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JBFA - BUOYANT FLIGHT

Toshikazu Ohari
et al.

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1980, pp. 1-94.

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3) A discussion of hot airship development.
4) A review of ballon development trends in America.
5) An article on plans for large airships that would employ solar energy.
6) A discussion of metalclad airships.
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TESTING OF BALLOON LOADING AND UNLOADING

Toshikazu Ohari*

1. Introduction

The Ministry of Agriculture, Forestry and Fisheries Forestry Experiment Station began research pertaining to balloon logging in 1976 in a 4 year plan. Actual testing was carried out in the final year, 1979. The purpose of this research was to develop a method whereby lumber is carried out from the skies over the forest using a balloon in order to continue lumber production without destroying the natural environment and view of the forest. For this reason, (1) tests on the best shape for a logging balloon, (2) development of a balloon logging system suitable for cutting lumber and safety plans, (3) tests on balloon construction and development of netting, and (4) weather of mountainous areas, especially solutions to problems caused by winds, were made the four bases of this research. Research on (1), (2) and (4) was carried out by the Forestry Experiment Station and on (3) by Kawasaki Heavy Industries, who was very enthusiastic about balloon development at the time, for two years starting with 1977. Logging is the operation whereby lumber that has been cut down is collected at one place. It is the operation that is the most technical and requires the most energy in the lumber production process. /1**

*Ministry of Agriculture, Forestry and Fisheries Forestry Experiment Station.

**Numbers in margin indicate pagination of original foreign text.

At the end of 1978, the 3rd year of research, a natural captive balloon with a capacity of 1,400 m^3 was made by Kawasaki Heavy Industries' Gifu factory and actual testing was carried out using this balloon in 1979.

2. Balloon Logging System

A test site was established in the Numata Local Forestry Office Itoshise State Forest at the foot of Yamakita in Akagi, Gunma-ken. Construction of a balloon system and filling the balloon with helium gas was started in July 24, 1979 and preparations were completed at the end of the same month. Tests were carried out during the first 10 days of August. The shape of the balloon that was used and the main parameters are shown in Figure 1 and Table 1. With regard to the shape of the balloon, the best natural shape for using a logging type balloon was selected, using actual foreign examples as a reference. Moreover, a PET textile (polyester), which was developed by both Kawasaki Heavy Industries and Toyo Spinning, was used as the main reinforcement for the netting of the balloon. A Tedora film superior in durability when compared to PET and a new material rivaling PET film with low gas permeability were used.

The actual balloon logging system is shown in Figure 2. All of the foreign examples are styles where the 2 wire ropes, namely, the main line and the haulback line, are attached to the lower end of the tether line and a straight line is formed between the two points. However, in Japan the main purpose of balloons that are actually being used is to engage in natural preservation. Therefore, 3 wire line stretching is employed as a method for carrying out lumber while preserving the forest, with a wide surface area being covered with one stretch of the line. This method is unique to Japan. Three operation lines are arranged for balloon operation. Movements in the horizontal direction of the balloon and in the vertical direction of the /2

TABLE 1. BALLOON PARAMETERS

STYLE	NATURAL
Capacity	1400 m^3
Surface Area	609 m^2
Diameter	14.4 m
Weight	370 Kg
Effective Buoyancy	890 Kg

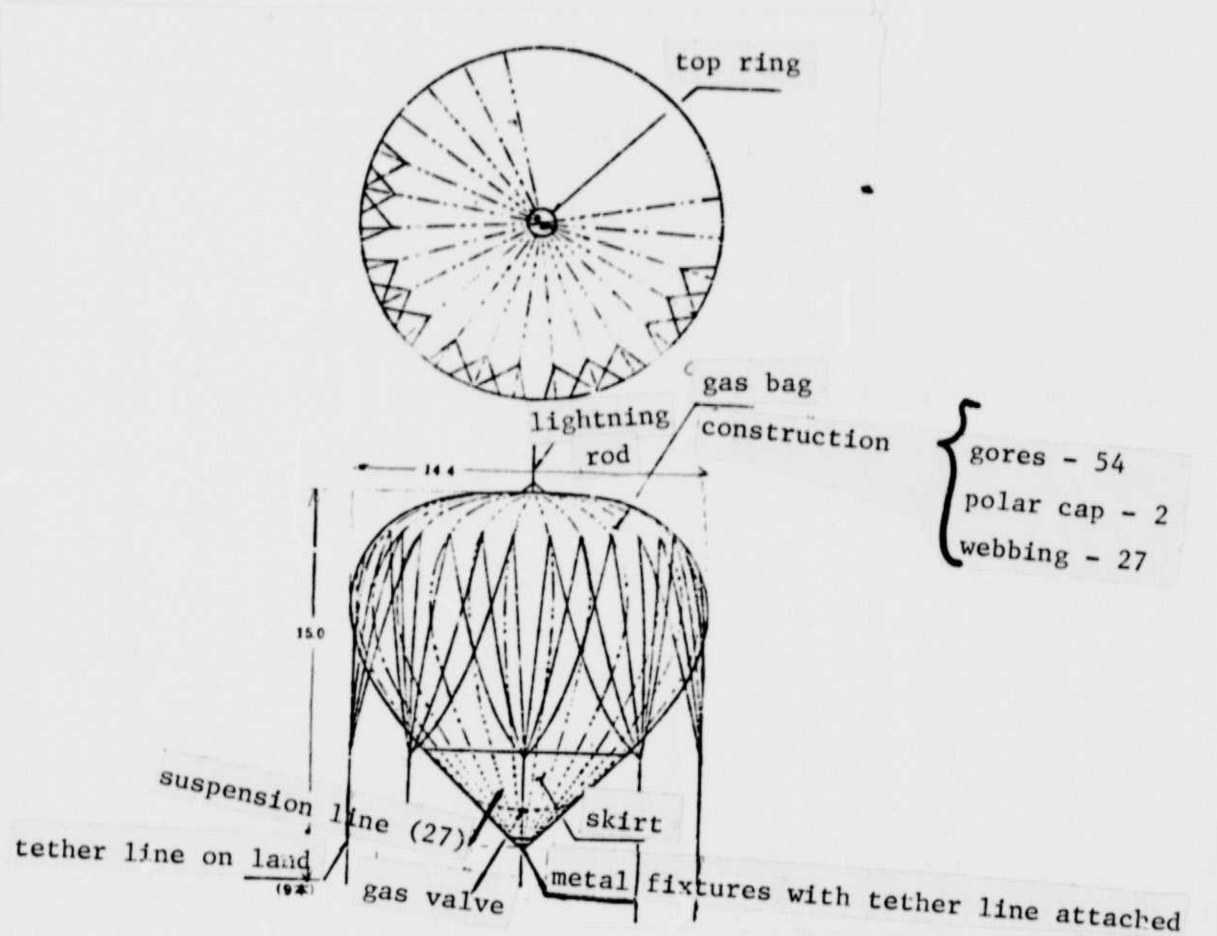

Figure 1. Natural Balloon Used in Logging.

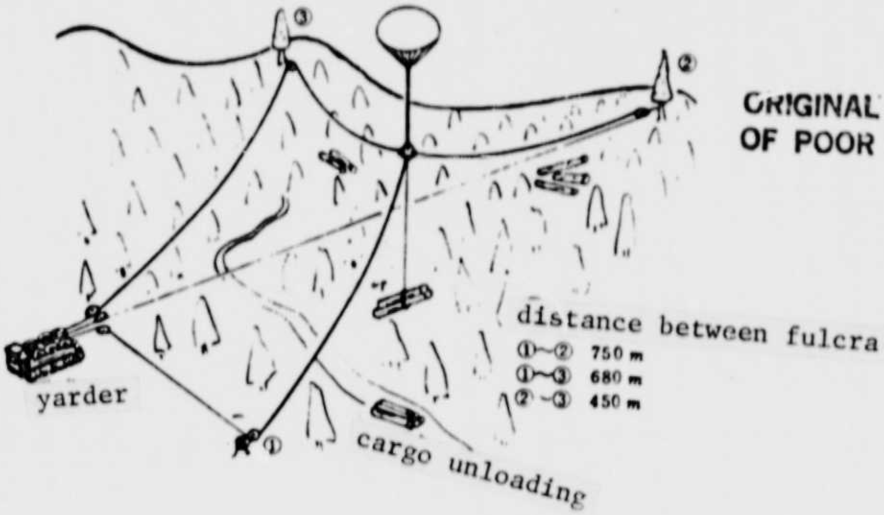

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Figure 2. Diagram of Test Site of Logging Balloon System at the Nimata Local Forestry Office.

balloon are carried out by operating the yarder with three cylinders. It has an advantage in that, when inside a triangular region, cargo can be carried from any spot to any other spot. As for the equipment used in the system, a torqueless wire rope 4 x RFWS (40) with a diameter of 12 m/m is used for the tether line (45 m) and for the auxilliary tether line (185 m), a wire rope JIS 12 no. 6 x Fi (25) 12 m/m is used for the operation line [1] (1,000 m), wire rope JIS 3 no. 6 x 19 10 m/m is used for operation line [2] (1,700 m) and operation line [3] (1,400 m) and three nylon ropes 9 m/m are used for the cargo carrying line (105 m). Moreover, a Y-33 HD yarder with 72 horsepower is used as the operating winch and a self-running winch with a horse-power of 100 is used for balloon movement and balloon anchoring.

The balloon was filled with helium gas at the local Forestry Office of Myohata, which was about 500 m away in a straight line. It took a total of 3 hours and 56 minutes to fill the balloon with 1,330 m^3 of gas over a 2 day period. After the balloon was full, it was moved to the actual testing spot with the self-running winch. An area for unloading cargo during the testing period was looked for and the self-running winch was used for land anchoring of the balloon during the evening hours and in emergencies. In accordance with the Aviation Act Practicing Bylaws, a landmark must be set up on structure 60 m above the surface of the land and therefore, anchoring during evening hours was always kept below this height.

3. Summary of Balloon Logging Tests

The daily operations began by letting out the auxilliary tether line and letting the balloon float up. When the auxilliary tether line was completely released, the operation of the balloon was transferred to the main 3 cylinder yarder. The balloon was guided to the point where lumber was cut, namely the cargo carrying point, with the transceiver connection between the yarder handle and operator. As for the operator organization, a total of 4 operators with one at the operation handle, 2 at the cargo carrying point and one at the cargo unloading point was sufficient. When the balloon reached the point above the cargo carrying point, the balloon was brought down with the tension of 3 wires. That is, when 3 operation lines were taken up at the same time, the balloon was brought down and, on the other hand, when the three lines were slackened out, the balloon rose. Movement in a horizontal direction was carried out with the mutual operation of these 3 lines. When the cargo carrying line reached land, lumber was attached to the end and the line was again allowed to float up. The cargo was then transported to the cargo unloading area. The height of the balloon during operations was about 200 m above land and the towing speed was about 1.2-2.1 m/second. The maximum weight of the load was 155 Kg. This was better than was anticipated because when, in the correlation of computations, the capacity of the balloon is smaller than the original plans. The surface area of the logging area is a little too wide.

During the actual testing, we focused on the technical possibility of a 3 wire system balloon logging method. /4 Therefore, tests pertaining to efficiency and economy were not carried out. The tension of the 3 operational lines, the three-dimensional location of the balloon, the weight of the lumber being carried out and the wind velocity and direction over the forest were determined. Changes in the operation tension, which were measured with a static computer and in the tension during actual operations were compared and thus, data for planning system safety was obtained.

4. Outlook for the Future

The tests were safely completed and we obtained the anticipated results. The two points of (1) balloon logging operations are possible with 3 wire system line stretching and (2) this system can be used to clear away lumber while preserving nature were made clear as a result of the tests. Operation efficiency tests were not carried out. However, when compared with the so-called aerial cable logging method, whereby lumber is taken up and carried out using the tension of the wire loop that was set up, it is estimated that just about the same efficiency is obtained. This method is very advantageous in that lumber scattered over a wide surface area can be carried out with one stretch of the line. However, with the balloon and winch used for anchoring, it is clear the the repayment of these devices is closely linked to a price increase. However, there is still room for improvement and therefore, it is very possible that tests on actual usage of this system will be carried out in the future.

The main problem with balloon loading and unloading is the wind. According to the logging tests using a natural balloon along the Oregon River of the United States in 1967, operations can be carried out with a wind velocity of up to 11.2 m/sec.

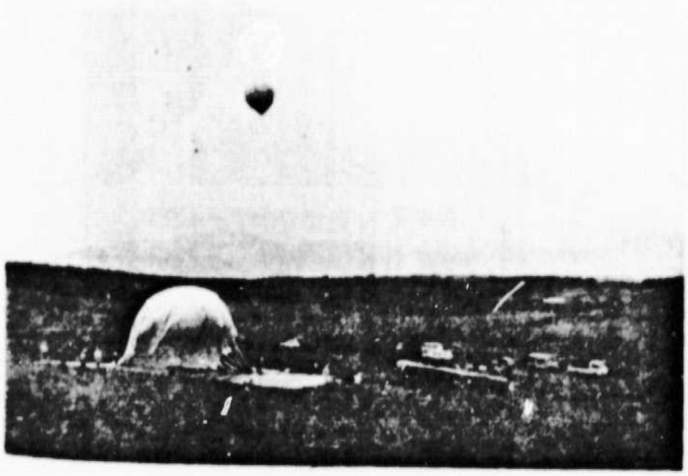
Moreover, it has been reported that a balloon can be safely dealt with, with complete anchoring to land, in a wind velocity of 26 m/sec. A period, when wind conditions were good at the end of the rainy season, was chosen for these tests. Tests on wind resistance could not be carried out. However, the limits of permissable resistance under given conditions can be determined with computer calculations. When a certain resistance is exceeded in the case of a 3 wire system, the balance of the system is destroyed. However, this all depends on the direction of the wind. A balloon cannot avoid being affected when a certain wind velocity is exceeded, due to the substances floating in the air. The development of a wind resistant system is necessary for the development of balloon loading and unloading.

Furthermore, there is still room for testing of flotation gases. Helium gas is superior from the points of buoyancy and safety. However, it is an imported good and therefore, a problem from the aspect of cost. If an inexpensive gas that can be easily obtained was developed, the economy of balloon loading and unloading would also probably be improved.

The possibility of using balloon loading and unloading for various purposes in the field of forestry was also tested. In the wake of the announcement by the U.S. Pentagon in 1973, Kawasaki Heavy Industries announced a plan for employing captive balloons in harbor loading and unloading in 1978. We hope to see further developments in balloon loading and unloading.

We would like to express our thanks to Todai Space Research, the many professors of the Nihon Daigaku Engineering Department, the Aircraft Business Department of Kawasaki Heavy Industries, Toyo Spinning Joint Research and the Fire Research Institute of Japan for their help in carrying out these tests. We would also like to thank the Numata Local Forestry Office and the local forestry associations for their cooperation in these tests.

Site where the balloon is filled with helium gas. /5



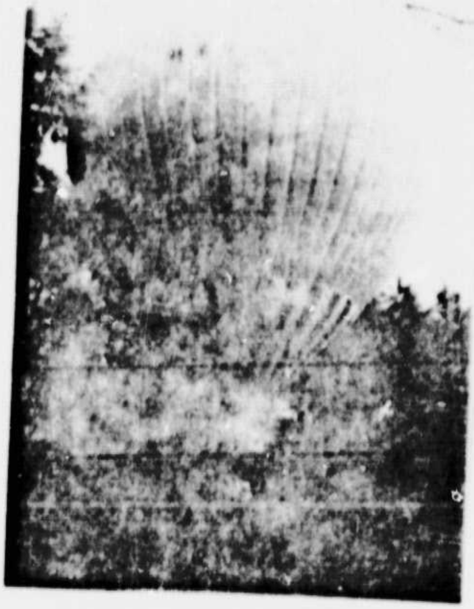
Operation of fil!ing balloon with helium gas.

Natural balloon after being filled with gas.

Preparation for transferring balloon to operation site.

Balloon floating up to point above the forest. /6

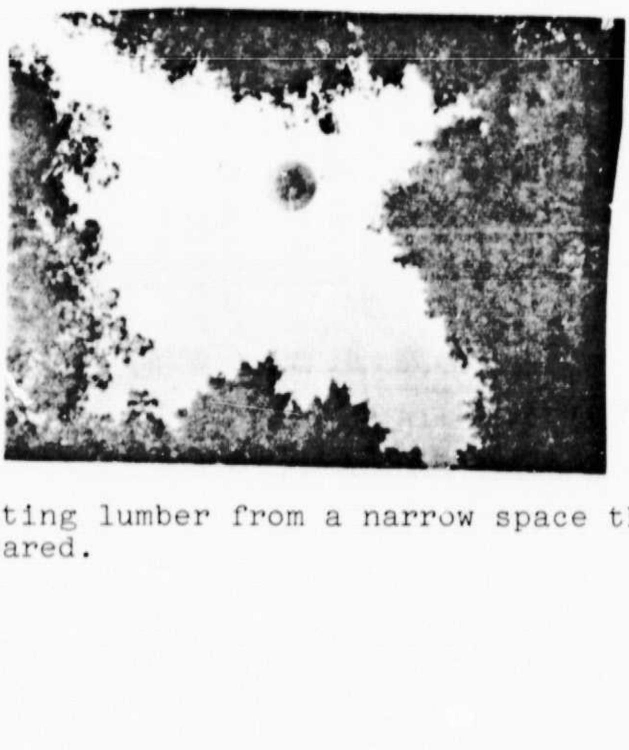
Float up operation using anchoring winch.



Balloon anchored to land at balloon base.
(area for unloading cargo)

Operation line used for operating and the balloon during flight.

Logging operation with logs. /7



Hosting lumber from a narrow space that has been cleared.

A balloon transporting felled trees just as they are.

View of the balloon logging operation site.

RESEARCH AND DEVELOPMENT OF THE CAPTIVE BALLOON SYSTEM

Kaoru Amano*

Today "aerial instruments" that can carry heavyweight bodies at a fixed altitude in air for long periods of time can only be found in captive balloon systems. The ability to take up heavy weight bodies in air is used and transport system is made whereby heavyweight bodies can be moved if tether lines (several) are used. Moreover, this can be called an instrument that answers the social needs of an energy saving device, low levels of pollution, and environmental protection. In order to respond to these types of demands, captive balloon technology was tested by the research divisions of the Forestry Experiment Station and the Japan Aviation and Space Industrial Association. The problems that need to be considered for the practical usage of this system in the future will be presented. /8

1. Logging Balloon System — Forestry Agency Forestry Testing Station

Testing of a "captive balloon logging system" was carried out with the 4 year plan starting in 1976. Tests of the Numata Local Forestry Office were completed from July 24 - August 6 of this year. The details were reported by the Forestry Experiment Station. The main points of the balloon logging

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*Kawasaki Heavy Industries Aircraft Business Department.

systems used in forestry are as follow.

(1) Environmental protection such as water resources, wildlife and scenery protection;

(2) Problems of aging and an insufficient labor force in the country due to migration of population to the cities;

(3) Intensification of regulations of the forestry logging rules (clearing of small areas, selection of areas where lumber is to be cut, periodic thinning).

The balloon for this logging system is used at relatively low altitudes (less than about 300 m) and wind velocities (less than about 15 m/s). A natural captive balloon was chosen for transporting heavy bodies. Please refer to page 4 for the construction of this balloon and the scope of the actual testing by the Numata Local Forestry Office [1]. The balloon netting is a multi-layered material with Tedora as the durable surface (38 μ), a PET film as the gas barrier (12 μ), a strong urethane resin for reinforcement, and a polyurethane cloth 500 D (329 μ) as the coating material laminated netting, 54 gores, 2 polar caps, and 27 webbings. The development of this netting material satisfies the netting planned values. Research will be necessary for a laminating /9 material using cabling. Future problems from the aspect of balloon design and balloon construction technology are as follow.

(1) Research to improve the adhesive.

With regard to the gores and gore connection, the surface of Hamataito S-110 (Yokohama Rubber) was chosen for the surface of the covering tape because of its peeling resistance at low temperatures and Bairon 309/Erufan PH 402 (Toyo Spinning/Nihon Matai) was chosen for the strong side of the tape (reverse side) to give shearing strength to common netting. However, further research will be necessary in order to develop an adhesive with a broad range of temperatures because Hamataito S-110 has poor thermal properties.

(2) Research on land anchoring methods and operation methods.

On land anchoring methods and operation methods appropriate for the development of a balloon system and for the surrounding environmental conditions must be developed.

(3) Research on gas emmision valves (including emergency separation valves).

This type of valve was not installed in this logging balloon. However, it is essential that this type of system be considered for practical usage of a balloon.

2. Technical Standards for Natural Captive Balloons

As for the technical scope of the practical usage of this type of natural captive balloon, the following balloon system scope, which was developed and studied by the U.S. Pentagon as a Balloon Transport System (ship-to-shore) [2,3] can be called the natural captive balloon system technical standard.

(1) Removal of an 8' x 8' x 20' container weighing 22.5 tons from a container vessel and unloading on the coast for a minimum of 12 times/hour;

(2) Transport from the vessel to the coast line, which is 8 km away;

(3) The possibility of using the balloon system with a normal wind velocity of 5.14 m/s and sudden gusts of 10.3 m/s in Sea State 1 (we would like to be able to use it with a Sea State of 2

or more where normal wind speed is 7.7 m/s and sudden gusts are 12.9 m/s);

(4) The possibility of using the balloon system in violent weather conditions (humidity, rain, snow, etc.);

(5) Whether it is suitable for coastal and island topography.

The following parameters were determined as the balloon parameters that would suit these needs.

Balloon Capacity	60,000 m^3
Balloon Diameter	50 m
Balloon Height	60 m

3. Experimental Research Pertaining to Streamlined Captive Balloons — Japan Aviation and Space Industries Association

Research on the balloon application system programmed from 1977 with the establishment of the Balloon Application System Investigative Committee (Committee Head: Seishu Kimura, Professor Emeritus). In 1977 tests were carried out on the applied field and production technology [4]. In 1978 small tests balloons were designed and built and various types of flotation and towing tests were carried out in order to gather structural and aerodynamic data for streamlined balloon designs [5]. An outline of the construction of the balloon that was trial produced for this study is shown in Figure 1. It can be said that an aerodynamic planning method for streamlined captive balloons was created with this research. However, a ballonet with air bag was not attached to this balloon and therefore, the internal pressure of the ballon had to be controlled during the tests (1,005-1,020 atmospheres). A ballonet device and control system for the internal pressure of the balloon will be installed in the future for practical usage. The hull construction /10

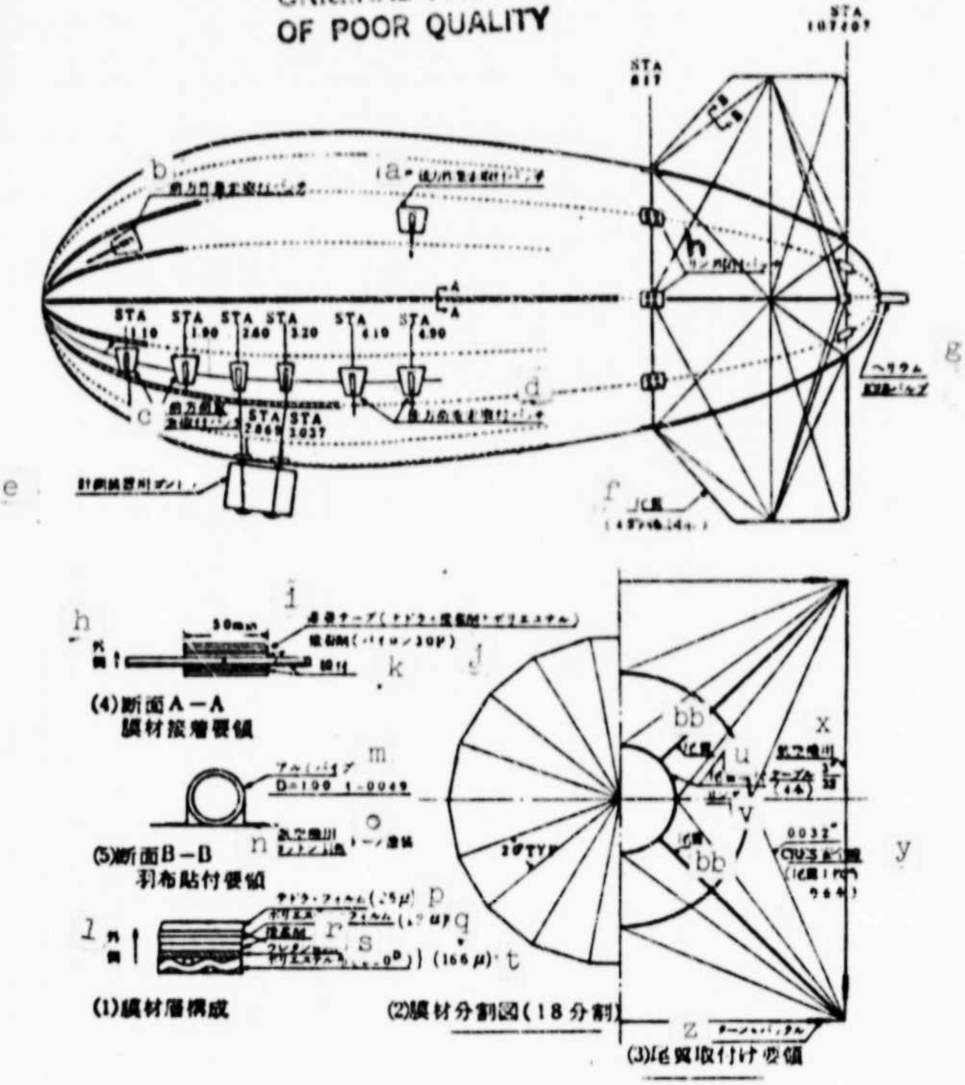

Figure 1. Small test balloon -- Japan Aviation and Space Industries Association.

