Can

A Physicist's Solution of

The Plan Is Theoretically Sound

THE editor makes no apology for publishing the accompanying article. It is not a Jules Verne story nor an H. G. Wells story, nor even one of Dr. Hacksaw's secrets. It is a physicist's conception of a method for getting close enough to Mars to see what Mars is really like. The article was first submitted to several laymen for opinion. They voted against it. It was then sent to several physicists. These favored publication. In itself this may have some significance. Mr. Randolph's plan cannot, of course, be realized at present; he says so himself.

The manuscript was submitted to Professor R. H. Goddard, Department of Physics, Clark University, famous for his experiments on high-speed rockets, with the request for a public statement. Professor Goddard replied as follows:

"According to recent press notices, interplanetary transportation must remain impossible until atomic energy can be obtained and controlled. This attitude is, however, much like that of the scientists of 30 years ago, who declared that an airplane could not operate unless the force of gravity could be neutralized.

"If atomic energy were available, it would be a very convenient means of propelling an interplanetary rocket. Atomic energy is not, however, necessary, as an interplanetary flight is possible with means even now at our disposal. This is set forth in my article in the Smithsonian Miscellaneous Collections, for 1919.

"If a propellant of high energy content, such as hydrogen together with oxygen, is used with high efficiency and in the proper way, an interplanetary flight is possible in a rocket that is neither tremendously bulky nor unwieldy. A rocket using a low energy propellant, and operating inefficiently, would, on the other hand, be impracticably large.

"The technique of such a flight constitutes a most interesting problem in physics, and is one to which I have given considerable thought for many years. In the light of the conclusions I have reached, I can say that, although Mr. James R. Randolph's article, 'Can We Go to Mars,' may read like romance, it is nevertheless thoroughly scientific, and, while not telling the whole story, it gives a good picture of what an interplanetary rocket must be like."

THE cave man looked across the river and wondered what was on the other side. Before long he learned to build rafts, and later canoes, so that he could go there and see. The Norsemen looked out upon the broad Atlantic and wondered what lay beyond that gray horizon. Presently they built ships in which they could go there and see.

Thus man has spread himself all over the surface of the earth, and within the past generation he has learned to fly through the air as well. And even the bottom of the ocean is yielding up its secrets.

Today man looks through his telescope at the other members of the solar system and wonders what is there. Will he ever be able to go there and see?

Several of these heavenly bodies might repay at least a passing visit, should such a thing prove possible. The Moon is too airless for anything more, but would be interesting to look at more closely than is now possible. Also its invisible back portion would be worth seeing. Venus and the large outer planets hide themselves behind dense veils of cloud, but there is a possibility that Venus might prove habitable for man.

BUT of them all, Mars presents the most interesting possibilities, and would probably be the first visited. Its skies are generally clear, permitting an easy view of the surface, and this surface appears to resemble our own in some respects, although in others it is very different. There is a possibility that men might be able to live there, although scientists are far from agreement on this question.

And over all this surface is a network of fine dark lines, the "canals" of Mars, which many people believe are the work of beings having intelligence comparable to our own. None of the other theories advanced to explain them have proved satisfactory, at least in the case of certain of these canals. Even a flying visit might settle this question beyond a reasonable doubt, and would show whether or not there really are "people" there.

THE space between the two planets is devoid of air, or any other kind of matter. Hence, there is only one way in which such a trip could be made. A projectile of some sort would have to be thrown off from the earth with sufficient velocity to clear the earth's attraction, and would then have to be directed into an orbit that would touch the orbit of Mars at the time Mars got to that particular part of it. Then, its velocity would have to be reduced so that it could be captured by the planet and become a satellite. Such it would remain for about a year, at the end of which time its speed would have to be increased, returning it to its own orbit, and thence back to the earth.

Thus the projectile would have to be able to change its velocity in a vacuum, and at the start it would have to attain a velocity of seven miles per second, as that is the velocity needed to escape the earth's attraction.

There is only one device known to science at the present time with which these requirements could be met. That is the high-altitude rocket invented by Professor Robert H. Goddard of Clark University. The shells from the largest naval guns have a muzzle velocity of little more than half a mile per second.

