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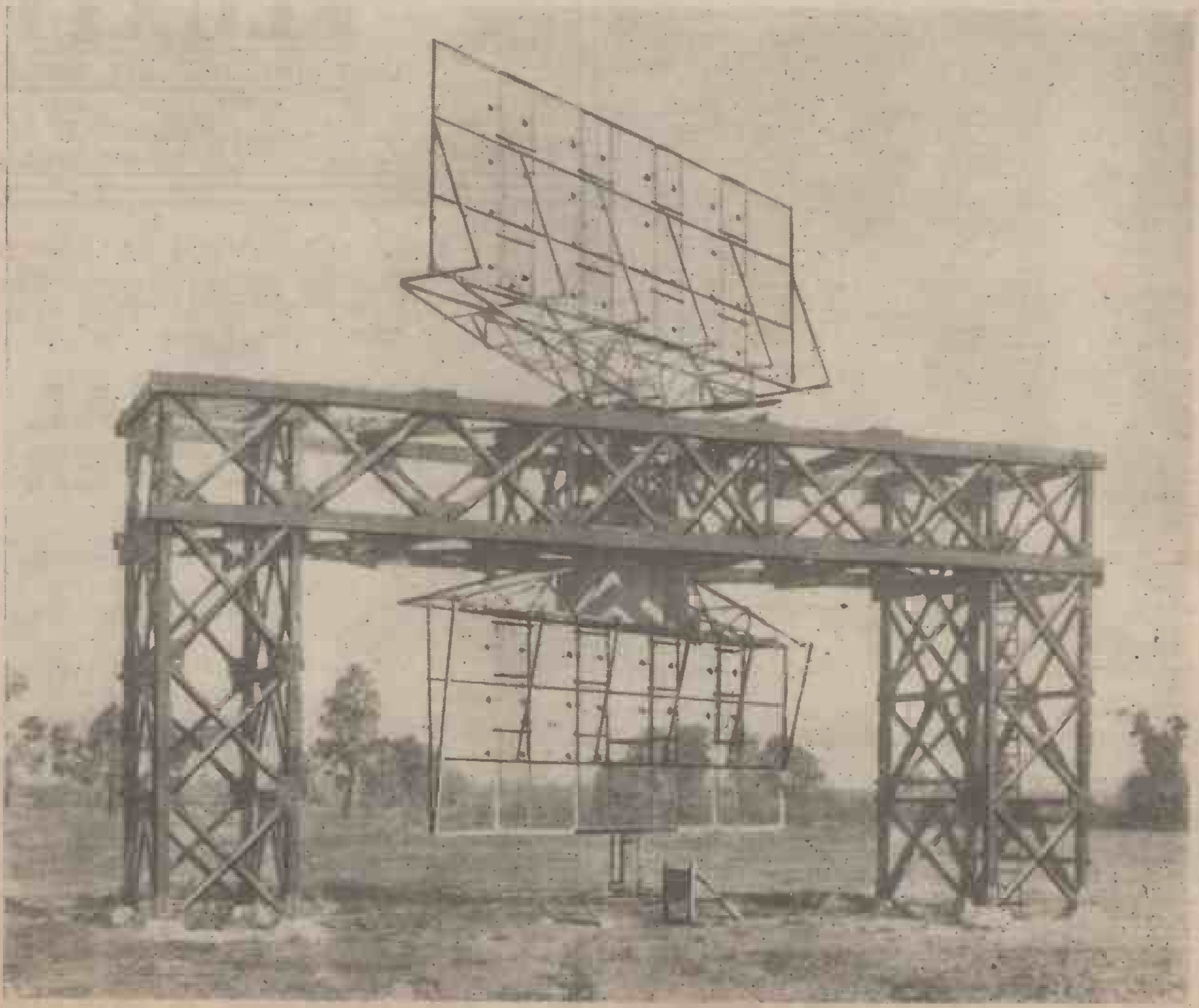

Rocket Propulsion

Further Details of the B.I.S. Space-vessel : The Lunar Flight

By K. W. GATLAND

(*Continued from page 20, October issue*)

AS has been emphasised earlier, the development and selection of a propellant in the B.I.S. Space-vessel conception cannot be governed by thrust yield alone. The cellular method of construction relies upon a high fuel density to provide its structural stability; and the "otherwise ideal" propellant may also be grossly unstable, liable to detonation. The problem is, obviously, no slight one, and much extensive research will doubtless be necessary before the "Lunar propellant" becomes reality.