Key: a. patch with backward operation line attached; b. patch with forward operation line attached; c. patch with forward load line attached; d. patch with backward load line attached; e. gondola used as a measuring device; f. tail assembly (shown with a 450 turn); g. helium filling bulb; h. patch with rings attached; i. connecting tape (Tedora + adhesive + polyester); j. adhesive (Bairon 30P); k. netting l. outside; m. aluminum pipe; n. cotton cloth used for aircraft; o. dope (illegible); p. Tedora film (25 μ); q. polyester film (12 μ); r. adhesive; s. urethane resin; t. polyester cloth (255 D) (166); u. cable with tail assembly (4); v. ring; x. for aircraft use; y. CRES (illegible) (6 per wing) z. turn buckle (1) netting layers, (2) netting section (18 sections), Key to Figure 1 (cont.)

(3) tail assembly, (4) cross-section A-A of netting adhesion, (5) cross-section B-B of cloth attachment, bb tail assembly.

MAIN PARAMETERS OF THE BALLOON

Hull Capacity	111 m^3
Total Length	11 m
Maximum Diameter	4.5 m
Tail Assembly Area	3.75 m^2 x 4
Balloon Weight	83 Kg
Flotation Ability	115 Kg

was made from 18 sections of netting gores (the netting was trial produced in 1977). As for the adhesion structure and adhesion method, the same method as was used with natural balloons was employed. In installing a tail assembly, a ring of an aluminum pipe was inserted to prevent buckling of the netting and for dispersion of a concentrated load. Then the pipe was joined with 2 ropes to 8 patches joined to the netting. There were 4 tail assemblies where cloth was glued to aluminum pipes that were 1 inch in diameter. As can be seen in Figure 1, a method whereby the tail assemblies stabilized with a 3/32 inch Ø cable and an 0.032 inch Ø stainless steel wire was used. Further research on netting properties with netting cylinder tests, large displacements, efficient hull construction designs with wireless limited element analysis, rigging designs, inspection methods, production methods, and on land systems will be necessary.

4. Technical Standards for Streamlined Captive Balloons

With streamlined captive balloons, a ballonet is installed inside the hull to maintain the hull shape. In contrast to changes in the pressure and temperature outside of the balloon, the inside pressure of the hull is normally held at a constant level, and thus, the shape of the hull is maintained (super pressure type). Consequently, with the stream-lined shape of the hull, the balloon can be used in high wind velocities (about 45 m/s) and from low altitudes to very high altitudes (about 20,000 ft.). For this reason, it is felt that this balloon will have many potential uses in the future. Aside from the technological prospect of various balloon structures, a technological standard for a streamlined captive balloon is the CBV-250A communication (television, radio, telegraph, telephone) relay balloon system [6]. Balloon designs, manufacturing technology and balloon system development technology will probably become technological standards. This communication relay system is as shown in Figure 2. A system is established when communication relay is set up on land. This balloon is in the sky for about one continuous week. Then it is on land for maintenance for a number of hours (fuel supply, helium supply, etc.) and again returns to the sky. The balloon has 5 functions (the following is the case where the balloon is captive at 10,000 ft.).

- Communication relay with vehicles/aircraft within a radius of 210 Km around the on land movement command post and the balloon;

- A television broadcasting service is possible for televisions within a 250 km radius by relaying 1 channel from color televisions from large city A; /13

- Relay of a 900 channel telephone circuit and 100 channel telegraph circuit carried out in between large city A and city E, which are separated by a distance of 400 km;

- The following communications relay is possible between small cities B and C, city D and city A, which exist within a

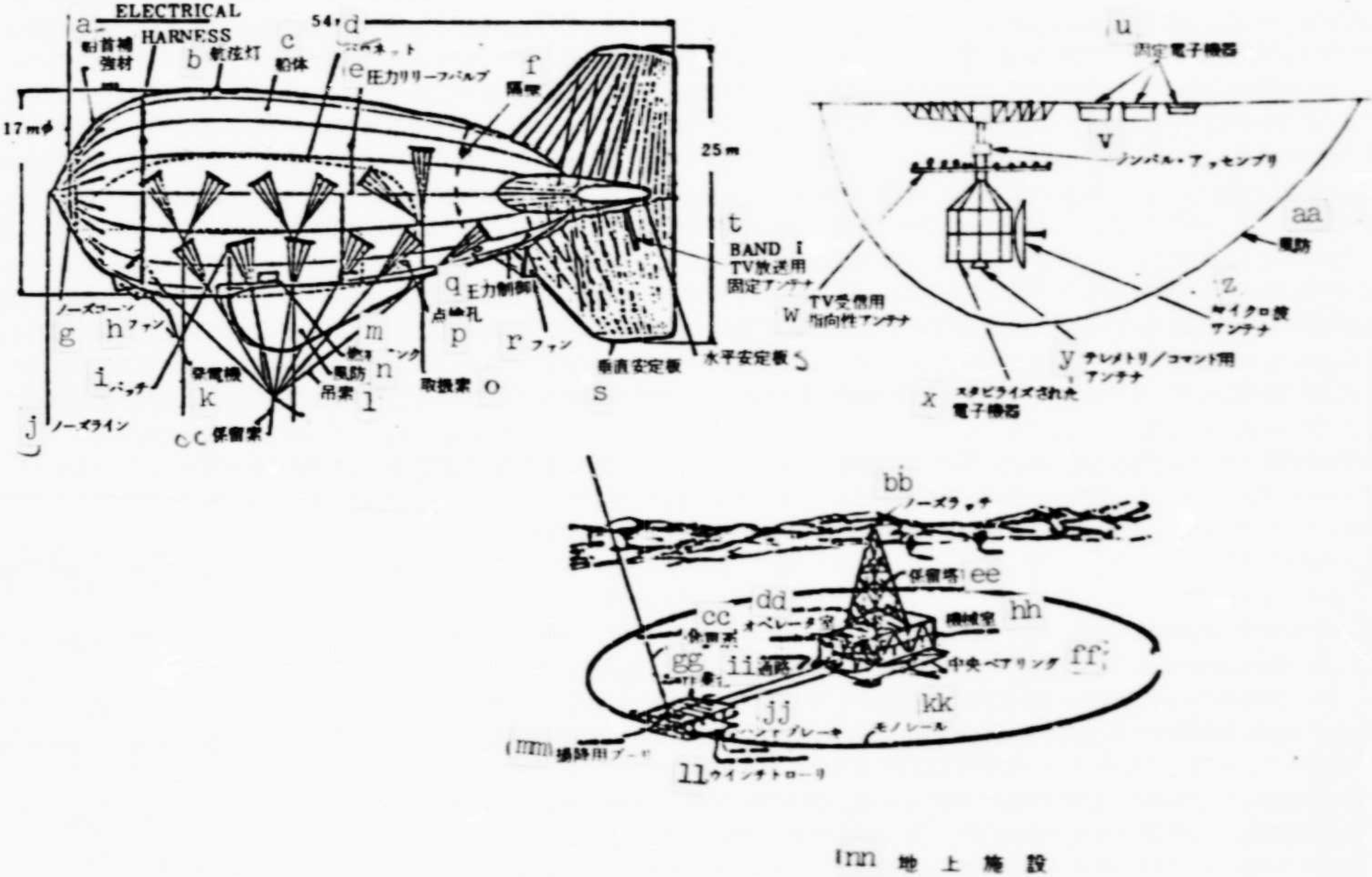

Figure 2. TCOM's CBV-250A Communication Relay Balloon System.

Key: a. bow reinforcing material; b.
c. hull; d. balonnet; 3. pressure relief valve; f. bulkhead; g. nose cone; h. fan; i. patch; j. nose line; k. generator; l. sling; m. fuel tank; n. windscreem; o. operation line; p. spot check hole; q. pressure control; r. fin; s. horizontal statilizer; t. stationary antenna for Bank I TV broadcasting; u. stationary electronic devices; v. simple assemble; w. directional antenna for TV reception; x. electronic devices that have been stabilized; y. antenna for telemetry and commands; z. micro wave antenna; aa. wind scream; bb. nose latch; cc. tether line; dd. operator room; ee. anchoring tower; ff. central bearing; gg. operation platform; hh. equipment room; ii. passageway; jj. hand brake; kk. monorail; ll. winch trolley; mm. pulley used for raising and lowering; nn. land facilities;

CBV-250A MODEL

Hull Capacity	7,560 m^3
Total Length	55 m
Maximum Diameter	17 m
Balloon Weight	2,300 kg
Wind Velocity - Above Sea Level	46 m/s
When Balloon Can Be Used - 10,000 ft.	51 m/s
Maximum Altitude at Which Balloon Can Be Used - 15,000 ft.	
Payload - 5,000 ft.	3,200 kg
- 15,000 ft.	450 kg

210 km radius around the balloon

A-B (distance: 117 km)	20 telephone circuits
	10 telegraph circuits
A-C (distance: 295 km)	20 telephone circuits
	10 telegraph circuits
A-D (distance: 177 km)	10 telephone circuits
	10 telegraph circuits

The payload package weight with which these 5 functions are performed is about 1,000 kg. 12 kilowatts of energy are consumed. It is said that because of these functions, the balloon can replace 15 microwave towers.

5. Potential Uses of the Captive Balloon System /13

The effective buoyancy of natural balloons is high because they are used at high altitudes and low wind velocities and their structure is simple. Therefore, they are suitable for suspension and transport of large heavyweight bodies. In contrast to this, stream-lined balloons are used at high altitudes and high wind velocities, and the structure of the hull is complex. Therefore, the effective buoyancy is relatively small in comparison to the total buoyancy. The use of these types of captive balloon systems, which each have their own characteristics, can be classified into the general categories of large scale, large heavyweight body transport systems, communications relay, supervision, and observation systems and military application.

(1) Large scale, heavyweight body transport system.

Haiburitto dirigibles are probably more effective as a transport system for large, heavyweight bodies on a large scale than are balloon systems when the transport distance is long. However, the use of a captive balloon system for logging/transport (Chapter 1) and unloading and loading systems (especially when harbor preparations are insufficient, during disasters, and when topographical conditions make port construction impossible) has shown satisfactory results.

(2) Communications relay, supervision and observation system.

Broadcasting and communications relay systems were introduced in Chapter 4. However, among the potential uses of the captive balloon system in communications, supervision and observation are a noise observation system, whereby the noise level is measured with a microphone attached to a balloon (noise reconnaissance balloon used for guerilla counterattacks at night during the Vietnam War), a system for determining the perpendicular distribution of pollution due to the accumulation of pollutants with a wind velocity and temperature sensor and suction pump installed on the tether line for each fixed altitude, observation of coastal pollution, observation of sea traffic, a fire fighting aid, fire observation system, etc. /14

(3) Military application.

In the future, balloon systems will probably be used to make up for the fragility of communications circuit cables. Local communications command relay, reconnaissance systems, systems for observing enemy submarines and naval vessels, and systems for early warning are substitute systems for the energy-savings era. Moreover, when used as a barrage balloon, this balloon system can be used for the defense of airfields against slow landing and quick landing ground attacks. The system has already been used in the Mid East War.

6. Future Research Problems

The technological problems in the development of captive balloons are

1. Balloon shape......wind tunnel tests in which the deformation due to air stress is considered-dynamic and static testing;

2. Stability and characteristics......determination of dynamic stability micro-coefficient;

3. Balloon materials and construction method.....high quality production technology for air bag netting materials, ballonet materials, patch materials, and line materials that are strong, have spreading resistance, are abrasion and bending resistant, have gas permeation resistance, and can withstand environmental effects;

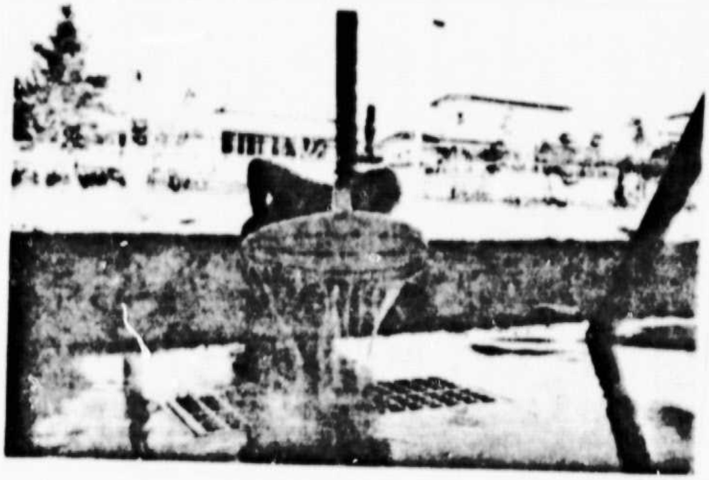

Figure 1. Water Model Tests.

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Figure 2. 10 m Model (S 53. 11).

4. Hull composition design.....development of a large displacement, wireless analysis program and cylinder testing method;

5. Development of adhesives and construction technology;

6. Balloon equipment and fitting designs;

7. Each type of data measuring sensor and measurement methods.

The following are technological problems encountered with the use of the balloon.

1. Designs for desired use, and method and economy of using balloons;

2. Research on the maneuverability of the balloons and on land facilities;

3. Resistance and safety of the balloons and helium recovery technology.

When the operation divisions in the development of balloon employment systems, which are collected in the aforementioned, are analyzed, they are as shown in Figure 3.

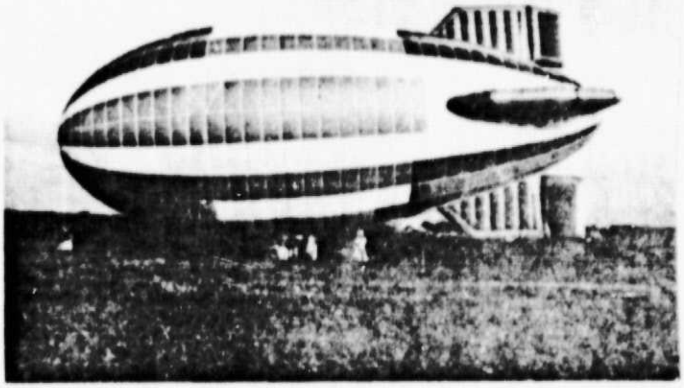

Figure 3. Pressure Defficiency During Early Flight. (S 55. 3. 25).

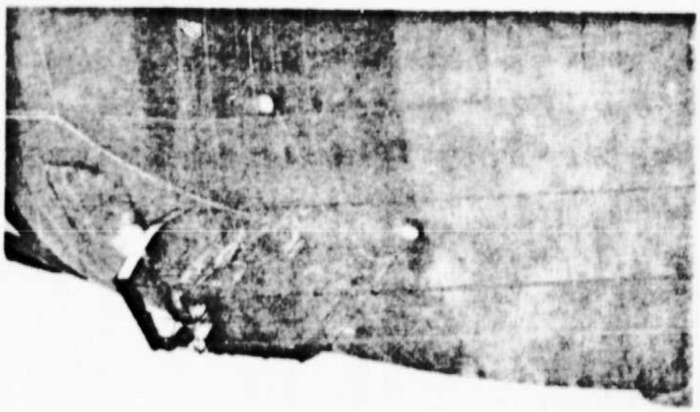

Figure 4. Round Exhaust Holes.

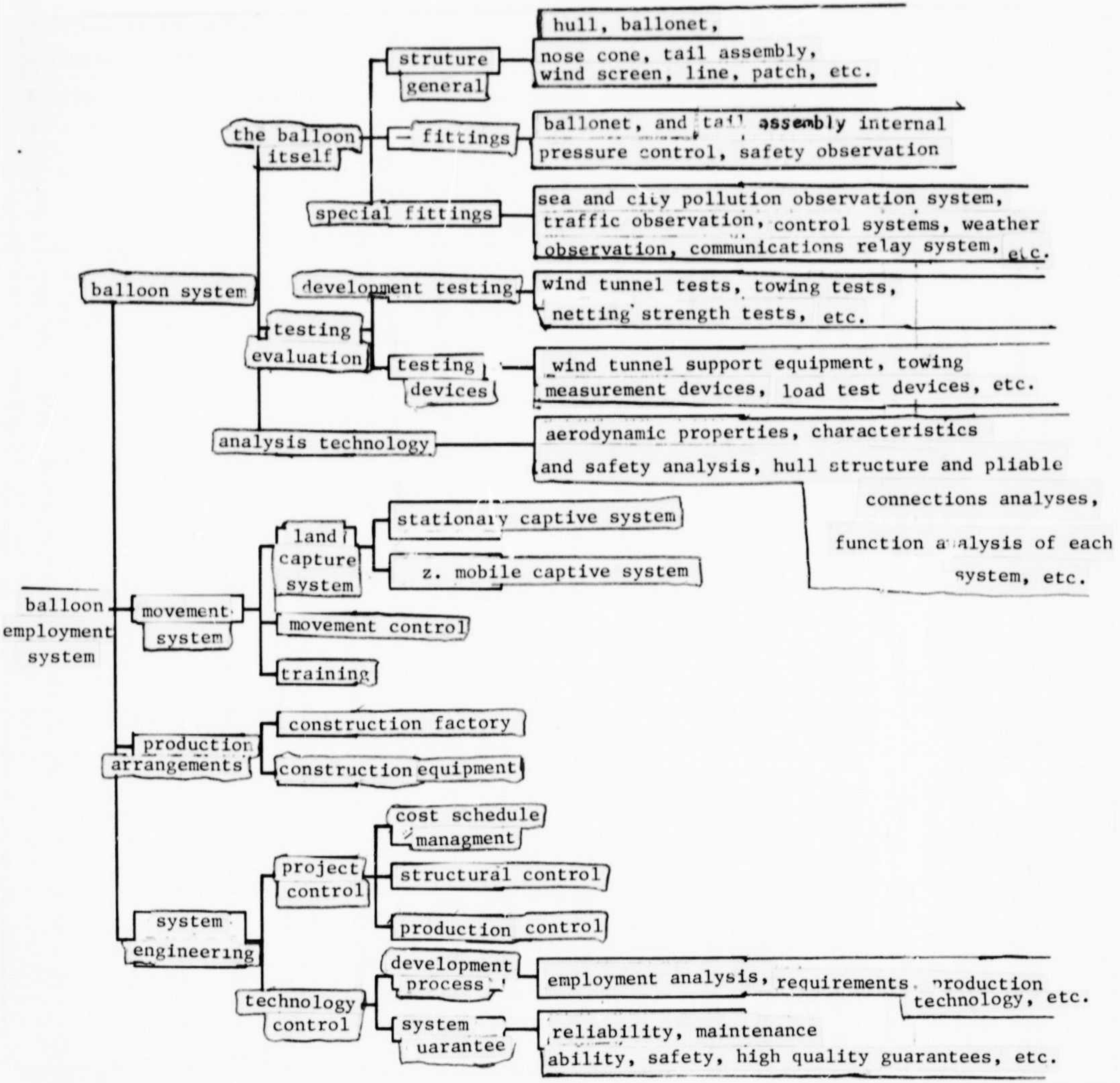

Figure 3. Operation divisions in the development of balloon systems for practical use.

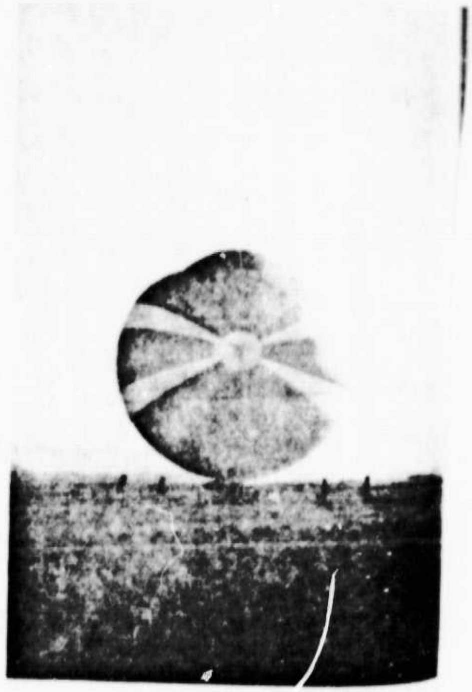

Figure 5. Indentations Due to Catenary Curtain.

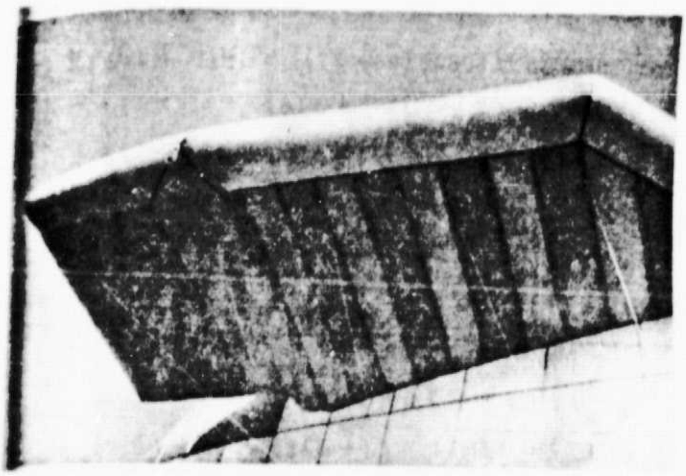

Figure 6. Hydrofoil — the elevator is stationary. Today it is mobile.

7. Conclusions

Research on captive balloons continued with a series of studies pertaining to the LTA aircraft, which began in 1975 under the direction of the Ministry of International Trade and Industry:

- the Equipment Promotion Association's 1st and 2nd "Investigative Studies on the LTA Aircraft System" (1975, 1976);

- the Japan Aviation and Space Industries Association's "Investigative Research on Balloon Application Systems" (1977, 1978), and

- the Agency of Industrial Science and Technology's "Technology Assessment of the LTA Aircraft" (1977), and

- the Forestry Agency Forestry Experiment Station's "Logging Method with Captive Balloons (1976-1979)". During this time a natural captive balloon for practical use was produced and a stream-lined captive test balloon was trial produced. Balloon design, netting trial production, balloon manufacturing /16 and flotation and safety tests were completed. Here we have presented an outline on these points and research problems. We would like to thank related agencies for their help in developing a captive balloon system and to those agencies that provided us with technological information used in the development of the International Trade and Industry's large scale project, "Haiburitto LTA". We would also like to thank the committee members who helped in the research and development of this practical balloon system.

Figure 7. Upper Reaches of Oten River.

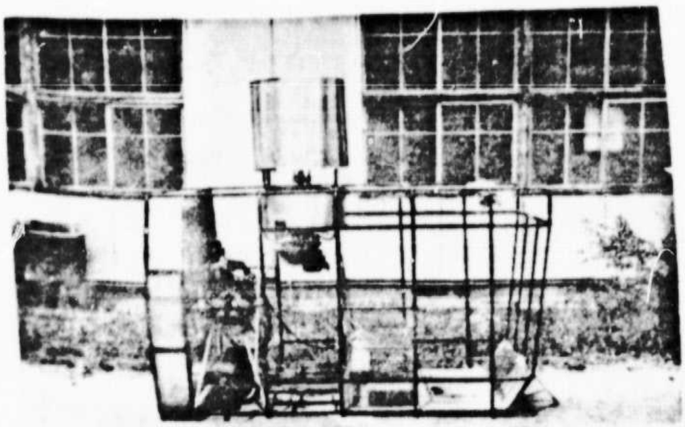

Figure 8. Gondola.

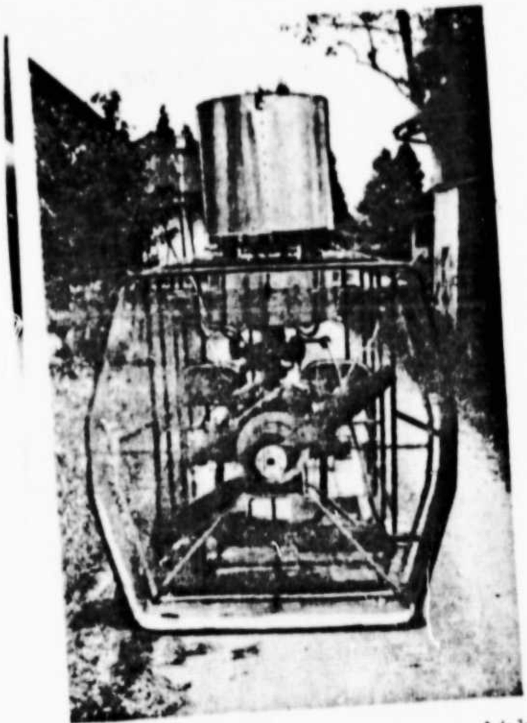

Figure 9. Gondola Propeller with a Diameter of 1.2 m.

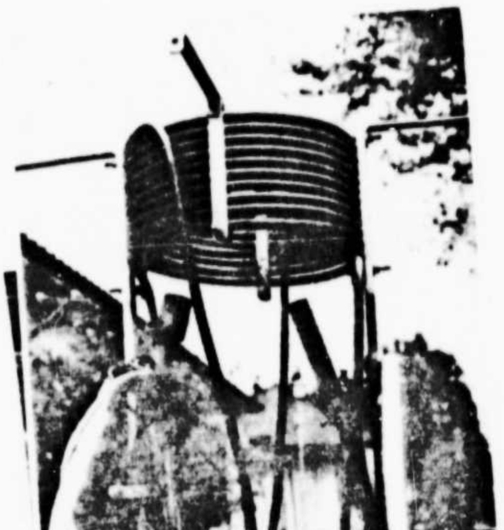

Figure 10. Burner.

