosure, filter wheel drive motor and housing, and the optical tube are shown.

Eight tracer materials were chosen: strontium, barium, silver, sodium, lithium, thallium, indium, and gallium.

Two spectral lines were chosen from each element, and narrow bandpass interference filters were manufactured by Thin Films, Incorporated, to fit these lines. If everything else were equal, the narrower the bandpass on the filters the better; however, everything else isn't equal and a practical limit must be put on the bandpass. The filters obtained vary from a half-power bandpass of approximately 15 Å at 3200 Å wavelength to 3 Å at 5500 Å wavelength.

A light-collecting optical system works into the photomultiplier tube increasing the system sensitivity by a factor of 25. Cooling of the tube is accomplished simply by discharging an ordinary 5-pound CO_2 fire extinguisher through an annular orifice into a chamber surrounding the tube. Cooling the tube reduces the signal-to-noise ratio by a factor of between 4 and 6.

The output from the photometer goes onto magnetic tape which will be fed directly into the GDC/604 computer at Sandia, thus reducing the data reduction effort and time to a reasonable level.

Fixed-Axis Cameras

As the name implies, a fixed-axis camera is one that does not track the reentry objects but, rather, remains stationary and allows the image of the reentry objects to streak across the film. Since fixed-axis cameras are not tracked, the field of view (20 degrees or more) must be larger than the narrow-field instrumentation carried on the tracking mounts.

There are several advantages to fixed-axis cameras. Probably the most important is that since tracking is not required, acquisition of the target is not required and, because the camera is rigidly fixed to the ground, smooth, highly resolved streaks are formed on the film by the reentry objects. There is no chance of miss-track with a wide-angle, fixed-axis camera if the reentry vehicles are within the prescribed limits of their trajectory. Next in importance is simplicity. There are few moving parts in the fixed-axis cameras used by Sandia, except for the framing plate cameras. A final major advantage is the fact that there are several types of aerial cameras that are surplus and can be obtained for little or no money. These cameras were originally built to rigid specifications and some carry top-quality lenses. By well-designed modifications, these cameras can be made into first-class reentry instrumentation at a small fraction of the cost of designing and building entirely new cameras.

Fixed-axis instrumentation has its disadvantages, too. The very fact that fixed-axis cameras must have wide fields of view for reentry work limits their capabilities. Large field of view is not compatible with large aperture and long focal length. Therefore, for practical cost reasons alone, one is restricted with wide-angle systems to apertures in the region of 12 inches and focal lengths to 36 inches.

Also, the exposure with a fixed-axis camera cannot be varied if the lens is wide open when used. Because of these shortcomings, tracking systems are used in conjunction with fixed-axis systems; they complement each other.

Trajectory Cameras

It is imperative that the time and position of such occurrences as reactor disassembly and fuel rod ablation and flareup during reentry be known. The NASA FPS-16 radar at Coopers Island will track the reentry vehicle by means of an on-board beacon until blackout occurs. To fill in after radar blackout and to supply trajectories on objects other than the reentry vehicle and as backup to the radar, simple ballistic or trajectory cameras will be used at High Point. These will be five modified K-37 aerial cameras (see Figure 6) using glass photo plates and solenoid-operated shutters to provide timing chops in the streaked images of the reentry.

Pointing orientation of these cameras will be determined by means of star trail backgrounds shot just before or after the operation. Data reduction will then use the radar trajectory as a starting point to determine trajectories from the trajectory camera plates. The camera shutters will be chopped in a time-coded sequence supplied by a punched tape. The time code allows approximately 112 seconds of operation without repeating and, even in the worst case, provides time to any streak that is at least 8 seconds in duration. By using five cameras, it is possible to have a 50% overlap in the field of view of the cameras, thus providing backup coverage and eliminating the vignetting problem at the edge of the field.

