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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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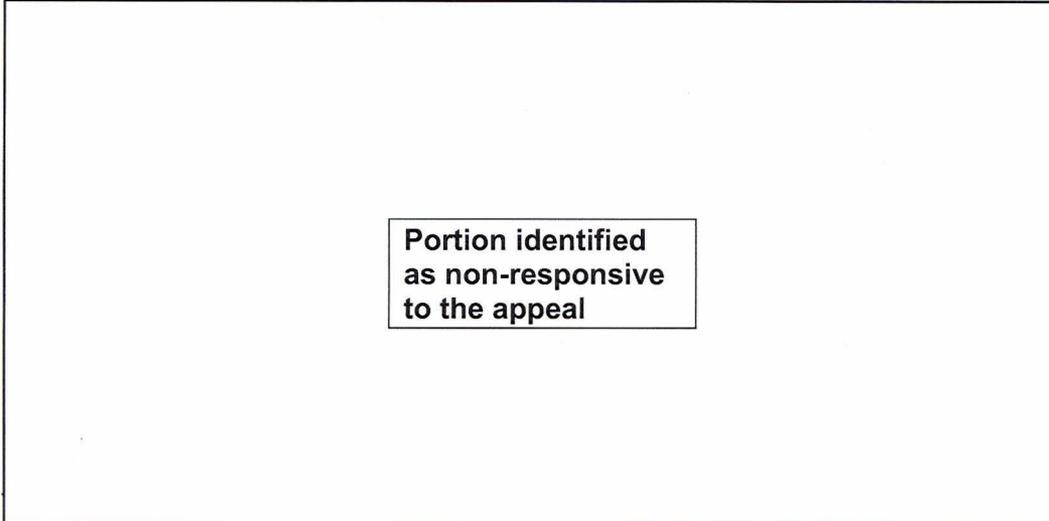
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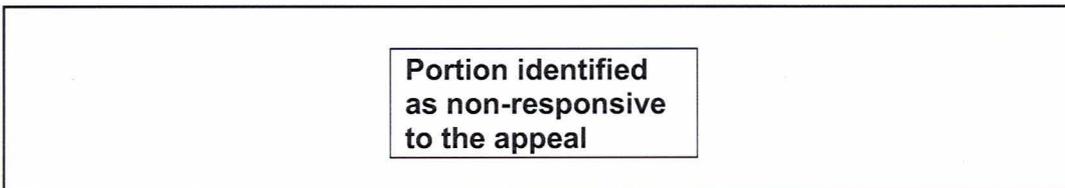
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- 8 (U) Soviet Pneumatic and Hydraulic Controls for Space Vehicles Mr. G. T. Minshall 9

The Soviets claim that they are ahead of the West in industrial production of new hydraulic and pneumatic control devices. They are probably rapidly developing and producing no-moving-part elements for incorporation into subsystems for space payload instrumentation. (S)

- 9 (U) Thrust Generation for Vehicle Flight Control Mr. T. R. McAllister 10

A recent patent reveals Soviet interest in the application of hot gas jets to generate vehicle attitude control in a space environment. If utilized in a major launch vehicle stage, this method of generating thrust for attitude control purposes is a departure from known Soviet practices. (S)



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2. (U) Use of Magnesium Alloys in Welding Cylinders
Mr. D. B. Van Winkle (TDEWP)

Recent Soviet research activities in resistance seam welding of magnesium sheet material (MA-8) indicate an undisclosed possible aerospace application for cylinders with diameters of 16, 32, and 60 inches. These cylinders were fabricated from .060-inch sheet material and reinforced by .072-inch thick outer ribs of unknown configuration. An opening was provided through a 4 x 4 inch reinforced section at an unidentified location on the cylinder. The welding development work was conducted by individuals associated with the Moscow Aviation Technological Institute (MATI). A review of their effort indicates that the work has progressed from laboratory to the prototype stage and reflects a very advanced capability as compared to US efforts in resistance welding of magnesium sheet material.

