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ARMY AIR FORCES
AIR TECHNICAL SERVICE COMMAND
ENGINEERING DIVISION
MEMORANDUM REPORT ON

No. of pages-16

SUBJECT: Development of Sub-stratosphere Pressure Suits in the German Air Force

VJW/wls
Ext. 3-5327
Date 11 Aug.1945

OFFICE Aero Medical Laboratory

Expenditure Order No. 660-85

SERIAL NO TSEAL-3-660-48-M

A. Purpose:

1. To present a translation of a summary of the development of pressure suits at the Draegerwerke, Luebeck, Germany, under contracts with the German Air Force.

2. To indicate the trend of this development as obtained from interrogation of personnel engaged in German aviation medical research.

B. Factual Data:

3. A translated version of a summary of pressure suit development, prepared by the project engineer at the Draegerwerke, is presented in Appendix I.

4. Interrogation of Dr. Theodor Benzinger, chief, Aeromedical Laboratory at the German Air Force Experimental Station, Rechlin, revealed the following:

a. The maintenance of a constant pressure (positive in relation to ambient pressures) environment during high altitude flight was to be accomplished by a pressurized cabin. Any developments which had a tendency toward limitation of the development of pressure cabins was discouraged. Consequently, the development of pressure suits designed to operate independently of a pressure cabin was discouraged. This is evident from the translated report presented in Appendix I.

b. Since the development of pressure cabins indicated the possibility of flight at extreme altitudes, between 50 and 65,000 feet, emergency procedures for the aircrew had to be considered in view of the limited time reserve (Time reserve-interval between exposure to ambient pressure and loss of useful conscious-

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The time reserve at 50,000 feet is 15 seconds and at 65,000 feet is less than 9 seconds) of human beings at these altitudes using pure oxygen at ambient pressures. An early proposal was to equip all pressure cabin aircraft with an automatic diving and leveling off mechanism which would automatically be activated by a loss of cabin pressure, bring the aircraft to an altitude where consciousness of aircrew breathing pure oxygen is certain and automatically resume level flight. The design and development of such a device was considered feasible by Dr. Benzinger.

5. Interrogation of Dr. Siegfried Ruff, chief of the Aromedical Institute of the Deutsche Versuchsanstalt für Luftfahrt, revealed the following:

a. Flight at altitudes in the range 65,000 ft. necessitate emergency dives at a speed which would endanger the aircraft. Since parachute escape at these altitudes may result in anoxic death it was suggested to develop a light pressure suit, which would automatically become operative only upon loss of cabin pressure. During normal flight this suit was to be worn in an uninflated condition, and the suit was to be designed for minimal interference with the activities of the aircrew. The emphasis on the development of such an emergency light weight pressure suit is corroborated in the report presented in Appendix I.

6. Interrogation of Dr. Wolfgang Lutz, aviation medical consultant to the Forschungsanstalt für Segelflug (Glider Research Institute) revealed:

a. In connection with the development of a high altitude glider, equipped with rocket propulsion and a pressure cabin, a pilot situated in a prone position was to be equipped with a light pressure suit. During normal flight this suit was to be ventilated by oxygen under cabin pressure. The exhaust gas from the suit was used to compensate for cabin pressure drop resulting from leaks. The hazard of a high oxygen tension in the cabin was investigated and found to be not dangerous. Upon loss of cabin pressure, the suit was to become operative automatically and permit eventual escape by parachute. Development of such a pressure suit is also indicated in the report of Appendix I.

C. Conclusions:

1. The German Air Force sponsored the development of heavy sub-stratosphere pressure suits but was primarily interested in the use of pressure cabins.

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2. The German Air Force was considerably interested in the development of a light-weight automatic operating, non-interfering pressure suit for use as an emergency device in case of cabin pressure loss at high altitudes.