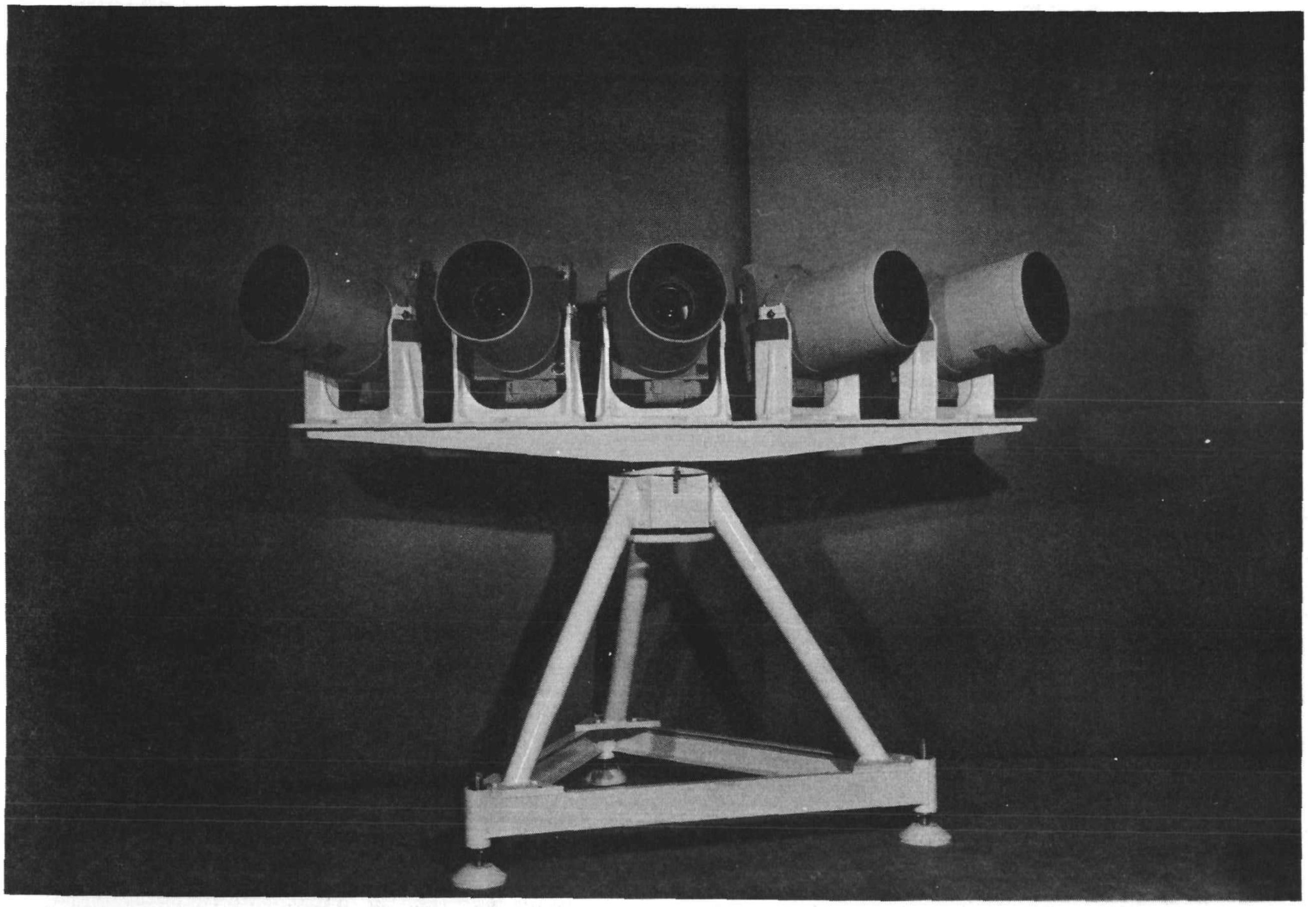

Figure 6. Trajectory, Framing, and Color Cameras - Typical Array. The basic instrument is the K-37 aerial camera, modified to operate in the three different modes. All these cameras use the 12-inch focal length, f/2.5 Aero Ektar lens.

Event Plate Cameras

There are three event plate camera systems that will be used at High Point: 12-inch focal length, f/2.5, with 10- by 12-inch glass plates (Figure 7); 24-inch focal length, f/3.5, with 10- by 19-inch glass plates (Figure 8); and 36-inch focal length, f/4.0, with 10- by 19-inch glass plates (Figure 9). Each of these cameras is essentially just a "box" camera that is pointed in the right direction. The shutter is opened and the images of the reentry objects are allowed to travel across the photographic plate, thus forming streaks or trails of the objects' paths through space.