A beginning, however, has already been made in the work of a research chemist, Dr. A. M. J. Janser, officer of the pre-war B.I.S. Council and member of the Technical Committee, whose researches have resulted in the development of certain original propellant forms which bear much promise in a cellular arrangement. These can be described as fuels which embody an oxygen-bearing organic substance of viscous consistency with a finely comminuted metal dispersed therein. Many exacting checks remain to be made before anything definite can be expressed of such compounds. What can be said, however, is that the factor of efficiency approaches more closely the theoretical value than any of the more conventional propellants previously tested. There are several metals and metaloids which release very great energies on oxidation, and the comparative values and corresponding exhaust velocities of these, as well as those tested by Dr. Janser, are given in the accompanying table.

The "Life-container"

The crew's compartment presents another factor of design that requires most careful consideration. It must be provided with means for sustaining an artificial atmosphere, sufficient to satisfy the needs of three for three weeks.

The B.I.S. suggest the solution to this problem lies in the use of hydrogen peroxide. This, they assert, would be carried as a syrupy viscous liquid that could be broken up into air and water either by the application of heat or by catalytic action; one molecule of which can be readily split up into one molecule of water and half a molecule of oxygen. Thus, not only is a continuous supply of oxygen issued into the life chamber, but also a supply of water is maintained which alone would satisfy the needs of the crew. It is found that 34lb. of hydrogen peroxide yields 16lb. of oxygen and 18lb. of water, and 1lb. of oxygen occupies 13 cu. ft. at N.T.P., which is sufficient for one man who is normally active for a period of six hours. Working from this basis, approximately 500lb. of hydrogen peroxide will provide sufficient oxygen for three men for 20 days, while allowing also a small surplus for emergency purposes. This same quantity of peroxide will also yield about three pints of water per man each day for 20 days, and allow a little to spare for chemical purposes and other uses.

In this arrangement, weight is saved by the use of one storage tank for two commodities, and also entails a saving in space, since the two substances could never be stored as compactly as when they are in chemical combination. Furthermore, only one set of controls would be necessary to regulate both air and water.

As a precaution against a possible breakdown of the peroxide water/oxygen plant, a small amount of liquid oxygen would also be taken. This would also be necessary as an air supply for the "space-suits," which the crew would use outside the Space-vessel while on the Lunar surface.

Navigational Instruments

One problem solved invariably presents another. The "Vessel's" axial rotation means that the control compartment is also revolving, and although, as already observed, this condition serves to stabilise, and also stimulates an artificial gravitation, it does not facilitate the navigational problem. First, however, the one other principal advantage—*gravitation*. In order to gain this condition, it will obviously be necessary for the crew also to be rotating—the gravitational effect being stimulated by centrifugal force. The crew are, therefore, accommodated on full-length couch type "chairs," radially fitted, which rotate on rails round the life-compartment, and the navigators recline on these with their heads towards the "Vessel's" axis. There is also provided a circular catwalk for them to move round the circumference of the chamber.

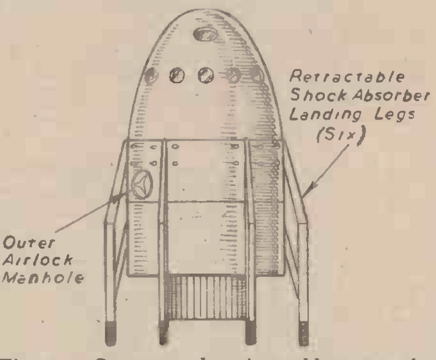

Fig. 39.—Space-vessel, as it would appear after alighting on Lunar surface.

The main ignition controls are fitted to the arms of the "chairs," while the navigational instruments, altimeter, speedometer, accelerometer—all functioned by impulse—are mounted on a central pillar in full view of the crew.

The difficulty lies in the fact that, under these conditions, the field of vision will be rotational, and since from time to time the crew will need to make navigational observation, this must be converted to one both stationary and accurate.

A satisfactory solution was found in the development of a system of rotating mirrors—a development of the stroboscope—and the B.I.S. have already constructed a successful test instrument along these lines. The new device has been termed the "coelostat."

The apparatus is fitted on the central control assembly (see Fig. 38) so that direct view in three directions is permitted: (a) axially, away from the firing face (three viewing ports, situated near the apex of the life-container shell); (b) axially, towards the firing face (viewing panels provided in that section of the "Vessel" where the circular life-container floor overhangs the hexagonal main body shell), and (c) radially (12 viewing ports provided in the dome of the life-container, circumferentially spaced equally at 30 degs.).