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HOT AIR AIRSHIP DEVELOPED IN THE EARLY STAGES OF AVIATION

Miyazaki University Balloon Department
(representative: Kiho Bokusaku)

1. Miyazaki University Technological Research Association (Balloon Department) and Airship Designs /17

The Miyazaki University Technological Research Association (Balloon Department) was established in May, 1974, with the purpose of teaching various types of engineering to students of mechanical engineering. From the time the association was established, the members considered making an airship. However, manufacturing an airship is difficult both technologically and from the aspect of money. As a preliminary step they produced a hot air balloon and in May of this same year, a balloon unit was formed. (In addition, there was also a go-card unit.) The balloon unit completed a hot air balloon called "Sekai No. 1" with their own technology, with polyester film as the raw materials, on March, 1977 by using model tests, etc. On February of 1978 the balloon unit was up-graded to a department called the Balloon Department. Airship designs were prepared, which had been a dream since the association was first established, in April of 1978. The structure of the department had changed and the constitution of the association had changed. Moreover, designs for producing a new balloon had been started and the airship designs were carried out in a new technological association. Collection of funds and data and testing were started. The Balloon Department completed a new balloon, which had concentrated on the dump valve, etc. in October of the same year. Participation in airship planning was discussed as the next act. Because a balloon is a passive suspension and should not readily move in the direction it wants, when suspended from a balloon, objects want to move freely in the air (this is the same with the history of balloons and airships). Thereupon, the Balloon Department, which had completed a balloon, also participated in airship planning. (This is assumed to have been the case).

Great progress has been made with airship designs in this way.

2. Experiment

"Single axis, 2 axis tensile strength and strain measurements", "water model tests", "airtight tests on cloth", "catenary tests", "combustion tests with 10 m machines", etc. are tests for hot air airships. Moreover, both combustion tests with regard to burners and stress measurements of gondolas with wire strain gauges are carried out.

(1) single axis, 2 axis tensile and strain measurements /18

As for measurements of single axis strength and strain, data was obtained during the production of hot air balloons, but for reference sake, tests were carried out.

Two axis tests were carried out in order to measure the real strength and strain of the cloth and to determine the amount of pressurization and the length of the suspension tire. With a tension ratio of vertical: horizontal of 2:1, the strength is 550 kg/m and is less than a value with a single axis. With regard to strain, ε(vertical) = 1.5% and ε(horizontal) = 1.0% with vertical = 34 kg/m and horizontal = 17 kg/m. The volume increase of the airship due to extension of the entire airship is almost equal to the decrease in volume due to indentation with a catenary curtain.

(2) Water model test (Figure 1).

The water model test was carried out the most often out of these tests. The water model length equal to the hull tension was l = 49 cm. Because a hot air airship using this size water model is absurd, tests were performed on the necessary amount of pressurization and on the catenary curtain, raising the amount of pressurization to destruction, and on the strength of the cloth. At the same time, differences in variations due to how the cloth was used (combined use of Toray and Asahi Chemical cloth and center used on the bias), changes due to differences in the ratio of length and diameter (L/D = 2.5-3), etc. were studied.

The part with the maximum computed tension is the peak of the area with the largest diameter. This is the same as the destruction point of the water model. However, tension during destruction showed fewer fluctuations than in the model. With Toray fabric it is about 450 kg/m and it drops to about 80% of the value from 2 axis stress test. Because the peak that was destroyed is equivalent to the machine sewn area, the efficiency of machine sewing becomes 80% when we ignore the manufacturing differences of the model, and in the case of Toray fabric, the strength of the cloth that was machine sewn becomes 450 kg/m.

Because the strength of Asahi Chemical's cloth is high, it was noticed that tension was 600 kg/m without increasing pressure, up to the point of destruction.

An effect on tension up to the point of destruction was not noticed when cloth was used on the bias.

With L/D = 2.5, bending of the hull was not noticed even when the amount of pressurization was 0 mm Ag. However, because their was a large identation in the part with a catenary curtain attached, pressurization of 5 mm Ag is necessary (converted to 31 m machine). (Pressurization of 5 mm Ag is the amount of pressurization necessary for wind pressure resistance.) When the L/D was 3, bending was not noticed at 0 mm Ag. However, an increased pressure of 5 mm Ag (31 m machine) was sufficient.

(3) Airtight tests on cloth.

In this test, the purpose was to measure the air flow from fabric and machine aspects and to determine the properties necessary for a pressurization engine fan.

As a result of the test, it was discovered that there was a large difference in airtight properties depending on the test sample. The value with an average amount of pressurization (6.5 mm Ag) were

/19

Test Sample	Air Flow (6.5 mm Ag)	Ratio
Toray S 112 F (blue)	0.22 ($m^3/m^3 \cdot min$)	1,700
Toray S 112 F (green)	0.0025 ($m^3/m^3 \cdot min$)	20
Toray S 112 F (white)	0.00012 ($m^3/m^3 \cdot min$)	1

Blue could not be used because the air flow was too high and was more than what was required for the burner.

Because it is not known whether the coating of the cloth used in this test was, by accident, irregular or insufficient, it was felt that the other types of cloth should be checked prior to manufacturing.

(4) Combustion experiments with 10 m machines (Figure 2).

A testing device was made in order to study the combustion conditions and catenary curtain conditions inside a spherical shell that had been sealed with a pressurization fan. (L = 10 m, D = 4 m, V = 80 m^3, and bucyancy B = 28 Kg).

Four expansion type stabilizers (Figure 6) are added to the wing assemblies to control pitching and rolling of the hull. These are reinforced with 10 ropes per each stabilizer. (The amount of pressurization is equal to that of the hull.) Radar is attached to the back of up-and-down fins in order to control direction and elevators are attached to the back of horizontal stabilizers in order to keep the hull horizontal. (The role of up and down movement is small.) They are operated with a moveable pulley. In contrast to the gas airship, the wing surface area is very large at 4 times that of the gas airship. The flotation medium of this airship (mass of hot air) is about 6 times that of helium (11.8 times that of hydrogen). The speed is 1/2 as much. Therefore, a surface area that is $6 \times 2^2 = 24$ times larger is necessary to obtain the same properties, when considered in simple terms. However, 4 times this surface area is probably the actual limit because of the problems of control and external appearance. Moreover, the ratio of rudders situated on the wings is normally 20%. However, we used 35%. The thickness of the wings is maintained with the cloth with holes and the webbing. The thickest part of the wings is near the back where they are attached and is 1.5 m. The front of the wings (end) is thin, 0.8 m. As for the radar and elevator, the front is 1.0 m and the back is 0.8 m. 100 pieces of cloth are sewn together for 1 tail assembly.

A dump valve is situated near the back of the gondola between the catenary curtain of the peak for sudden falls (main and sub dump valves). They are operated by 1 rope with driving force. Lip valves are located on top near the front and back of the dump valve (total exhaust valve).

There are six round exhaust holes near the gondola (Figure 4). The number of exhaust holes varies with the combustion conditions.

Moreover, a windmill type pressure gauge is attached to one of these exhaust holes.

(1) Hot air airship hull.

The external appearance of the hull is a circle that is elongated with the adequate function at the front and back. The spherical shell is made of 24 leaf-shaped gores. One gore is made from 37 panels. There are some differences because of the reinforced areas, dump valves, etc., but generally, the spherical shell is made from 888 (24 x 37) pieces of cloth /22
sewn together.

The size of the hull is:

Total length..........L 34 m
Maximum diameter...........D 12.4 m, and
Volume...........V 2,370 m^3

A catenary curtain was dropped so that it was separated from the peak by 2 gores. The load of the gondola was distributed over the spherical shell by introducing this catenary curtain with a wire.

In order to maintain the shape of the hull (mainly against wind pressure), pressurization of 5 mm Ag (kg/m^2) is carried out on the bottom part of the hull. The top part of the hull is pressurized 3 mm Ag higher than the bottom part. Moreover, due to the effect of the catenary curtain, the maximum tension is T max = 40 kg/m.

The gondola is attached on the lower part in front of the center of buoyancy. Because the center of gravity is also a little in front of the center of buoyancy, the hull leans about 5 degrees toward the front when it is at a standstill. The travelling speed of our airship is 30 km/h. We are planning to keep the airship horizontal during travelling with driving power (40 kg).

[Gondola]

As for the size of the gondola (Figure 8), the length is 2.3 m, the maximum width and height are both 1.4 m, and the weight of the total equipment excluding passengers is 310 Kg. Steel tubing with an external diameter of 2.17 mm and a thickness of t=2mm is the main frame. The frame has a structure that is a mixture of steel piping and square pipes. /23

The drive engine is the Toyota 2U-C (800 cc, 40 PS/5,000 rpm, 3.6 Kg-m/3,000 rpm). However it does have problems with the strength, vibrations, noise, etc. of the propeller (external diameter of 1.2 m, wood product). The maximum rpm is 2,500 rpm. The driving force was not measured, but it is probably 40 Kg.

The vertical axle model of the Fuji robin EC-10 (maximum 4 PS/1,800 rpm) is used for an engin that transmits the pressure of the hull and the necessary air for combustion. It is combined with a Dakuteddo fan. An output of 1/10 is satisfactory for pressurization only, but we decided to consider the speed of inflation.

The burner is situated on top of the pressurization fan. A heat exchange coil (diameter: D=30 cm) is covered with two layers of steel pipes. The output is 500 Kcal/sec (nozzle: 5mm x 2, LP pressure: 5 Kg/cm^2). 2 pilot lamps are used to light the piezoelectric and electronic igniting devices, which are the source of flames for the burner (Figure 10). There is no need for concern that the flames may go out during flight.

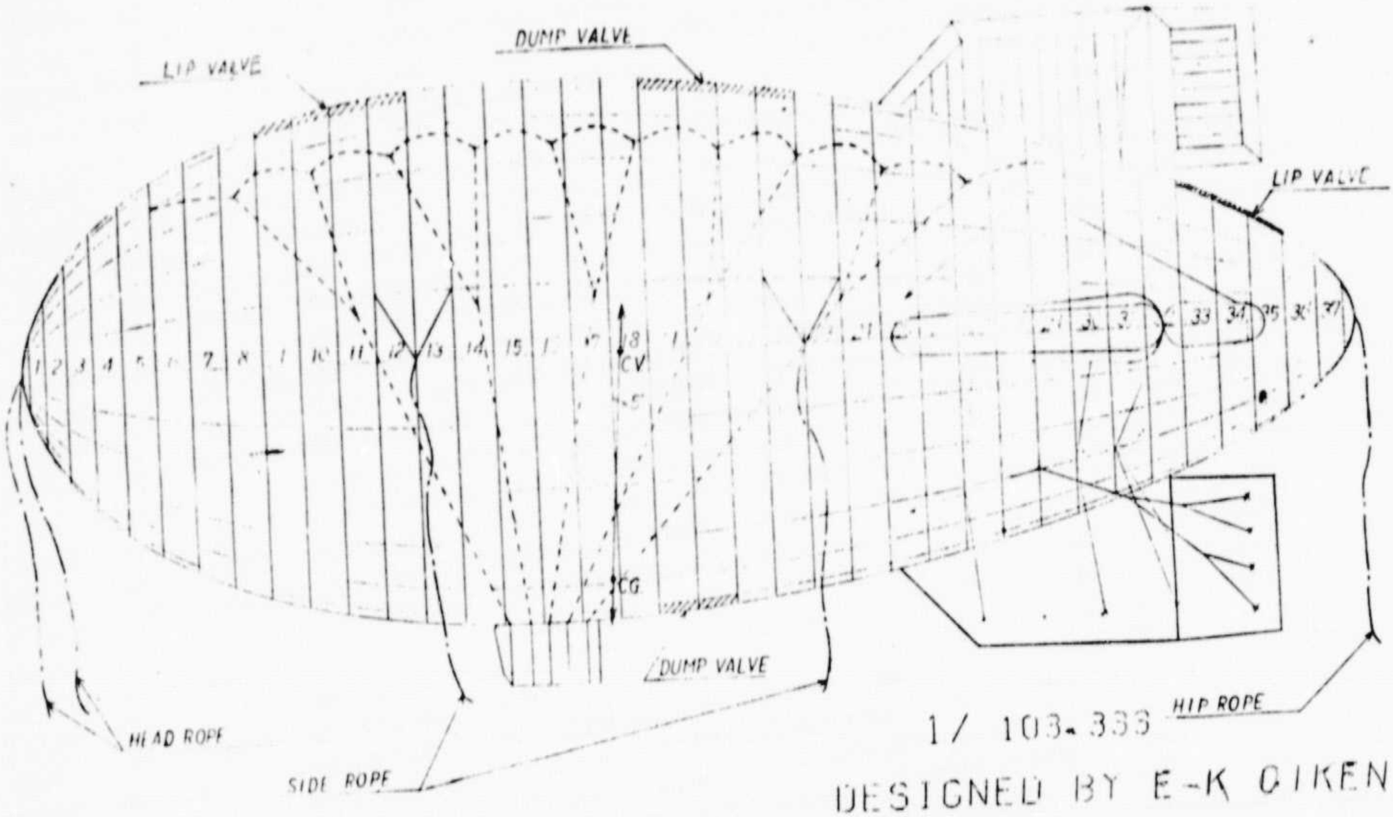
4. Manufacturing

Manufacturing began in June, 1979.

Because this group does not have a long history, was moderate

HOT AIR AIRSHIP

LENGTH	=	31.00
PANEL WIDTH	=	0.910
VOLUME	=	2367.7
GOA NUMBER	=	24



in university affairs, the building of this department, etc. was difficult. This group did not have the necessary laboratories and factories and therefore, during summer vacation, they used the Engineering Department classrooms after lectures (4:30-7:00) to make a model of the spherical shell and then cut the cloth (a total of 1/5). From August (part time from 7/11-8/31) along with cutting the cloth, they used 3 industrial machines to sew the cloth (9:00 a.m. - 7:00 p.m.). Because the arrival of machine thread was late, only 7 sections of the spherical shell could be completed by the end of the summer break.

Because the classroom could not be used after first term tests (October), the factory was transferred to the Ryokyu Cafeteria and operations were started once more. Sewing of the spherical shell, making the catenary curtain, and laying out the tail assembly were carried out.

In December, operations on the gondola, which were separate from the shell construction, were started in the Mechanical Science Labs. First welding and drilling were carried out. Then operations on the frame engine completion, burner construction, etc., were carried out from 4:30 (p.m.) (during breaks at 10:00 a.m.) to 10:00 (p.m.).

From the end of January to February, the spherical shell and gondola operations were interrupted because of finals. During the spring break, the spherical shell operations were transferred to the Engineering Department. Completion was set for the middle /25 of March. Several days later sewing of the tail assembly and insertion of load tape were carried out. The operations were difficult due to the fact that the machine broke down and the spherical shell became larger and larger. We did not progress as we had planned, and the completion date was set back one week. In the final two days, the spherical shell and tail assemblies were sewn together, final sewing of the shell was carried out and the catenary curtain wire was attached. The balloon was completed two days prior to the date that had been set for flying tests.

5. Results of Flying Tests

Flying tests were carried out on March 24 and 25, 1980 at Miyashiro-shi, Takaboku-cho.

On the first day, sufficient testing could not be carried out because a tuck had been sewn in the shell on the top part of the stern and, therefore, leaks were noticed during spot checks. We returned to the university to make repairs.

On the 25th, weather conditions were good, and flight tests were carried out for 1/2 hour.

As a result, satisfactory results were obtained in the inclination of the hull at rest and during flight, in the movement of the catenary curtain, and in the burner properties. Directional changes with a radius of 50 m, which was more than was anticipated, were possible, especially with regard to vertical rudders (the effect of the propeller back flow was hardly considered). Because the shape of the front part of the lower vertical tail assembly changed shapes due to the influence from the propeller back flow, pressurization was necessary.

According to the original designs, inflation should not have been difficult. However, more people and time were required than in the case of hot air balloons, (if a propeller is used for ventillation, fewer people and less time would be needed). However, there were no large differences.

6. Expense and Supply

Heretofore, the total cost of designing a hot air airship (since 1973) has been 2,000,000 yen (including improvements).

The cost of testing and transport vehicles are included in this price. The cost of Toray cloth (66 nylon), which is used for most of the spherical shell was donated by Toray (1,500m), is not included in this price.

The manufacturing cost of this airship alone (cost of materials), including Asahi Chemical cloth, (Teijin's flame retardent cloth), load tape, engine (second hand), propeller, steel pipes, etc. is 1,000,000 yen. (At first there was some waste, such as loss of materials, etc., but it did not amount to very much.)

The work was carried out by department personnel on a part-time basis, and funds were donated from the OB club, various businesses such as Kirishima Brewery and Seiyama Construction and Miyazaki University Mechanical Science OB.

The plans for this year are to collect data on thermal testing of balloons (cloth manufacturer: polyethylene film manufacturer) and hot air airship spherical shells, flight training, and manufacturing for the future, and to carry out tests and construction, emphasizing improvements in the present airships.

In concrete terms: /26

1. Pressurization of the Lower Vertical Tail Assembly

The tail assembly is pressurized at 5 mm Ag at the lower part through the hull. However, the shape of the lower vertical wing, which is attached 6 m behind the propeller, is affected by the propeller back flow (pressurization: 14 mm Ag) (located at 6 m). Therefore, a different pressurization is necessary. The necessary flow has been measured and the fan shape is being tested. (The weight increases somewhat when a duct is installed behind the propeller in order to leave room for the driving engine (power necessary for pressurization is small.) However, it is probably best if a different fan is operated from the aspect of speed.)

2. Thermal Tests on Balloons and Airship Spherical Shells

The strength of the airship and balloon spherical shells has been determined at normal temperatures. However, strength at temperatures actually used is a problem, and therefore, it is necessary to study the temperature distribution from the standpoint of thermal efficiency. Experimental data has been collected by this group on the distribution of temperature inside the spherical shells of balloons made of polyethylene and nylon. However, we would like to measure three machines, because these materials are not used in airships and the experimenters have not graduated.

3. Making the Elevator of the Horizontal Tail Assembly Mobile

In the plans, this operated in the same way as the radar did. However, the pressure had to be maintained at 5 mm, so an unreasonably high or low pressure would not be exerted on the spherical shell. During the first flights, a micro pressure gauge was used. Today a windmill generator type pressure gauge is installed. The speedometer is the same. In addition, a fuel guage (LP gas), balloon thermometer (today a thermometer is installed inside the shell), an altimeter, and a gauge for ascent and descent are also used. In connection with the engine, a revolution indicator and oil pressure gauge are necessary, and

5. Various proposals, such as an over craft, gyrocopter, etc. have been made for future plans. However, we do not feel that it is important to add other devices. This year, we have carried out the production of a 3-engine balloons or 2-engine airships. The plan is to develop a machine that is lightweight and consumes a small amount of fuel.

People Involved in Airship Designs

Eishi Kagamiyama, Engineering Department Mechanical Engineering Graduate. He participated in plans for the Miyazaki hot air airship. He is a member of the Miyazaki University Technological Research Association. He graduated the previous year. However he remained at the university for one more year as a researcher /27
in order to complete the hot air airship. He instructs some 3rd and 4th year students, but mainly is interested in teaching 1st year students.

He comes from Fukuoka-ken Fukuoka shi. He has been interested in Engineering since he was young. While in elementary school he made a raft resembling a very tiny floating island in a harbor (he called this treasure island).

This year he will apply t Bodaite Electronics.

Furi Toshimoru }
Hiroyashi Eto } 1978 graduates of the Mechanical Engineering Dept.

Main members of the "Sekai No. 1" construction group. They were on the airship design staff. For their graduating thesis, these two men researched "Thermal Analysis in Ballons".

Seiichi Saijo - Applied Physical Engineering Department Graduate.

When the completion of the airship was almost near, this student went to Osaka for employment. He makes very good "white polar bears" (a "white polar" is an ice made with all types of fruits). He walks in his sleep. He was one of the Main members of the Sekai No. 1 group. He worked with Kagamiyama during the summer. He comes from Kumatai-ken.

Heino Kuruda - Applied Physical Engineering Department Student.

Photographer during tests and flights. He is presently enrolled in the art department of the university. He is researching avant-garde art. He would like to become a professional photographer. He comes from Miyazaki-ken Enoku-shi.

Teiten Tanaka - Engineering Department Mechanical Engineering Student graduates this spring.

Staff of 1978. Merit student.

Shiho Bakuban - 4th year Mechanical Engineering Student.

Participated in the plans for the hot air airship. In charge of wing assemblies. Directed gondola construction. Has had influence in the program. Comes from Kumatai-ken. Is the present head of the department.

Kishibo Harada - 4th year student of Applied Physics Dept.

Head of the department in 1979. In charge of balloon shell. Directed machine sewing. Carried out tests on safety. Researching Ocean Balloons. Comes from Kagoshima-ken.

Ken'nichi Seiki - Applied Physical Engineering Department.

In charge of the catenary curtain. Has self-confidence. Head of department in 1978. Likes bananas. Comes from Kochi-ken. /28

Hirogawa - Applied Physical Engineering Department.

Helped with catenary curtain. Humanitarian. Helped with gondola. Comes from Kumatai-ken. Likes fall and summer.

Seini Chifu - Applied Physical Engineering Department 4th Year Student.

Merit student. Directed destruction of G pan with machine of (illegible) . Interested in comics. Comes from Yamaguchi-ken Ko-shi.

Yowa Yamazaki - 2nd Year Art Student.

Has natural gift for sewing. Likes birds. Interested in comics and children. Comes from Shimatori-ken Beiko-shi.

Fun'ichi Matsuma - 2nd Year Civil Engineering Department Student.

In charge of machine sewing. Constructed pressure gauge of airship. Strong background in electronics. Comes from Nagoya.

Waochi Taiura - 2nd Year Mechanical Engineering Department Student.

Helped with the gondola. Interested in computers. Comes from Kojima.

Wajin Yokomatsu - 2nd Year Engineering Department Student.

Helped make the gondola. Would like to be white-collar worker. Talented welder. Comes from Fukuoka-ken.

Chiko Fujita - 2nd Year Elementary Education Student.

Feels that industry will quickly become an exact science. Resides in Miyazaki-shi.

Yama 2nd Year Special Education Department.

Went to school with Miss Fujita. Also resides in in Miyazaki-shi.

Ebiko Shono - 2nd Year Special Education Department Student.

She does not want to be known as a super-woman. From Daibu-shi.

Sekko Hagashiko - Graduated in 1978 from Art School.

Designed "Sekai No. 1" and this airship. Beautiful elementary school teacher. Also contributed a bonus to the cost of manufacturing the airship. She made the shell bag for the airship.

TABLE 1.

[hull]		
shell cloth (Toray 66 nylon)	810 m^2 (0.047 Kg/m2)	38.1 (Kg)
shell cloth (Asahi Chemical nylon)	160 m^2 (0.077 Kg/m^2)	12.5
tail assembly Cloth (Toray 66 nylon)	468 m^2 (0.047 Kg/m^2)	22.0
load tape	1,917 m (0.020 Kg/m)	38.4
catenary curtain cloth (Teijin Konekkusu**)	30 m^2 (0.250 Kg/m)	7.5
wire	27.8 (0.033 Kg/m)	7.5
shackle, ropes, tire clip, etc.		23.7
hull weight - 149.7 Kg		
[Gondola]		
frame	69.5 (Kg)	
2U-C driving engine	93.5	(batteries, muffler, gasoline, etc. included)
propeller and flange	8.5	
EC-10 engine used for pressurization	16.8	(gasoline and oil included)
2 tanks of propane	90.0	(container-25 Kg, gas 20 Kg)x2
burner, etc.	33.0	
* passengers-2	(140.0)	70 Kg/person
Gondola weight - 310.8 Kg (*449.8 Kg)		
Hot air airship total weight - 460.5 Kg (*600.5 Kg)		

**Translator's note: term unknown; transliteration of Japanese phonetic characters.

Infra-red hot air balloons

from: UP-TO-DATE CNES BALLOONS STUDIES

by: M. Rougeron (Centre National d'Etudes Spatiales Centre Spatial de Toulouse Division des Systemes de Projets Balloons, Toulouse, France)

Ichiro Saburo-translator (Balloonist, Buoyant Aviation Consultation Secretary, F.A.I. (International Flight Federation) International Balloon Committee)

Various countries have researched the question of whether or not balloons are cheaper as a platform for long term flight in the stratosphere in comparison to man made satellites. However, tests and observations in space were made simple with the practical utilization of the space shuttle. This probably weakened the importance of conventional stratospheric balloons.

As for these conventional balloons, the flight duration is short and they are not suitable for long term atmospheric observations. Super-pressure balloons made out of polyester film with a round shape having a diameter of several meters (200 mb level) have been used by France in weather observations. A pumpkin shaped Kebura balloon, etc. have also been developed and used.

However, the major disadvantage with this type of pressurized balloon is that they fly only at isobaric levels. At the present time we are looking for the broadest 3-dimensional flight capacity. Tests are being carried out by from Mt. Everest in order to solve this problem. The balloon descends with packing outside air into the ballonet with a pump after the ballonet is installed and the balloon ascends by emitting this air through an open valve.

