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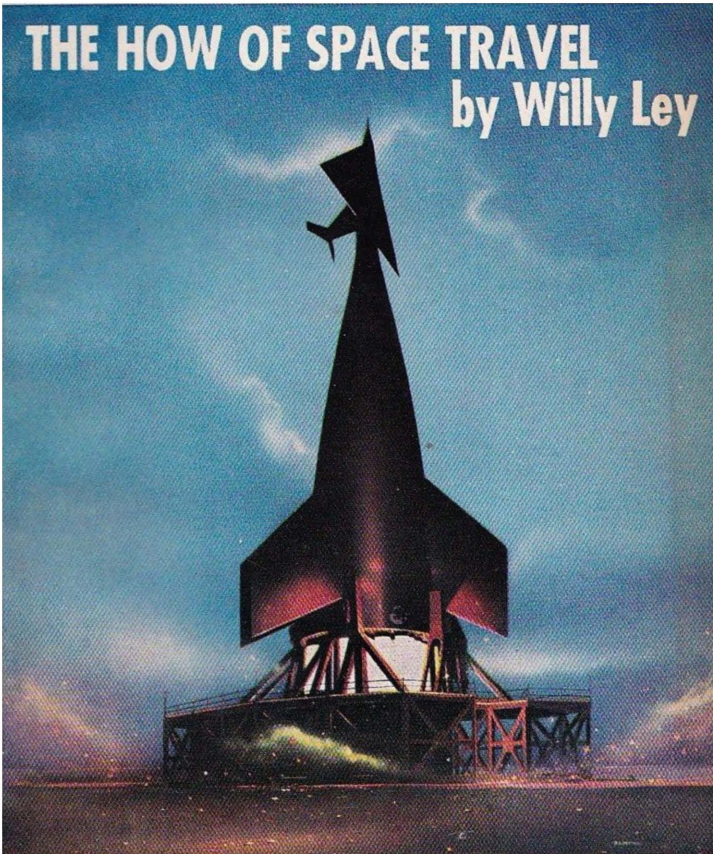
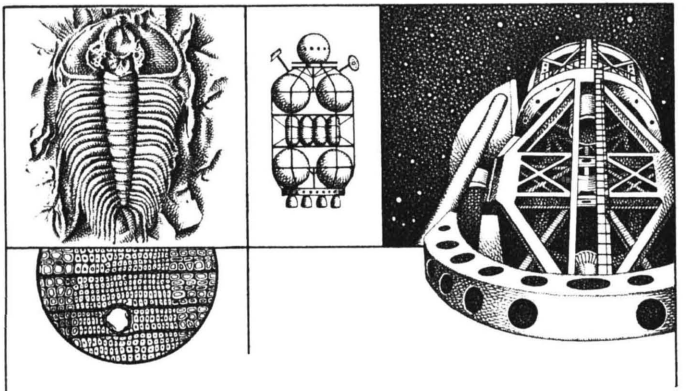
THE HOW OF SPACE TRAVEL
by Willy Ley





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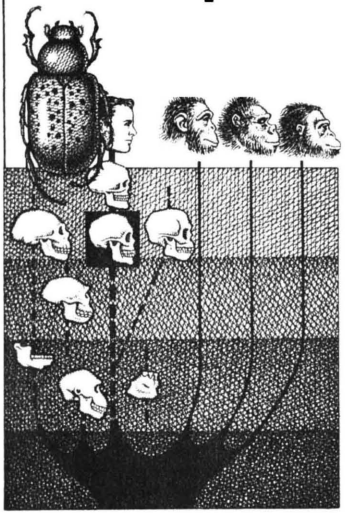