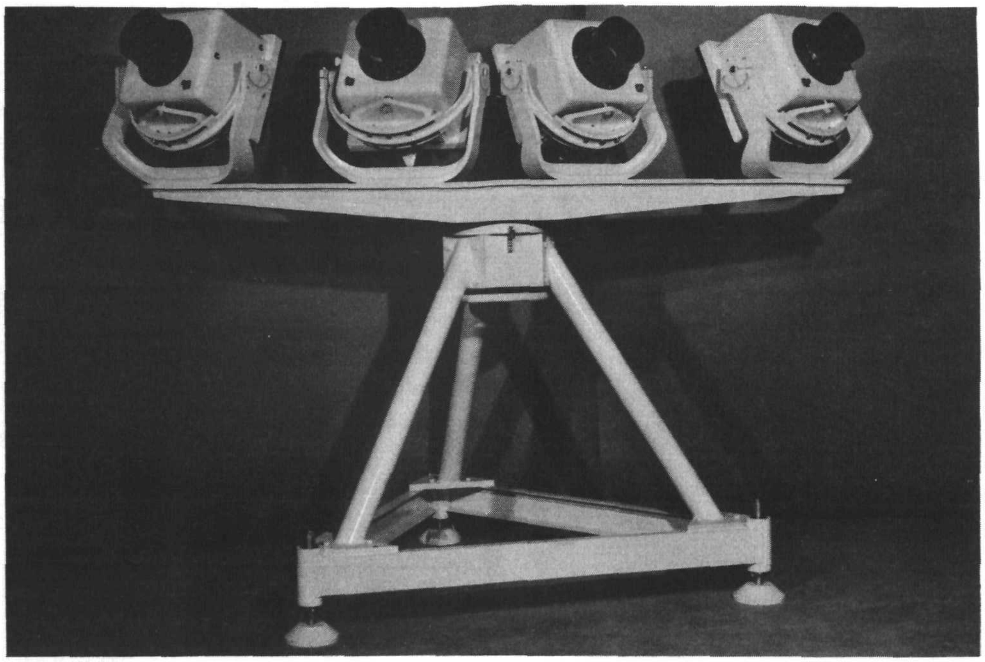

Figure 7. Twelve-Inch Plate and Plate Spectrograph Cameras - Typical Array. The mount design allows rotation of the camera about an axis parallel to the optical axis so that the grating lines can be set nearly parallel with the reentry path. All these cameras use the 12-inch focal length, f/2.5 Aero Ektar lens.

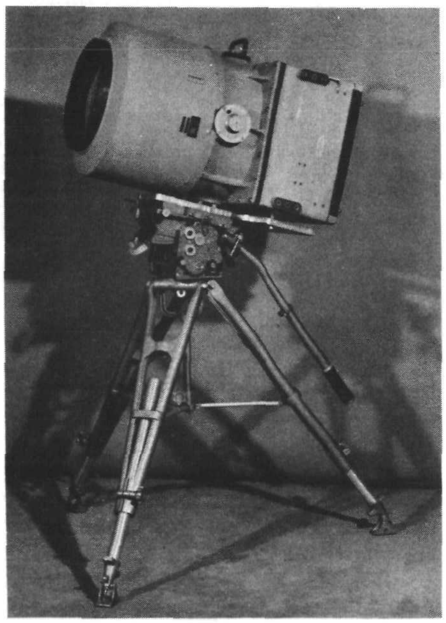

Figure 8. Twenty-Four-Inch Plate Camera. A surplus K-36 aerial camera modified to use 10- by 18-inch glass plates in place of roll film. The lens is 24-inch focal length, f/3.5.

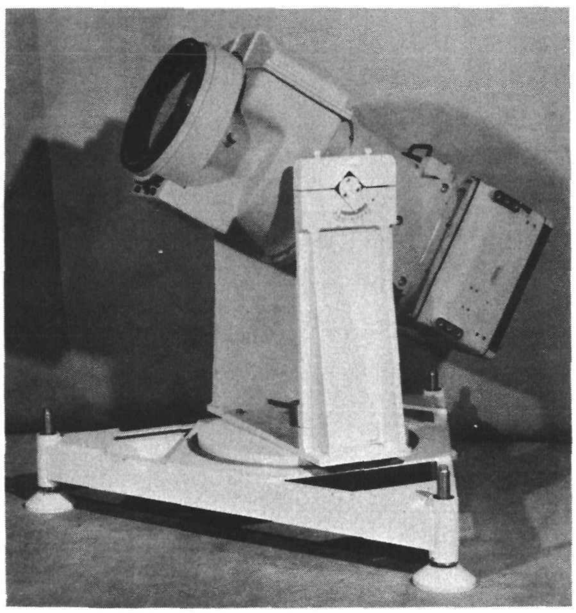

Figure 9. Thirty-Six-Inch Plate Camera. A surplus aerial camera modified to use 10- by 18-inch glass plates in place of roll film. The lens is 36-inch focal length, f/4.0.

The purpose of the event plate cameras is to provide event information on the reentry objects and thus assist in the interpretation of the trajectory and plate spectrograph cameras. They also provide an uninterrupted record of the apparent relative paths through space of all the reentry objects that are glowing brightly enough to record on the film. The 24- and 36-inch focal length cameras were added to provide a more detailed closeup view of the reentry. The longer focal length will give greater streak separation in the vertical plane, and the larger aperture should resolve greater detail; thus, we hope, allowing the identification of more objects.

Framing Plate Cameras

Again the K-37 aerial cameras have been modified to fit a particular need. As framing plate cameras, they will follow most closely their original concept of taking a picture every few seconds on roll film. The array is shown in Figure 6. Modifications to the cameras consist of the changing of the film advance drive to decrease dead time between exposures, removal of the shutter, and addition of dual timing lights. As with the chopping shutters on the trajectory cameras, the framing sequence is preprogrammed and controlled by a punched tape that allows any desired sequence to be used. Present plans call for a frame or picture rate of 1 per 2 seconds: film advance time is approximately 1/2 second and exposure time is 1-1/2 seconds. By having two complete sets of cameras, one camera will be exposing while the other camera, pointing at the same sector, will be advancing film, thus preventing dead time. This plan will be used on the aircraft, but not at High Point.

