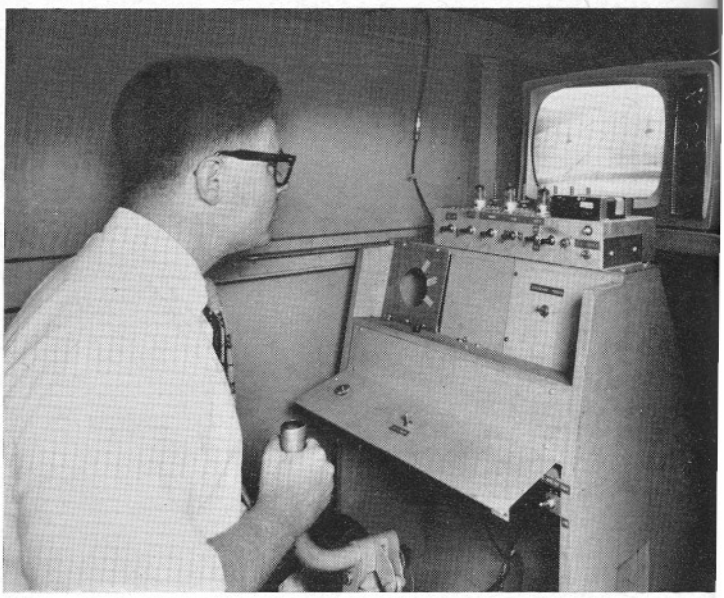
A joy stick and closed-circuit TV—that's all you use when you steer a prototype of the car that some day may explore our satellite



Watching a TV monitor to see where the Moon jeep was headed, I steered the vehicle remotely by pushing a hefty control stick to the left or right. The jeep's route was a twisting 440-foot-long course marked by pairs of rubber cones set 12 feet apart. Lots of room, I figured.

I Drove a Jeep "on the Moon"

By Erik H. Arctander

THE TV screen in front of me cast a dim light in the dark cubicle. I sat on a stool, grasping an aircraft-type control stick in my hand. I was about to steer a jeep I couldn't see or hear over a zigzag course 12 feet wide and 440 feet long.

To make it harder, every change-of-direction signal would be delayed. I'd have to make each steering correction 2½ seconds before I wanted it to take effect.

Why was this weird challenge to human skill devised? Not out of idle curiosity. Grumman Aircraft engineers want to find out how an unmanned vehicle can be guided over the moon's surface by remote control. A TV camera on the vehicle there would broadcast pictures to earth; from here, a "driver" could send back signals to control the vehicle.

The reason for the time delay on the test apparatus: Radio signals take about 1¼ seconds to span 239,000 miles—the average distance of the moon from earth. Round-trip time for a signal to reach the vehicle and for the result to show on the TV monitor is 2½ seconds.

My test run was about to begin. I sat in a blacked-out cubicle—a small trailer on an unused airstrip outside the vast Grumman plant in Bethpage, Long Island.

The moon vehicle was a specially altered jeep dubbed Luna-tick I. The test would be at "high" speed: The governor in the jeep was set for 4.25 m.p.h.

Suddenly two columns of rubber cones

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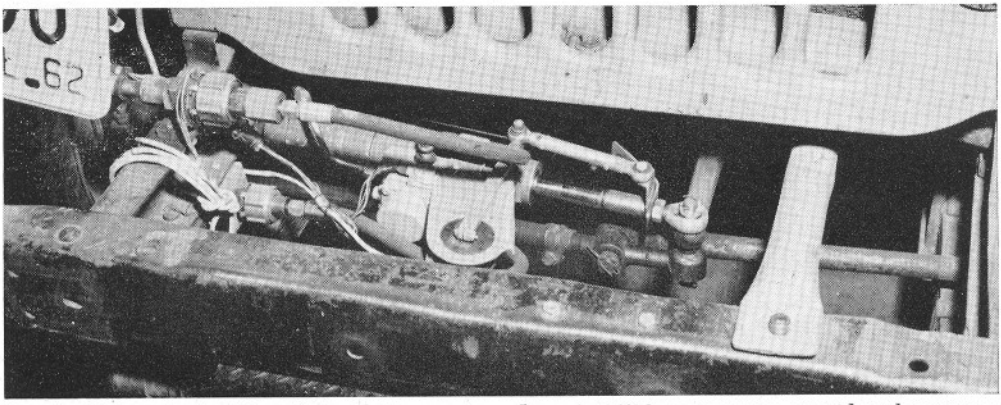
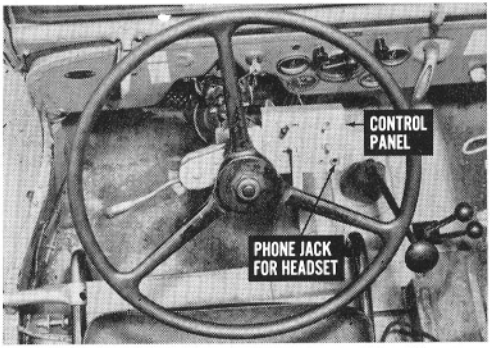
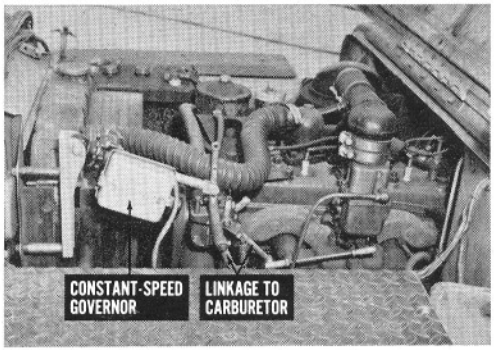


Steering is by a hydraulic cylinder that was originally designed to actuate an airplane wing flap. A 1,500-p.s.i. pump provides the power; servo motors relay the control signals.