However, little altitude control was displayed in the test.

An entirely new balloon called an infrared hot air balloon (La Montgolfiere infra-red: MIR) was developed by the Aeronomics Research Lab (Service d-Aeronomic: SA) of the CNRS in 1976 under these conditions (Figure 1). Up until that time the Aeronomics Lab of the CRNS used a super pressure balloon. It seems that the SA considered the application of this hot air balloon for stratospheric investigations.

A burner is installed in this hot air balloon as with the classical Montgolfiere balloon. Thermal energy existing in the atmosphere is taken and converted into buoyancy. The air inside the shell of this balloon is heated with the shell as a medium. Elevation is controlled with the opening and closing of the valve.

The first tests on these designs were carried out in 1977. SA manufactured a solar heat balloon with a black shell. It was flown from Pretoria in South Africa. The amount of heat produced from solar energy is very high and the temperature difference inside the shell at 70 mb is 80-100°C. Flight ability at a broad altitude difference was displayed and when necessary, quick altitude changes could be made. The time from the completed descent with the end of the reaction to elevation with the valve closing line was very short. We regret that the solar hot air /31 balloon could not be flown during the night. The combination of an open balloon with a transparent shell, a solar hot air balloon, and a Kebura reinforced pressurized balloon was considered for excursion flights at different altitudes during the daytime and for maintaining flights over a long period of time.

Even though the amount of energy that is absorbed during the evening with this type of infrared ray hot air balloon is small, if a fixed altitude can be maintained, a more simple balloon can be produced. It is necessary that this type of balloon be made

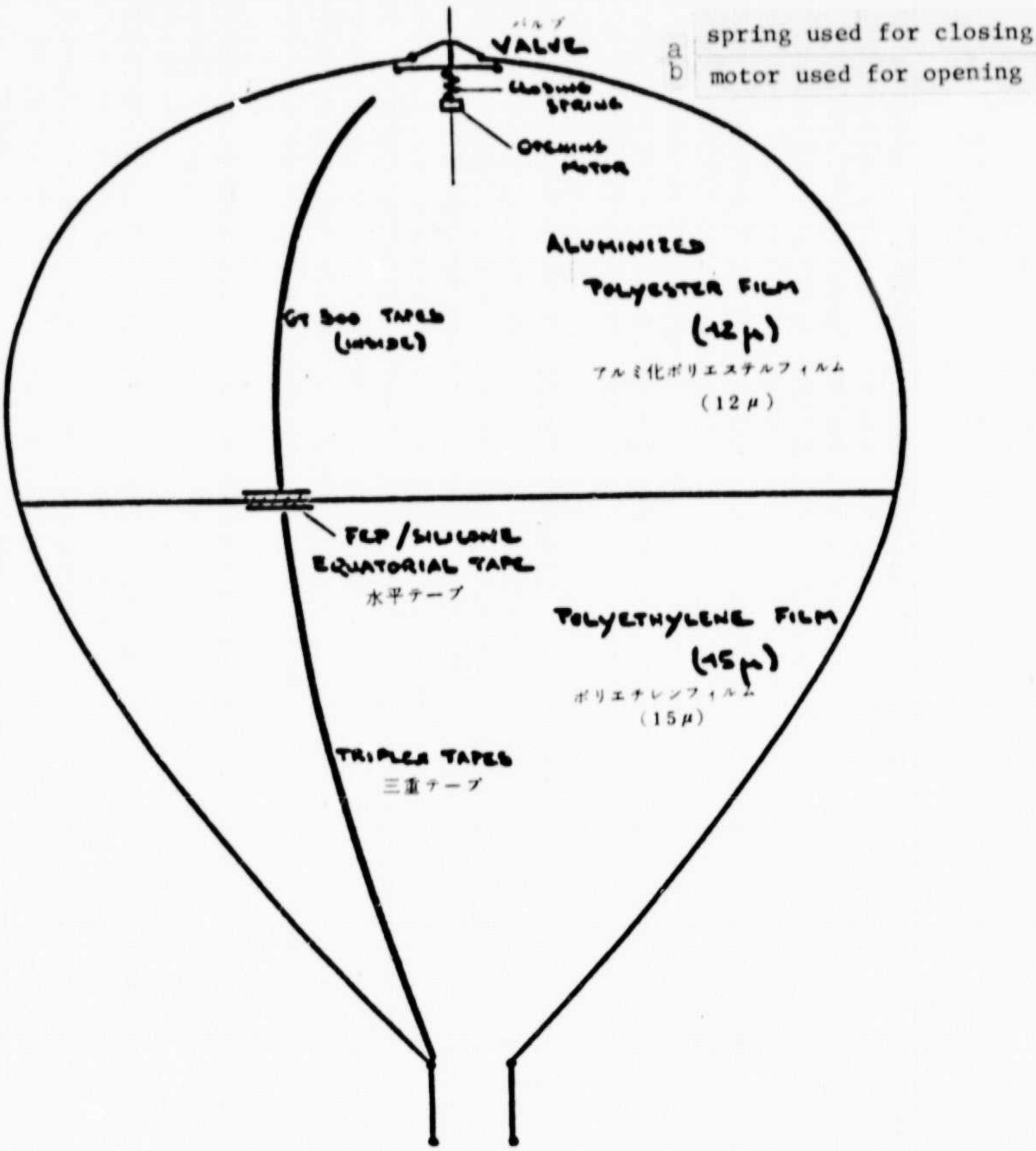

バルブ
VALVE
a spring used for closing
b motor used for opening
CLOSING SPRING
OPENING MOTOR
ALUMINIZED POLYESTER FILM
(12μ)
アルミ化ポリエステルフィルム
（12μ）
GT 300 TAPES (INSIDE)
FEP/SILICONE EQUATORIAL TAPE
水平テープ
POLYETHYLENE FILM
(15μ)
ポリエチレンフィルム
（15μ）
TRIPLEX TAPES
三重テープ

Figure 1. MIR

so that the top half has the lowest heat diffusion ability and the maximum amount of radiant heat from the convection zone is collected by the lower half, without diffusing the equivalent amount of heat at the same time.

In comparison to the amount of heat collected from the sun during the day, the amount of heat obtained in this way during the evening is small. However, with a clear sky it can reach 20-30°C. However, it is difficult to reach even 5-10°C when an altostratus is present (produced in an incus of cumulo-nimbus clouds; thick cirrus clouds, etc.). Nevertheless, it is essential that super light weight materials be used and that the surface area of this infrared ray hot air balloon be large. However, even if the capacity of this balloon is too large and the absorption efficiency of solar energy of the shell is poor during the day, this type of balloon can still have excursion flight ability over a broad range of altitudes.

Flight Tests

Preliminary tests were carried out by the CNRS, which took the lead in developing this balloon for practical usage, and the CNES, in order to determine the efficiency of infrared ray hot air balloon. They relied on existing materials, production, etc. technology for these preliminary tests. The results did not necessarily display adequate reliability.

The shell was made from two parts. On the outside a 12μ aluminized polyester film was used for the top half and a 15μ polyethelene film was used for the bottom half. An open duct reinforced with fiber glass is made at the bottom pole (appendix). A flexible valve reinforced with fiber glass is installed at the peak. It closes so that it extends to the top from the inside of the shell.

With regard to the launching of the balloon, the balloon is either filled with hydrogen or helium, reaches the stratosphere as a gas balloon, and then from there begins free flight as a hot air balloon, or part of the balloon is filled with hydrogen or helium and from the very first, it ascends with its own strength as a hot air balloon. The hydrogen, or helium, is forced out with the opening of the valve.

Infrared ray hot air balloons (MIR) with surface areas of 6,000 m^3 and 13,000 m^3 were made and four flights were carried out. The effective load was 10-20 kG (Figure 5). The following results were obtained.

- The balloon theory was displayed with the capture of infrared ray energy from the earth to the convection zone. The average temperature in the shell was about the same as the anticipated value. A buoyancy of more than 6-8 g/m^3 was obtained at all times.

- Excursion was possible with a difference in altitudes of 10 km from 18-28 km above earth during the day. There was no decrease in capacity during descent and the maximum cross section /32
for the opening, with which reliability of stable flights would not be lost, could be chosen.

On the other hand, there were several problem points and these became obstacles to carrying out long term flights.

- The MIR easily shakes in a horizontal direction during rapid descents. This is due to the fact that the ratio of capacity: effective load is much too small. The center of gravity is close to the center of the balloon.

Wind resistance of the vertical components of the balloon is weak (the inertia of the MIR is very large). Glass shaped tears may be produced on polyethylene shells near low temperature zones close to the tropopause.

A valve that is rigid and light weight has not been developed yet.

Future Outlook

The first step in the MIR has been completed. In the future the development of a program emphasizing the practical usage of the balloon in the remainder of the 1980's is being planned. The three main uses of the MIR are:

- platform — The daytime flight level (15-30 mb) and night time flight level (50-90 mb) of a balloon without a valve will vary with changes in outside conditions. However, because there is almost no need to be concerned about leakage with the MIR balloon, endurance over a long period of time can be anticipated;

- sonde — The balloon will have unique excursion ability due to the opening and closing of the valve, and

- pursuit balloon — Selection of the optimum flight course, recovery of pilots after mission completion, flights to a specific point, etc. will be possible due to the fact that flight controls and flight levels will change in accordance with fixed laws of isothermal location, etc. or with distant operations, etc.

The effective load is always 150 kg or less with MIR balloons with several 10,000 of cubic meters, which is not very large. The maximum altitude is limited to 30 km and the lowest altitude is the tropopause.

The following are the conditions of this balloon.

- The entire balloon is made of polyester has a thickness of 6-12μ and is reinforced with fiber like grid. The top half of the balloon is aluminzed. The efficiency of this balloon is somewhat worse than that of the balloon used in the preliminary tests. However, the reliability is far better.

- The polyester film becomes reddish with time and the efficiency of the hot air balloon during the day increases. Consequently, the maximum altitude that is reached is high.

- Flexible valve

The balloon is launched with the inflation method (expansion of the balloon) in the convection zone using an auxilliary balloon with small capacity.

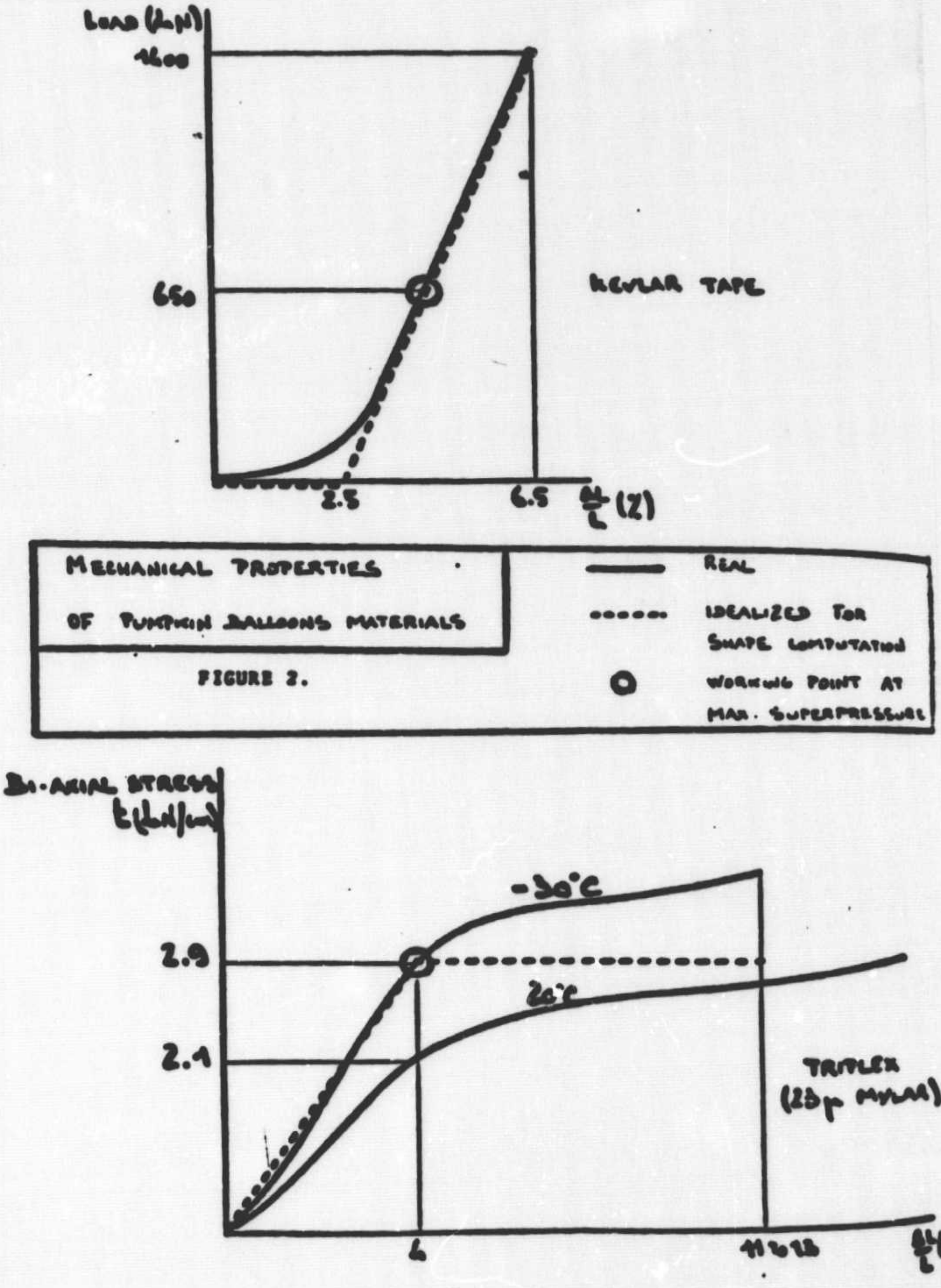

650
2.5
6.5
KEVLAR TAPE
MECHANICAL PROPERTIES
OF PUMPKIN BALLOONS MATERIALS
FIGURE 2.
REAL
IDEALIZED FOR
SHAPE COMPUTATION
WORKING POINT AT
MAX. SUPERPRESSURE
BI-AXIAL STRESS
-30°C
2.9
20°C
TRIPLEX
(23μ MYLAR)
6
52

Figure 2.

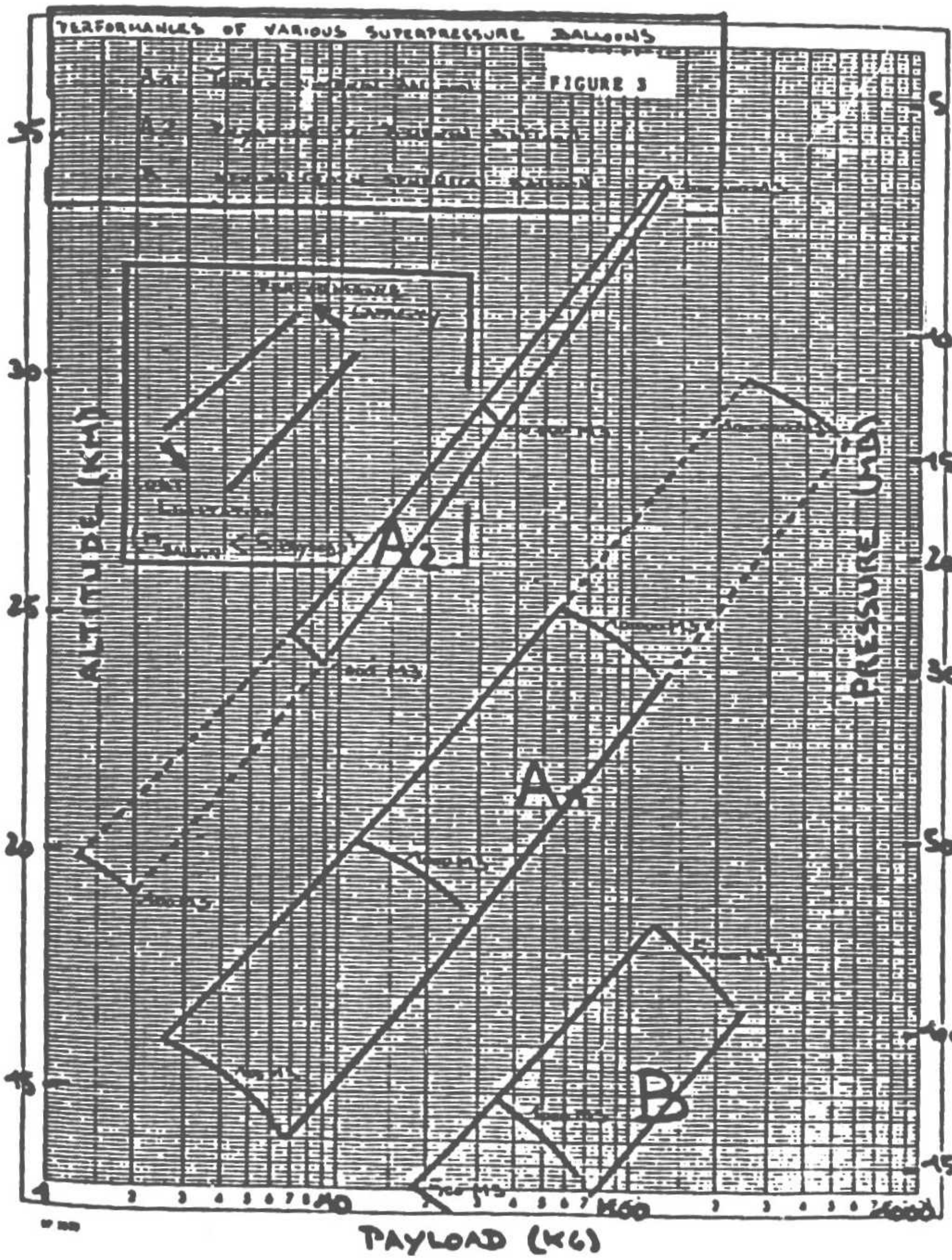

PERFORMANCES OF VARIOUS SUPERPRESSURE BALLOONS
FIGURE 3
A2
A1
B
ALTITUDE (KM)
PRESSURE (MB)
PAYLOAD (KG)

Figure 3.

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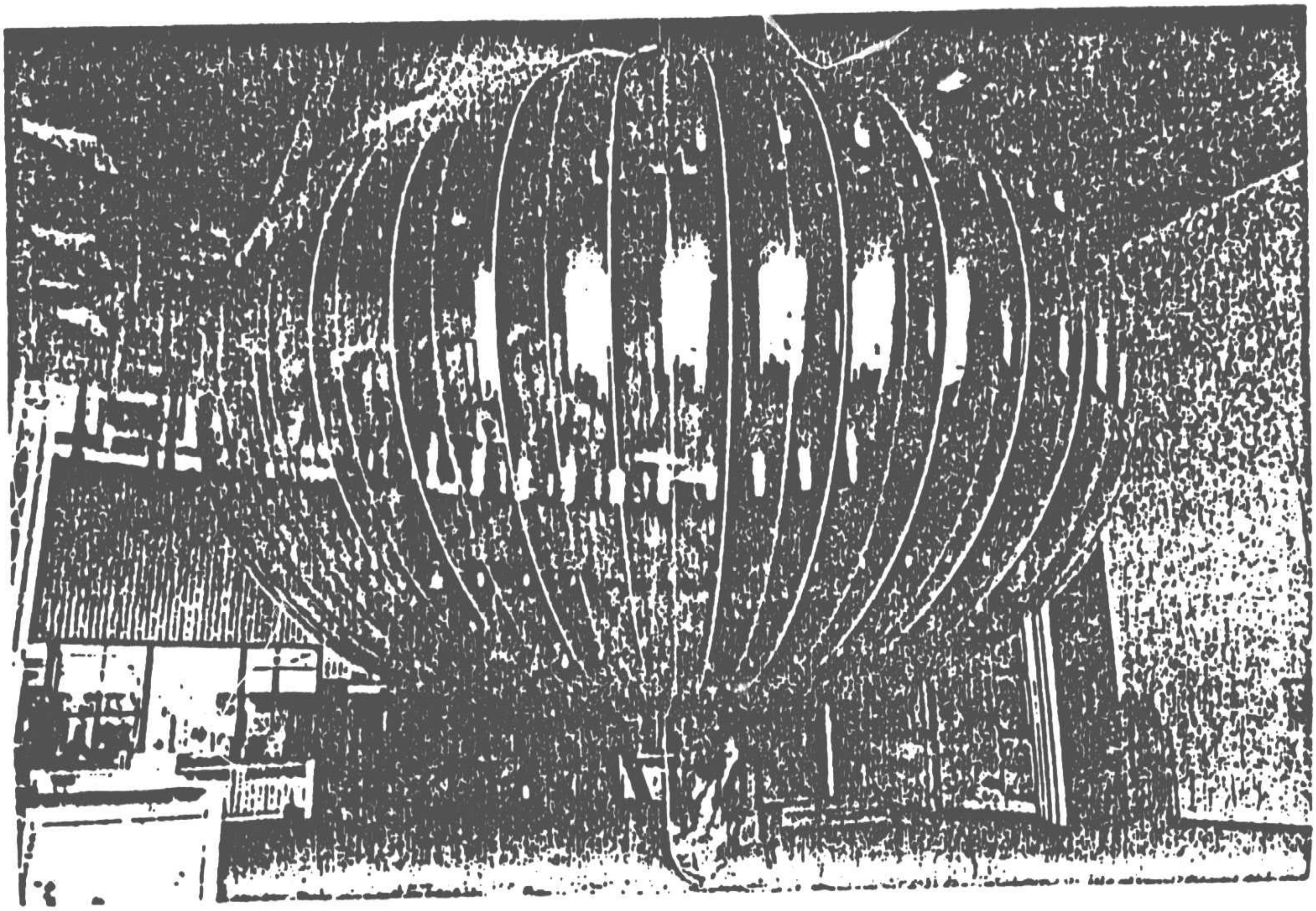

Figure 4. 200 M3 "Pumpkin Balloon"

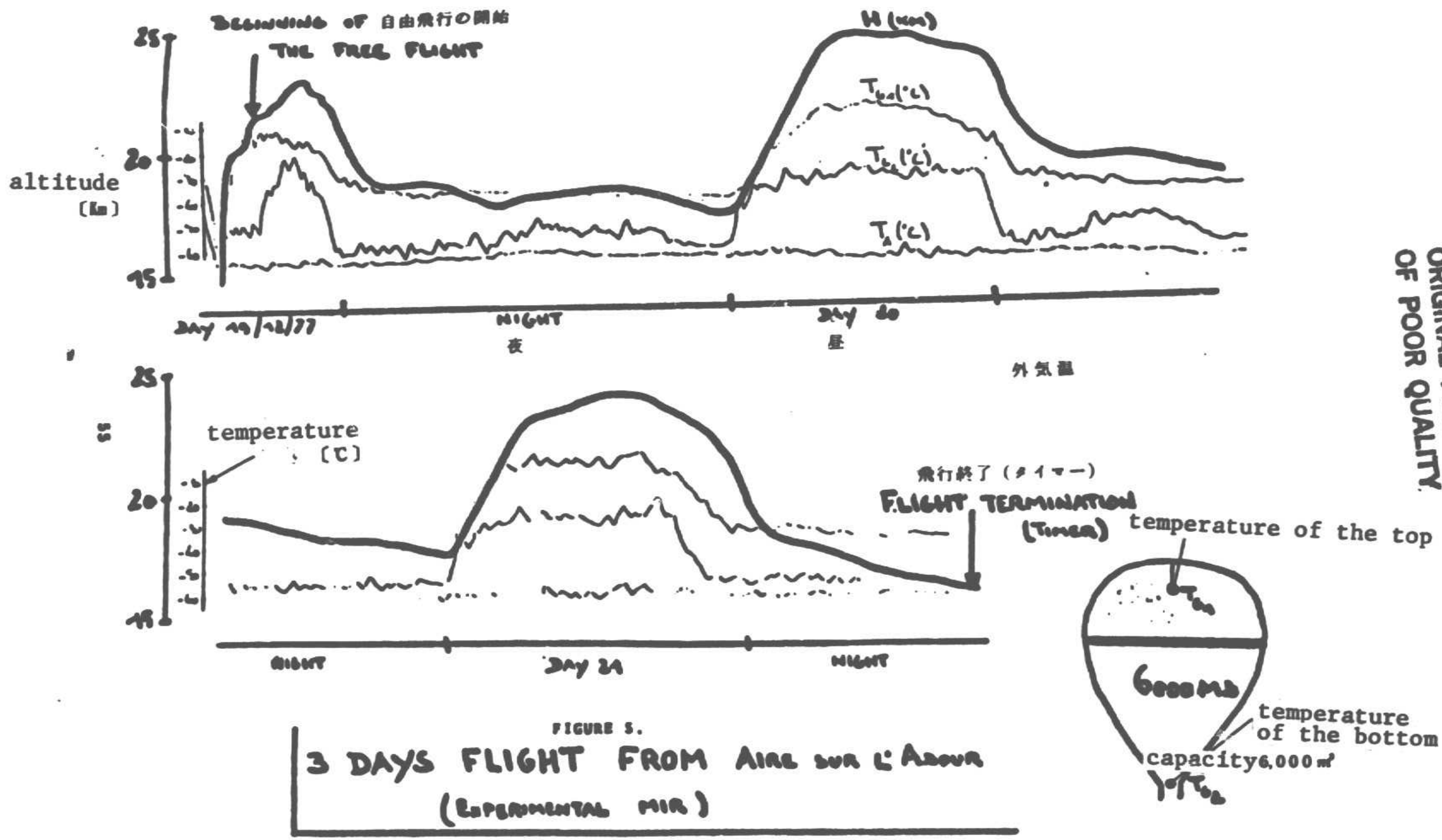

Figure 5. 3 Days flight from MIR used in tests; profile.