The Goddard rocket is now in a stage of development corresponding to the small airplanes built by Langley. Small rockets have been built to test the principle that would be employed in constructing one to reach very high altitudes. The theory has been proved sound, and it has been shown that the problems to be encountered in going from these to large rockets capable of infinite range are no more serious than those involved in the design of huge transatlantic liners. Engineering difficulties may be looked for because of the enormous size of the machine, and the cost will be very great, but the plan is by no means impossible.

STRANGE as it may at first seem, the Goddard rocket, or any rocket, for that matter, works just as well in a vacuum as in the air. In fact it may work even a little better. So the rocket would not have to come up to full speed while in the air, and the changes of speed required after leaving the air entirely behind could readily be made.

This fact has been proved by experiment. It can be readily understood, however, when the principle on which the rocket works is understood. This is the law known as Newton's Third Law of Motion, and states that *to every action there is an equal and opposite reaction.*

For example, if you are standing in an unmoored boat, and walk toward the shore, the boat will drift away from the shore. The air has nothing to do with this. In order to start your body forward you have had to give it a push. This push, acting backward just as much as it does forward, causes the boat to move in the opposite direction.

Again, when the powder explodes in a gun, its pressure drives the bullet forward. But this pressure acts backward on the gun as well as forward on the bullet, and causes the "kick" of the gun. In a rocket there is no bullet, but the gases are expelled downward with high velocity, and the "kick" drives the rocket up at rates of acceleration which could be nicely controlled.

The Goddard rocket differs from the

We Go To Mars?

Approach to a Fascinating Problem, the Which Is, However, Far Away

By JAMES R. RANDOLPH

ordinary rocket, much as a modern turbine differs from a hurdy-gurdy, or flutter wheel. It works on the same principle, but it has been designed for the highest possible efficiency and power output. Some of the latest rockets use liquid fuel whose nature is being kept secret, but the earlier ones used smokeless powder.

In these rockets the powder is confined in a strong steel chamber capable of resisting the pressure of the explosion, and the gases are ejected at the lower end through the expanding nozzle. This nozzle resembles those used in steam turbines, and is designed to give the highest possible velocity to the gas. In some experiments using smokeless powder, this velocity was found to be 8000 feet per second; while more recent tests indicate that velocities as high as 12,000 feet per second can be obtained.

The velocity given to the rocket as the gas shoots out can be calculated by the momentum equation of elementary physics. This shows that a pound of gas coming out at 8000 feet per second would give a 100-pound rocket an increase of velocity of 80 feet per second. ($8000 \times 1 = 80 \times 100$)

The next pound of gas ejected will increase the rocket's velocity by a somewhat greater amount, for the rocket weighs less by the weight of the ejected material; and this process can be kept up indefinitely. Strange as it may seem, the rocket can be made to go a great deal faster than 8000 feet per second, for the momentum equation is not in the least concerned with the absolute velocity of the bodies. It affects only their relative velocity.

BUT as the final velocity of the rocket is increased the amount of powder required goes up enormously. If the final velocity were 3.5 miles per second there would have to be at least 20 pounds of powder for every pound of rocket left at the end of the firing period. If the velocity is to be twice as great, or seven miles per second, the weight of powder will not be twice 20, but will be 20 *squared*, or 400 pounds.

Consequently, these high-altitude rockets are to be made in several sections, so that the chambers carrying the powder charge can be thrown off as fast as they are emptied, retaining only full ones which give the rapidly increasing velocity. Magazine rockets have also been tried, in which the propellant is not put into the pressure vessel until it is to be fired.

Such a rocket could be made in two sections. After the powder charge in the larger rocket has been burned, the casing would be discarded and the smaller rocket would go on alone. This process may be repeated any number of times.

A very large rocket, capable of leaving the earth, and of carrying men, would involve serious engineering problems. The same is true of any structure. A bridge across a small mountain stream is easy to design. One across the Hudson River at New York is very difficult. The same is true of large steamers, large airplanes, and large rockets.

