VOICES OF THE SATELLITES!

SCIENCE SERIES

FOLKWAYS RECORDS FX 6200

RECORDED AND NOTES BY T. A. BENHAM

COVER DESIGN BY RONALD CLYNE

VOICES OF THE SATELLITES!

DESCRIPTIVE NOTES ARE INSIDE POCKET

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SIDE ONE

1—Introduction / Sputnik #1 / Doppler effect; information derived from it.

2—Description of Sputniks #1 and #2; Laika's heart.

3—Sputnik #1 alone.

4—Sputnik #1 showing Doppler effect.

5—Sputnik #3.

6—Laika's heart.

SIDE TWO

1—Explorer #1 / Telemetering signals.

2—"Explorer #2 goes a ride."

3—Vanguard (third attempt).

4—Explorer #3.

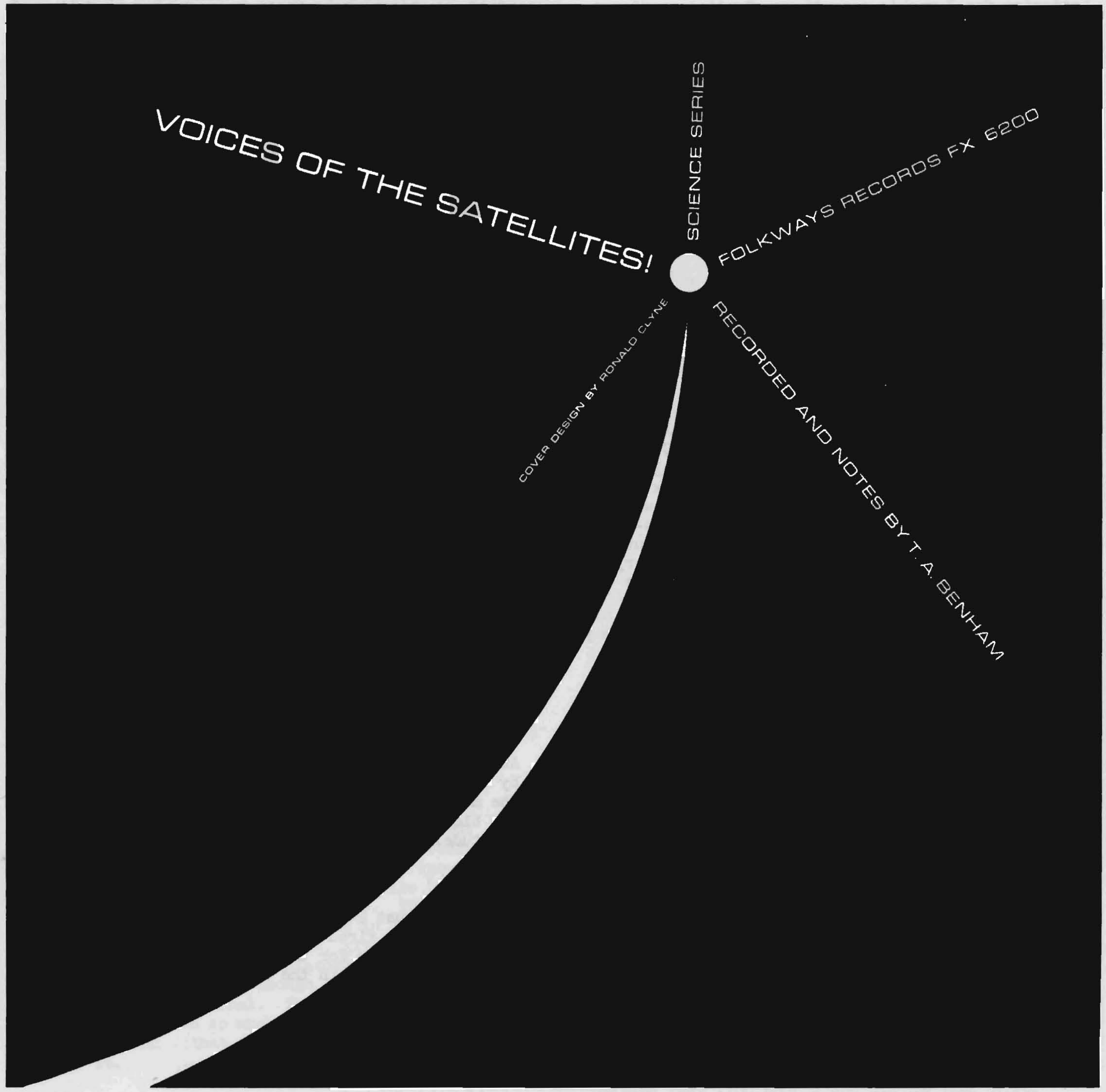
5—Vanguard (second attempt).