The presence of the ceramic nosing carapace will mean that the ascent through the atmosphere will have to be made without external vision. This is no great problem, however, as the navigational corrections would, in any event, be best left until after the predetermined thrust phase.

The Lunar Flight

Navigational requirements made it desirable for the launching to take place from near the Equator.

The "Vessel" would ascend from a special launching installation, and be pre-rotated at a designed rate of one revolution every three seconds. This rotation would be maintained throughout the voyage—a duration of almost four days.

Acceleration would be applied to obtain "release velocity" (6.95 miles per second) within $7\frac{1}{2}$ minutes, and the "Vessel" would emerge from the extreme limits of atmosphere after three minutes. At this stage, the ceramic nosing would be jettisoned, and as the propulsion cellules become expended, these, too, would drop away, together with their retaining structure and shell segments.

Having attained "release velocity," power would be cut off; momentum carrying the machine to the Lunar orbit. It is during this period that any navigational corrections would be made.

Still travelling under momentum, the "Vessel" would be steadily slowed by the influence of the Earth's gravity until the transitional point of the opposing gravities—Earth and Moon—is reached. Once beyond this, however, the Lunar influence would come into effect, causing the machine to accelerate toward the Moon's surface. During this period of natural acceleration, the "Vessel" would be turned completely through 180 deg., so that, in preparation for the landing, it approaches the surface stern first. This manœuvre may appear, at first thought, a somewhat delicate operation, but taking into consideration the absence of atmosphere, and remembering that the acceleration at this period would not be very great, the difficulties involved are really slight. It would, of course, be necessary to check the machine's axial rotation before applying lateral forces, employing sensitive steam jets in both instances. This would involve a loss of stimulated gravity, although a limited gravitational "pull" would have effect from the Moon.

Once the turning manœuvre had been fully executed, further banks of cellules would be fired to retard the "Vessel's" speed. These would exert a negative acceleration and serve to further stimulate artificial gravitation within the machine.

The immediate approach to the surface would be made in conjunction with special instruments developed on the basis of time, and rate of negative acceleration. There would also be an instrument to check height, similar in application to the "echo sounding" device used at sea. The individual readings would need to be automatically integrated. In this way direct figures would be shown of the "Vessel's" position, relative to the surface, at every instant of descent, and the thrust modulated accordingly, ultimately, to just balance the Lunar gravitation a few feet above the point of alightment. The force of landing would be taken by six hydraulic shock-absorber "legs," and if correctly done, this should not be excessive, allowing a reasonably level surface. The "Vessel's" mass will have been reduced to less than a third at the time of landing (Fig. 39), and, in consequence, will allow a fine degree of control, with a minimum expenditure of fuel.

The return would be made in much the same manner as the outward journey, although, of course, there would be no launching device or means of pre-rotation. The "Vessel" would simply thrust off on its landing "legs," allowing steam jets to set up the axial stabilising spin as soon as possible. This solution is considered practicable only through the decreased masses involved, and the diminished gravity, which enable the rocket to attain Lunar release velocity with considerably less expended energy than in gaining exit from the Earth. Once this figure is reached the "Vessel" would be allowed to coast under momentum, and having re-passed the area of gravitational equilibrium, would accelerate in free fall towards the Earth. Having attended to any necessary navigational adjustments earlier in the momentum phase, the "Vessel" would be again completely turned about its axis, and further cellules fired to retard it to a safe velocity for re-entering the atmosphere. Having consumed almost completely the propulsive cellules, any reserve that remained would be jettisoned to further lighten the "Vessel."

Once at a specified distance from the surface the supporting parachute would be released, and the life-container, housing crew and records, brought gently to the ground (Fig. 40).

Space-vessel Development Programme

The B.I.S. Space-vessel conception was developed for the express purpose of obtaining a bird's-eye view of the space-flight problem as a whole. Thus, the preliminary design of a space-rocket was commenced; a work started during 1937, and which occupied the B.I.S. technicians for over 18 months.

