By LT. COL. JOHN H. DeWITT

RADIO TO THE MOON

Lt. Col. John DeWitt, the first man to send signals across cosmic space, tells how he did it. The cover shows the Colonel and a part of his radar apparatus.

THE Signal Corps' nationwide announcement on January 25th that the first earth-to-moon contact had been made by radar was not the result of a few weeks experiment, but of long-term thinking that began as early as 1940. We reasoned that there might well be no theoretical limit to the distance our ionosphere-piercing signals might travel, and therefore no theoretical straight line limit to the protecting umbrella of our military radar.

Our contact with the German Luftwaffe proved this. The higher the enemy raiders approached, the better our radar worked. From the start, in fact, the operation of radar outpaced the ceiling of high-altitude planes, and far exceeded the vertical travel of man's most powerful anti-aircraft shell.

This led us to rightly reason that we had an instrument which, being used for the very vital mission of saving lives, was nonetheless realizing a small fraction of its potential use.

If, overnight, the enemy had evolved a very high-flying plane, even our wartime radar could have coped with it. Chances are it will be a long time before such a plane will be produced, indicating that radar science is so far ahead of man's propellent knowledge that no tests on a par with its space-piercing ability are as yet available on earth.

This thinking led us to the next logical target 238,000 miles away — the moon. When we broke through to this satellite at two minutes before noon on January 10, just as it cleared the horizon, we knew we had broken through the encircling ring of the ionosphere. A priceless bit of information—that our signals could and were piercing the void of ether between planets—was ours!

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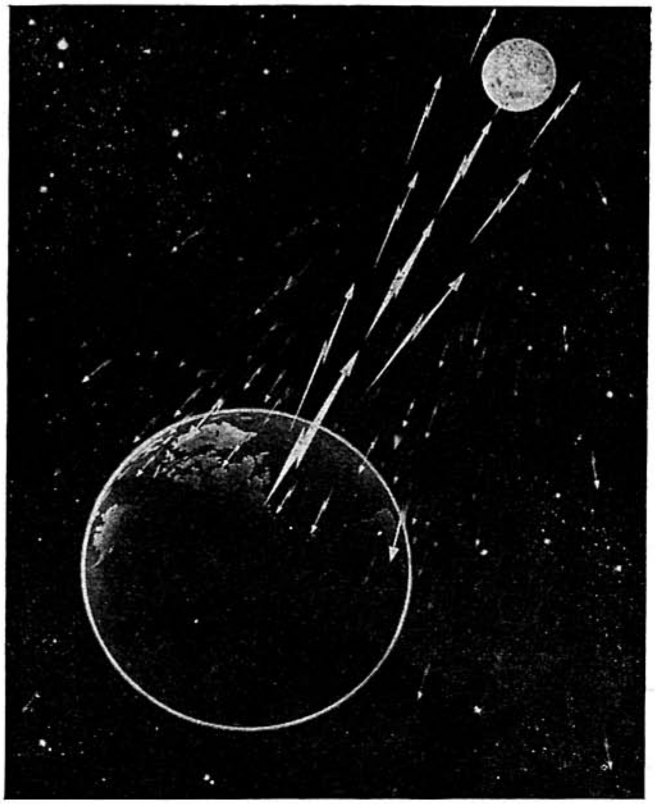
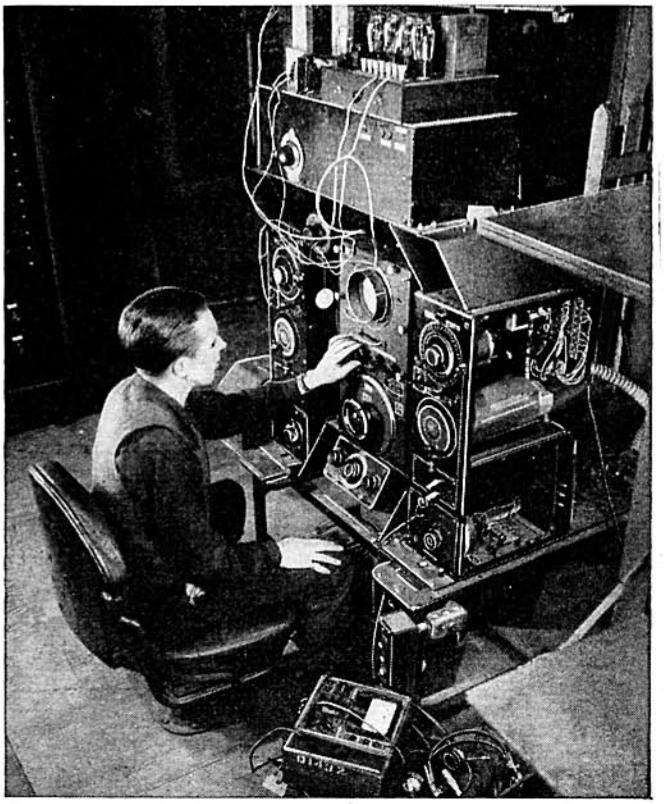
Lt. Col. John DeWitt was born 40 years ago in Nashville, Tennessee. He has been active in radio for 20 years, during much of which time he was one of the South's leading amateurs, W4ERI. On the professional side, he was chief engineer of Radio WSM and its sister FM station W47NV, at Nashville, from 1922 to 1943. Later he was with Bell Telephone Laboratories, engaged in telephone research.