D. Recommendations:

1. That the Aero Medical Laboratory develop a light-weight emergency pressure suit.

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## APPENDIX I

## TRANSLATION OF A REPORT ON DEVELOPMENT OF PRESSURE SUITS

In the Fall of 1935 we received an order from the German Air Ministry to develop a pressure suit based on the following specifications:

1. No leakage with an internal pressure of 0.6 atmospheres, (11.6 p.s.i.) with a minimal three fold safety factor.

2. Form and size to fit a seated pilot approximately 1.8 meters (5.9ft) in height.

3. Sufficient subdivisions of the suit to permit rapid dressing and undressing without additional help.

4. Unlimited slight and free hands for take-off and landing aircraft, and a visor-type lock.

5. Electric heating or utilization of other heat for protection against cold.

6. Utilization of a circulatory system for the renewal of the air supply and replacement of losses sustained by leakage.

7. No fogging of the windows

8. Free and easy movement:

   a. of the arms for steering and manipulation of instruments

   b. of the legs

   c. of the fingers

9. Possibility of parachute escape

10. Safety against disturbances such as:

    a. Automatic supply of oxygen upon loss of pressure.

    b. Relief valve to protect against position pressure.

11. Possibility of utilizing earphones and microphones.

12. Utilization of unseamed and undivided materials.

13. Light construction.

Calculations for the required test pressure of 2.4 atmospheres (35.3p.s.i.) indicated a load of more than 220 kilograms (484 pounds) on a width of 5 centimeters in the trunk region. Since the determination of the load is based on the elasticity rather than on the resistance to tearing, these values require a material which is quite heavy and cannot readily be formed into a garment.

We were provided with natural silk cloth and silk cord for our experiments. The cloth was rubberized in such a manner so that we had a layer of 0.5 millimeters thickness with the following construction: rubber, cloth, rubber, cloth, rubber. The resistance to tearing of this material when stretched 10% was 180 kilograms on a breadth of 5.4 cm. This low resistance to tearing, and therefore the accentuated stretching, was to be prevented by an external net of silk cord. The available silk cord had a resistance to tearing of 140 kilograms when stretched 50 per cent. In consideration of the available cockpit space and the height of the window in the helmet the elongation of the suit under pressure had to be held at a minimum. This was not possible with the cloth and cord available. We therefore reduced the operating pressure to 0.3 atmosphere (4.4p.s.i.). The initial model indicated that the external net was not only difficult to make but also presented the nuisance of hooking on to things. In addition, the elongation of the suit upon inflation was so great that the subject could no longer see out of the window. Another suit was built in which the external net was made of very strong broad bands, Exhibit A. In this suit the elongation was too great also.

In additional experimental models the external net was made out of steel wire in order to reduce the elongation. This experiment indicated that preparation of such a steel wire pressure suit was quite difficult and the possibility of catching on to things was equally as great as with the net made of silk cord. It was concluded, therefore, to provide a cloth suit with a metallic coat to reduce the hazard of hooking onto things and yet meet the minimal increase in length requirement. One of the most difficult chapters in this development was the movable joints of the suit. We started with a tube with longitudinal folds held in place with one longitudinal band. Thereby, one obtained under pressure a tube which was flexible in one plane. Such joints result in a reduced freedom of motion and are not possible without additional support.

The joints at the shoulder and at the hip were particularly difficult. After these more or less negative attempts no further work was accomplished until toward the end of 1940.

The results and experience obtained to date led to the consideration that the inflated and stiff suit need not necessarily be made of a rubberized cloth but that only the movable parts should be made of rubber. This provided the possibility of maintaining the elongation of the inflated suit at a minimum, and the movable parts can be introduced between the metallic layers so easily that free movement of the joints is possible. However, in this case only one cylindrical joint was possible at the knee and at the elbow. These joints were not universal as were the joints in the shoulder and in the hip.

Since in the airplane one has to move the arms only forward and backward and cannot move them sideways because of lack of room, a light, easily movable and leakproof ballbearing joint was introduced into the shoulder region(Exhibits B,C,and D). This joint permitted extraordinarily easy raising and lowering of the arms. Additional ball bearing joints were installed at the upper and lower arms. By means of the arrangement of these three ball bearings and an easily movable cylindrical joint in the elbow an extraordinary freedom of movement of the arms was obtained. The metal support to this suit permitted raising of the pressure to 0.75 atmospheres (11.0 p.s.i.) without reducing the freedom of movement in the prescribed space. Exhibit B shows such a suit without the above-described ball bearing joints. This suit (Exhibit B) was demonstrated to the German Air Ministry in the middle of June, 1942.

DEVELOPMENT OF A LIGHT PRESSURE SUIT.