The framing plate camera is used to overcome two shortcomings of the event, unchopped plate camera. First, by exposing up to 35 pictures during the reentry, the time of either the start or finish of the reentry streaks produced on each picture is known. Second, by having this number of pictures, the reentry streaks do not pile on one another as they do in just one picture of the whole reentry. Thus, the framing plate cameras provide additional timing and event correlation for both the trajectory (chopped plate) and event plate cameras.

Plate Spectrographs

By placing a transmission diffraction grating over an event plate camera, we have a plate spectrograph which can be one of the most useful, yet simple, instruments in reentry studies. Figure 7 shows a typical array of plate spectrographs that will be set up at High Point. These cameras were converted from the Sandia "night cameras" used several years ago at the Yucca Lake Range and then at the Tonopah Test Range. Again, the plate spectrograph is a simple "box" camera with no moving parts or timing, requiring only that it be pointed in the proper direction and that the lens capping cover be removed.

The sole purpose of the plate spectrographs is to provide spectrograms of the reentry bodies and, in particular, of the inert fuel rods loaded with the known tracer materials. Tracer materials with certain strong spectral lines have been chosen and these lines will show on the spectrograms if they flare with enough brilliance to expose the film.

Color-Plate Cameras

Three K-37 aerial cameras will be used as ordinary event plate cameras, except that sheet color film will be used in place of glass plates. It was discovered that backs were made for the K-37 cameras that would hold the standard 8- by 10-inch cut film holders. Several of these backs were located and ordered from a surplus house. These cameras will be operated as an experiment to determine the usefulness of color film in fixed-axis plate cameras.

Hand-Tracked Mounts

Three types of instrumentation will be hand-tracked at the High Point installation: the cinespectrograph, the streak spectrograph, and the 16mm framing camera.

Cinespectrograph

The cinespectrograph is shown in Figure 10 and consists simply of a standard Photo-Sonics 70mm intermittent motion framing camera fitted with a 12-inch focal length, f/2.5 Aero Ektar lens and a 200 lines/mm transmission replica grating. It is planned to run this camera at its lowest frame rate of 5 per second and at its widest shutter of 120 degrees. Timing will be placed on the edge of the film.