By WILLY LEY

THE HOW OF SPACE TRAVEL

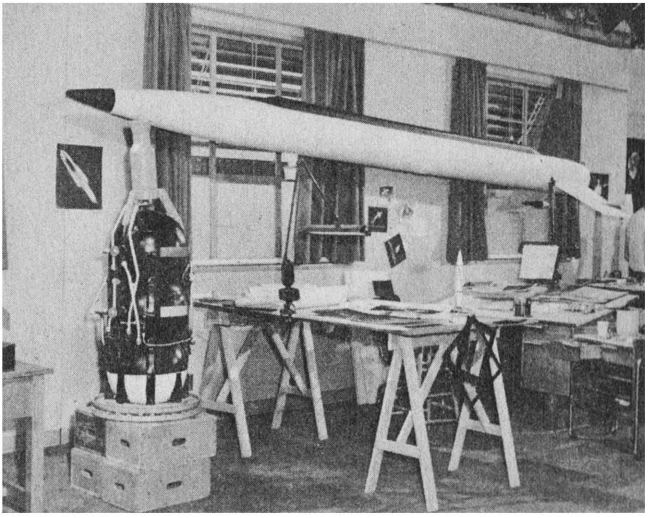
DURING THE interval which must elapse between the writing of this column and its appearance on the newsstands, Walt Disney's *Man in Space* will have had its second showing on television. Naturally I do not know how many viewers will tune in on the repeat showing, but the audience for the premiere, in March of this year, was around forty million. This, I may add in the very

In front of a "story board" in the Walt Disney studios. This scene, in which Willy Ley explains the principle of the instrument carrier to artists Svendsen and O'Connor, was used in the film.

strictest confidence, was higher than we thought it would be while we were planning and making the film.

As far as I am concerned, it began with a long distance call from Hollywood — just as in the movies — asking me to come out and act as adviser. No notice was offered, but I did have to ask for three days because I was slated to appear at a cocktail party given by the New York *Herald Tribune* where I was to receive the prize my book *Engineers' Dreams* had just won.

The timing of flights was such, at that time, that I could not attend the party, go home for my luggage and catch the non-stop transcontinental DC-7 afterward. What I could do was to take a flight from LaGuardia to Chicago and catch a non-stop



Studio scene during the filming. The large rocket is a WAC-Corporal, the item at left a liquid fuel JATO unit. Model on drafting table is a V-2.

DC-7 for the West Coast at midnight in Chicago. Needless to say, flying all night, even as a passenger, is not conducive to alertness.

WHEN I SAT in the beautiful air-conditioned studios of Walt Disney Productions in Burbank, California, I mentally weighed the problems involved. A nationwide network television show would have millions of viewers — especially if it had Disney's name attached to it — which meant that we must take nothing for granted. Writing such a script — at that moment, I still thought a script had to be written — would be entirely different from writing for publication, where you can take some things for granted.

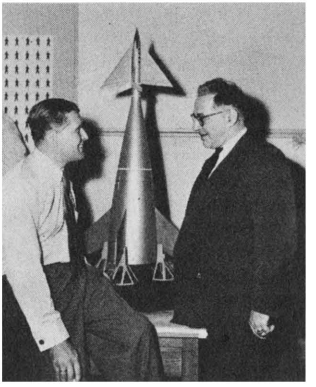
A man who spends five dollars for a book is obviously willing

and probably eager to read it. Furthermore, he is reasonably solvent — or, if not, he is all the more interested in the subject matter — and he must have had a fair amount of education, for very few uneducated people buy books. Similarly, in writing this column, I can assume that every reader is interested in science and science fiction. But with a television audience of millions, all getting a free show, no such assumption could be made. Obviously everything had to be explained right from scratch.

On the other hand, the most instructive device invented so far was at our disposal: the animated cartoon. We would not have to *explain* with words, as I do in lectures; we could *show* how things work. As a means of visual instruction, this was superior even to ordinary film.

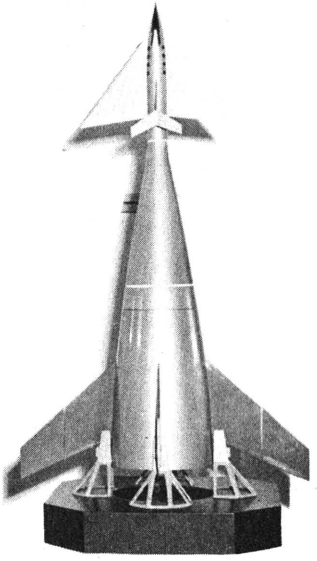
Sitting down with Ward Kimball, the director of the film, and his group of artists, I had the procedure explained to me. They don't have "scripts" at Disney's, at least not in the customary meaning of the word.