On the 28th of October, 1941, we received from the German Air Ministry the problem of developing an emergency pressure suit for use in pressurized cabins. It was required that this suit be worn during normal flight but without pressure and that, upon loss of cabin pressure, the suit could be quickly locked and be inflated to the cabin pressure which existed during normal flight. The operating pressure was set at 150 centimeters water column (2.2 p.s.i.). Several experimental suits were prepared to determine the proper tailoring of the suit and the leakage at the entrance. A completely transparent helmet was developed which permitted extraordinarily good vision and which was simply fastened to the suit resulting in a leak-proof connection (Exhibit C,D,andE). A series of models were tested by the German Air Force experimental station at Rechlin. During the course of this development it became apparent that the suit designed for the rescue of the personnel in a pressure cabin had to

be developed as a pressure suit in order to permit attainment of an altitude without cabin pressurization equal to the altitudes flown by the pressurized cabin. This necessitated changing of the pressure suit so that steering of the aircraft when the suit was inflated could be accomplished without any difficulty. A development program was begun similar to the program for the development of the heavy pressure suit previously described. It was quickly learned that by this reduced pressure of 150 centimeters water column (2.2 p.s.i.) the joints had to be constructed very carefully if free and easy movement were to be obtained. This led to the use of the easily movable leak-tight ball bearing joints. Exhibits C and D indicate the light pressure suit containing these ball bearing joints at the shoulder, upper and lower arms. The elbow has a completely metal free cylindrical joint. The gloves are fastened to the ball bearing joint of the lower arm by means of a bayonet lock resulting in a leak proof connection. The helmet with complete visibility was very easily adapted to this suit. In the course of further development the helmet was made out of plexiglass and was provided with a sliding window so that the oxygen mask could be adjusted through this window. It was then necessary to increase the size of the helmet so that the mask hoses would not bind upon rotation of the head. The shape of the helmet was completely changed as is indicated in Exhibit D. The pressure suit constructed out of rubberized cloth has the entrance located at the neck. Here the suit is united to the helmet in a leak-proof connection. It was also attempted to construct a suit which was divided in the waist region. It was finally demanded that the gloves and particularly the fingers have a high freedom of motion since the hand tires very easily when holding the stick under conditions of inflation. The finger joints are demonstrated in Exhibit C.

DEVELOPMENT OF RESCUE SUIT FOR GLIDER AIRCRAFT

In the summer of 1944, the Glider Research Institute gave us and order for the construction of a rescue suit for use in gliders. This glider was to be equipped with a pressure cabin and the suit was to become functional only when the cabin was destroyed in one way or another. The pilot was to be situated in a prone position in the aircraft. This suit is illustrated in Exhibits E,F, and G. It was to be inflated by manual release of a valve connected to a compressed air source. The maximal pressure was 210 centimeters water column (3.1 p.s.i.). Freedom of movement under pressure was not necessary.