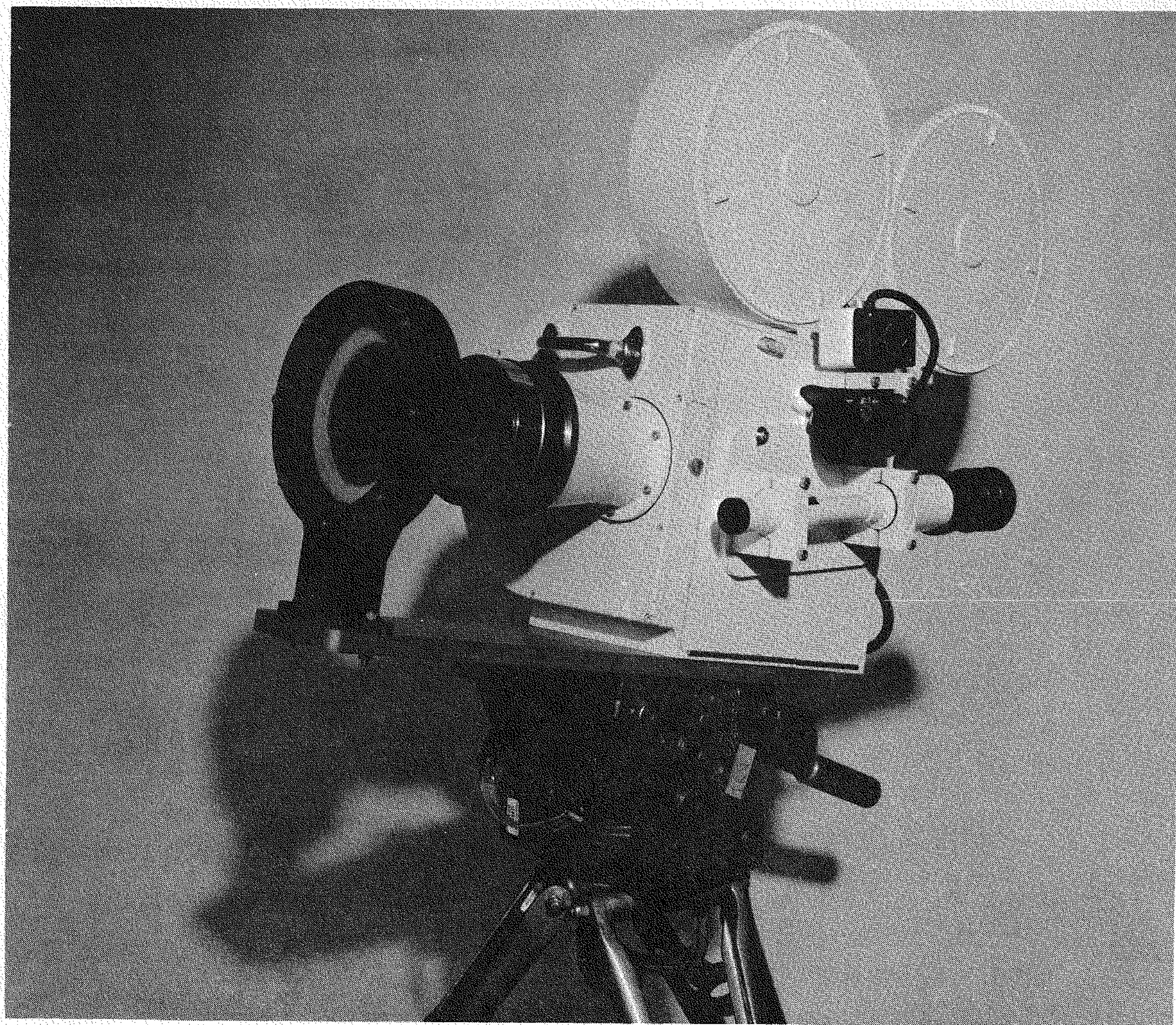

Figure 10. 70mm Cinespectrograph. The Photo-Sonics 10A 70mm intermittent camera works into a 12-inch focal length, f/2.5 Aero Ektar lens fitted with a 200 lines/mm transmission grating. Frame rates of 5, 10, or 15 per second.

Streak Spectrograph and 16mm Millican

This instrument has been described on page 12; therefore, it will not be described again except as it pertains to this installation. Figure 11 shows the two streak spectrographs and 16mm Millican framing camera mounted on the base plate and tripod. These instruments were originally used in the C-54 aircraft on RFD-1. When it was decided that it was not feasible to use them in aircraft again, they were placed at High Point as backup to the other spectrographic instrumentation. The use of two systems allows one mount to track the reentry vehicle and the other to track the external inert fuel rods. The 16mm Millican camera is used to show what the streak spectrograph was tracking and also to record the sequence of events of the reentry.