Magnesium alloys do not lend themselves to high reliability applications unless elaborate control of weld variables is implemented and very sophisticated equipment is utilized. The Soviets have clearly achieved a good level of reliability by photomacrographing the weld, overlapping the first seam weld with a second seam weld and the apparent close control of other variables inherent in the resistance welding process. An additional requirement for weld development

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was to achieve a hermetic seal. This was achieved and confirmed through a helium leak test inspection method.

Magnesium alloy sheet material is difficult to form into most shapes unless high temperature forming techniques are employed. The additional effort in utilizing hot dies or external heating methods adds to fabrication cost. However, the redeeming feature of this material is its high strength-to-density ratio which makes it ideal as a light structural material in aerospace work; it is used in such applications in the Gemini Adapter Module Structure, Agena and Mariner C space vehicles.

Aerospace application is implied as a result of the type of developmental research conducted and the facility association of the authors. Because a prototype configuration has been achieved, the final hardware probably will appear in the near future.

It is believed that the diameters indicated for these cylinders are not to scale, but are probably the finished item size. This opinion is based upon the fact that new weld procedure development would have to be initiated for any change in cylindrical diameter. This would be required in order to establish the high degree of reliability needed for aerospace applications. (The overall classification of this item is ~~CONFIDENTIAL~~.) (~~Gr 3 Normal - Downgraded at 12 year intervals; not automatically declassified.~~) (NO FOREIGN DISSEM, except UK, Can, Aus, NZ and NATO.)

3. (U) Soviet Lunar Base Concepts
Capt R. J. Talbot (TDEWG)

One of the first public announcements of Soviet intentions in lunar base design and construction occurred in September at the Fifteenth Congress of the International Astronautical Federation which was held in Warsaw, Poland. A paper, entitled "Architectural Problems as Applied to Building on the Moon" was presented at the meeting.

The information revealed by this paper supports previous FTD assessments concerning the Soviet lunar program, i.e., that the program is in an exploratory phase. However, it does add another technical indicator to the previously published list and further aids in establishing the existence of a manned lunar exploration program.

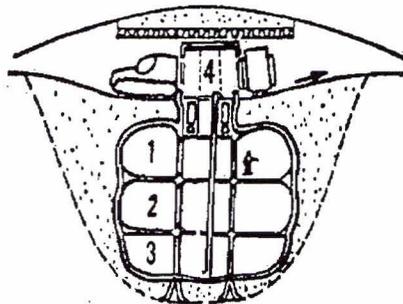
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The design concepts reported in the paper are not revolutionary, but the approach proposed by the authors is interesting and may well be a significant indicator of Soviet planning in this area. The paper stresses the use of inflatable structures for the construction of shelters, but points out that a spherical shape probably would not provide an optimum configuration for the solution of all problems. The problem areas listed in the paper are:

- (1) The "geometry" of the gravitational forces.
- (2) Fabrication techniques.
- (3) Assembly methods.
- (4) Exploitation of natural resources.
- (5) Replacement of components.
- (6) Adding new units.

The paper also emphasizes the burying of lunar shelters in order to gain protection from the meteorite and radiation hazards and to avoid the extreme temperature variations which occur on the lunar surface. Figure 1 is a sketch of a proposed design which illustrates the features described above. The center of the buried shelter is a rigid hexagonal cylinder which supports the inflated surrounding structure. The top of the shelter forms an airlock, through which supplies and personnel may be directly transferred from the shelter to a lunar vehicle.



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Fig. 1. Cross-Section of Station: (1) Working Level; (2) Living Quarters; (3) "Technical" Level; (4) Air Lock

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The paper does not explicitly state whether these design concepts are being considered for first generation bases or later, more permanent, installations. However, a reference to the use of final stages of space rockets for living quarters in the initial stages of space exploration tends to indicate the latter. This philosophy is in accordance with current US plans, in which early bases will use conventional surface structures, while later bases will probably be buried and may be of the expandable type. (The overall classification of this item is ~~SECRET.~~) (~~Gp 3 Normal - Downgraded at 12 year intervals; not automatically declassified.~~) (NO FOREIGN DISSEM, except UK, Can, Aus, NZ and NATO.)