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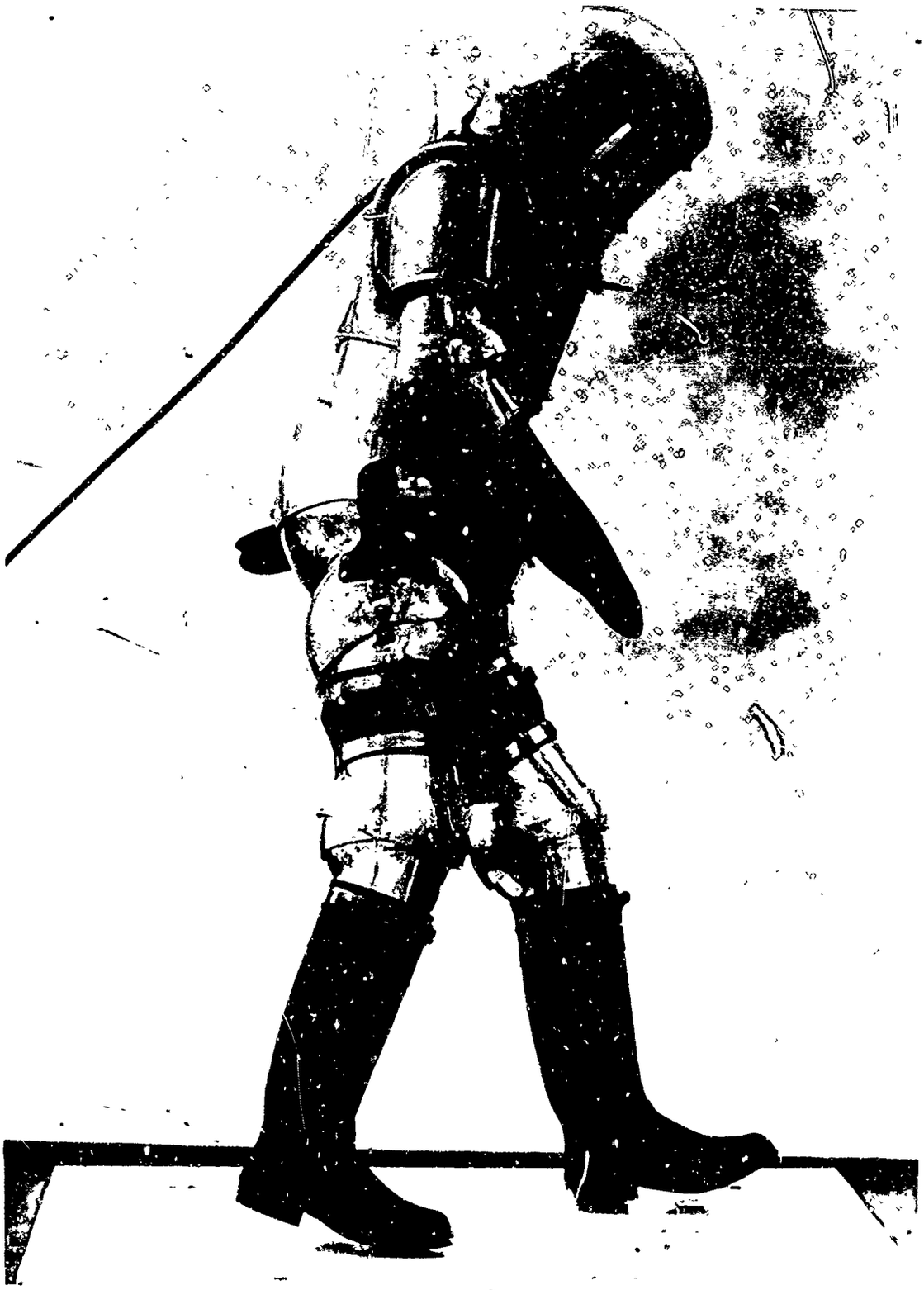
EXHIBIT A

Appearance of the pressure suit at the beginning of the development.





Armored type heavy suit.

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EXHIBIT C



Light emergency
pressure suit
Model 1.

Light emergency pressure suit, model 8.

Rettungsanzug Nr. 230

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EXHIBIT E



Light emergency pressure suit model 230.