TRENDS IN BALLOON DEVELOPMENT IN AMERICA /38

Chuta Wada (technological consultant; JBFA)

In America balloons are used in place of high priced stationary satellites. They have been designed to float like the "familiar atmospheric satellites" and tests on flights of manned super pressure balloons for observing atmospheric pollution are being carried out.

1. The HAPP System as a High Altitude Platform

(1) Properties of HAPP

HAPP (High Altitude Powered Platform) is an LTA being tested by NASA (National Aeronautics and Space Administration). The plan is for an unmanned buoyant body to float at a height of about 20 km above the earth's surface for a long period time extending over "years". In comparison with stationary satellites, the altitude is much lower. However, as might be expected, it is advantageous for detailed uses and is inexpensive.

In the original conception, the use of aircraft continuing to circle a fixed radius was considered, in addition to the method whereby the LTA is used [1]. However, as a result of studies it has been decided that today a flexible airship will be used. The structure and driving power are being discussed in detail. Because an altitude is chosen where the wind velocity is zero and the balloon floats to this altitude, the driving power for movement should be just as high. An airship with "microwave beam" driving power has been suggested. In this method the electric waves would be changed and transmitted as 2.45 GHz electronic waves from the ground station. The airship receiving these waves would obtain driving power from a propeller with the turning of a motor when the beam of microwaves is converted to direct current power, or would employ an electrical source from other devices (Figure 1) [2].

The device on the airship that receives the beams is called a rectenna. The rectenna is composed of many small elements that combine the functions of a rectifier and antenna.

There has also been a great deal of progress made in technology for transmitting power with microwaves. In 1977, tests were completed on the wireless transmission of 30 kW of electricity to location 1.6 m away. It was also reported that a rectenna achieving an efficiency of 90% was developed. A substance in the air is affected when it is irradiated with these beams. The present safety standard is $10mW/cm^2$, even in the case of continuous irradiation. The example of HAPP designs is included within this range. When necessary, a wide clear zone is set up /39
around the transmitted electricity and should be isolated from the effects of the electricity. (The safety standard for microwave leakage used in Japan is less than $1mW/cm^2$ with new products in the case of the electronic range for home use.)

In using this driving system, the employment of a high performance direct current motor using samarium=cobalt magnet was tested. The motor is 95% effective and is light, with a weight of about 0.6 Kg/kW. Efficiency of 85% and a weight per output ratio of 1.5 Kg/kW is achieved when this is combined with a speed reduction device.

Mylar is used for the air bag material of the airship. The airship is a super pressure airship with a ballonet (air room). The gas is helium in an unmanned airship and the recovery operations for maintaining a fixed location are all controlled from land.

Two types of hulls have been proposed (Table 1), one with a payload of 130 Kg and the other with a payload of 720 Kg, as standard plans [2]. The cost of each has been computed. According to these computations, the cost of the former is $210,000.00 and the cost of the latter is $410,000.00, including the cost of the hull, rectenna, driving power device, and helium. The cost of the land electrical transmission facility of the former is $1,300,000.00 and of the latter is $1,600,000.00. Moreover, the annual cost for operation is $360,000.00 for the former and $560,000.00 for the latter (provided that the cost of electricity is 2.6 cents/kWh and restoration of the hull and exchange of the rectenna are carried out each year).

(2) HASPA Plans

The new research plans for high altitude employment, which were started by the Pentagon in 1968, are the basis for this idea. The HASPA, which was sponsored by the U.S. Navy, is one of these plans. Even though it has the same purpose, its construction is unique and the HASPA is promising. HASPA stands for High Altitude Superpressure Powered Aerostat. A solar cell and battery system is installed in the flexible airship with helium, where Mylar and Kebura are used. The plans call for the maintenance of a fixed altitude while the airship is driven so as to resist the wind. It is also called "Hi Spot". The speed is 46.3 Km/h (25 knots) during the day and 27.8 Km/h (15 knots) during the evening.

(3) Substratospheric Air

Meteorologically, when moving to a higher altitude, there is an area that is almost calm with windless conditions. It is along the boundary of the layer where a strong westerly wind blows and the layer where an easterly wind blows. This height is a cross over altitude and changes with the season and location. It is not constant. For instance, during the summer in the northern hemisphere, a height of 20 Km in a windless zone extends

TABLE 1. BASIC MEASUREMENT OF OF AIRSHIP

payload	130	720
hull weight (Kg)	234	610
rectenna weight (Kg)	278	525
gondola motor weight (Kg)	134	214
capacity (m^3)	14,000	37,000
linear ratio	4	4
drag coefficient Cdv	0.06	0.05
output (total from both motors) (KW)	31	46

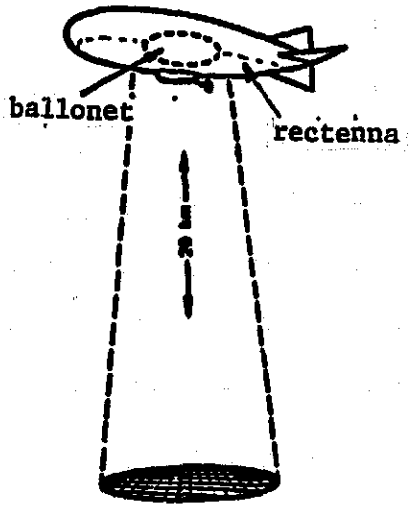

Figure 1. On land transmission post (diameter of 70 mb).

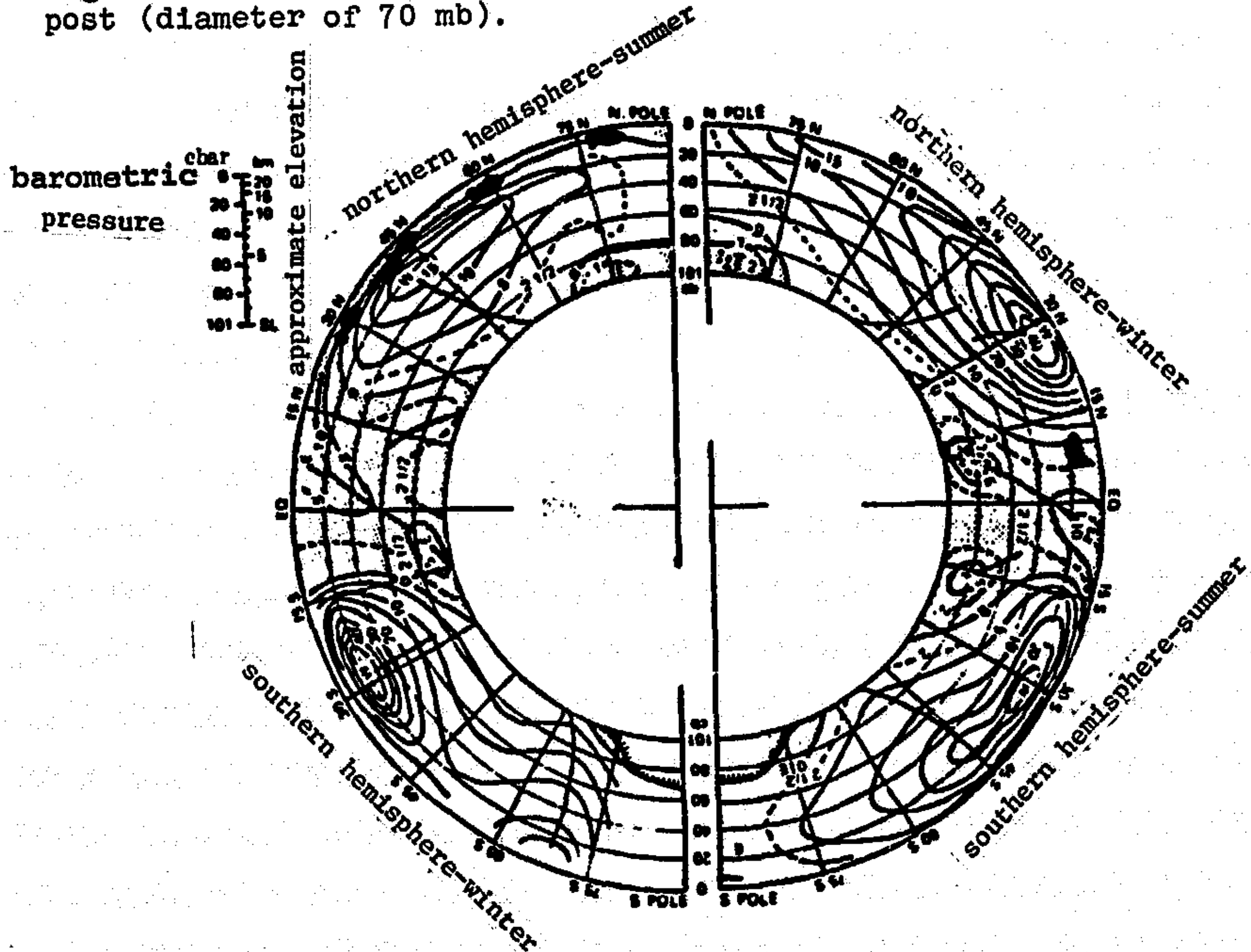

Figure 2. Wind direction and wind speed around the earth (cross section).

/40

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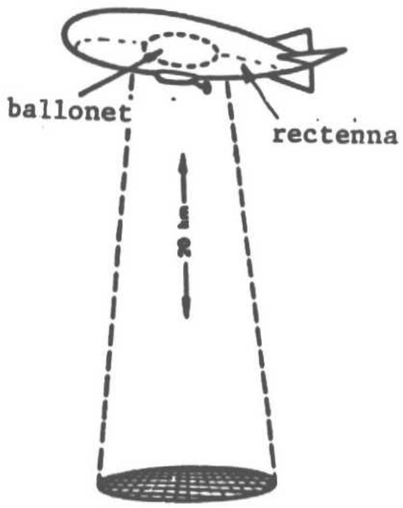

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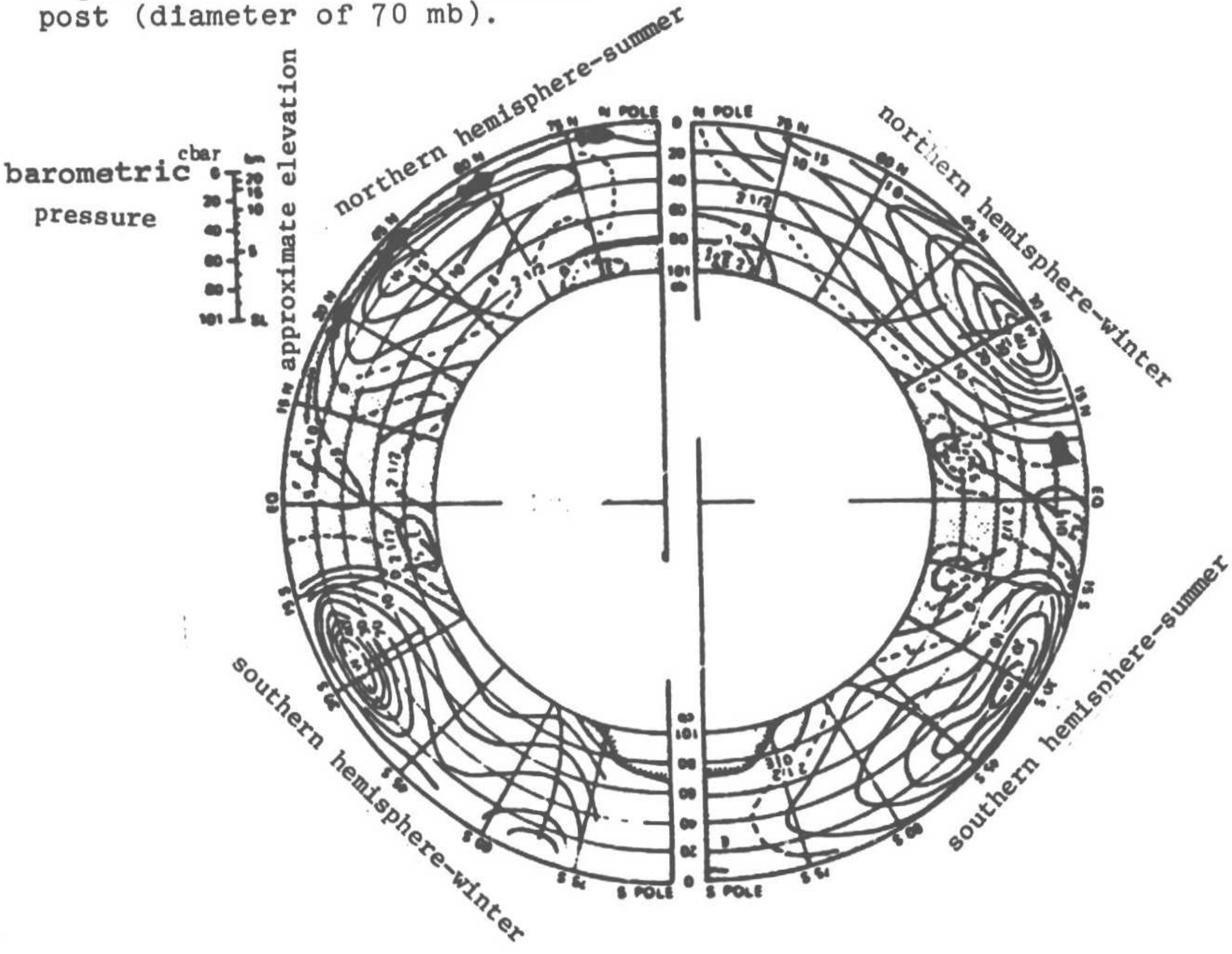

Figure 2. Wind direction and wind speed around the earth (cross section). /40

from a latitiude of about $30^{o}N$ to $80^{o}N$. It seems that with the changing of seasons to winter this condition moves south to a latitude of about $10^{o}N$ (Figure 2) [3].

In the HASPA plans the velocity is determined with a planned altitude of 50 mbar (about 21 Km). However, according to the results of observations, it is often difficult to return to former /41 locations because the wind speed picks up once again. When this is the case, changes must be made because of the fact that the annual operation period is limited and there is a loss of utility.

One countermeasure is to change the altitude to 30 mbar and 70 mbar. Then the airship should be moved to a layer where winds are weak as quickly as possible. However, this has more of an effect on the service capabilities and therefore, it cannot be called a satisfactory method. If there is efficiency in improving the location recovery ability by increasing the speed of the hull, for instance, if the system driving of the HASPA is intensified and increased to 55.6 Km/h (30 knots), the operation time is almost doubled.

If a fixed location maintenance is emphasized, for instance, if control posts are situated in the east-west direction, or if more operation control posts are installed, the utility will be improved from land.

In the HAPP research of NASA wind conditions from the ground to an altitude of 10 mbar (about 31 Km) were studied in the United States, the Pacific Ocean and in Europe. In particular, the most important point was situated between 100 mbar (about 16 Km) to 25 mbar (about 25 Km) [4]. According to these studies, a method has been proposed whereby the altitude that is employed would vary with the seasons. During the summer it would be lower and during the other seasons the altitude would be higher.

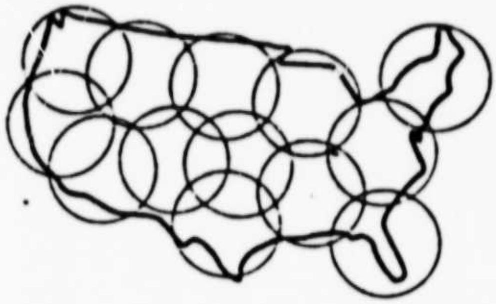

Figure 3. 13 HAPP covering the entire U.S. /42

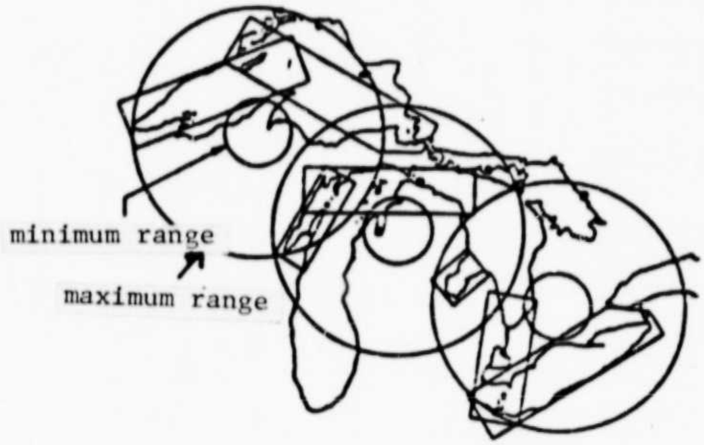

Figure 4. Pattern of HAPP covering the % Great Lakes.

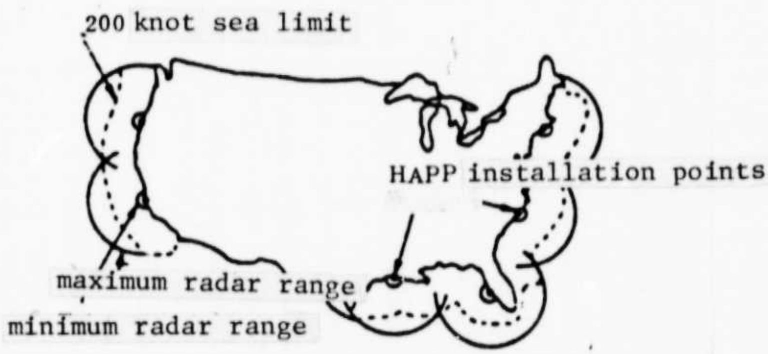

Figure 5. Covering the 200 knot sea limit.

When we look at the maximum wind velocities at an altitude of 50 mbar (about 20 Km), which were collected from 7 representative observation areas in the United States, one velocity was 31 m/s and the rest were from 26 m/s to 19 m/s. This data showed that if the velocity was a maximum of 30 m/s (speed per hour: 108 Km), the area that is used is limited, for the most part, to the sky above the post [2]. We should develop HAPP microwave beam technology to counter a large driving power.

(4) Employment of Platforms

The HAPP is used as a stationary satellite for "low altitudes". In particular, it is widely used for the two fields of "communications" and "remote sensing". The various requirements for this type of system were collected at NASA through questionnaires and interviews.

A television station with an antenna at a height of 305 m (1,000 ft) can only directly service an area that is about 90 Km (55 miles) away. However, the altitude of the HAPP is about 20 Km and therefore, the antenna reaches a broad area and can directly serve an area 520 Km (322 miles) away. If expanded, there should be 13 HAPP for television broadcasting that covers the North American continent. (Figure 3) [5].

From the viewpoint of planning, it is possible to increase the payload of the HAPP to 6,000 Kg. This will probably lead to complex and high function broadcasting equipment. The HAPP can also be used as a new medium for combining on land networks and communications satellites.

The NHK was interrupted with the testing of the broadcasting satellite. Both parabolic antennas and adapters had to be installed. In comparison to these, the direct reception with HAPP is very inexpensive. The advantages of HAPP are clear even when compared to cable T.V. /43

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Concrete studies have been carried out on remote sensing such as "observation of forest fires". "Flight Aids and Freezing Reconnaissance Over the Great Lake Regions", and "observation of 200 knot fishing limits".

Early discovery of forest fires is a large problem to controllers. The infrared ray device can look over a broad piece of land instantaneously from the sky. It is not certain whether or not this method is economically advantageous.

Traffic over the Great Lakes has a large effect on local industries. In particular, heretofore there has been concern over the occurrence of problems due to dense fog and ice. If 3 HAPP with radar were set up, these problems could be greatly improved (Figure 4) [5].

In comparison with carrying out observations of coastal and fishing limits using ships and aircraft patrols, the use of HAPP is much more effective in endurance, discrimination from high areas and continuity. Six should be installed to cover the United States (Figure 5) [5,6]. The HAPP would also be useful in sea disaster training. Therefore, we expect good results in the future.

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2. Plans for an ATMOSAT Used to Study Pollution (Atmospheric Pollution)

(1) ATMOSAT

The conception of the ATMOSAT is called that development of a new LTA. However, past records are not satisfactory. Manufacturing and test related to this ATMOSAT have been carried out. It is a project where the technology of several years have been accumulated.

ATMOSAT stands for Atmospheric Satellite. Basic research was started in 1975. From 1976 to 1978 flight tests were gradually carried out. Improvement operations are being continued. The Aerospace Corporation developed and owns the /44 ATMOSAT system. Because this is actually progressing as a business development, the conditions in its progress vary somewhat.

In this project a manned super pressure balloon was made. Kepura and Mylar are used and the helium level is maintained with stable pressure. This system has shown very reliable flight ability over long periods of time. Moreover, it can carry skilled observers. Therefore, atmospheric data on the ozone, NO_x, SO_2, temperature, turbulence, etc. can be accurately collected. A balloon with a diameter of 3.5 m and the ATMOSAT "America" with a diameter of 10 m well produced during the test stages.

(2) Prototype Stages

The first prototype was a direct series wiring between a towing balloon and an ATMOSAT balloon. The prototype had enough buoyancy to raise the entire device to a height of about 15,600 m. Flight control was carried out from a control center, and a radar for missile pursuit was used (Figure 6) [7]. According to the flight results, the super pressure was more than 100 mbar all day long and data on temperature differences at daytime and night time, etc. were obtained.

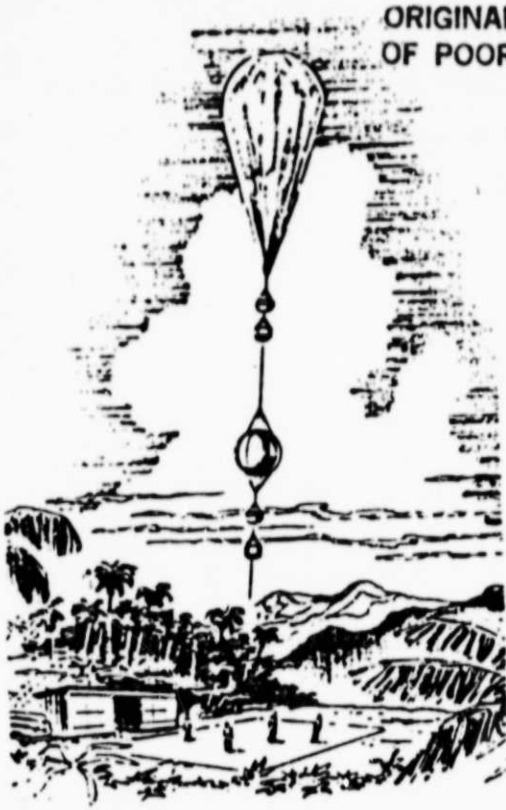

Figure 6. Idea of ATMOSAT

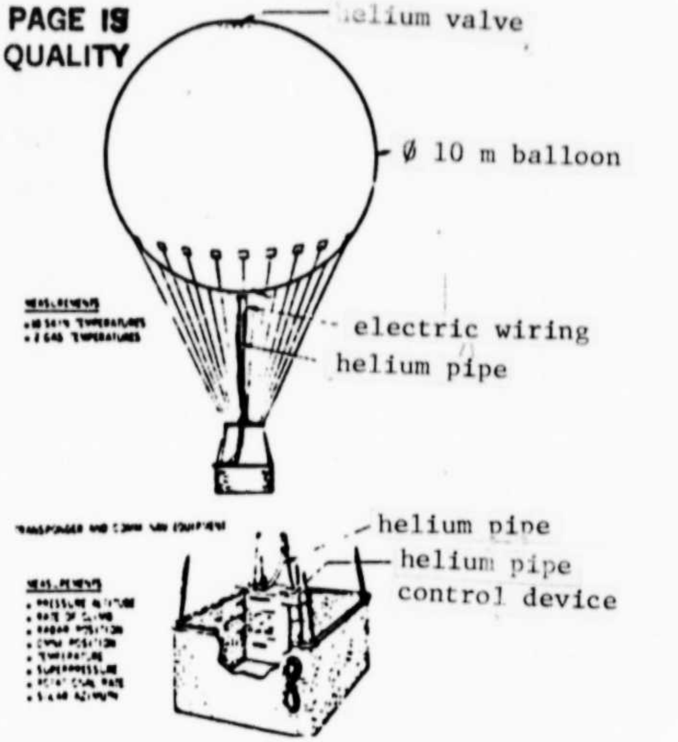

Figure 7. Ø 10 m ATMOSAT Balloon

TABLE 2. TEST FLIGHT CONDITIONS

Heading	Flight 1	Flight 2	Flight 3
launching time	Feb. 18, 1976	April 18, 1976	July 2, 1976
launching area	Los Angeles (California)	San Angelo (Texas)	Los Angeles (California)
landing area	(Arizona)	Goodland (Kansas)	Death Valley (California)
flight time	30 hrs. 24 min.	31 hrs. 44 min.	32 hrs.30 min.
maximum altitude (above sea level)	1,922 m	2,349 m	2,532 m
straight line flight distance	559.2 Km	1,088 Km	323.3 Km
flight course distance	712 Km	1,616 Km	504 Km

(3) ATMOSAT "America"

The purpose of the ATMOSAT was to carry out manned flight operations at different low altitudes. The Ø m ATMOSAT is called "America". The height, including the balloon and gondola, is 18 m. The air bag capacity is 525 m^3 and the total weight is 575 Kg. It is filled from the top to the bottom with helium using a flexible pipe. The super pressure is set at 50 mbar before flying and 40 mbar during flight (Figure 7).