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8. (U) Soviet Pneumatic and Hydraulic Controls for Space Vehicles
Mr. G. T. Minshall (TDEEC).

A leading Soviet scientist claims that the Soviets are ahead of the West in new hydraulic and pneumatic control devices. These devices achieve transfer of flow between two or more outlets with no moving mechanical parts. The scientist's interest concerns the application of these components to discrete data systems. He is pursuing control system design philosophy comparing operational units versus integrated packages and additional related manufacturing and production problems. Many of the devices are in advanced production status.

The Soviets have reached their present status through first overselling some earlier moving-part devices with their attendant higher cost of introduction into production. They now have the task of stopping the production of the moving-part devices to justify the industrial channeling of the more recent development.

The no-moving-parts pneumatic and hydraulic elements are heralded because they do not suffer from time exposure to space radiation, while electronic elements are affected in the radiation environment. Typical replacements that the new devices will effect include amplifiers, decision-making devices and controls.

M. A. Ayzerman and a subordinate named Tal, are receiving recognition for their work in this field of control elements. Highly reliable space systems are anticipated when development is completed.

Their open discussions at symposia are directed toward industrial applications. Here they claim they have systems that are ready to be placed in high rate production. The mentioned space applications, through recognized priorities, would logically precede extensive allocation to production applications. There is no reason to doubt their production status for industry. A relatively

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urgent schedule and well planned effort then is probable for solution of on-board space payload instrumentation problems. The result of this work may be the production of lightweight but highly effective building-block modules for control and computer applications. (The overall classification of this item is ~~SECRET~~.) (~~Gr 1 Excluded from automatic downgrading and declassification.~~) (NO FOREIGN DISSEM, except UK, Can, Aus, NZ and NATO.)

9. (U) Thrust Generation for Vehicle Flight Control
Mr. T. R. McAllister (TDEPR)

A patent entitled "A Jet Control Nozzle for Creating Controlling Moment on Flying Vehicles" was published in the fourth issue of Byulletin Izobreteniy I Tovain'ykh Znakow in 1964. A preliminary review of the patent sketches indicates the primary application of this device is vehicle attitude control in a space environment. No facility associations are currently available for authors of this patent.

The design of a control nozzle whose support assembly lies outside the high temperature gas zone is the theme of the patent. A nozzle assembly is shaft mounted, permitting nozzle movement in a plane perpendicular to the shaft's longitudinal axis. The degree of movement within this plane is not discernible on the basis of available information. Both the plane of movement, and the method of supporting the nozzle suggests that this device was designed to create a control vector. Functions of attitude control and incremental velocity termination are possible utilizing a combination of these devices.

The obvious absence of a combustion chamber preceding the nozzle throat, in the patent sketches, requires the device be fed hot gases. The source of these gases limits generation of thrust to the period of main propulsion system operation, i.e., if this device were mounted on the second stage of a vehicle, the thrust generated by this device would be available only during 2nd stage operation.

There are many possible sources for this gas supply. Two of the most obvious and likely are (1) a gas generator to supply only the nozzle or nozzles and (2) the ducting of turbine exhaust gases through the nozzle. While the first would provide greater thrusts, the weight increase would be extremely penalizing. The turbine exhaust gas feed system would account for a weight reduction, eliminate the possibility of thrust vector malalignment from turbine exhaust, provide for

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vehicle attitude control and could accomplish incremental velocity termination in one installation. This is highly desirable from a design viewpoint. Such an application could perform the functions of vernier rocket engines, but is only feasible on stages having a turbine mass flow rate of sufficient magnitude to generate a thrust capable of vehicle attitude control.

The US Atlas ICBM utilizes turbine exhaust gases ducted through a converging nozzle to obtain an incremental thrust increase. The converging nozzle is utilized because of the low operating pressure ratio and the existence of atmospheric pressure during operation.