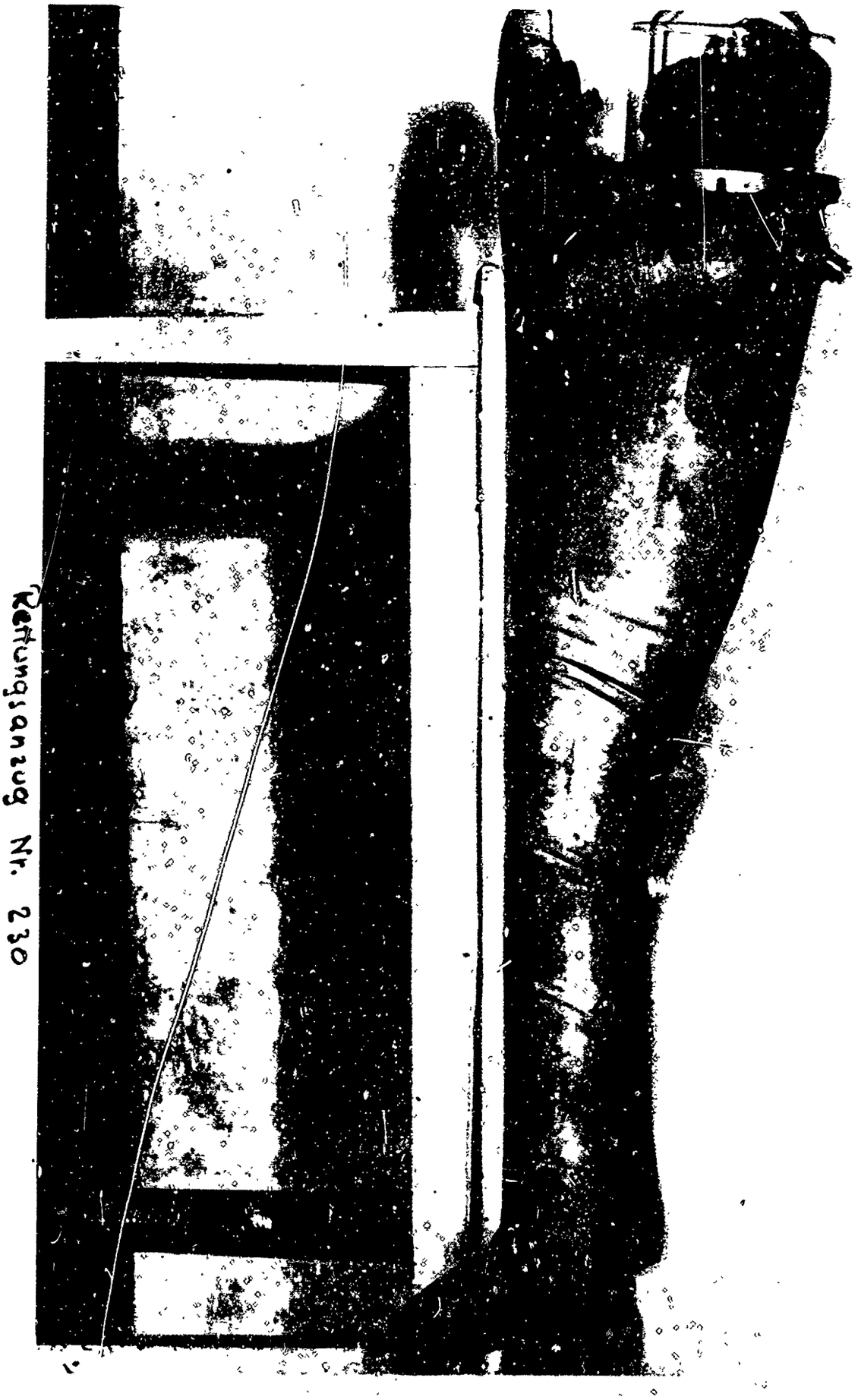


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EXHIBIT F



Light emergency pressure suit, model 