Commissioned as Major in June, 1943, he served with the Electronics Branch of the Engineering and Technical Service of the Office of the Chief Signal Officer, and later as director of the Camp Evans Signal Laboratory. In this work he was responsible for direction of a large number of projects on important weapons for the ETO, perfecting among other devices several types of equipment for locating and pin-pointing enemy mortar fire. Favorite hobbies, as of 1943, were amateur astronomy and amateur radio. Is also an inveterate hunter and hiking enthusiast.



Radar Signals leaving Belmar to the moon, and echoes reflected in scattered fashion to the earth and into the space surrounding it.



Selsyn devices for keeping the antenna array firing on the moon. The very heavy oversize array required unusual apparatus to turn it.

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Knowledge that we have this power to carry through the vacuum of outer stellar space, proved by the echo from the satellite, means even more: that we can extend man's control and influence into voids far removed from the earth.

What I mean by control is our everyday ability to push a button and reroute a railroad train, or press a switch and light up a room, or dial a phone and talk across a city.

On January 10th we learned we could push a button and make *things happen in outer space*, for the calculated intensity of our signal delivered on the face of the moon, sufficient to produce an echo on earth, is far more than needed to control a device on the face of the moon, or anywhere in space between us and it.

It's no trick at all, for instance, to control a pilotless plane or operate a driverless vehicle on the face of the earth by a simple remote control box. We did that five years before the war. But after January 10th we know that we can do it *as far away as the moon*, or on the face of the moon if you like.

That really is the significance of our discovery. Not that with a dozen years of delicate watchlike radar improvement we could map the moon, now fairly well done with a good telescope. By the time we map the moon by earth radar, these radars will be controlling an intersatellite service which, being on the spot, will be able to do map making as a subsidiary or incidental assignment. In short, radar has presented a means of control and communication well in advance of man's ability to project himself in space. And it may well be the means which will lead to it.

To provide any sort of concrete proof that our radar was reaching the moon it was obvious, lacking a lunar receiving station to report on our signals, that we had to send a signal to the satellite *so strong* that we could check our own echo.

For this we used 64 dipole antennas in phase with a reflecting surface behind—standard radar equipment merely doubled in size, power gain approximately 200. Our transmitter operated on 112 megacycles, peak power around 4 kw, pulse duration ½ second, repetition rate 1 pulse each 5 seconds. The transmitter was crystal controlled, using a 500 kc bar and employing frequency multiplier stages to reach a final amplifier output of 112 megacycles. This final power amplifier used during early tests and prior to the announcement of the contact, used two Eimac 1000-T tubes in a conventional v.h.f. push-pull circuit.

Far more complex was the receiver which, built with a sensitivity of 0.01 microvolts, is about 200 times as sensitive as the most progressive type communications receiver available to the public today. This sensitivity was absolutely necessary, our closest calculations showed us.

Astronomically, we knew that the surface of the moon was lava which, measured on earth, has a dielectric constant of about 6. This meant that about 16 percent or 3 watts of our energy striking the moon would be reradiated in all directions. Our receiver, therefore, would have to be sensitive enough to pick up signals not stronger than would be sent from a 3-watt walkie-talkie operating on the moon.

Basically, the receiver is a 4-mixer superheterodyne with all but one of the mixer injection frequencies controlled by the transmitter crystal to provide locking with the transmitter frequency. The fourth mixer is provided with an adjustable-frequency crystal to establish the final i.f. for the exact frequency to be received.

The receiver's input frequency differs from the transmitter frequency by an amount depending upon the *Doppler*

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Signal Corps Photo
Part of the supersensitive receiver and test equipment used for the measurements.