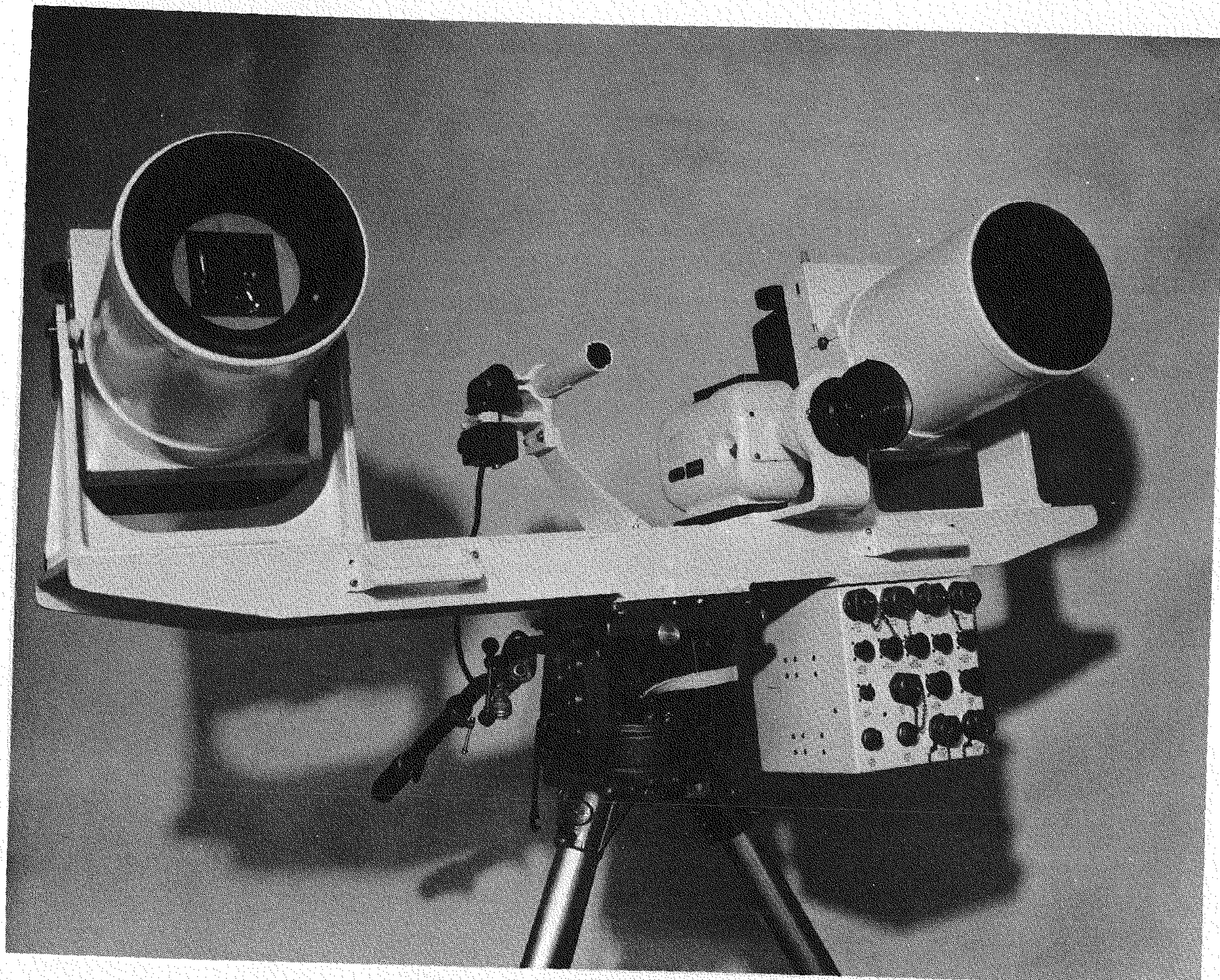

Figure 11. Handtracked Streak Spectrographs. By using two streak spectrographs per mount, a larger field of view is covered.

Electronics

All the electronic design and development encompassing communications, recording, timing, parallax computers, mount controls, and camera power was handled by Design Section, 7222-2, and will be covered in its reports.

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PART TWO: AIRBORNE INSTRUMENTATION

Aircraft-borne, or airborne, instrumentation has two very important advantages over ground-based instrumentation located on islands. First, the aircraft can generally fly above the clouds so prevalent over the ocean; second, the airborne instrumentation is lifted above much of the haze that hampers ground instrumentation and, therefore, receives several times the amount of light as that received by the ground instrumentation. Airborne instrumentation also provides a solid backup in case a sudden and unpredictable cloud cover were to cover a large portion of the reentry area as seen from High Point. Airborne instrumentation provided extremely valuable data on RFD-1; however, advantages are generally accompanied by almost equal disadvantages. The main disadvantage of airborne instrumentation is the lack of a steady platform; therefore, image quality is degraded. Other disadvantages are: difficulties in handling tracking instrumentation, and lack of availability of aircraft. Thus, airborne instrumentation is a balance of compromises that, working in conjunction with ground instrumentation, provides a much better overall capability than with ground instrumentation alone.

An extensive effort was made by Sandia to utilize optical instrumentation aircraft already in service. In all cases, the aircraft were tied in with other programs and could not be diverted for the necessary 4 months. Most of the aircraft studied were converted KC-135's and, in most cases, the window configuration was not compatible with the Sandia instrumentation. It is an expensive operation to install proper windows in a KC-135.

During the investigation of all possible leads on available aircraft, the AVCO Corporation advised Sandia that its DC-6 might be available. This aircraft is used to cover ICBM reentries at both Ascension and Kwajalein Islands. Because of this possibility, Sandia personnel visited airborne instrumentation personnel at the AVCO Laboratory in Everett, Massachusetts, and obtained much valuable information. Examination of photographic and spectrographic records of reentries taken from both DC-6 and KC-135 aircraft made it obvious that a DC-6 type of aircraft would perform as well or better than a KC-135 on RFD-2. Further studies quickly showed that the passenger version of a DC-7B aircraft lent itself very well to Sandia's type of operation because of:

1. Adequate number of windows (18). See Figure 12 for plan view of instrumentation layout.
2. Relative large size of windows (15 1/2 by 17 1/4 inches)
3. Ease of replacing plastic windows with optical glass
4. Ease and versatility of mounting instrumentation to seat rails
5. Suitability without the need for major modifications
6. Ready availability
7. Low operating cost compared to an all-jet aircraft
8. Long on-station time capability