A FEW examples will give an idea of what this difficulty is. A brick pier a few feet high would support a weight of 4000 pounds for each square inch of its surface. But a pier a mile high weighs more than 4000 pounds per square inch of horizontal section. Hence it would break of its own weight, unless spread out like a mountain to give a broader base. Five miles of steel wire form a heavier weight than the wire itself can support. And as these limiting weights are approached, the proportion of structure to useful load increases, and the skill required in design becomes greater, in order to keep this proportion down.

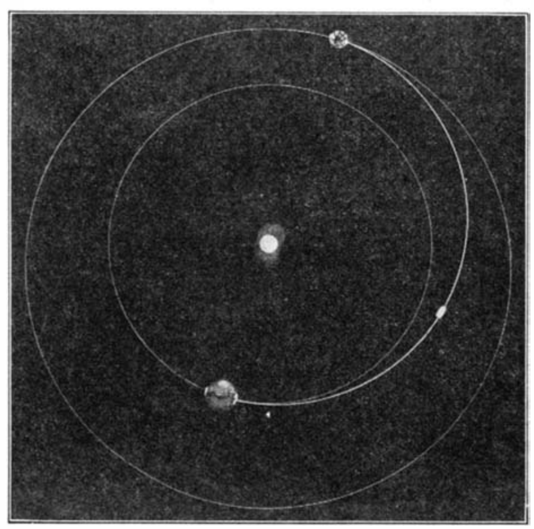
In a rocket, all loads would be greatly increased by the rapid acceleration at the start, but this could be calculated in advance and allowed for. Acceleration in a rocket like this is under perfect control. The numerous small charges are fired by a time clock, and at any rate desired. Even in the simpler rockets, like Goddard's present forms, there are ways of controlling this, as by making the grains of the powder small or large. The smaller the grains the faster the powder burns. But in an actual trip the acceleration should be made just as great as the passengers could stand. This would be tried out beforehand, possibly in a rapidly revolving drum, and the start of the rocket governed accordingly.

A suggested design is shown for the head of a rocket to go to Mars. This gives some idea of the problems that would have to be met in such a structure. Only the top part of the main propelling charge is shown. It is divided among several thousand cylindrical containers, each with a separate nozzle. These are burned in order, beginning at the bottom, and are so proportioned that the charge in each is burned out before there is time for the heat to damage the nozzle. Then the container is dropped, and the one above it comes into play. The walls of the containers awaiting their turn, and hence not under pressure, are counted on to furnish the strength required to support the weight above them.

ABOVE the cabin, and just below it, are shown the powder charges used to slow the rocket down when reaching Mars, for speeding it up to get away again, and for slowing down on reaching Earth. Above and below the cabin are two special jets for making small and controllable changes in the rocket's velocity. The regular containers make changes of definite size.

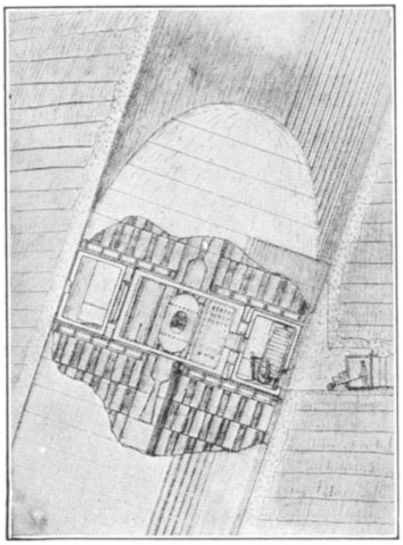
In the cabin structure is a central chamber in which are shown several tanks for the fuel required by these special jets; a pair of gyroscopes to hold the rocket on its course (these are in the spherical ended shell at the center); and at the right the switchboard through which the firing charges are governed.

This chamber is occupied only when starting or changing speed. There would be no people in it during flight.



ORBIT OF EARTH-MARS ROCKET

The earth is shown in position at the start; Mars at time of arrival, seven months later. Round trip, say, two years



MARS ROCKET—AUTHOR'S DESIGN

It starts from a shaft in the earth, but by means of its own propellant—no explosion

Around the outside are the passenger quarters, and when in flight these rotate about the central chamber. This creates a centrifugal force that takes the place of gravitation, and holds the people against the outside wall, which then becomes the floor. This provision is essential to the comfort of the passengers. Once the push of the jets had stopped, no action of gravitation would be felt. Man is not adjusted to this condition, and would probably get very seasick. Also, any liquids or small objects that were spilled would float around in the air indefinitely.