6—Modulation from Explorer #1.

7—Explorer #3

8—Explorer #4.

FOLKWAYS RECORDS Album No. FX 6200



A Summary of Satellite Activity

Sputnik I

23 inch diameter sphere weighing 184 lbs. launched October 4, 1957. Carried two radio transmitters and batteries for 3 week's operation. Sending on 20 and 40 megacycles. Elliptical orbit approximately 150 miles at closest approach, and 600 miles at farthest distance. Came down January 4, 1958.

Sputnik II

Launched November 3, 1957 weighing 1100 pounds. Carried the same type of radio equipment as Sputnik I, and a special chamber containing the dog, Leika, who lived for one week. Closest approach about 200 miles; farthest 1100 miles. Came down April 13, 1958.

Vanguard A

Fired about noon EST December 6th, 1957, and it did not get off the launching pad. The satellite was the 6 inch test model.

Explorer I

Launched January 31, 1958 from Cape Canaveral, Florida. Put into orbit by an Army Jupiter C four-stage rocket. Explorer I weighed about 30 lbs. and was a cylinder five feet long and six inches in diameter. The orbit was elliptical with closest approach 220 miles and the farthest distance 1700 miles. It sent back information about cosmic rays, temperature, and meteorites. Battery life was about 3 months. It is estimated to have a life of 5 years.

Explorer II

Launched March 5, 1958. Failed to get into orbit because the fourth stage of the launching rocket did not go off.

Vanguard I

Navy test satellite launched March 17, 1958. The $6\frac{1}{2}$ inch sphere weighs 3.2 lbs. and carries two transmitters, one operated from mercury cell battery supply with a life of about three weeks; the other operated from a solar battery, life indefinite. The solar battery transmitter sends back information about temperature of the surface of the satellite. Put into orbit by Vanguard 3-stage rocket. Minimum distance is about 400 miles, and maximum, 2500 miles. The lifetime is estimated to be about 200 years.

Explorer III

Launched March 26, 1958. Same as Explorer I, expect contains a small tape recorder which can be triggered from the ground by means of radio. The orbit is unusual, having a **minimum** distance of approx. 120 miles and a maximum of 1730 miles. Rather unstable because of close approach. It expired during the last week of June 1958.

Vanguard B

Launched April 28, 1958 about 11:00 pm EST and went quite high. Noticed it had telemetering signals on either side of the main signal. It was the first full scale 20 inch diameter 21 lb. Vanguard satellite. The attempt was unsuccessful.

Sputnik III

Fired May 14, 1958 at about 2:40 EST and weighed 2900 lbs! It transmitted on 20 and 40 megacycles sending .-.. with spacing variable according to information to be transmitted. Same orbit as other Sputniks with a maximum height of 1168 miles and a minimum of 168 miles. Its period was 105 minutes, and the batteries lasted about 75 days. It is estimated to have a life of

Vanguard C

Full scale model Navy Vanguard launched May 27, 1958 at 9:30 EST. The third stage fired with the rocket at too steep an angle and rose to 2200 miles and fell into the ocean near the east coast of Africa. Noticed the same extra telemetering signals. Signals were audible for a much longer time because of the great height.

Vanguard D

Launched on June 26, 1958 at 2:00 am EST. Got up to about 35 miles and did not get above the horizon for a latitude of Philadelphia.