It was presupposed that certain essential conditions must be met, and the "Vessel" designed to satisfy these conditions. In this way it was readily determined within reasonably close limits where contemporary knowledge would require supplementing by further research. The limitations imposed can be classified as follows: (a) The voyage should serve a definite scientific purpose, and the crew and equipment should be the minimum that could serve that purpose. (b) That provision should be made to allow a reasonable chance of the successful return of the participants. (c) That every danger that could be foreseen should be provided against as far as was practicable; and (d) That no assumption should be made as to the possible development of new fuels or materials of construction that might not reasonably be expected to be developed from those in existence. Having concluded the provisional design of the Cellular-space-vessel, the Technical Committee of the B.I.S. published a report of its findings in the Society "Journal" (January, 1939), and appended a further recommendation to cover an extension of the research programme for the purpose of investigating the following points: (1) The exact experimental verification of the laws of rocket reaction to show how the power developed by a rocket motor was determined and governed by the method of combustion. (2) That a given list of fuel combinations should be tested to discover the maximum energy available, and the best means of preparing and igniting the fuels. Also, that the results of the tests be applied to the production of improvements in the performance of rockets used for life-saving, signalling, etc., etc. (3) That the results of the foregoing experiments should be applied to the design of high-altitude atmosphere sounding rockets bearing recording instruments for the purpose of recording the extent and density of the atmosphere, and the prevalence and density of cosmic radiation. (4) That a mathematical treatment of the dynamics of space-flight should be prepared in such a form as to establish the navigational procedure and power requirements of the Lunar Trajectory. (5) That working models of the instruments, and such original mechanical devices as were embodied in the Report should be made to ascertain their efficiency in so far as circumstances made this possible; and (6) That the physiological aspects of certain conditions the space-navigators might encounter should be investigated as far as possible.

Propellant	C	V
C to CO_2	2,220	4.3
C to CO	1,050	2.9
H_2(1/2 O_2)	3,240	5.2
C_2H_2(2-1/2 O_2)	2,880	4.9
C_2H_4(3 O_2)	2,580	4.6
CH_4(2 O_2)	2,400	4.5
C_6H_6(7-1/2 O_2)	2,430	4.5
C_2H_5OH (3 O_2)	1,970	4.0
H_2S (1-1/2 O_2)	1,380	3.4
$C_{14}H_{10}$ (16-1/2 O_2)	2,500	4.6
B (B_2O_3)	3,980	5.8
Al (Al^2O_3)	3,850	5.7
Mg (MgO)	3,590	5.6
Si (SiO^2)	3,000	5.1
Ca (CaO)	2,720	4.7
P (P^2O_5)	2,580	4.6
Metal Sol.	2,300	4.4
Cordite	1,240	3.2

C = Calories per gramme of reaction mixture.
V = Exhaust velocity in km/sec. − 1.

Various propellants tabulated to show comparative efficiencies, including those tested by the B.I.S.

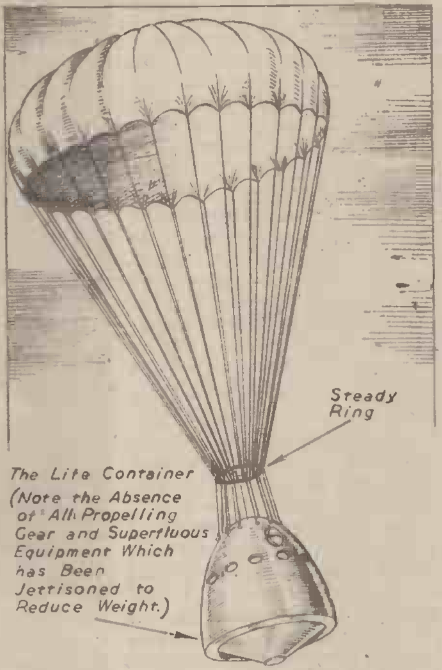

Fig. 40.—The "Vessel," having decelerated against gravity to zero at a safe distance within the earth's atmosphere, descends by parachute.

This second part of the programme was curtailed by the outbreak of war, which caused the British Interplanetary Society to abandon its activities in September, 1939. A Nuclear Committee, however, remained in existence, and although little active participation in the science was possible for some little while following the formal disbandment, in more recent years this body has recommenced theoretical work in the form of calculations of the exact masses and cellule powers involved in the Lunar Space-rocket. Other investigations have concerned the calculation of space-rocket trajectories, and similar research connected with spacial navigation.

A National Society?

This same Committee, two years before the conclusion of the war in Europe, was busy formulating plans for the official re-inauguration of the Society, and in league with the remaining British rocket groups the Astronautical Development Society and the Manchester Astronautical Association (now coalesced under the title, Combined British Astronautical Societies), preparations are now in hand for the amalgamation of the three groups under a common heading.

During the war small craft of the Light Coastal Force did invaluable work in sinking, destroying and capturing enemy supply ships, escort vessels and E-boats. Our illustration shows one of these small fighting craft, a British motor-torpedo-boat, at speed in heavy weather.