The "working scripts" are story boards, as they are called, large boards in wooden frames on which the sequence to be shown is pinned up with push pins. What goes on the first story board may be almost anything, quick sketches, photographs if they happen to be around, even pictures clipped from magazines. The boards are gradually refined and improved, the words which may be on the sound track are written down and also pinned up, and after what looks like a minimum of a thousand changes and after approval by Walt Disney, this narration finally does become a kind of script. It is actually typed out to be recorded on the sound track.



Dr. Wernher von Braun (left) and Willy Ley between "takes".

The very first problem was not so much what to put on the story boards, but what to leave out. At first, the idea had been to show the present concept of the Universe and of the Solar



The model of the four-stage ship designed by Dr. Wernher von Braun for the film.

System in particular, then to trace the story of the idea of space travel in old science fiction to the present, and finally to tell how today's experts think space travel can be brought about, the climax being a rocket flight to the Moon or to Mars.

VERY LITTLE of these first story boards survived the discussions with the experts, not because it was wrong in any way, but because each expert dumped an hours' worth of additional information into the debate.

Dr. Heinz Haber delivered several fine lectures on problems of space medicine. Dr. Wernher von Braun, when turned loose on engineering detail, could go on until stopped by darkness or other appointments. As for me, I talked for about a week on the history of rocket research and the fundamental principles involved. I don't know just what had been expected of the experts before they arrived; what we did do was to turn offices and sketch rooms into classrooms and apparently everybody was very pleased.

The result of this large-scale influx of information was that Walt Disney first split the original first show into two and then authorized another split so that we worked on three shows instead of one.

The first, *Man in Space,* comprised history up to now, the problems of space medicine — the section where the Disney crew really let fly, it being the

Dr. Heinz Haber (left), Dr. von Braun (center) and the author examining model of non-form-fitting spacesuit.

only section where humor was possible — and the immediate future, as embodied in the von Braun plan. The second film will show the building of the space station and the trip around the Moon (without landing). The trip to Mars, at first thought to be merely the climax of the picture, will be a show in itself.

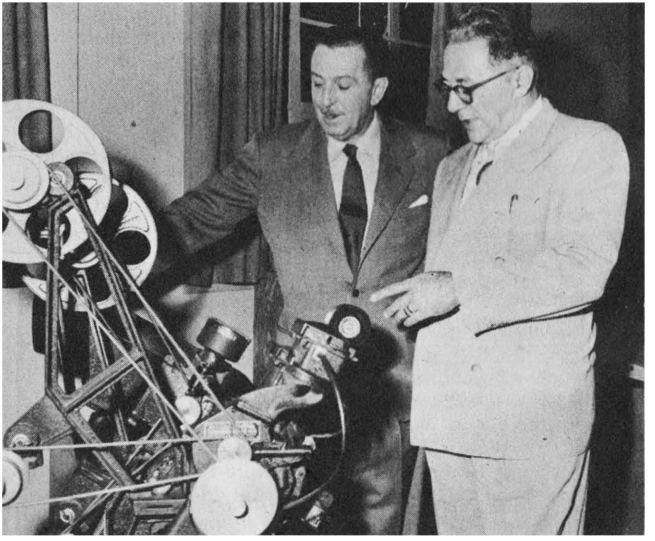
When it came to the more detailed story boards, a new set of problems arose. The history was comparatively simple. Of the earliest Chinese rockets of 1230 A.D. and thereafter, not much more is known than that they existed. This left free rein for Ward Kimball and his crew to draw entertaining pictures. Of the later rockets, contemporary pictures are available, so we used these, although they often had to be redrawn to show up well on a television screen. (Let me insert here that the original film is in color, for foreign releases and possible theatrical showing in this country.) Of the most modern rockets, films are available,

though they are sometimes not easy to come by.

An interesting little item was a film showing the (unsuccessful) takeoff of one of the earliest V-2 rockets at Peenemünde, Germany. When we screened the section, Wernher von Braun naturally recognized the film, for he had been there when it was taken. But he had been certain that this had been a silent film and yet the typical thunder of the V-2 motor came out of the loudspeaker. The solution of the puzzle was very simple, of course — one V-2 sounds like another and the sound was "courtesy White Sands Proving Grounds."

BUT I WAS speaking about the problems of explaining fundamentals. The most basic point of space travel is, of course, that the thrust of a rocket is independent of its surroundings; in other words, that the rocket will work in air, under water and also in a vacuum.