Explorer IV

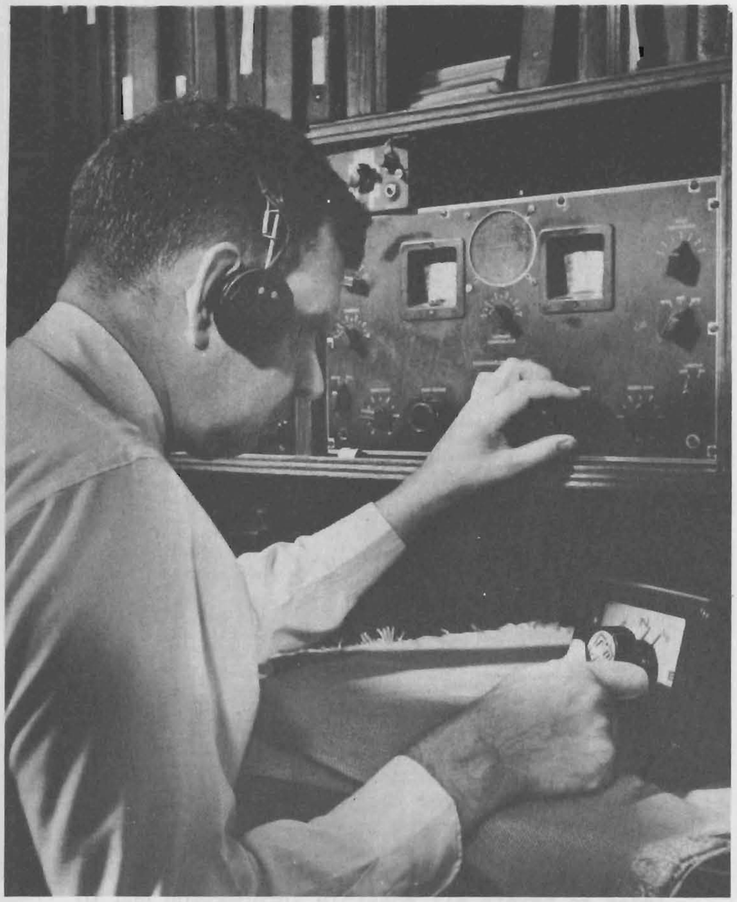
Launched July 26, 1958 at 10:00 EST. Shot toward the northeast instead of the southeast as the previous one had been. It weighed 38 lbs. and had the same 80 by 6 inch cylindrical shape. Reaching 50° Latitude North, its maximum height is 1400 miles and minimum is 220 miles. This satellite was specifically designed to study the intense band of radiation discovered by Explorer III at about 1200 miles. Its estimated life is 5 years.

Moonshot A

August 14, 1958 at 7:18 am EST the first attempt by the Air Force to launch a satellite to encircle the moon and return. Unsuccessful shot due to the blow up of the first stage rocket at 10 miles altitude.

Explorer V

Launched August 24, 1958 at 1:18 EST. Unsuccessful. The last stage fired at too low an angle. Got above the horizon for the Philadelphia latitude for 2 minutes. Headed in the same direction as Explorer IV.



During 1956 and 1957, there was much talk amongst scientists about the satellites that the United States proposed to launch. In January or February of 1957, the schedule was to make the first attempt during March, 1958. I knew this first hand because I was consulted about the design of the equipment that was to pickup the noise made by meteorites impinging on the skin of the satellite. It was during these conferences that the 1958 date was mentioned.

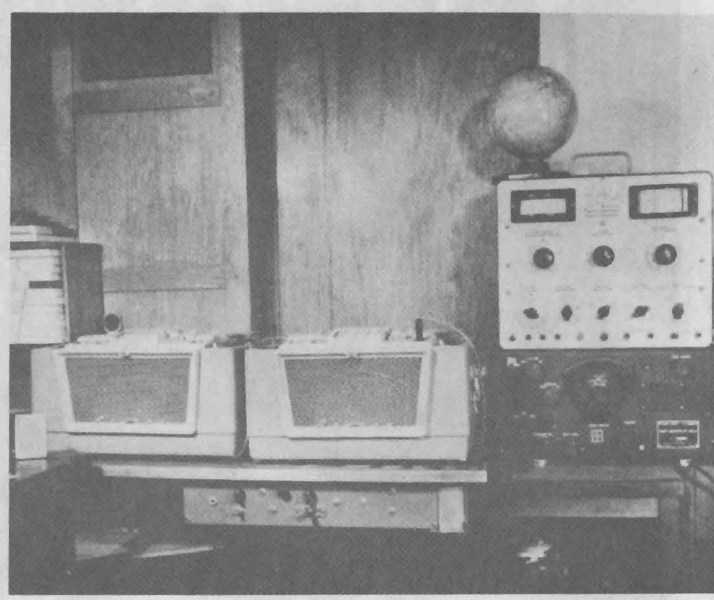
By this time, most everyone knows what happened. On October 4, 1957, Russian scientists successfully launched man's first artificial satellite known as Sputnik I. It came as a great surprise to everyone, although it should not have. The Russian scientists had published an article in June of that year announcing their intentions, giving some technical information. Translators the world over missed this article even though it appeared in a reputable Russian journal. The reason given was that there had been so much material published during 1956 and 7 that translators could not keep up with it.

Sputnik did, however, violate one bit of etiquette. One of the committees for the International Geophysical Year had decided that radio signals should be sent from satellites on a frequency of 108 megacycles. Consequently, everyone but the Russians were set up on this frequency. Sputnik I. transmitted on 20.005 megacycles as well as 40.010 megacycles.