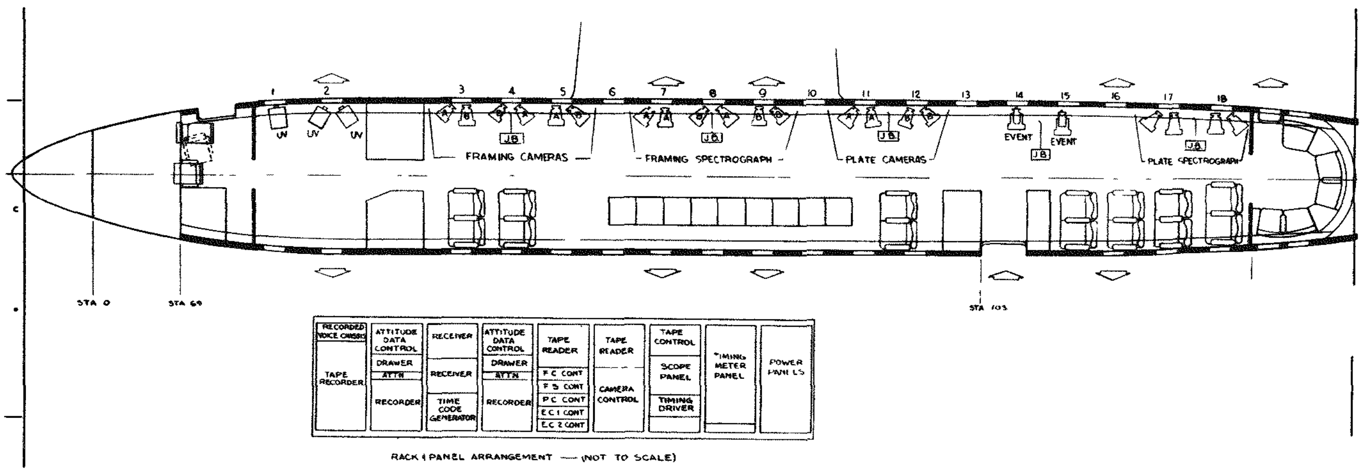

Figure 12. Plan View of Instrumentation Layout in DC-7B.

When it became known that AVCO's DC-6 would not be available, an all-out effort was begun to obtain and instrument a DC-7B aircraft. Invitations to bid were sent out to supply, convert, operate, and maintain a DC-7B passenger-type aircraft. AVCO won the contract and they delivered the plane to Albuquerque on June 11, 1964 (Figure 13).

Figure 13. DC-7B Photo-Instrumentation Aircraft.

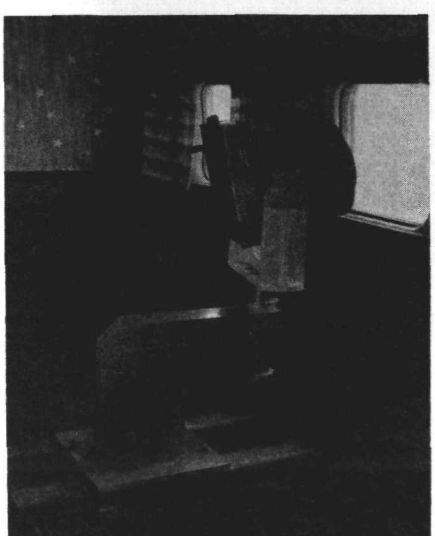

Figure 14. Typical Airborne Camera Mount and Camera.

As soon as the decision to use a DC-7B was made, design on the installation of the instrumentation was begun. The chief aims of the design were that modifications to the aircraft be kept to an absolute minimun and that any passenger DC-7B could be converted and reconverted in 2 or 3 weeks. These aims, coupled with a shortage of time, dictated a simple design.

In most, if not all DC-7B passenger aircraft, the seats are bolted to a pair of continuous rails that run down both sides of the aircraft. With the windows close to the floor, these rails were a ready-made solution to the problem on how to fasten the camera mounts and electronic racks to the aircraft with little or no modification to the aircraft. The camera mount itself, although simple and rugged, is fully adjustable and allows the camera to be placed properly in front of its window (see Figure 14). Most windows are accommodating two cameras.

Fixed-Axis Cameras

As in the ground instrumentation, the prime airborne type is spectrographic. With the exception of the ultraviolet plate spectrographs and the 35mm Mitchell event cameras, all the cameras are modified K-37 aerial cameras as listed on page 7 and described elsewhere in this report. These cameras utilize the same design—including power, control, and timing—as those on the ground at High Point. Figures 15 and 16 show the instrumentation in the aircraft.

Figure 15. Typical Camera Mount Arrangement in Aircraft. Bolting to the seat rails allows longitudinal adjustment. Transverse, vertical, and 2 degrees of rotational adjustments are also provided.

Figure 16. Electronic Racks in Aircraft. Looking forward, the empty racks as shown during the installation. They are bolted to the seat rails.

Ultraviolet Plate Spectrographs

During the later stages of the instrumentation development for RFD-2, it was decided that the near ultraviolet region, from 3000Å to 4000Å, should be investigated and, although time was short, it would be well worth the effort to rig some simple ultraviolet camera. Ultraviolet lenses in the 12-inch focal length f/4 size are almost nonexistent, as was discovered after several phone calls around the country. Thus a design effort was begun, using the Los Alamos lens design code and the IBM 7090 computer.