The rocket does not move be-



Walt Disney (left) and the author checking some film footage.

cause the exhaust blast "pushes against the air." Then again, you can't say that it does not "push against the air," for if there is air around, it obviously cannot help doing so. The point is that this is not what causes the motion. What does cause the motion is that backward thrust produces forward movement. But how to show this?

Now it is a fact that you can propel yourself in a canoe on a quiet lake if you have a supply of rocks with you and throw them as hard as you can to the rear. But we were not sure whether this would make a good picture.

Another obvious fact is that a gun kicks back and that there is no reason to think that it wouldn't kick back when fired in a vacuum. One of the early story boards contained sketches of a machine gun mounted on a small railroad car, the machine gun firing over the tail end of the car, accelerating it in the opposite direction. Then somebody pinned up a sketch of a little dog sneezing violently. This one was used, along with a general explanation of "action" and "reaction" by means of the animated cartoon.

It all made two other problems which I know to be "tough" from lecture experience easy to explain.

In the solid fuel rocket, you have a stick of powder that burns off, producing quantities of exhaust gases that escape at high speed through the rearward nozzle like millions of molecular bullets, producing thrust. The tube that houses the powder stick must naturally be able to stand the strain and the heat of combustion. It does so mostly by virtue of the fact that the burning time of a solid-fuel rocket is usually less than a second.

But in the liquid-fuel rocket, this compact device has been, so to speak, taken apart. In place of the powder mixture, you have two liquids in separate tanks, one the fuel proper, the other a liquid providing oxygen for combustion. Instead of burning the fuel in the tank which contains it, it has to be forced into a combustion chamber either by gas pressure on the liquids or else by means of fuel pumps.

So far, there is no special problem. But the liquid-fuel rocket motor has to last for a full minute or more and the flame produced by the liquid fuels is usually hotter than that of solid fuels. At any event, the temperature of the flame is far above the melting point of the metal.

The way out of this dilemma is to put a cooling jacket around the combustion chamber and the exhaust nozzle and to send one of the two liquids, usually the fuel, through this cooling jacket

before it is injected into the motor for burning.

AS I SAID, I know from lecture experience that a non-technical audience has a good deal of trouble understanding this solution. I don't know whether it is the idea of using a fuel for cooling that is so novel — after all, anybody should know that a drum of gasoline left in the garage on a cold winter's night is mighty cold and yet is still fuel. Or possibly a non-technical audience just cannot visualize how the liquid flows from the tank through the pumps into the distributing pipes and the cooling jacket to the injection nozzles.

But when it was shown in animated diagrams on the screen, nobody failed to grasp it literally at a glance.

The other "tough" problem has to do with the artificial satellite. A Viking rocket will climb to 158 miles and then fall back. The WAC Corporal rocket of "Project Bumper" climbed to 250 miles and then fell back. But the artificial satellite is supposed to stay in space, and when you say this, you get the inevitable question, "What holds it up?"

The correct and truthful answer is that the artificial satellite will stay in space because it is a satellite, but that does not sound like an answer to most people. In explanation by word of mouth, you usually have to resort to the comparison of a stone tied to a string swinging in a circle and say that centrifugal force counter balances the Earth's gravitational attraction.

In the film, we could show what happens — namely, that it is the Earth's gravitational pull which keeps the artificial satellite in a closed orbit. We first showed what would happen if the Earth's gravity did not exist: The rocket, rising at a slant, would simply keep going and escape into space. But then a set of lines representing gravity was drawn in, showing how gravity bends the otherwise straight line of the rocket's path into a closed orbit.

ANOTHER "toughie" which belonged in Dr. Heinz Haber's sequence on space medicine also has to do with gravity. With only a negligible number of exceptions, all citizens, resident aliens and temporary visitors are convinced that they can feel gravity. The plain truth is that they can't.

What they feel when standing up or sitting down is the effect of resisting the pull of gravity which appears in the sensation of weight. If they did not resist, they would, of course, fall, but while falling they'd feel weight-

less. Which proves two things, first that you can be deep in a powerful gravitational field and still feel weightless, and second that you cannot feel the gravity itself, but only the effect of resisting its pull.