The diameter of the helium valve at the balloon peak is 61 cm (24 in.) and the balloon operates with a direct current motor. At first all measurements of location, altitude, temperature, azimuthal angle of the sun, rotation percentage, etc. during flight were taken by manually. However, afterwards a automatic data recording device was installed. Of course, communications for aircraft/navigation devices, transponder, altimeter, ascent and descent gauges, etc. are installed in the gondola. Three independent lithium batteries are used for the direct current electrical source.

(4) Flight Tests

Three tests were originally carried out on basic technology (Table 2).

"Flight 1" and "Flight 2" were practice flights. During "Flight 3" the device was flown from Los Angeles to Death Valley as a simulation for using atmospheric pollution observation.

(5) Pollution Observation Flights

"Flight 4" was launched from Farmington (New Mexico) at 5:14 p.m. on December 8, 1976. This balloon was steady even along mountain terrain during the evening and landed 7 hours and 16 /46 minutes later.

"Flight 5" started at 6:30 a.m. on June 27, 1977 and was completed at 12:30 p.m. of the same day. The purpose of this flight was to follow the smog that was produced from Los Angeles during the day.

"Flight 6" lifted off from Long Beach (California) on September 8, 1977 at 8:09 a.m. It landed in the western side of the national forest at San Bernadino at 5:20 p.m. on the same day. This aircraft collected important data, such as measurements related to the ozone, measurements concerning the accumulation of HC (Hydrocarbons), etc.

In October of 1977 Long Beach published a "Environmental Impact Report" (EIR). The report presented the serious effects of the emission from tankers carrying petroleum, which was stocked at facilities in Long Beach, from Alaska on the atmosphere. The city of Long Beach entered a contract with the Aerospace Corporation, which had developed ATMOSAT. In particular, the effect on the Santa Barbara area was studied. In order to carry out this plan, a balloon had to be launched from the coast to a distance out over the ocean.

Two methods were suggested for this. In one method, the trailer for helium gas to fill the balloon and the collapsed balloon were placed on the ship and transported to the launching area. The balloon was inflated on the ship and launched. The other method involves the inflation of the balloon on land. The balloon is then towed out to sea with a tugboat and launched to a fixed location. This method is not complex and, as a result of tests, the second method was judged suitable and was employed.

"Flight 7" was carried out the two days of October 10 and 11, 1977. When the balloon was launched over the ocean after it was towed with a boat from the U.S. Coast Guard, it moved in a south east direction along the coast at a speed of about 15 Km/hr. It did not move very much during the evening. It landed near the beach

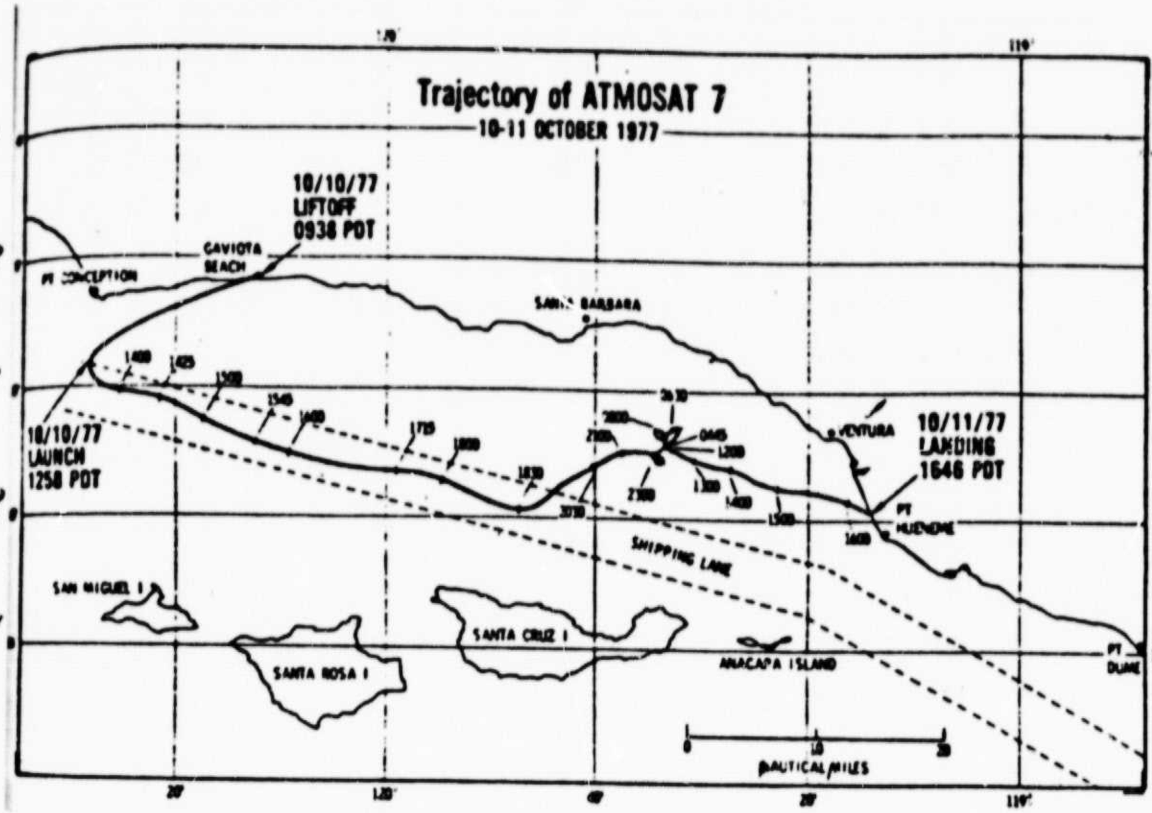

Figure 8. "Flight 7" Flight Map.

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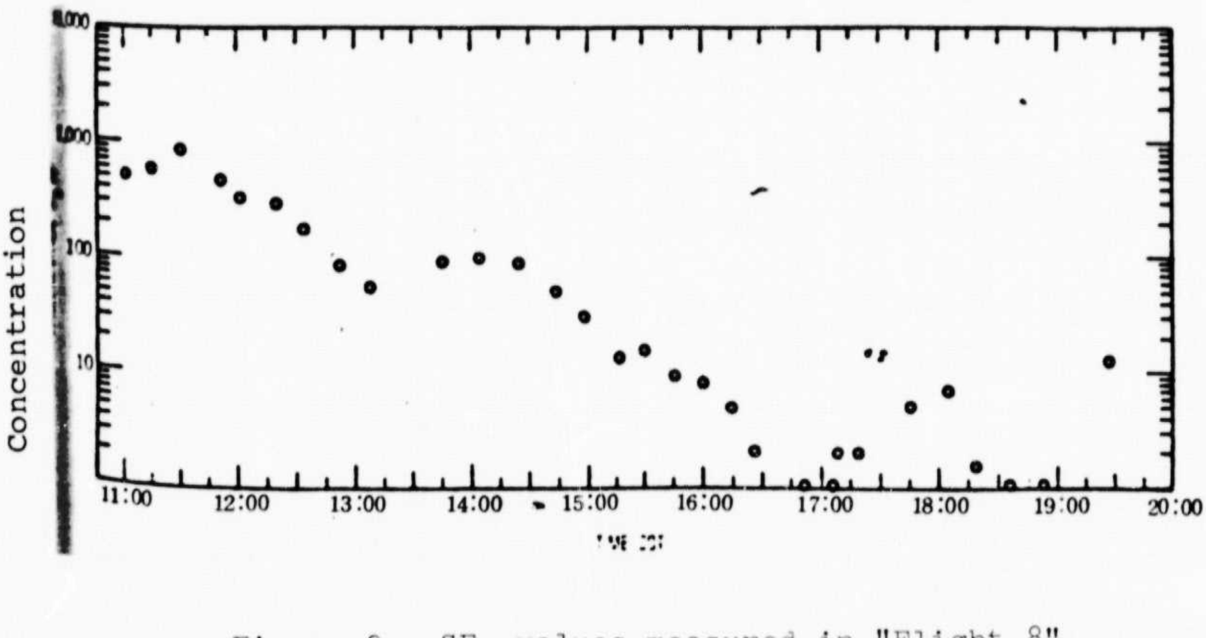

Figure 9. SF_6 values measured in "Flight 8".

about 26 hours later. A flight altitude of from about 60 m to 75 m was maintained. This is a typical height for the flow of a polluted atmosphere (Figure 8).

There are many scientific demands that must be met in order to make the ATMOSAT plans useful. At first, it was necessary that the payload exceed 60 Kg with scientific devices of 10 Kg or 20 Kg, for example, as shown with the contract with the Environmental Protection Agency (EPA). The flight plan had to be revised and "the two member crew" was reduced to "1 person".

Since 1978, ATMOSAT flights have been very important, especially in studying the air that is down stream from large carbon burning power plants. Various demands have increased, along with intensification of the energy problem.

"Flight 8" was first a pursuit flight. The purpose was to /48
actually study the height of soot and smoke. The ATMOSAT was launched for this altitude. The flight took place at 10:24 p.m. on August, 1978. Reports were sent from the aircraft and the height of the soot and smoke was recorded as from 340 m to 580 m (above sea level). The balloon floated up to the level of 540 m. Each hour it moved about 15 Km to the southwest due to the winds. Observation became gradually worse, until the studies were concluded after 8 hours and 21 minutes of flight. The conditions of SF_6 (sulfur hexafluoride) were studied during flight (Figure 9).

"Flight 9" was carried out from August 25, 1978. It was a continuation of the work done by the Environmental Protection Agency (EPA). The study continued for 6 hours and 18 minutes.

(6) Future Plans

There is a plan for using buoyant balloons to probe the surface of Mars. However, we are not certain that ATMOSAT will be advanced in the field of space research by the second half of the 1980's. The Jet Propulsion Lab (JPL) of NASA is pondering this plan.

For instance, several ball shaped "planet surface probing bodies" made from strong materials have been scattered throughout the universe. The balloon naturally expands and contracts or operates by control from earth. These balloons will probably fly on the strong winds of the surface of Mars. A driving device may also be installed inside the balloons.

If the balloon must be stopped during the flight, it will probably set down on the indented area when part of the balloon contracts in the shape of a kick ball that is punctured. This idea is somewhat promising because of the low cost and long life span.

There are various ideas for shapes for the balloon, such as a balloon with a large ball shape with a diameter of from 3 m to 10 m and a payload of 20 Kg to 30 Kg. It can move by rolling from 100 Km and 200 Km. There have been some detailed suggestions, such as a balloon that is filled by a blower with CO_2 (carbon dioxide), which is the main component of the atmosphere of Mars, or a balloon where the stability and manueverability can be increased or decreased by adjusting the height of the center of gravity. This balloon can easily clear a height one third its diameter.

The ATMOSAT was originally a manned super pressure balloon system. It was first developed to observe air pollution, etc. Practical usage of the system will probably require further improvements. Employment of this technology in future space development is indeed a dream.

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PLANS FOR LARGE AIRSHIPS THAT EMPLOY SOLAR ENERGY

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1. Introduction

The cost of an airship as an energy saving transporting device has been noted in the midst of a worldwide energy crisis. The airship itself has a medium speed range (50-200 Km/h) and is better than other transporting devices in transporting efficiency. The amount of fuel needed to drive the airship can be greatly curtailed if energy from solar cells on the surface of this huge hull of the airship are used. The use of solar energy is one advantage of the hull of the airship. Electrically driven airships that use solar energy show promise for future transporting devices. In this chapter the basic structure, operation performance, uses, and future prospects of the airship will be discussed. Furthermore, basic data on the hull is used. This data was collected from the thesis of Professor Tosho of the Tokyo University Space and Aviation Research Lab (Japan Aviation and Space Society Report Volume 24, no. 270, July, 1976).

2. Outline of the Plan

2.1 Basic Structure

A large airship with a payload of 1,000 tons and 100 tons has already been designed by Professor Tosho. Based on these plans, the basic data and appearance of an electrically driven airship with solar cells are shown respectively in Table 1 and Figure 1.

On a clear day flying can be carried out at a speed of 80 Km/h with only the output of the solar cells. When output cannot be obtained from solar cells during the evening, etc., it obtains power when a light weight superconduction generator is driven with a gas turbine with hydrogen as the fuel. Reduction in weight with a super conductor is planned. Because a strong magnetic field is used due to the super conduction current by the super conduction rotary device, it is possible to reduce the weight to less than 1/10 of conventional rotary devices.

He gas is preferred as the buoyancy gas from the point of safety. However, it cannot be said that there is a sufficient supply of helium. In the future, it seems that it would be best if hydrogen were used. Furthermore, the buoyancy of Hydrogen is 13% greater than that of He. It is also advantageous from /50
the point of effective loads.

The gas turbine of the driving engine uses hydrogen as fuel. If liquid hydrogen and hydrogen gas are used as fuel in the proper ratio, there is the advantage that regulation of buoyancy during operation can be carried out at will. The basic structure of the electric propulsion system from this idea is shown in Figure 2.

2.2 Solar Cells

The most appropriate method for using solar energy from the point of weight is the method whereby thin film solar cells are used. In comparison with conventional solar cells, the thickness of the thin film solar cell is very small at 0.1 mm and a high surface area can be covered. The cost is also lower. One example

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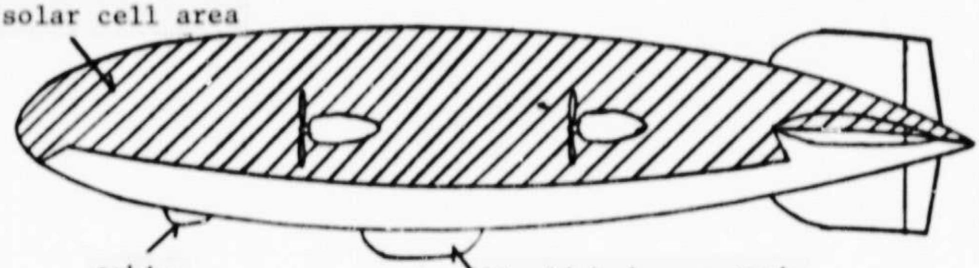

Figure 1. Appearance of an airship that employs solar energy.

TABLE 1. DETAILS OF AIRSHIP THAT USES SOLAR ENERGY

	Type— A	Type— B
length (m)	550	240
diameter (m)	110	48
gas capacity (m^3)	2.45×10^6	2.15×10^5
passengers	4	4
empty weight (tons)	1,160	110
total weight with equipment (tons)	2,620	230
effective load (tons)	1,400	110
engine (HP)	7,000	1,350
fuel	hydrogen	hydrogen
generator (Kw)	4,720	900
motor (HP)	6,270	1,210
solar cell efficiency (%)	10	10
cruising speed (Km/h)	80	80

of a thin film solar cell that is being developed for use in a solar driven satellite by NASA is shown in Figure 3. Furthermore, NASA estimates that the efficiency of this solar cell is about 18.2%.

The amount of heat from the sun that comes to earth on a clear day is about 1 Kw per $1m^3$. On the other hand, when the

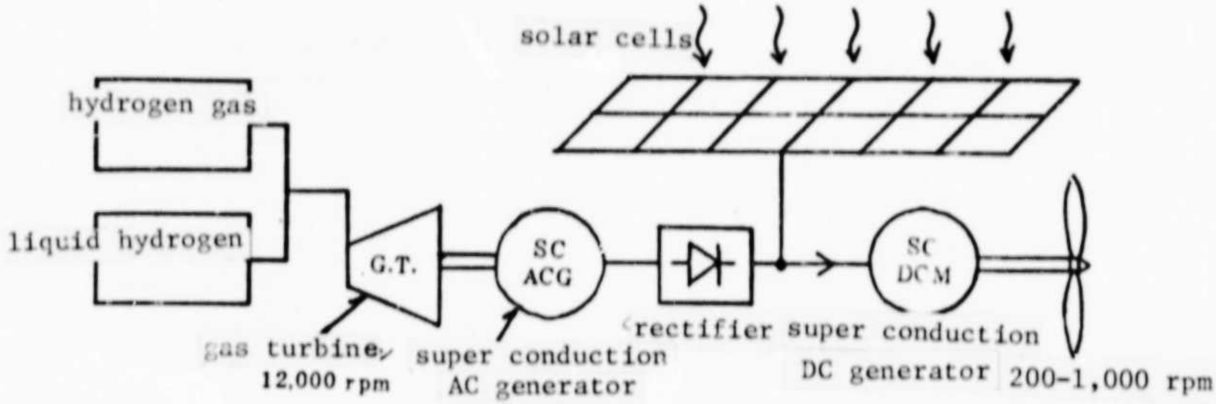

Figure 2. Basic structure of the propulsion system.

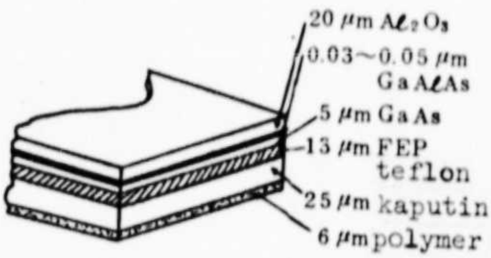

Figure 3. One example of a thin film solar cell.

total efficiency of a solar cell (value when loss of lead sires, etc. is considered) is 10%, solar energy of 100 W per 1 m^2 can be obtained on a clear day.

The weight of thin film solar cells is about 30 g per 1 m^2. It is possible to use the outside shell of the airship as the base of the solar cell. Furthermore, this would reduce the weight even further. In any case, when compared with the weight of the airship shell (about 1 Kg/m^2) the solar cells are so light that they can be disregarded. In general, even though the thin film solar cells are installed on the hull of the airship, an increase in weight due to the cells will probably present no problems.

The lost cost of the solar cells was announced by the U.S. DOE (Department of Energy). According to the announcement, in the last half of the 1980's they expect the cost to drop to \$0.5 per an output of 1 W. /51

2.3 Hydrogen Fuel Gas Turbine

Solar cells cannot produce output during night-time or when it is raining or cloudy. In this case, other auxilliary sources of energy are necessary. For this reason an electrical source with a gas turbine as the motor is used. Today gas turbines are very light weight and their weight per output is about 0.2 Kg/kW.

As was previously mentioned, hydrogen is used as the fuel. The density of hydrogen liquid is very light at 0.071 Kg/l and therefore, it is suitable as fuel used for aircraft. The use of hydrogen as a jet engine fuel is being tested in the U.S. by Boeing, Grumman and Lockheed. Moreover, a hydrogen energy system has been proposed as a future energy system. It seems that in the future hydrogen fuel systems will be used. The buoyancy of hydrogen is 1.12 Kg per 1 m^3. Therefore, in order to fix the buoyancy, in relation to weight, a ratio of liquid hydrogen: 92.6% and hydrogen gas: 7.4% should be used as fuel. When we consider flying with only a 10 hour gas turbine, about 4.3 tons of liquid hydrogen (about 61 m^3) and about 0.35 tons of hydrogen gas(under standard conditions about 3,870 m^3) should be used for fuel for aircraft Type A in Table 1 (payload of 1,400 tons).

2.4 Superconduction Rotary Device

In addition to the fact that output from solar cells is used, the following can be mentioned as advantages of the electrical propulsion system:

1. Exchange of slow speed adjustment during take off and landing and front and back revolution is easy; /52

2. Automation and control are simple;

3. Arrangement of motor and propulsion devices are chosen at will;

4. Gear reduction is unnecessary;

5. Pitch control of the propeller is unnecessary;

6. A generator for supplying electricity inside the hull is unnecessary.

Nevertheless, when conventional generators and motors are used there is a large increase in weight. This problem can be solved with superconduction. The U.S. GE Company's plan is one example of a plan for superconduction generators used for flight. It is an AC generator with an output of 20 MW and rotational frequency of 12,000 rpm. The weight per output is about 0.05 Kg/kW. There are no examples for plans for a motor that is propeller driven for use during flight. However, judging from the examples of plans for a vessel propulsion, it is possible to have a weight/output ratio of less than 1 Kg/kW.

With today's technology, the use of liquid He is indispensible for the use of superconductors. Therefore, it is necessary that an He liquefaction device be installed. It must be possible to use liquid hydrogen fuel for heating and cooling and the He liquefaction device should be very small. Moreover, in the future, if materials that attain superconduction conditions with the temperature of liquid hydrogen (about 22 K Ø) are made, an He liquefaction device will not be necessary.

The results of computing the weight of each device in a propulsion system are shown in Table 2. Furthermore, for reference sake, the estimated weight of the engine parts of a Type-A aircraft (excluding the propellers and gears) is 120-250 tons, based on data from past aircraft. In comparison to this estimate, the weight of this propulsion system in this plan is very small (9.7 tons).

TABLE 2. WEIGHT OF ELECTRICAL PROPULSION SYSTEM

	Type A	Type B
motor (Kg)	940	180
super conduction generator (Kg)	240	50
super conduction electric motor (Kg)	4,720	900
solar cells (Kg)	2,300	440
helium liquefaction device (Kg)	1,500	500
Total (Kg)	9,700	2,070

3. Motion Properties

According to the studies of the Transportation Ministry Electronic Technology Research Lab, the annual amount of direct sunlight is about 10^6 Kcal per 1 m^2. When the average annual solar energy is computed from this value, it is about 130 W per 1 m^2. With the aircraft in this plan, when the cruising speed is 80 Km/h, regardless of weather conditions, the economy of fuel with solar energy is about 13%. Nevertheless, if the flight of the aircraft is limited to 8-9 hours during the day, an average of 38% of the fuel can be saved.

The aforementioned computations are estimates of only domestic flight in our country. When flights are carried out in low longitude areas (for instance, the South Pacific, North America, the Arabic Penninsula, and Northern Australia), the amount of sunlight is clearly large. With the appropriate flight plans it is possible to save more than 50% of the fuel. /53

With concrete flight plans, the number of days of flight is about 1.5 days for long distance flights of about 3,000 Km. If flying begins in the morning, so that arrival is the next evening, the efficiency of using solar energy can be large. Even with longer flight distances, flight plans should be made so that as many flight hours as possible will be during daylight hours.

As was previously mentioned, regulation of buoyancy can be carried out during flight by proper ratio of liquid hydrogen and hydrogen gas. Furthermore, when the buoyancy needs to be adjusted in emergencies, it is necessary to emit hydrogen gas into the atmosphere. When hydrogen is used as the buoyancy gas, the fact that this operation can be carried out with ease is one advantage.

4. Uses and Future

4.1 Long Distance Transoceanic Transport of Liquid Hydrogen

The Pourshe plan, which was suggested by Professor Jidan Fuda of the Yokohama National University, is a method for finally solving the energy crisis. According to this plan, a large raft floats on the South Pacific Ocean, where there are the most number of daylight hours and the solar rays are strong, and generation of electricity is carried out with solar energy. Hydrogen is obtained by electrolysis of the ocean water with this electricity. In this plan, there is a problem with how the hydrogen that is produced will be transported to land for consumption.

The density of liquid hydrogen is very low at 0.071 Kg/l. When this is transported with a common tanker, the surface area is very large in comparison with the weight, and the travelling resistance of the vessel is too large. When liquid hydrogen is transported only about 1/14 of the weight of petroleum, which has a specific gravity close to 1, can be transported with the same size vessel.

In contrast to this, because originally the size of the hull of aircraft was large, the capacity of the liquid hydrogen cargo was so small that it could be disregarded in comparison with the capacity of the hull itself. There was hardly any change in the travelling resistance. That is, aircraft are probably the most appropriate type of vessel for transporting substances with low densities, such as liquid hydrogen.

Now, we will try to consider the transport of liquid hydrogen with Type A aircraft. Because the effective load is 1,400 tons, when this is converted to energy it becomes 4.72×10^7 kWh per 1 ship. If liquid hydrogen supplies a power plant with an output of 1,000,000 Kw (heat efficiency of 40%), it is necessary that an average of 1.27 ships arrive each day. When the transport distance is 5,000 Km, there must be 8 aircraft. According to the 1970's long term energy supply and demand forecast of the Ministry of Transportation's Industrial Technology Department, the annual amount of petroleum that is imported is 366,000,000 kl. When this is replaced with liquid hydrogen, it is about 233 aircraft per day. When the transport distance is 5,000 Km, it is necessary to use about 1,500 Type A aircraft, provided that the /54 weight of material per 1 aircraft does not exceed about 1,000 tons, and construction of the aircraft could be carried out domestically.

Furthermore, in comparison to common tankers (LPG vessels), when we considered the fact that the capacity of 1,400 tons of liquid hydrogen is about 20,000 m^3 and the flight speed (80 Km/h) is about 3 times that of common tankers (about 27 Km/h), the transporting ability of a Type A aircraft is the equivalent of a 60,000 ton tanker.

4.2 Transport of Hydrogen to Inland Areas

As was previously mentioned, plans are being established by the U.S. companies of Boeing, Douglas, and Lockheed to fly private subsonic speed aircraft carrying several hundred passengers with liquid hydrogen as the fuel. According to the report where Boeing and Douglas received a commission from NASA, a 400 passenger plan (0.85 Mach) will fly 59 times/day inside the U.S. and 11 times/day oversea. Out of the 11 overseas trips, 5 will be to Japan. Therefore, Japan will have to supply some liquid hydrogen.

