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A Simple Classification of the Present and Future Stages of Manned Flight*

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Whenever great inventions or discoveries are made, we observe some confusion with regard to their potentialities and the length of time it will take for their full realization. This has been notably true with the application of the rocket principle of propulsion to flight. The moment the words rocket flight and space flight are uttered in public, the mind visualizes trips to the Moon or to Mars. As long as these trips do not materialize, in the public view there is no such thing as space flight. This all or nothing attitude is often found in conversations, on the radio, and in television programs, and in print.

It is true that the development of the rocket principle of propulsion is an achievement of revolutionary significance. Yet its complete exploitation will probably follow the pattern of a gradual evolution step by step. These stages can be understood best if we examine three factors: the physiological and mechanical properties of the environment, the speeds attained by rockets and the distances they travel over and away from the earth. These factors will serve as yardsticks in the following attempt to classify the various stages of manned flight - as it has been achieved today, as it can be expected tomorrow, as it may occur in the

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remote future, or perhaps not at all.

Environment: It is well known that the border between the atmosphere and space, in meteorological and astrophysical terms, lies at an altitude of about 600 miles. As an environment for the flyer and the vehicle, however, the atmosphere shows conditions typical of space at much lower altitudes. As various publications[1,3,5,17,22,24] have explained, we encounter within our atmosphere, beginning at 50,000 feet, a region which becomes increasingly space equivalent with regard to one or more of the conditions that are important for manned flight. These conditions are anoxia (50,000 feet), the boiling point of body fluids (63,000 feet), the necessity for a sealed cabin (80,000 feet), meteors at 75 miles, and the darkness of space (100 miles).

From the standpoint of aerodynamics and aerothermodynamics, we face space equivalent conditions at 120 miles in the permanence of the gravity free state and in frictionless movement.

Above 120 miles, we find space equivalent conditions in almost all respects. The atmospheric region from 50,000 feet (about 10 miles) up to 120 miles may be considered partially space equivalent, and the region above 120 miles totally space equivalent, if we ignore certain environmental effects which are caused by the solid body of the earth, its magnetic field and its own and reflected radiation.[23] Figure 1. Above the 120 mile level, the atmosphere is unrecognizable in manned flight. It is imperceptable to the flyer although for the astronomer it exists up to 600 miles.

This being true, the rocket powered plane which has carried man to 90,000 feet and the rockets which have carried animals up to 36 miles[13], have flown in a region, which is space-equivalent to a high degree. A two stage rocket, the WAC corporal mounted on the nose of a V-2, which attained an altitude of 250 miles, was flying under conditions of total space-equivalence, even though for a few minutes only. Do not these achievements in very high altitude flying, justify the statement that we have already reached the era of space flight? From the standpoint of the environment we are at present in the partial space equivalent phase of manned flight.

Speed: Just as we find levels that are characteristic in the environment around the earth, so too do we find certain characteristic points in the factor of speed. They also mark distinctive stages in the development of flight. Figure 2.

The first of these is the speed of sound (760 m.p.h. at sea level). Exceeding this speed, or breaking the sonic barrier, is now past history (Major Charles Yeager, USAF 1948). The present record in the supersonic speed range exceeds Mach 2. In the higher range of Mach 3 or 4 - in horizontal flight - centrifugal forces begin to counteract gravitation to an increasingly noticeable degree. This brings on the phenomenon of decreased weight or subgravity. Theoretically, at about 19,000 m.p.h. or 5 miles per second - in a horizontal flight - a state of weightlessness, or the gravity free state, is finally reached. This speed of 5 miles per second or 8 km per sec, where centrifugal force equals the gravitational pull of the earth, is known as the orbital, or better, circular velocity. It is the speed which will enable a craft to circle about the earth in a fixed circular orbit like an artificial satellite.

Beyond 5 miles per second the circular orbit will expand into an eliptic orbit and eventually at 7 miles per second or 11 km per second, into a parabolic trajectory. When this speed is attained, the craft breaks away from the earth's gravitational pull and escapes into the depths of interplanetary space. It is called the escape velocity.

The highest speed so far attained in a two stage rocket (the WAC Corporal mounted on a V-2) is 1.4 miles per second. This is 30 percent of the orbital and 20 percent of the escape velocity. This is where we stand today with regard to speed. The three stage rocket[2,18] or the atomic rocket[4, 21], may perhaps bring in the remaining percent.

<u>Distances</u>: The various stages of flight can also be classified by the factor of the distance they cover. The craft may fly from one point on the globe to another point on the globe, in a certain distance around the globe or far away from the globe into space.

If we combine the factors of environment, speed and distance with their characteristic levels into one picture, we see an evolutionary course in the development of manned flight that looks somewhat as follows:

The long distance flights of today take us at subsonic speed, under normal gravitational conditions, in pressurized cabins through the lower regions of the atmosphere, from one point on the globe to another distant point on the globe, across a number of time zones and/or across zones of different seasons - in a single day. These are global flights. This epoch in flying began, when Charles Lindbergh first crossed the Atlantic, 1926.

We are now on the threshold of the next stage. In that epoch, rocket powered planes will take us at supersonic speed under subgravitational conditions, in sealed cabins through the space equivalent regions of the atmosphere, from one point on the globe to another even more distant point on the globe in a matter of hours.[8] Still bound to the earth, they will fall into the category of global space equivalent flight. The precursors of this long distance global space flight are seen in the short distance, short time flights of rocket powered planes and unmanned rockets of today. They can be termed local space flight.

As soon as the circular velocity (5 mi/sec) is reached, flights of long duration around the globe in a satellite orbit under conditions of zero gravity and in an environment equivalent to space will become possible. But these craft still will operate within the gravitational hold of the earth and will remain within the earth's vicinity. This eventual stage may be called circumglobal space flight.

The next step will follow as the escape velocity (7 mi/sec) is reached. When, one day, a manned rocket leaves the earth, attains this speed and moves freely in space, then we will have arrived at interplanetary spacd flight or what we may now call "space travel."

This classification* (Table I), gives us, I believe, a clearly defined and realistic picture of the stage at which we stand today and of the possibilities we may expect in the future. At present, we are actually in the first phase of space flight, the phase which we have defined as global space flight. Solution of the medical problems in this stage is, therefore, of immediate concern to the physiologist, the engineer, and the flyer. Incidently, most of the medical problems involved in the final stage (space travel) are encountered in the stage of global space flight.

This step by step approach to the possibilities of rocket powered flight by human beings is perhaps more stimulating, and more fruitful for research and development, than the all or nothing attitude displayed by those who constantly gaze upon remote celestial bodies like the Moon or Mars, with a kind of space fascination. The psychological power of attraction of these objects as the final goal[2,6,7,10,12a,15,16] however, must not be underestimated. They are extremely valuable as a background stimulus for our efforts towards the advancement of human flight.

*To complete the picture with regard to specific lines of work in the technical development of flight the reader's attention is directed to the references 2a, 9, 13, 11, 14, 19, 21.

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