On the screen, this was shown in the form of an outline elevator happily occupied by Mr. Average Man who, to his great surprise, begins to feel weightless and float as Fate, represented by a huge pair of scissors, cuts the ropes.

Having told the history of rockets, shown the rockets probing beyond the stratosphere, explained why a rocket will work in empty space, demonstrated what happens in a rocket motor, illustrated the principle of the artificial satellite and given a quick course in space medicine, our next job was to go into the future for just a few years.

The first goal of liquid-fuel rocket research was to make one rise off the ground. Once that was accomplished, the goal may be called the altitude record, although I am fully aware that this is a gross oversimplication and that the actual altitude record is merely a part, and not the most important part, of the goal. The unmanned artificial satellite will be the next long step forward, but the ultimate goal is to get Man into space.

The first steps have already been made. Pilots have flown twice the speed of sound at high altitudes and piloted rocket-propelled airplanes have beaten the high-altitude record held for so many years by the manned stratosphere balloon *Explorer II*. In fact, it has now been revealed that a piloted plane has gone to 100,000 feet, a height where no rudder, elevator or aileron does much good any more. Space, however, is beyond that. And to go that far, the rocket-propelled airplane will need rocket boosters.

AGAIN, the medium of the animated cartoon made it easy to show just how such a project would be approached. If you have the finished rocket ship in mind, the work begins at the top of the whole thing. The top is a rocket-propelled airplane with sealed cabin. It would be built first and go through the customary series of tests, being towed by a big jet plane, without using any power of its own. Having been disconnected from the towing plane, the pilot would make glide landings.

After all this has worked to everybody's full satisfaction, a takeoff must be made with one rocket booster, followed by powered flight, unpowered glide and landing. Then the plane, which

by then has become the top stage of a multi-stage rocket ship, would make a rather long flight with two rocket boosters pushing it in succession.

Finally, the whole ship would be assembled and be readied for "the flight" — the flight into space where the top stage (the "plane") circles the Earth a few times until the pilot reduces its speed by firing the forward rocket motors. The reduced speed will then make it change to another orbit, part of which is inside the atmosphere. And once the ship has entered the atmosphere, air resistance will reduce the speed more and more.

I want to interrupt my story here for two explanations. The rocket ship (Fig. 4 shows a photograph of the model) used in the film is Dr. Wernher von Braun's most recent design and constitutes a decided improvement over the original three-stage ship which he first described in his book *The Mars Project.*

It is not only lighter and smaller than the first design, but also differs in concept in several respects. However, I can't dwell on questions of detail until the designer has published it himself in a professional journal first.

The other thing I want to point out has to do with the meeting in space of this ship with the nose cone of the instrument-carrying rocket.

The meeting as shown in the film is correct insofar as the instrument carrier was stated to have been put into an orbit leading over both poles of the Earth. The manned ship was assumed to circle the Earth temporarily in the same orbit in which the space station is to be built at a later date. This would put the ship at a distance of 1075 miles from the ground. And though there may be an instrument carrier at that distance, it would not be the first one, which would be sent into an orbit much nearer the ground.

THE DETAILS of that first flight were worked out with all the care of which everybody involved was capable. A lot of data that would never show in the film was worked out just the same to see where it would lead.

At one point, von Braun and I forgot in an interesting manner what we were really doing. It had been suggested that ground control should have an instrument which would show the position of the manned ship at any time during its flight. The instrument, somebody said, might be a globe of the Earth, with a ring of transparent plastic around it, representing the orbit. But this ring should touch the ground, for it was to show takeoff and landing,

too. The position of the ship could be indicated by a moving spot of light in the ring of transparent plastic.

This sounded fine and von Braun mused, "Now how would one build that?" whereupon we started debating how one might go about it. After a few minutes, one of the artists brought us down to sea level with the remark: "You know, here at Disney's, we just *draw* things."

Well, this is the story of how a very large portion of the public of the United States and Canada got to see a first lesson in the principles of space travel, or rather of the beginnings of space travel, the first step outside the atmosphere.

I am quite sure that a decade from now, lecturers will rent copies of the film to explain to their audiences how prediction differed from reality.

I hope they won't forget to mention that prediction is one of the causes of reality. That's true of research. It's also true of science fiction.

— WILLY LEY

All Photographs Courtesy Walt Disney Productions