The liquid hydrogen capacity of one plane is 28 tons (about 390 m^3). Therefore, several hundred tons of liquid hydrogen will have to be supplied each day. The international airport in Japan is the Narita Airport. Because it is inland, the transport of liquid hydrogen to the airport will be complicated. Tanks must be used to transport this liquid hydrogen inland at this time. However, because of the restrictions on road transport, a maximum of only 50 m^3 can be transported. The transport of a large amount of hydrogen would be effective without the restrictions on road transport.

In particular, because the emission of evaporated hydrogen gas into the atmosphere is forbidden and transporting must be carried out with all valves closed during travelling to insure safety, in contrast to the fact that the tank must be a pressure resistant type (2 atmospheres with absolute pressure), during transport with aircraft, the hydrogen gas that has evaporated can be emitted into the atmosphere, or can be released into a hydrogen gas bag. Therefore, aircraft transport has an advantage in that it is not necessary to make the tank into a pressure resistant type.

With liquid hydrogen transport using aircraft, the operation of transshipment at the airport, as in the case with tanks and tank trucks, is not necessary. Moreover, there is an advantage in that transport to land can be continuous with the same aircraft used for ocean transport.

Furthermore, the results of comparing the liquid hydrogen transport efficiency with aircraft with the efficiency of tankers (LPG vessels) and tank trucks is shown in Figure 4. This is the case, provided that during transport with aircraft, it is possible to save 30-50% of the fuel by using solar energy. Therefore, from the aspect of fuel consumption, efficiency is much higher with aircraft transporting.

5. Conclusions /55

The plan for aircraft that employ solar energy has been explained above. The following can be said in conclusion.

(1) The hull of the aircraft is employed as the solar cell area covering the largest surface area. During clear days the aircraft can fly at a speed of 80 Km/h using only the output from the solar cells.

(2) An electricity propulsion system using a superconduction rotary device is light weight and can be easily controlled. The output from solar cells can be efficiently employed.

(3) The combination of hydrogen energy system has been considered for the future. In comparison to other types of transporting systems for liquid hydrogen with a low density, this system has a high transporting efficiency.

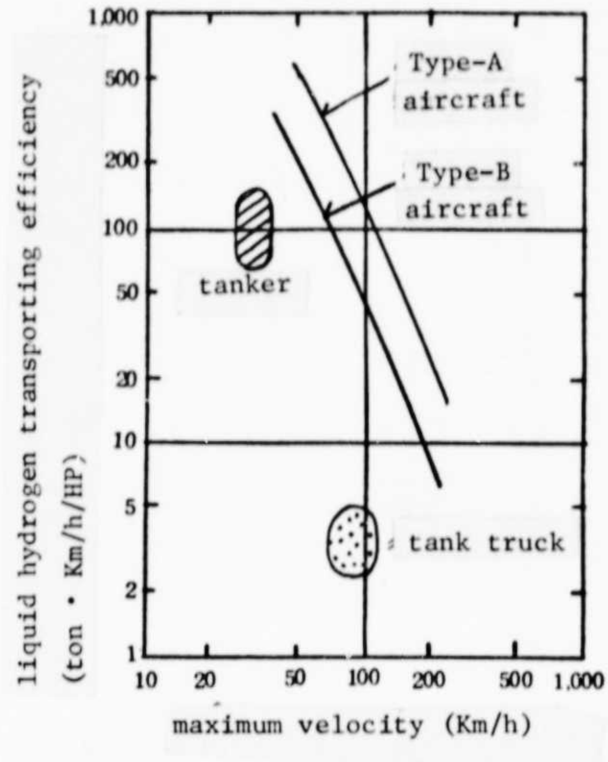

Figure 4. Liquid hydrogen transporting efficiency of each type of transporting device.

Furthermore, the technological problems that must be solved in the future are:

(1) Development of inexpensive thin film solar cells;

(2) Development of superconduction rotary devices with high reliability that are light weight, and

(3) Establishment of a broad range of safety countermeasures, including a thunder damage prevention system.

There are many problems and risks with the development of new technology. However, today Japan feels that it is necessary to develop new technology in order to solve the energy crisis. It is felt that one of the most important developments is that of aircraft as devices for energy-saving transport.

In conclusion, we would like to thank Professor Tosho of the Tokyo University and Aviation Research Labs for its technical information, and we would also like to extend out appreciation to Mr. Wasei Bansho of the Buoyant Aviation Committee for his help in presenting this text.

ON THE CONSTRUCTION OF A METALCLAD AIRSHIP

Yoichi Heino*

This text will briefly explain the construction of a metalclad airship.

1. Introduction

Metalclad airships have longerons reinforced in a vertical direction, ring frame reinforced in the direction of the circumference, and a metal outer shell. They are used by exerting internal pressure. The original shape of the metalclad airship was made by Schwarz of Australia in 1887. The airframe had a total length of 155 ft., an maximum diameter of 44 ft., and a capacity of 130,000 cu.ft. The outer shell was made from aluminum. This airship was destroyed because it could not land due to obstruction of the propulsion system during the first flight. An airframe of metal called the ZMC-2 was made by Upson and Fritsche in the U.S. in 1929, 32 years after this airship of Schwarz. The airframe had a total length of 149 ft. 5 in., a maximum diameter of 52 ft. 8 in., and a capacity of 202,200 cu.ft. Its performance is as shown in Table 1. The ZMC-2 was dismantled 12 years after its first flight. Consequently, during this time there were probably no problems with the airship. Upson and Fritsche considered making a practical MC-25 using this airship as the basis for their work. The MC-25 had a total length of 472 ft., a maximum diameter /56

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of 105 ft., and a capacity of 2,540,000 cu. ft. The plan was for the MC-25 to fly between California and Hawaii. However, this was never realized. This report will describe the construction of a metalclad vessel based on the 2 detailed reports on the ZMC-2 [1,2].

TABLE 1. ZMC-2 PROPERTIES

Total buoyancy	12,242 lb.
Empty weight	9,115 lb.
Effective buoyancy	3,127 lb.
Travelling radius	680 miles
Cruising speed	50±2 mph
Maximum altitude	9,000 ft.
Total length	149 ft. 5 in.
Maximum diameter	52 ft. 8 in.
Capacity	202,000 ft^3

2. Outline of the Structure of AMC-2

The outside of a so-called flexible vessel is made from an outer shell, a shearing wire, a gas pressure wire, and a gas bag. It is complex and there is a lot of waste. Thereupon, the ZMC-2 was designed to replace this flexible vessel by using a metal pl te. By using metal, improvements such as flame retardence, durability, resistance to secular changes, etc. were obtained. /57

Three sides of the ZMC-2 and a photograph are shown in Figures 1 and 2. The ZMC-2 is made from 24 longerons, arranged in regular intervals, 12 ring frames and an aluminum alloy chin plate for the outer shell (refer to Figure 3). The aluminum alloy longerons are omega (Ω) Ø shaped. The flange is connected to the outer plate with rivets. The height of the longerons cross-section is 1 in. at the bow and stern and 2 in. at the other areas. Holes to make the ship lighter are found on the longerons with a

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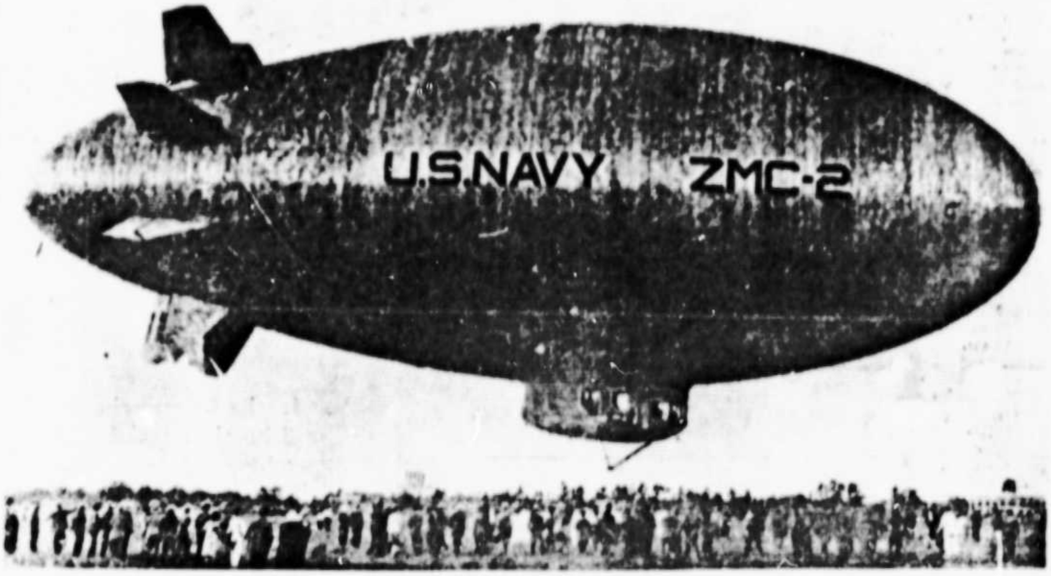

Figure 1. ZMC-2 [2].

height of 2 in. The longerons are 0.014 in. (0.36 mm) to 0.032 in. (0.8 mm) thick. The ring frames are divided into 5 main ring frames and 7 auxilliary ring frames. All of the cross sections are triangular. The height of the cross section of the main ring frame is 8 in. The base is 8-10 in. The 3 sides of the triangle are connected at the peak with channel materials. The thickness of the channel materials is 0.025 in. (0.64 mm). The thickness of the wave is 0.020 (0.51 mm). The thickness of the base is 0.014 in. (0.36 mm). Each ring frame is divided into arcs. Then they are assembled. The outer shell is an aluminum alloy plate with a thickness of 0.0095 in. (0.24 mm). First, 142 cone shells are joined with rivets to make a airframe shape. Aluminum wire is used for the rivets with a diameter of 0.035 in.(0.89 mm). An automatic riveting device is used for this purpose. The total number of rivets used is 3,500,000. A shiranto is inserted after rivet joining in order to maintain airtightness.

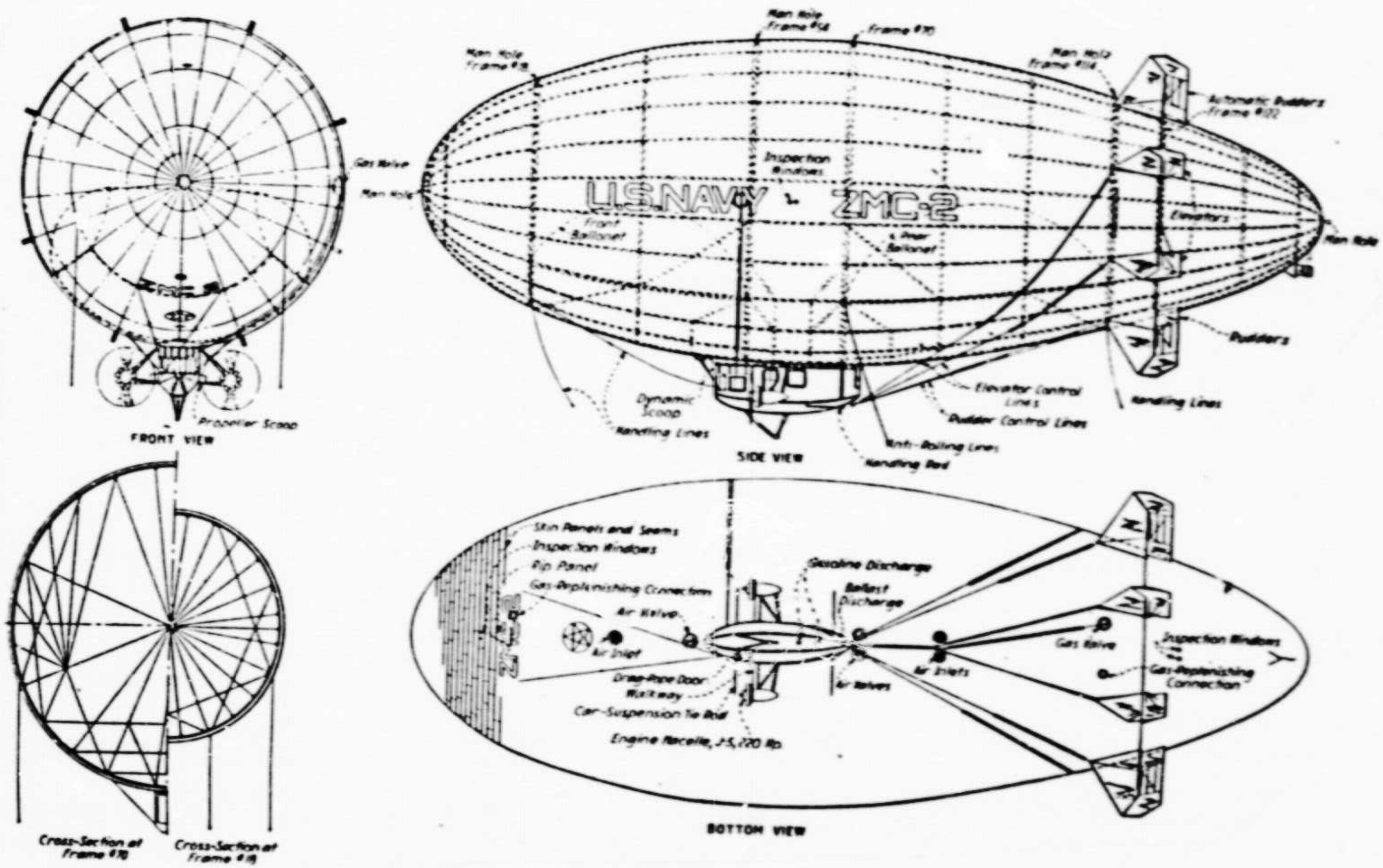

Figure 2. Outline of the ZMC-2 [2].

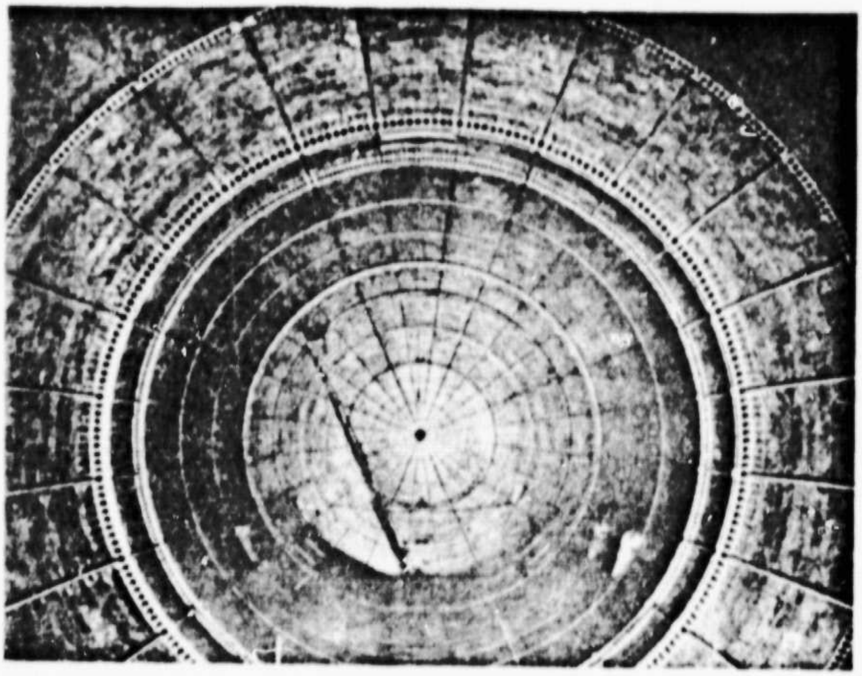

Figure 3. Internal structure of the ZMC-2 [2].

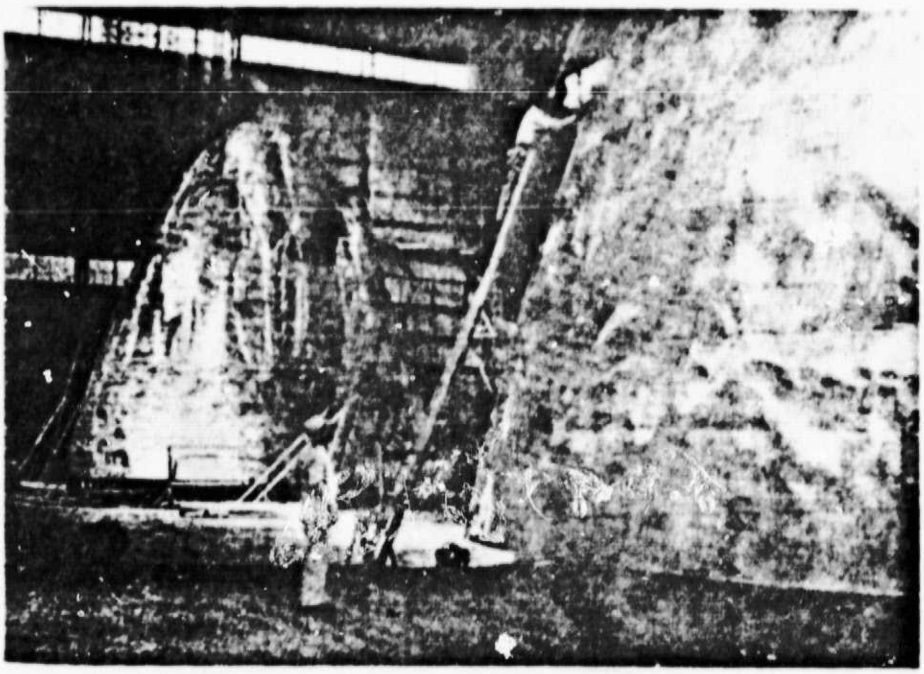

Figure 4. Outer shell with an internal pressure of 0 [2].

3. Consideration of the Metalclad Hull

The author considers the metalclad vessel to be flexible vessel from the point of structural dynamics. Longerons and ring frames were used in the ZMC-2 and therefore, at first glance it seems to be a rigid vessel. However, the longerons /60 are used for shape maintenance when there is no pressure difference between the inside and outside of the airframe. It is difficult to consider longerons used for bending moment because of the total surface area. Moreover, the ring frames maintain the shape when there are no pressure differences and disperse the load of the gondola and tail assembly to the airship. Even with a flexible vessel the load is sufficiently dispersed through the airframe. Consequently, the outershell made from a thin plate of an aluminum alloy is nothing more than the counterpart of the outer shell of a flexible vessel. As shown in Figure 4, when the outside pressure in the vessel is not maintained, the outer shell collaspses. Under this type of condition, the outer shell cannot obtain compressive force due to bending moment. Compressive force is obtained inside the cylinder of airplanes by maintaining shape when the outside plate (outer plate) is firm. For example, because the longerons are inserted, even though the outer shell is indented, compressive force is obtained in part of the outer shell with the longerons. However, in the ZMC-2 the longeron intervals are very large and compressive force is obtained only with the longerons when the outer shell is collapsed. As can be seen in the photograph in Figure 1, the outer shell that is collapsed is made taut by building inside pressure. Next, we can consider whether or not the bending moment can be obtained with a shell when inside pressure is exerted.

A so-called air film construction is a construction that is used by exerting inside pressure on the construction made from a film. It seems that one of the restrictions to the use of this type of structure is the stage wherein wrinkling is produced due to compressive force. Research was carried out on how the axial curvature of the ring frame changed with the axial tension caused

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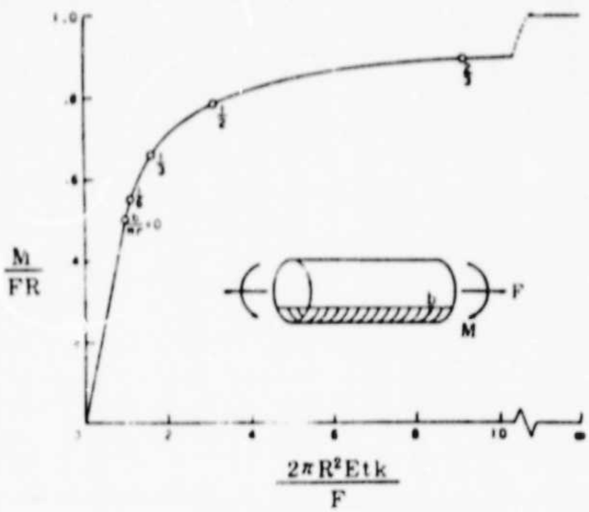

Figure 5. Correlation between the bending movement and curvature of the cylinder affected by axial strength [3].

by pressure when the bending moment was exerted after pressure was built in the cylinder made from the film [3].

The correlation between the bending moment M and curvature K when bending moment M is placed on the cylinder made from a film with radius R, thickness t, and material Young's modulus E, which are shown in the figure also, is shown in Figure 5. Here F is the axial tension. With only the internal pressure p, $F=\pi R^2 p$. Moreover, b is the distance between the region where wrinkling is produced and the region where wrinkling is not produced, which were determined at the lowest area. According /61
to Figure 5, when the point where wrinkling is produced on the compressed side of the cylinder by exerting moment M, becomes the usage limit

$$M/FR = 0.5 \qquad (1)$$

is obtained. Of course, if the axial tension is 0, bending moment M can not be exerted.

With airships, when the difference in pressure from the outside of the lowest part of the hull (super pressure) is made p_o, the height from the lowest part is made h, and the buoyancy per unit capacity is made k (with He, about 1 Kg/m^3), the difference in pressure between the outside and inside is

$$P = p_o + kh \tag{2}$$

Thereupon, by considering the shape of the airship to be cylinder with radius R, when axial tension F, which is caused by the aforementioned pressure difference p, is computed, it becomes

$$F = \pi R^2 P_o + \pi k R^3 \quad . \tag{3}$$

The production of wrinkles when bending moment M is added to the hull, to which this tension has been added, is one of the usage limits. We have decided to use the bending moment Me [4], which is given with the equation, as the bending moment exerted on the hull.

$$Me = 0.01\ qV^{2/3}L \tag{4}$$

Here q is the dynamic pressure (1,2) ρv^2 is the hull capacity and L is the total length. In the case of the ZMC-2, when $V = 2.022 \times 10^5\ ft^3 = 5.73 \times 10^3\ m^3$, L = 149 ft 5 in. = 45 m, and the dynamic pressure is v = 60 m.p.h. = 2.67×10 m/s, q 4.46×10 Kg/m2. Consequently,

$$Me=0.01x4.46x10x(5.73x10^3)^{2/3}x45=6.42x10^3(Kg \cdot m) \tag{5}$$

Me is smaller than the critical moment

$$M = 0.5\ R\ (\pi R^2 p_o + \pi k R^3) \tag{6}$$

which is found from equations (1) and (3). That is,

$$6.42 \times 10^3 (Kg \cdot m) < 0.5 \pi R^3\ (p_o + kR) \tag{7}$$

Now, with $R = 7$ m and $k = 1$ Kg/m^3, the necessary super pressure is

$$p_o > \frac{6.42 \times 10^3}{0.5\pi R^3} - kR = 11.9 - 7 = 4.9 \ (\text{Kg/m}^2) \qquad (8)$$

when found from equation (7). That is, the wrinkling is produced with Me when there is a pressure difference of more than 4.9 Kg/m^2 at the lowest part of the hull. This corresponds to an 0.2 in. column of water. Normally, this pressure difference is said to be a 1 in. column of water with conventional flexible vessels. In the aforementioned it is clear that the ZMC-2 is made from a structure where internal pressure is exerted.

Next, we will try to consider the differences between an outer shell that is commonly used in flexible vessels and the outer shell of aluminum alloy plates. In Figure 5 the axis of abscissus is $2\pi R^2 Etk/F$. Young's modulus E, the materials of the film, is included in this. Consequently, if E is large in contrast to the bending moment that is given, the curvature K is small. Because E of aluminum alloy plate is larger than E of common flexible hulls, there are fewer changes in the shape of metalclad airships due to bending than with common flexible vessels.

Finally, we will briefly consider weight. Because the weight of an aluminum alloy plate with a thickness of 1 mm is 2.8 Kg/m^3, the outershell of the AMC-2 with a thickness of 0.24 mm is 0.67 Kg/m^2. Because data on outer shells of flexible vessels is not available, we will consider a water proof nylon canvas. The weight of a nylon canvas with a thickness of 0.8 mm (tension in the direction of the circumference is sufficiently withstood, due to internal pressure of an airship with a diameter of 14 m) is 0.6 Kg/m^2. Therefore, from the view point of weight, the metalclad airship is a rival of the flexible vessel in all ways. /62

4. Conclusion

The authors state that the metalclad airship is not constructed on the basis of the construction of conventional airships. This is due to the fact that only the aluminum alloy outer shell of the metalclad airship corresponds to the common flexible airship outer shell. Today, fibers with a relatively high tensile strength, such as Kevlar are used. The properties of these composite fibers improve on the aluminum alloy. Thereupon, the cloth made from Kevlar reinforced fibers is used for the shell and when necessary, longerons and ring frames made with carbon fiber composite materials are used. A flexible airship made in this way is probably one candidate for the future. Furthermore, please refer to reference [5] for an explanation of the general construction of an airship. /62

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SUMMARY OF INVESTIGATION RESEARCH REPORT ON THE 2nd LTA BY THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)*

Kingo Chodaku - translator (Aviation and Space Technology Research Lab New Aircraft Research Group)

/This article was not translated into English/

*Translator's note: The original source is not given.