230 with subject in a prove position.

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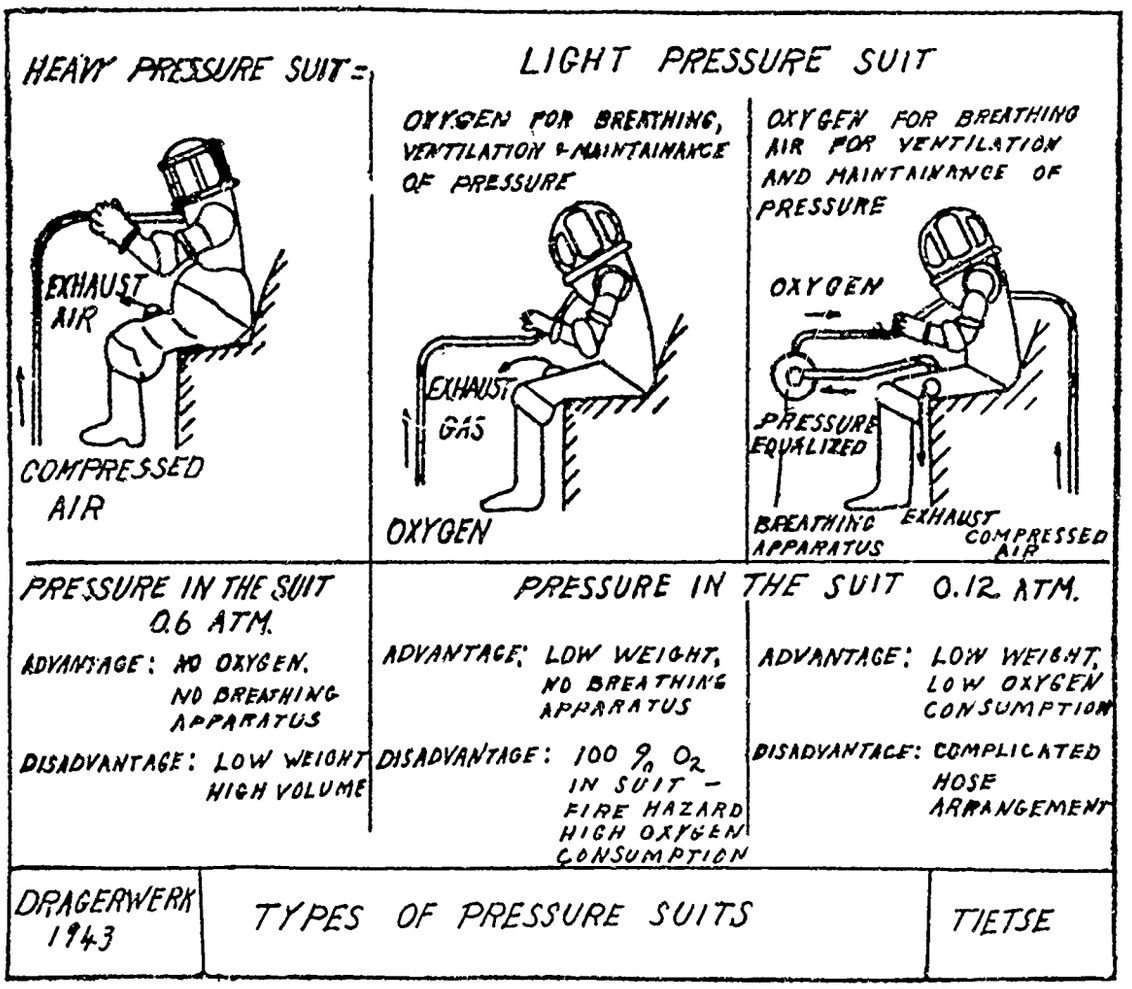
EXHIBIT G