THIS rocket, when clear of the Earth, would be given an added velocity of about two miles per second in the direction in which the Earth is moving with a velocity of 18.5 miles per second. This would throw it into a much more elliptical orbit, which would bring it to the orbit of Mars about seven months later. Departure would be so timed that Mars would be there when it arrived. It would then be slowed down until it became a satellite of Mars, which it would remain for about a year. Then, the positions of the planets being suitable, it would be speeded up and brought back to Earth.

ROCKETS AND WARFARE

Shaded areas are within 300 miles of foreign frontiers, and subject to air raids. Rockets would make this aerial danger worldwide

A large and heavy mass like this, approaching the Earth at seven miles per second, could not be safely landed. Hence it would be abandoned when near the air, and the occupants would come down in the landing plane, shown on the right near the door. This is a small air tight glider, with folding wings, and having a special door to permit its release.

A rocket such as this would weigh as much as an ocean liner, but would probably be easier to design, as the structure is more compact and the forces more definitely known. But its accommodations would be severely limited, as food, water, and even oxygen for the entire journey of over two years would have to be taken along.

READY FOR A TEST

Professor Goddard and a small experimental rocket (in the tube which is open at bottom)

Because of its high cost, and the lack of a financial motive for the trip, it is likely to be a long time before such large rockets are built.

The Goddard rocket in its present size could be used for exploring the upper atmosphere, beyond the range of sounding balloons. The next development that is planned is the study of the Heaviside layer, which is supposed to exist at an altitude of about 60 miles above the Earth's surface, and to play an important part in the transmission of radio signals.

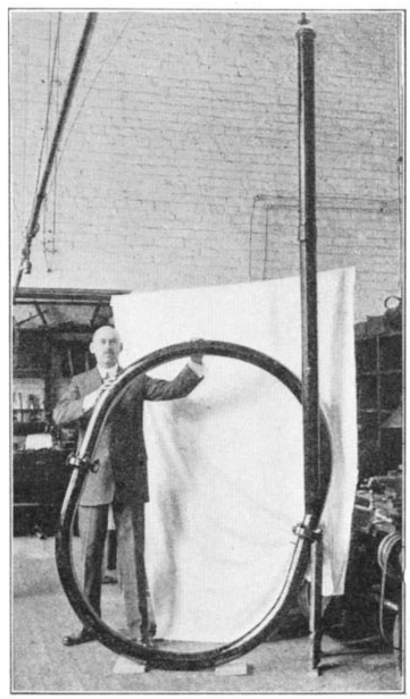
It is also planned to take astronomical photographs from outside the Earth's atmosphere.

A further development of the Goddard type of rocket is likely to be that for war. Experiments along this line were begun during the World War, but were dropped when the armistice was signed. At that time they had resulted in a multiple-charge rocket that fired several charges in succession, and traveled straight. It was shown that these rockets could be made at least as accurate as a long range gun, with vastly greater possibilities as to size and range.

Rockets are possible that could shoot half way around the Earth, carrying loads of hundreds of tons—and this offers interesting possibilities for the next war. They could be steered to a limited extent, the pilot staying in the rocket until the last possible moment, and then going off in a landing plane.

Decided changes in world politics would follow the introduction of such a weapon. The armored horseman brought in the feudal system. The gun restored democracy. The modern battleship suppressed piracy, and abolished the rights of small nations. The airplane made the League of Nations a necessity by bringing possible enemies entirely too close for comfort. The rocket would bring America and Russia as close together, in a military sense, as France and Germany now are.

IN the right hands the rocket would bring universal peace. In the wrong hands it would lead to conquest more absolute than anything the world has ever known. The largest empires of past and present could not exist without great numbers of loyal soldiers to hold them together. An empire using rockets would need only governors and spies. The mechanics who made the rockets could be slaves, and a mere handful of men could direct them.



TESTED IN A VACUUM

Rocket is in the straight part. Loop keeps the gases from affecting it. The rocket worked