CHAPTER II

ACTS AND OPERATIONS OF THE BUOYANT FLIGHT ASSOCIATION /72

CONTENTS

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Balance Sheet for 1979	108
Business Plans for 1980	112
Budget for 1980	114
Association Laws	117
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FISCAL REPORT FOR 1979

(1) Trends in Japan
(2) Acts of this Committee
(3) Membership
(4) Financial Affairs of this Association

(1) Trends in Japan

The following are the 3 trends for 1979 in the LTA aircraft.

1. The large scale project of LTA aircraft, which was tested by the Transportation Ministry's Industrial Technology Agency, failed.

2. France, America, etc. participated in a technological symposium to facilitate international exchange. Face to face communication exchange was opened upon the research done by each country. The head of the American Coast Guard visited Japan to discuss development of aircraft for ocean patrol, etc.

3. Propaganda flights were carried out semi-annually inside Japan with the airship of West Germany's WDL Company. This was planned by TV companies in observance of the International Year of the Child.

(2) Acts of this Association

Four regular meetings of this association, including the general conference of May 28, 1979, well opened and this association participated also in the Tokyo University Space and Aviation Research Symposium.

The 1st of the 4 regular meetings was co-sponsored by the Aviation and Space Industries Association. Rear Admiral Manning of the U.S. Coast Guard delivered an address to this meeting. A total of about 200 people participated in this meeting.

Moreover, the association journal was issued twice, in May and July. They were entitled "LTA for Passenger Transport" (73 pages total) and "Overseas Investigation Report" (82 pages).

In addition, the members compiled 2 pamphlets as reference materials. One is "Addresses and Reports by Members of Foreign Aviation and Space Industries" (Japan Aviation and Space Industries Association). This details the aforementioned lecture of Rear Admiral Manning. This association planned the lecture and invited Mr. Manning. This association was in charge of the details of the address. The other reference material is "Preliminary Manuscript on the Tokyo University LTA Symposium". This was compiled with the funds from this association, after obtaining permission from Tokyo University Aviation and Space Research Department.

The aforementioned 2 1979 pamphlets appeared as reference materials in magazines at the end of April, 1980.

The main studies and lectures of the 4 regular sessions, /74
with the exception of the Tokyo University LTA Symposium, are as follow.

May, 1979 regular meeting: annual regular conference
"Overseas Observation Report"
Mr. Azuma (Tokyo University Professor)
Mr. Harabo Shomatsu (Tokyo Shiura Production Department Head)

May regular meeting: "Supply and Demand of Helium"

Shomitsu Tanaka (Japan Helium - business department)

"Participation in U.S. Balloon Contest"

Mr. Mitsuro Shiyashi (balloonist - Japan Balloon League)

October regular meeting: "Possibility of Using Airships for overseas Patrol"

Rear Admiral P.A. Manning (U.S. Coast Guard Research and Development Division Head)

January, 1980 regular meeting: "Operation of WDL Airships and Future Prospects"

Mr. Taiben Tominaga (Japanese Representative to the WDL Company of West Germany)

"On the Conditions of Hydroplanes and their Possibilities"

Mr. Tekiumu Shoya (Shinmeiwa Aviation-technology division head)

Furthermore, many members of this committee made presentations at the Tokyo University LTA Symposium, which opened on March 6, 1980.

(3) Membership (figures in parentheses are for the previous year)

individuals	109	(95)
corporations	11	(11)

(4) Financial Affairs of the Association (please refer to the balance sheet)

a) over-all condition

income for this period about 2,870,000 yen (balance from previous fiscal year + 280,000 yen)

expenditures for this period about 2,950,000 yen (balance from previous fiscal year + 400,000 yen)

difference between income and expenditures -80,000 yen

total of balance forwarded up to previous period 320,000 yen

balance forwarded to next period 320,000 yen - 80,000 yen = 240,000 yen.

With regard to income and expenditures, the committee was in the red for 80,000 yen this period. This was due to the payment for the manuscript (6 people) of the first committee journal, which should be published in 1980. The balance forwarded to the next period is a large sum. Since we would prefer to have a balance (usual practice of corporations, etc.) we will pay for the manuscript soon.

b) over-all condition of receipts (total of 2,870,000 yen) /75

balance of corporate fees from previous year - 100,000 yen

balance from previous year for individual fees - 0 yen

balance from previous year for regular meeting cost - 50,000 yen

balance for previous year from miscellaneous expenditures + 350,000 yen.

There was a decrease in receipts in comparison to the previous year with regard to the cost of regular sessions. This was due to the fact that the first regular meeting was free. This was the session that was co-sponsored by the Aviation and Space Industries Association. This association was in charge of the basic idea and business of the meeting. The former was in charge of the meeting location cost, the lectures, and cost of printing, etc. For this reason, the "receipts from the annual meetings" decreased.

Miscellaneous receipts include planning receipts, including overseas investigation corporation dispatches (about 440,000 yen), etc.

c) over-all condition of expenditures (total of 2,950,000 yen)

the costs related to the association journal will be forwarded to next year.

There has also been a gradual decrease in the business office expenditures.

The association journal expenditure is - 80,000 yen.

The 450,000 yen overseas extension cost is a new heading. (This is counterbalanced with the cost of planning, including overseas investigation delegate dispatch.)

d) difference between expenditures and receipts

For this term only, the difference in receipts and expenditures was - 80,000 yen. The reason for this was already explained in (a) "over-all conditions".

The total of the balance forwarded up to the previous fiscal year was 320,000 yen. Therefore, the balance forwarded to the following year is (320,000 yen - 80,000 yen) = 240,000 yen.

BALANCE SHEET

STATEMENT OF PROFIT AND LOSS (APRIL/79-MARCH/80)

[the figures in parentheses are for the previous fiscal year (units:yen)]

(1) Reports

Corporate annual fees (11 corporations)	1,800,000	(1,900,000)	12 corporations
Individual annual membership fees (67 people)	328,950	(342,000)	69 people
Regular meeting fees (4 times/year)	217,500	(366,500)	3 times/year
Miscellaneous receipts	528,485	(181,240)	
Total receipts	2,874,935	(2,789,740)	

(2) Expenditures

Meeting lectures (regular meeting, management meetings)	291,705	(371,880)	
Lecturer renumeration	32,000	648,000	(652,171)
Journal publication	336,000		
Printing expenditures	280,000		
Data expenditures	69,071	(112,696)	
Business expenditures	1,414,952	(1,427,330)	
a) business expenditure	214,925		
b) business office expenditures	1,200,000		
Part time expenditures	78,750		
Overseas extension	450,000		

Balance sheet continued.

Price reduction	0	(Δ14,000)
Total Expenditures	2,952,451	(2,550,077)

Difference between expenditures and receipts for this period —
(1)-(2) Δ77,516 (239,663)

BALANCE SHEET FOR 1979 (S 4/79-3/80) /77

figures in parentheses are for previous fiscal year (units:yen)

(1) Assets

Cash	144,506	(9,306)
Ordinary bank account	96,389	(220,085)
Postal savings	3,385	(182,405)
Total of Assets	244,280	(411,796)

(2) Debts/surplus

Balance forward from previous term	321,796	(82,133)
Difference between receipts and expenditures for this term	△77,516	(239,663)
Total of debts/surplus	244,280	(321,796)

AUDITING REPORT FOR BUDGET FOR PREVIOUS PERIOD /78

Auditing Report

With regard to the 1979 fiscal year budget of the Buoyant Flight Association of Japan, the budget was audited and the receipts and expenditures seemed to be in order.

1980 May 1, 1980
Committee Chairman - Seimi Bokubura

Buoyant Flight Association of Japan
Association Budget Auditor Jisui Nagamura

PLANS FOR 1980

This association will enter its 7th year. It has made progress as a research association. The regular meetings will continue and there will be a slight increase in their frequency. There will also be an increase in the publications of the association journal and reference pamphlets.

There will also be a sponsored study, which was "Buoyant Aviation Conference" last year. This will be "Foreign Trends in LTA Technology", which will be entrusted by the Japan Aviation and Space Industries Association. This will be published in the new year and will be entered in the "New Year" as an operation.

The committee will carry out basic research and studies in the new year. In fact, we have already been doing this.

From this viewpoint, the 2 basic new year operations are the following.

1. Establishment of a Pacific Ocean Crossing Balloon Research Committee.

2. Establishment of a "Buoyant Helicopter System" Research Committee.

[Explanation]

Last year a small group participated in 1. This year a basic report will be issued and the members in charge will be determined.

As a result of tests on 2, plans for producing and testing a helistat will be made. A helicopter veteran group (3 people, head of agencies for civilian transport) participated in the association (at the end of last year). This group can develop a new model airplane by combining solar operation and the knowledge of the model aircraft group. They will also receive help from aircraft experts, such as Mr. Azuma (Tokyo University professor) and Mr. Gikyoku Beni (Kawasaki Heavy Industries). We anticipate the first basic plan and summary reports by this fall.

We would of course like to continue previous operations along with new ones this year.

As was previously explained, based on the new year operation plans, we would like to propose the following budget for the new year.

BUDGET FOR 1980

Income and expenditure plans for the new year (1980)
(April 1, 1980 - March 31, 1981)

Receipts

I	Corporation membership fees (annual) (Y 200,000 x 11 corporations + 10 corporations)	4,200,000 yen
II	Individual membership fees (annual) (Y 5,000 x 90)	450,000 yen
III	Meeting fees (5 times/year, Y 80,000/one time)	400,000 yen
IV	Balance Forwarded	240,000 yen
V.	Investigation and research funds	2,000,000 yen
VI.	Miscellaneous receipts	10,000 yen
	Total	7,300,000 yen

Expenditures

I.	Lecture expenditures (regular meeting, management meetings)	450,000 yen
II.	Lecturer reimbursements	100,000 yen
III.	Journal publication (printing, manuscript, etc.)	400,000 yen
IV.	Printing (regular committee reports, etc.)	300,000 yen
V.	Reference pamphlets	300,000 yen
VI.	Business office expenditures	1,900,000 yen
	a) business expenditures (mail, telephone, travel, entertainment, etc.)	(400,000 yen)
	b) business office expenses (salaries, rent, etc.)	(1,500,000 yen)
VII.	Part time expenses	100,000 yen
VIII.	Studies and research (entrusted by the Space and Aviation Industries Association)	1,300,000 yen
	a) research	(600,000 yen)
	b) manuscripts (planning, manuscripts, compilation, proofreading, etc.)	(700,000 yen)
IX.	Experiment and research plans	2,150,000 yen
	a) Pacific Ocean crossing balloon plans	(150,000 yen)
	b) buoyant helicopter system plans	(250,000 yen)
	c) changes in plans	(1,750,000 yen)

Expenditures continued.

X.	Balance forwarded to next year	300,000 yen
	Total	7,300,000 yen

BUOYANT AVIATION ASSOCIATION LAWS (as of June 1978) /82

Section 1

Clause 1. This association is called the Japan Buoyant Flight Association.

Clause 2. This association will encourage the exchange of scientific and technological knowledge in buoyant flight and related fields. In addition, it will strengthen general recognition of the importance of these fields.

Clause 3. In order to accomplish the aforementioned purposes, this association will carry out the following operations.

1) opening of research meetings, training courses,discussion groups, etc.

2) publication of journals, bibliography summaries, etc.

3) collection of information both inside and outside of Japan dealing with buoyant aviation and related fields.

4) carry out related activities with printed materials, group discussions, etc.

5) anything in addition to the aforementioned that is necessary to achieve the purpose of the association.

Clause 4. The business office of this association will be located in the Scientific and Technological Development Center of the 17th Hayashi Building at 1-26-5 Sonomon, Minato-ku, Tokyo-to.

Clause 5. There are 3 types of members of this association, individuals, students, and corporations.

Clause 6. The individual members should support the purpose of the establishment of this committee and should be admitted to this association in accordance with the following headings.

1) research for scientific technology pertaining to buoyant aviation.

2) participation in studies, statistics, bibliography summaries, etc. pertaining to buoyant aviation.

3) participation in operations pertaining to buoyant aviation.

4) participation in other fields pertaining to buoyant aviation other than the 3 aforementioned items.

Clause 7. The corporate membership is members or corporations paying membership fees, in accordance with the purposes of this association.

Clause 8. The individuals and students must pay membership fees.

Clause 9. Individuals, students, and corporate members may attend all technical and scientific meetings of this association.

Clause 10. The members may receive copies of printed materials issued by this association.

Clause 11. Anyone wishing to become a corporate, student or individual must apply in accordance with stipulated regulations.

Clause 12. Any individual, student or corporate member wishing to withdraw from the association must report to the head of the association. /84

Clause 13. Any individual who has been judged inadequate as a member of this association by the managing committee and any corporate member who has not paid funds for 1 year will be removed from membership of the association.

Section 3.

Clause 14. There will be 1 chairman of this association. He will represent this association.

Clause 15. There will be 1 vice chairman of this committee. The vice-chairman will assume the role of the chairman when the present chairman is unable to fulfill his duties.

Clause 16. There will be a management committee of this association. Management will be selected by the entire committee through a discussion of the management association consisting of the chairman, vice-chairman and members*.

Clause 17. 2 members will form the association accounting committee. The accounting committee members will be chosen by the chairman, after discussion of the management committee.

Clause 18. The chairman, vice-chairman and management and accounts auditing committee will serve for a period of 1 year and will not be allowed to serve a second term.

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*Translator's note: the number of members is left blank in Japanese text.

Section 4. Composition and Operations of the As ation

Clause 19. This association's general meetings will include individuals and corporate members. The general meeting can be called by either the chairman or vice-chairman.

A general meeting can be called upon the request of more than half of the management committee.

A general meeting must have 1/3 of the total individual and corporation membership.

A general meeting is to be held at least one time a year.

Clause 20. The chairman and vice-chairman will be chosen at the general meeting.

Management and management representatives will be chosen at the general meeting.

The auditing committee members will be chosen at the general meeting.

Clause 21. Management meetings will be held.

Clause 22. The basic policies of the operations of this association will be determined at the management meetings. The head of the business office will also be chosen at these meetings.

Clause 23. A management meeting will be called upon the request of the chairman, vice-chairman, or management or business office heads.

Section 5.

Clause 24. The funds necessary for the operations of this association will be received from individual and corporate fees, grants, and other receipts.

Clause 25. This committee can accept other aid necessary to carry out operations, such as aid from public organizations, provided that they are not opposed to the established purpose of this association.

Clause 26. The chairman will be in charge of the assets of this association. /86

Clause 27. The fiscal year of this association is from April 1, of each year until March 31 of the following year.

Section 6. Changes in Law, etc.

Clause 28. Changes in these laws cannot be carried out unless half of the management agrees in the management meetings.

Clause 29. Necessary by-laws for executing these laws will be determined in discussion of management meetings.

COMMITTEE FUNDS REGULATIONS (revised on April, 1979) /87

Corporate membership fees:	200,000 yen/1 company for 1 year
Individual annual membership fees:	5,000 yen/person for 1 year
Student annual membership fees:	2,000 yen/person for 1 year

Furthermore, fees will be requested on attendance during regular meeting and other meetings.

(table on following page)

	Management Meeting	Regular Meeting	Reports	Journal	Use of bus. Office Data Bank	Participation in Sumposium, etc.
corporate members	O	participation of anyone from 1 company (fee)	10/1 company (free)	5/1 co. (free)	O	O
individual members	O	(fee)	1/1 person (free)	1/1 pers. (free)	O	O
students	X	(fee)	1/person (free)	(free)		O
summary	determined by assoc.	estimated at 10/year. meeting openings non-members pay of cost of more than ¥ 1,000	summary of meetings	4/year (marketed)	use of data collected by business office and copy	

MEMBER'S NAMES

July 31, 1980

Individuals — Listed alphabetically

Name	Employer	Address (top -business, bottom-home)	Phone
Akiba, Kannichiro	Tokyo Univ. Space and Aviation Research Lab Professor	153 Meguro-ku, Komaba 4-6-1 180 Musashino-shi Yoshihanji Kita-sho 3-13-14	467-1111
Akiyama, Seichi	International Airport Operations	332 Kawaguchi-shi, Seiki 1-16-13 Yoshino (home)	0482-55-1650
Azuma, Sho	Tokyo Univ. Space and Aviation Research Lab Professor	153 Meguro-ku, Komaba 4-6-1	467-1111
Enzaki, Eto	Electronics and Communications, Univ. Physics	182 Chofu Fuhei 1 chome 182 Chofu-shi Fuda 2-21-7 Chofu Shurosu 313	0424-83-2161 0424-88-8814
Enzaki, Shisei	Professor	102 Sendaida-ku, Bandahashi	261-2444
Enzaki, Shisei	Enzaki Research Labs	2-16-4 Tanaka Building	
H Yosei Haruki		563-01 Osaka, Kyoku-no Tokiwa-dai 6-5-13 (home)	0727-38-1294
Chiki Hayashi	Yamakei University Engineering Student	992 Beidaku-shi hon cho 2 chome 3-10 Miya Apt. building 362 Sakishu-ken, 142 uemo-shi 78-13 (home)	0238-21-4217 0487-25-1805
Hayashi, Imei		251 Fujisawa-shi, Tsujijo Nishi Kaigan 2-3-5-205 (home)	
Harada, Sho		130 Kuroda-ku, Edohashi 2-19-4-24	635-1952
Hiryu, Shiro	Japan Science Planning	102 Sendaida-ku, Fujimi 2-3-3 TARO Building 4F (home)	263-6577

Individuals | Listed alphabetically

Names	Employer	Address (top - business, bottom - home)	Phone
Heigen, Seifuro	Osaka Shipbuilding Research Labs	552 Osaka-shi Minato-ku Fukuzaki 3-1-201	06-571-5701
Harikawa, Tosei	Toyo Spinning Research Labs	520-02 Otsu-shi, Honban cho, 1300-1 Toyo Spinning (home)	07757-3-211
Heino, Yoichi	Tokyo University Space and Aviation Research Labs Professor	153 Mekuro-ku Kumaba 4-61	467-1111
Fukuichi, Ichiro		280 Denba-shi, Omiya-cho 318-24 (home)	0472-65-8841
Horida, Meiddn		244 Shomei-ku Chunak Chuda-cho 3416 (home)	045-801-7204
Hosoi, Sigo	FujiTsukc Co.	160 Shiden-ku, Hoban-cho 23 2nd Tanaka Building 156 Sedatani-ku, Ohara 1-23-6 (home)	355-6561 460-3967
I. Ishii, Sejiten	Shinyo Co.	116 Sakikawa-ku Nishimebansho 6-52-1	
Ishii, Sendu	Shoyama Gakui Univ. Engineering Dept.	154 Sedantani-ku Senbandai 6-16 Kokyo-ku Senishi 3-19-3 (home)	300-2121 946-1850
Iyoshi, Michiro	Taikyo Rubber Co.	131 Kuroda-ku Duroda 3-38 167 Mana-ku Josaki 2-19-2-402	614-5461 /89 389-1551
Imamura, Senkiten	Japan Science Planning	102 Sendaida-ku, Fujimi 2-3-3 TARO Building 4F	263-6577
Imatsu, Yocho		311-41 Suisho-shi Otan 1225 (home)	0292-51-8517
K Katsudai, Sen'nichi	Kaninishikai Co.	153 Meguro-ku Jomeguro 4-1-32 (home)	713-4703
Kindaku, Shoten	Toa Domestic Aviation Pilot	157 Sendatani-ku Josaki, 3 chome 9-25 (home)	415-0749

Individuals | Listed alphabetically

Names	Employer	Address (top-business, bottom-home)	Phone
Kyono, Umi	Kawasaki Heavy Industries Aircraft Dept.	105 Minato-ku Tamamatsu 2-4-1 World Trand Center Bldg.	435-2935
		156 Sedantani-ku Kohashi 3-22-6 (home)	482-7834
Kyugen, Hoi	Kanebo Research Lab Shobo Machinery Research	181 Migen-shi, Chugen 3-14-1	0422-44-8381
Kasaki, Shiu	Tokyo Univ. Space and Aviation Engineering Professor	259-12 Heshi Kitakin 1117 Sedantani-ku Daidan 4-1-13-801	0463-58-1211 323-7073
Kawamura, Shibo	Waseda Univ. Physical Engineering Dept.	124 Shigen-ku Shikogan 1-11-1	653-5890
Kimura-Tosei	Japan Univ. Professor Emeritus	101 Sendaidan-ku Kamidan Shodankai 1-8 Room 4	0463-58-1211
		161 Tentani-ku Fufutani 2-11-13 (home)	467-7700
Kosen, Kenshi		462 Meiyoshiya Kita-ku Homo-sho 16 (home)	052-991-8171
Kimura, Fudairo	Tokai Univ. Aviation and Space Professor	254 Heibo-shi Kitakin 1117 151 Tentani-ku, Fufutani 2-11-3 (home)	0463-58-1211 467-7700
Iso, Ishi	photographer	238 Yokotogun-shi Funyu 3-56	0468-24-0977
Kinsaki, Todaiko		154 Sedantani-ku Chibyo 3-30-5 (home)	412-0571
Koseji, Tosihi	Agriculture and Forestry Ministry, Forestry Experiment Station	300-12 Kinseki-ku, Mabyogun Sakizaki Muramatsu-1 305 Kinseki-ken, Shidaigun Shomura Hoboku 4-904-305 (home)	02987-3-3211

Individuals Listed alphabetically

Names	Employer	Address (top-business, bottom-home)	Phone
Koshi, Seiji	Shimeiwa Industries Aviation Production Planning Dept.	658 Toku-ku Seihon 1-1-1	078-431-4151
Kosaki, Sei		117 Nerutori-ku Ishikamiidai 2-22-10 (home)	995-3310
Ken, Tsuji	Transportation Studies	100 Snedaidan-ku, Kotsu Building 280 Senba-shi Toba Minami 1-8-9 (home)	211-4019 0472-22-3371
Kosen, Chobo	Meisho Denki Co.	112 Kokyo-ku Koishikawa 2-5-7 Sazaboku Building 116 Kengawa-ku Kengawa 1-33-2 Sranporu Santo 901	814-5111 606-4563
Koben, Tsuji	Japan Long Term Banking Development 1st Dept. head of studies	100 Snedaida-ku Ote-cho 1-2-4 223 Yokohama-shi Minato Kita-ku Meyoshihon-cho 3 Chokin shibo A-203 (home)	211-5111 044-62-4128
M. Makuban, Kiho	Miyazaki Univ. Balloon Dept.	880 Miyazaki-shi Nishimaru yama-cho 118 Miyazaki Univ. Engineering Dept.	0985-26-3155
Monjo, Naru	Technical Pumamia	108 Minato-ku Sendan 5-2-18-1002	455-3224
Minsen, To		160 Shinbo-ku, Daikyo 26 Fuji Apt. 604	351-7703
Matsushita, Ten	Meihi International	103 Chuo-ku Hinoh Hashiku 1-32-2	669-5547
Matsuura, Kin	Meihi Helicopter	136 Edo-ku Shinsan 3 chome chisaki 14-1	552-0231
Meino, Kouma	Japan Univ. Mechanical Engineering Dept.	101 Sendaidan-ku, Kamitan Yukandai 1-8 194 Codan-shi Kokawa 1-14-11	293-3251

1

ishoto 2-4-5 332-7211
tsusho 2-1-3 0422-48-5097

27

Sanmura, Goich

Individuals

Listed alphabetically

Names	Employer	Address (top-business, bottom-home)	Phone
Koshi, Seiji	Shimeiwa Industries Aviation Production Planning Dept.	658 Toku-ku Seihon 1-1-1	078-431-4151
Kosaki, Sei		117 Nerutori-ku Ishikamiidai 2-22-10 (home)	995-3310
Ken, Tsuji	Transportation Studies	100 Snedaidan-ku, Kotsu Building 280 Senba-shi Toba Minami 1-8-9 (home)	211-4019 0472-22-3371
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Koben, Tsuji	Japan Long Term Banking Development 1st Dept. head of studies	100 Snedaida-ku Ote-cho 1-2-4 223 Yokohama-shi Minato Kita-ku Meyoshihon-cho 3 Chokin shibo A-203 (home)	211-5111 044-62-4128
M. Makuban, Kiho	Miyazaki Univ. Balloon Dept.	880 Miyazaki-shi Nishimaru yama-cho 118 Miyazaki Univ. Engineering Dept.	0985-26-3155
Monjo, Naru	Technical Pumamia	108 Minato-ku Sendan 5-2-18-1002	455-3224
Minsen, To		160 Shinbo-ku, Daikyo 26 Fuji Apt. 604	351-7703
Matsushita, Ten	Meihi International	103 Chuo-ku Hinoh Hashiku 1-32-2	669-5547
Matsuura, Kin	Meihi Helicopter	136 Edo-ku Shinsan 3 chome chisaki 14-1	552-0231
Meino, Kouma	Japan Univ. Mechanical Engineering Dept.	101 Sendaidan-ku, Kamitan Yukandai 1-8 194 Codan-shi Kokawa 1-14-11 (home)	293-3251
Sanmura, Goichi	Misawahomu Company Operation Planning Div.	168 Keinara-ku Koishoto 2-4-5 181 Sansaki-shi Ke tsusho 2-1-3	332-7211 0422-48-5097

Individuals | Listed alphabetically

Names	Employer	Address (top-business bottom-home)	Phone
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N Nagagen, Kami	Fujita Industries	151 Sentani-ku, Senguntani 4-615 228 Somakugen-shi Toritori hayashi 30H-302	402-1911
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Nagasoku, Giten	Zenoa Co.	167 Manaru-ku Minami Seishin 4-37-16 (home)	334-1349
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