Light emergency pressure suit model 230, showing arrangement of oxygen mask and hose.



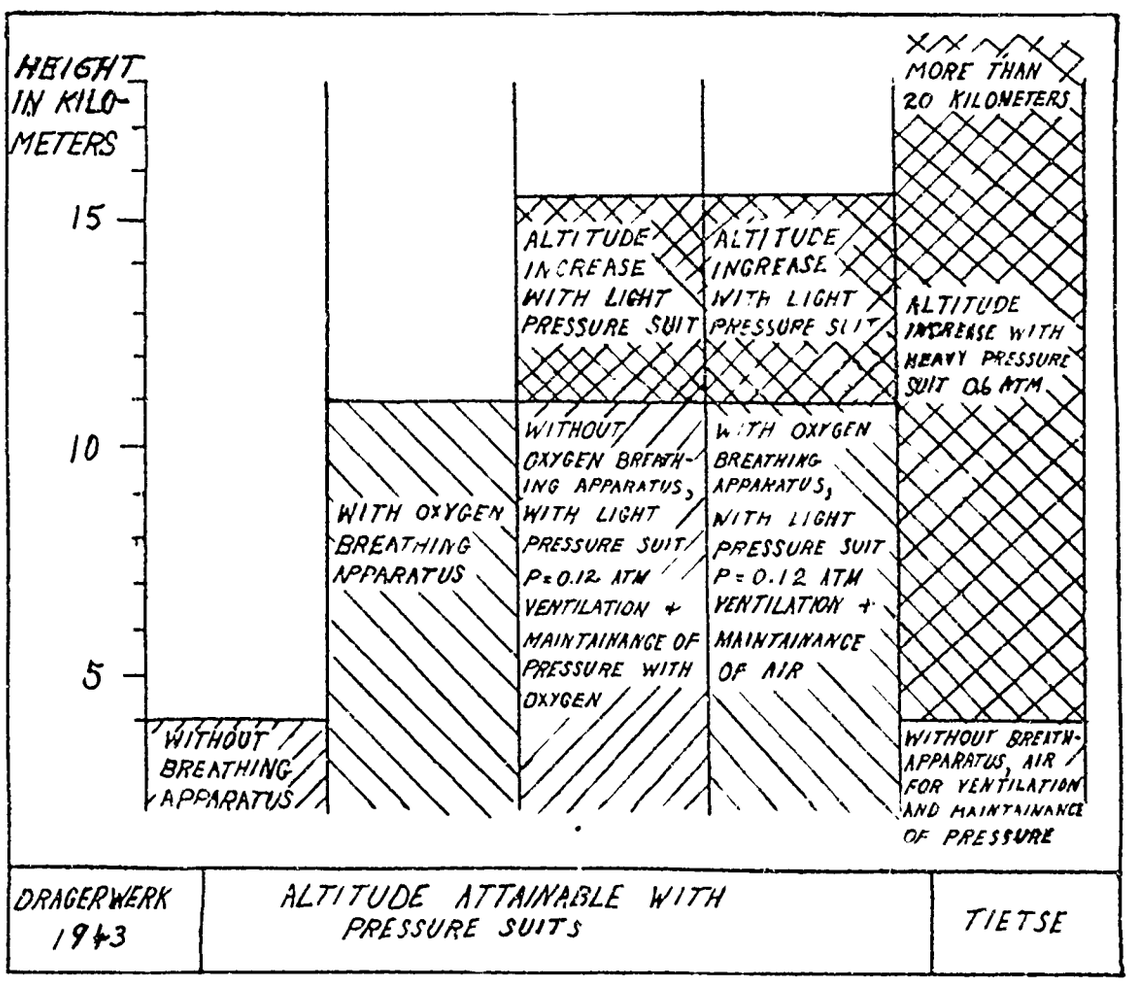




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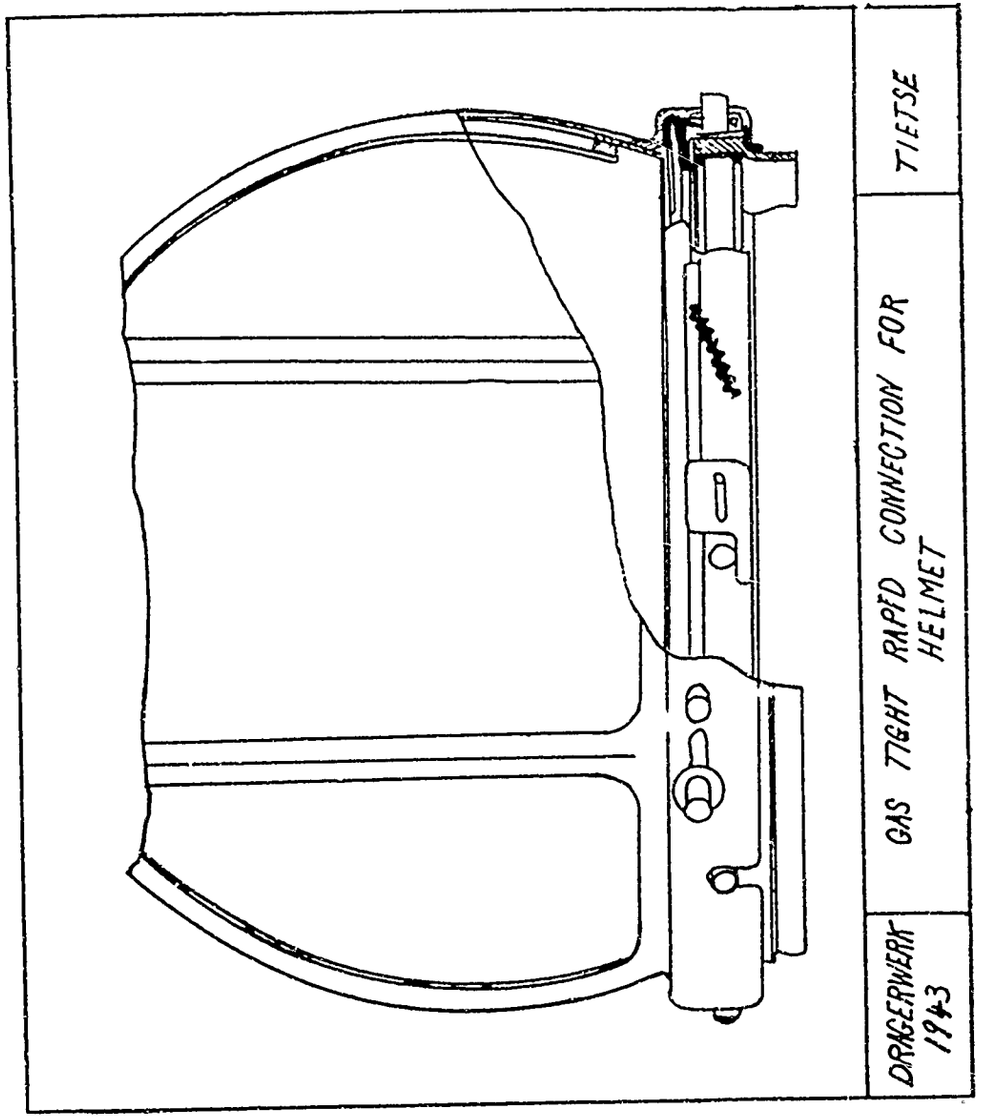
EXHIBIT H

Graphic Presentation of various types of pressure suits and attainable altitudes.