The design started with a single fused-quartz lens which, of course, proved almost useless and ended with a four-element calcium fluoride fused-quartz combination plus fused-quartz field flattener (see Figure 17). The lens has a 12-inch focal length, is f/4 and, although it certainly is not the ultimate, we hope it will produce results which are sufficient to identify a strong line of silver at 3280Å and to indicate whether further development along these lines is justified.

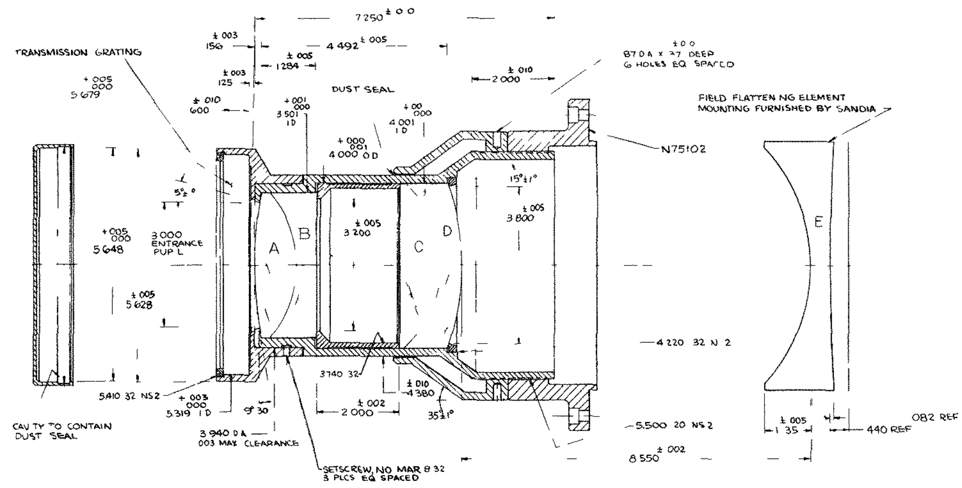

Figure 17. Ultraviolet Lens Cross Section.

Two fused-quartz windows will be installed in the forward compartment of the DC-7B and will allow the three ultraviolet plate spectrograph cameras to cover approximately 60 degrees of the reentry trajectory. The ultraviolet camera has been designed to use 5- by 7-inch glass plates in a standard plate holder (see Figure 18), and the camera fits into the same camera mount as is used by the K-37 cameras.

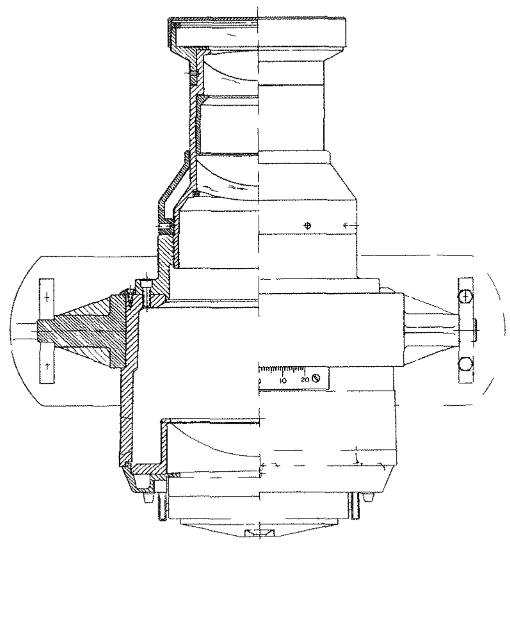

Figure 18. Assembly Drawing of Ultraviolet Camera.

Tracking Cameras

Only two cameras in the aircraft will be tracking cameras, both 35mm Mitchell framing cameras. Their purpose is to provide sequential event data plus possible flare identification on color film.

Windows

The double plastic windows normally used in passenger aircraft are completely unsuitable for use as photographic windows with the lenses that will be used on RFD-2. Simple laboratory tests which simulated the aircraft installation quickly showed that even single-pane plastic windows were unusable. In view of this, the plastic windows will be replaced by 1 1/4-inch glass windows, utilizing Pittsburgh rolled optical plate ground and polished by two optical shops, Pacific Optical and Davidson Optical, to the following surface specifications:

1. Not to exceed 10 wave power
2. Not to exceed 1 wave smooth
3. Not to exceed wedge angle, 1 minute

No protective covers for the windows are planned. Windows installed over 4 years ago in the AVCO DC-6 and never covered were inspected and found to be in excellent condition.

Both the glass and fused-quartz windows will be mounted in identical cells, designed and built by Pacific Airmotive, that are interchangeable with the plastic window cells.

Electronics

As with ground instrumentation, all the electronic design and development encompassing communications, recording, timing, and camera power was handled by Design Section, 7222-2, and will be covered in its reports.

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