The patented device utilizes a divergent, slightly bell-shaped nozzle with an indicated expansion ratio of sixty to one. This ratio stipulates space as the operational environment. If this device were operated in the atmosphere, the optimum nozzle shape would be a converging duct, similar to the Atlas turbine exhaust nozzle.

No firm decision can be made concerning the existence of vernier rocket engines on the Lunik, Interplanetary or KY Cosmos stages. A device such as this could provide sufficient thrust for attitude control of these stages during their operation. The existence of this device on any of these stages is pure speculation at this time. If this method of generating attitude control thrust is utilized, it is a major departure from known Soviet practices. (The overall classification of this item is ~~SECRET~~.) (~~Gp 3 Normal - Downgraded at 12 year intervals; not automatically declassified.~~) (NO FOREIGN DISSEM, except UK, Can, Aus, NZ and NATO.)

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12. (U) Possible Soviet Horizon Definition Program
Mr. D. A. Bierley (TDEEC)

During the recent Voskhod manned orbital flight, scientist-cosmonaut Feoktistov conducted observations on the earth's horizon. Feoktistov stated that, "Observations of the horizon were made to obtain information concerning the optical range for purposes of navigation and orientation in orbital and interplanetary flights when we shall have to use the earth as a base celestial body for astronavigation measurements and for spaceship orientation, and the orientation of automatic space programs."

The significance of Feoktistov's statement is that spacecraft vertical determination and attitude control can be accomplished by using a planet's horizon as a reference. Vertical reference information is required for accurate spacecraft orientation and stabilization. This type of information is applicable to earth orbiting vehicles as well as planetary probes.

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A horizon sensor can be used for determining this information. In addition to sensor component errors (electro-optical), this measurement technique has inherent errors caused by the reference planet's deviation from a perfect sphere. Terrain irregularities appearing on the horizon may also produce measurement errors. The errors due to geophysical reasons can be reduced to a minimum through the use of smoothing filter techniques. However design of such a filter requires a better knowledge of the statistics of the horizon variations and the statistical data must be obtained by a space measurement program.

The Soviets have previously used the earth as an attitude reference during space exploration; however, in order to realize the full potential of the earth as an orientation reference, it is believed further horizon definition data probably are required. Based on Soviet statements as to the use of the earth as a navigational reference for future space flights and the requirement to reduce geophysical errors, FTD concludes that a horizon definition program is probably being undertaken and it will utilize data obtained during the Voskhod flight and subsequent orbital manned and unmanned flights. (This item is UNCLASSIFIED.)

13. (U) Soviet Fuel Cell Developments

Mr. W. G. Kroggel &
Lt B. T. Madden (TDEWG)

According to Dr. V. S. Bagotsky, member of the Institute of Electrochemistry (Moscow) and Professor at the University of Moscow, the Soviets are working on military applications of fuel cells.

In a recent interview, Dr. Bagotsky avoided specific questions by answering, "You must understand that fuel cells have now become in the category of a military secret."

This supports other information to the effect that 40 to 50 people at the Institute were working on military applications of the oxygen-methanol cell.

The main research effort at the Institute of Electrochemistry apparently is in the field of oxygen-hydrocarbon cells, particularly oxygen-methanol.

The oxygen-methanol cell does not appear to be adaptable to space application. First, the methanol-oxygen cell only has a specific power output of about one-fifth that of the hydrogen-oxygen cell. Second, unlike the hydrogen-oxygen

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cell, the methanol-oxygen cell does not produce potable water as a waste product, which complicates the problem of life support and waste rejection in space. However, this cell can be used as a noiseless power generator for ground applications.

Dr. Gabotsky's statement, along with the lack of open source literature information on fuel cells, tends to confirm the FTD position that the Soviets are engaged in a classified fuel cell development program. (The overall classification of this item is ~~SECRET.~~) (~~Gp 3 Normal - Downgraded at 12 year intervals; not automatically declassified.~~) (NO FOREIGN DISSEM, except UK, Can, Aus and NZ.)

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