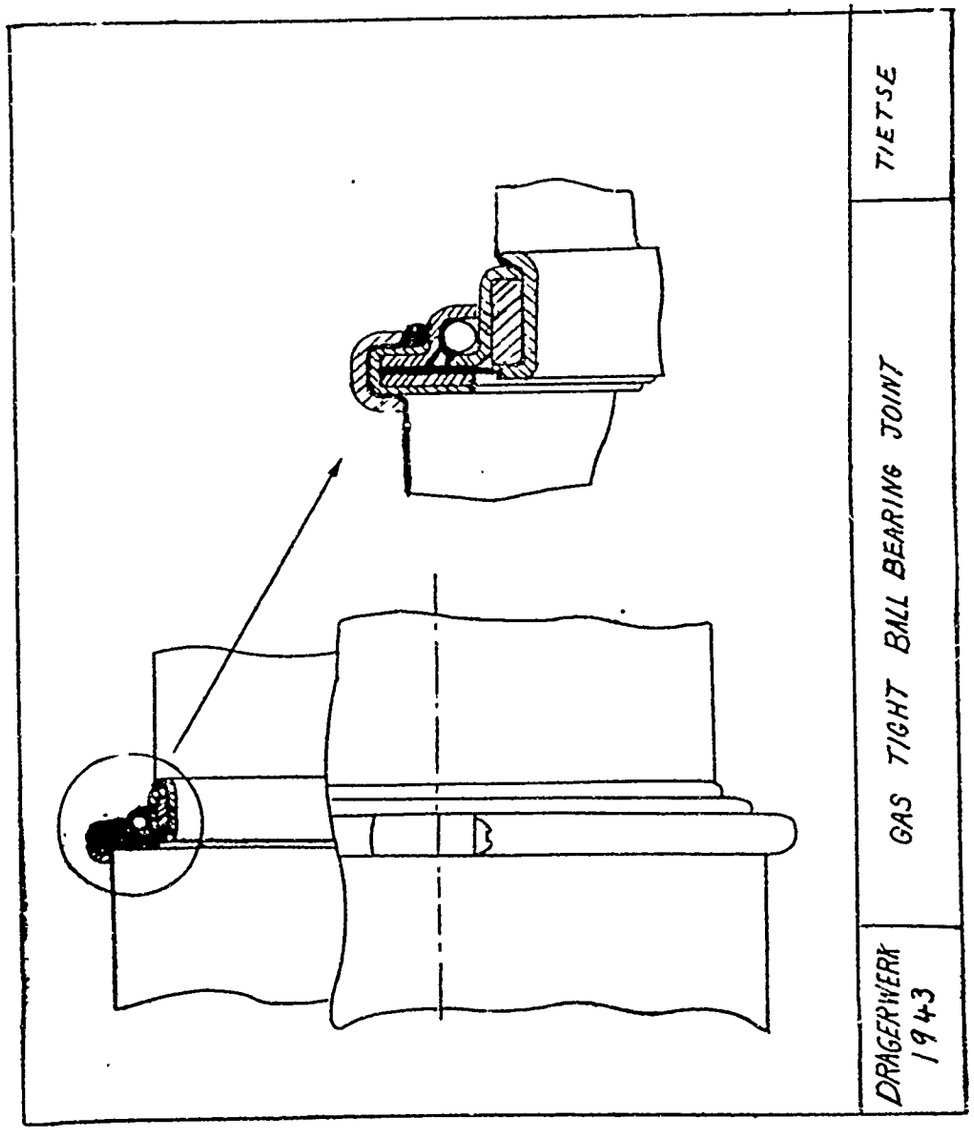




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EXHIBIT I

Schematic sketch of helmet connection and ball bearing joint.