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Effect due to the moon's velocity. When the moon rises we are speeding toward it 834 to 626 miles per hour, Doppler Effect *increasing* the frequency of the echo signal between 279 and 209 cycles from the transmitted signal. At moonset, we recede from the satellite at from 891 to 578 m.p.h. which *decreases* the echo signal frequency anywhere from 287 to 188 cycles. This exact frequency measurement of the Doppler Effect on our radar signals, incidentally, provided a proof positive of contact with the satellite.

The experiments which established the first contact with the satellite on January 10th are, of course, only the merest beginning of developments which may rapidly occur in a short space of time.

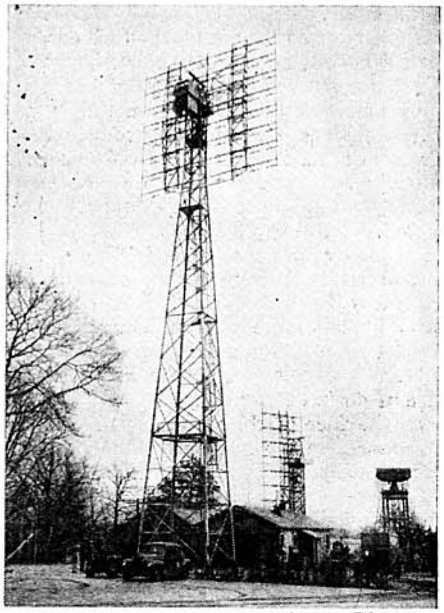
In establishing our 476,000 mile contact we now have an invaluable circuit *through* the ionosphere which, our experiments show so far, is interrupted by unexplained phenomena. For instance, while it is too early to say with assurance, sun spots appear to disrupt continuity of the circuit, whereas for terrestrial straight-line u.h.f. they have little or no effect. Also on one or two occasions we contacted the moon *before* it rose over the horizon. And we are just beginning research on the effect of radically shifting frequency, say from the present frequency to 500 megacycles, or to 1000 megacycles, and the concurrent gain realized from a very large parabolic antenna. What will happen then? We will find out!

These are vast fields of unanswered scientific questions to which we may apply to outer space a research weapon as valuable to man's electronic knowledge as the microscope to bacteriology.

Another question of prime importance: just how far will our signals *really* travel? Calculations show our radar transmitter, using a peak power of from 3 to 4 kw (which actually is not very large), produced a *reradiated* power from the moon of 3 watts, indicating a signal strength delivered to that satellite easily equal to that received by rural listeners of our network broadcast programs.

First conclusion, of course, is that we will not have any trouble at all broadcasting programs to a moon audience, when and if anyone wants to go there and listen. By the same token if we want to remotely control devices between the earth and the moon, or on the surface of the moon itself we could do it without too much difficulty from an electronic standpoint. But the question leads to this: if our signals are now strong enough to exercise control on the moon, how much of a signal are we getting to Mars and Venus?

Interplanetary contact rests on the development of improved equipment: a superpower transmitter, a razor-sharp antenna beam and an increased receiver sensitivity. Only when we can deliver a signal to these planets *so strong* that we receive an echo from the impact, can we know we are getting there. When we receive this echo, we will know, *ipso facto*, we can exercise electronic control in the void between and on that planet.



Acme Photo

Antennas at Evans Signal Laboratory, Belmar, New Jersey, where the moon contact was made. The big one in foreground sent the signals.

With continued and accelerated research at the Signal Corps Engineering Laboratories we hope to break through to these new horizons of man's ability to talk and impose his will in space.

No nation on earth wants another war. And it is everyone's hope, and the end toward which we are working, that our research will benefit mankind and make this world a better place to live in.

But if America *is* ever faced with a push-button war, the Signal Corps will design the button. . . .

MOON-RADIO PREDICTED IN 1927

READERS of the Gernsback publications will not be too surprised to hear of radio-radar contacts with the moon, since such communication was accurately predicted 19 years ago in an article by Hugo Gernsback, entitled: "Can We Radio the Planets?", and published by him in his former magazine, *Radio News*, February, 1927.

The article foretold exactly the results now had by the Army Signal Corps scientists. An illustration pictured a radio transmitter on the earth with the moon overhead and the reflected radio beam coming back. At each side of the earth an observer was shown monitoring the transmitter and received waves, with a clock indicating two and a half seconds elapsed time between the outgoing and incoming signal.