Dash switches allow manual control. Observer in jeep took over when I completed each run.



Governor is set by hand. It permits three constant speeds: 1.4, 3.1, or 4.25 m.p.h.

moved on the TV screen. The jeep had started through the twisting course lined by the cones.

The pair of cones marking the first turn spread apart on the screen. When they were at opposite edges of the screen, I shoved the control stick left against stiff spring pressure, then quickly brought it back. The two nearest cones disappeared off the sides of the screen, but the jeep continued straight ahead.

Just as all seemed lost, the front end of the jeep, visible at the bottom of the screen, swung sharply left.

The next pair of cones was off to the right. I jabbed again at the stick. After an agonizing 2½ seconds, the jeep swung right. Three new pairs of markers lined up on the screen.

It soon became apparent that I hadn't gauged the last turn so well. The jeep was too far right. I scraped past the first right-hand cone, crushed the second, and went off the "road"—passing on the outside of the third.

I remembered that the course veered left at this point. I shoved the stick hard over and held it there a few seconds. It was sheer guesswork, but 2½ seconds later the jeep swung violently to the left and straightened out smack on the centerline.

The rest of the run went beautifully except for a single miscue that flattened a cone. I was relieved when the run was over; it had been an exhausting 70 seconds.

The hardware: no problems. Russ Hagerman, a project engineer for the Lunar Roving Vehicle, has few doubts about hardware for exploring the moon. Remote-control devices and self-propelled vehicles, he says, are highly de-

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veloped now. Storage batteries, possibly recharged by solar cells, could power electric motors. Special wheels, already designed on paper, could negotiate rugged mountains and deep moon dust.

What still stumps the engineers is a purely human problem: tailoring the remote controls to the "drivers." Guiding a vehicle electronically is extremely demanding, as I discovered during the seven runs I sweated out.

I first tried a low-speed (1.4-m.p.h.) and a medium-speed (3.1-m.p.h.) trial, both without time delay, as a warmup. It was unlike anything I'd ever tried before. There was a stick instead of a steering wheel, a constant-speed governor instead of an accelerator pedal, a flickering picture instead of direct vision, a rigid stool instead of a seat that moved with the weaving jeep. And no brakes.

Even so, the first two runs weren't too hard. At low and medium speed there was time to correct mistakes.

The feedback lag. The 2½-second delay introduced an irrational, nightmarish quality to my earthbound lunar trip.

Practically everything we do with our hands has an immediate result. A delay in the familiar cause-effect pattern causes uneasiness and frustration. Furthermore, the learning process is severely impaired by a lag in feedback; by the time you see the effect of your last action you've forgotton exactly what the action was.

Hagerman and Bill Obert-Thorn, a human-factors specialist at Grumman, have been trying a variety of control arrangements. They soon learned that the fewer tasks a driver has to perform, the better —for him and the vehicle.

They selected three constant speeds on the basis of trial runs—1.4, 3.1, and 4.25 m.p.h. A driver could then concentrate on steering, since speed was outside his control. An actual moon vehicle, however, might have a speed control so it could scurry over long, flat stretches.

Steering could be the familiar proportional type—in which the wheels turn at an angle proportional to the angle of movement of the control device. Or it could be "bang-bang"—an all-or-nothing type in which the wheels point only straight, hard right, or hard left.

Finally, the TV camera was rigged so it could point ahead or pan with the wheels. This made 12 possible combinations.

My first experience with the time delay was at medium speed (3.1 m.p.h.) with proportional steering and fixed camera. I ran over five cones and went on the wrong side of four others.

The second run was also at medium speed with proportional steering; but the camera was linked to the front wheels to pan with them. This time I clobbered six cones, but stayed inside all the others.

Though this was better than my previous showing, I found the pan effect distracting. The camera seemed to swing over too far. And while it was aimed to one side I lost sight of the windshield latch, which I had been using to aim the jeep.

The third run, described earlier, was at high speed (4.25 m.p.h.) with proportional steering and fixed camera. I flattened two cones, outflanked two others.

On the fourth run I surprised myself and my Grumman mentors. This was a medium-speed, bang-bang steering, fixed-camera combination. With bang-bang the amount of deflection was constant at 30 degrees. I had to worry only about duration of the turn. Instead of shoving a clumsy stick, I flicked a small toggle switch. My score: one cone down, none outflanked.

High-speed, bang-bang. My fifth, and last, run was a high-speed, bang-bang, no-camera-pan combination. I really blew it. Whether from overconfidence, fatigue, or heavy ignition interference from a plane taking off nearby, I couldn't tell. But I squashed six cones and went on the outside of another.

I climbed out of the darkened trailer convinced that they had better provide plenty of replacements for the Lunar Roving Vehicle—and its driver. But Hagerman assured me he was working on a driving aid that would overcome the time-lag handicap.

"It's a mechanical analogue computer for constant-speed, bang-bang-steering control," Hagerman said. "It will superimpose a spot on the screen that indicates the jeep's position 2½ seconds later, based on present course and speed. You steer the spot instead of the front of the vehicle."

Even with such a predictor, moon-vehicle drivers will be busy, harried men. But here's one volunteer. Talk about armchair adventuring! ■■