As a result, American scientists were not ready to track Sputnik I. by its radio signals. Radio amateurs from all parts of the world came to the rescue during the first few days while the very complicated and accurate equipment of the official tracking stations was being converted. Results sent into headquarters by these amateurs together with those of stations which were able to function since they do not depend on radio signals, gave scientists sufficient data to enable them to establish the velocity and orbit of Sputnik I.

As soon as the news was released that the satellite had been launched, I turned on the receiver and tuned to 20 megacycles. The choice of 20.005 megacycles was pretty clever since it is right next to WWV, Americas Bureau of Standards station which served as a land mark to make it easy for people to find the frequency of Sputnik. You see, since the radio signals from a satellite are audible for only a few minutes at a time, it is necessary to listen constantly on the frequency until the schedule of the satellite is determined. This schedule is rather complicated since it moves backward each day. For example, the signals might be heard at six, eight and ten A.M. and seven, nine and eleven P.M. on one day. The next day, the times might be a half hour earlier. Also, because of slight atmospheric resistance up where the satellite is, the schedule changes gradually. The moon which is a satellite, of course, is absolutely predictable because there is no friction way out there and because the orbit has had plenty of time to stabilize. Also, slight irregularities in the earth's shape do not produce any influence on the moon at 240,000 miles.

Then, on November third, 1957, Sputnik II. came along carrying Leika, the first living creature to be put into an orbit around the earth. Otherwise, this satellite was pretty much a repetition of Sputnik I. except, as announced by Russia, it weighed over 1100 pounds and had the dog in it. Both of these facts, however, represented a tremendous achievement. One small consolation could be found in the fact that it appeared that the apparatus with which the dog's heartbeat was made audible had been developed at Johnsville Naval Development Laboratory near Philadelphia.



This is a picture of the tracking equipment as it finally evolved at our listening station. On the left is the audio oscillator mentioned in the record with which the pitch of the signal is determined. Above it can be seen the control panel with the switches that turn on and control the various pieces of equipment. Above that is a small auxiliary tape recorder which is used for special signals when the regular recorders are both in use. To the right of these units is the receiver. When listening to sputniks, this is tuned to 20 megacycles, but when listening to American satellites, it is tuned to 6 megacycles as will be explained later. Remember that our satellites transmit of 108 megacycles. At the far right and at the desk level is the instrument that controls the horizontal rotation of the antenna. This antenna is described later. To the left of this is the unit that controls the vertical rotation of the antenna while above these is the panel which carries the indicator that tells at what verticle angle the antenna is pointing. If the pointer is horizontal, as shown in the picture, the antenna is pointing horizontal. The typewriter can be seen in its nitch above the panel.

In order to track satellites, the receiver must be very accurately set and it must be extremely stable. That is, it must not change its setting. The chief cause of a change is differences in temperature and humidity. For this reason, the receiver is left on all the time. In fact, it was not turned off during the first year of satellite activity. On top of the receiver on the left corner can be seen a small box. This contains quartz crystals which produce known frequencies by which the receiver is set and with which it is often checked. In the picture, the equipment is set for 108 megacycles. Actually, we should say 108.000 megacycles.

In the left side of the right picture, (1-B) you will notice the two tape recorders that are used for making a permanent copy of the signals as they come in over the receiver. The lower intrument to the right is a second receiver. The American satellites transmit of two frequencies, 108.000 and 108.030 megacycles. In order to obtain all possible information and to have a check on performance, signals from both transmitters are recorded, one on each tape machine. The signal at 108.030 megacycles is usually the stronger of the two since it is transmitted at a power level 60 milliwats, (0.060 watts) while the other is transmitted at only 10 milliwatts. The more powerful transmitter uses a battery that will last about a month; while the battery for the weaker one lasts for perhaps three months. Almost all of the telemetering signals that are sent down to inform scientists about conditions in space are sent on 108.030 megacycles on the 60 milliwatt transmitter. We use the right hand receiver for this frequency while the other one is tuned to 108 megacycles. Since the signal at this frequency is clean, (not encombered with telemetering information) the latter is better for dopplar shift measurements.

On top of the right hand receiver is an instrument that we call our artificial satellite. The real satellite signal comes in for only a few minutes at a time. If the receiving equipment and recorders are not ready when the satellite first comes over the horizon, there is not time to get ready before the signal has faded out. In fact, starting from scratch, that is, nothing tuned or adjusted, it takes about 20 minutes to prepare everything. The artificial satellite puts out a signal very similar to the real one and on the same frequencies. We can check receiver tuning, antenna direction, recorder settings, etc. In fact, we can actually make artificial dopplar runs to see if everything is working properly. Because its signal is not connected to an antenna, it does not disturb others.

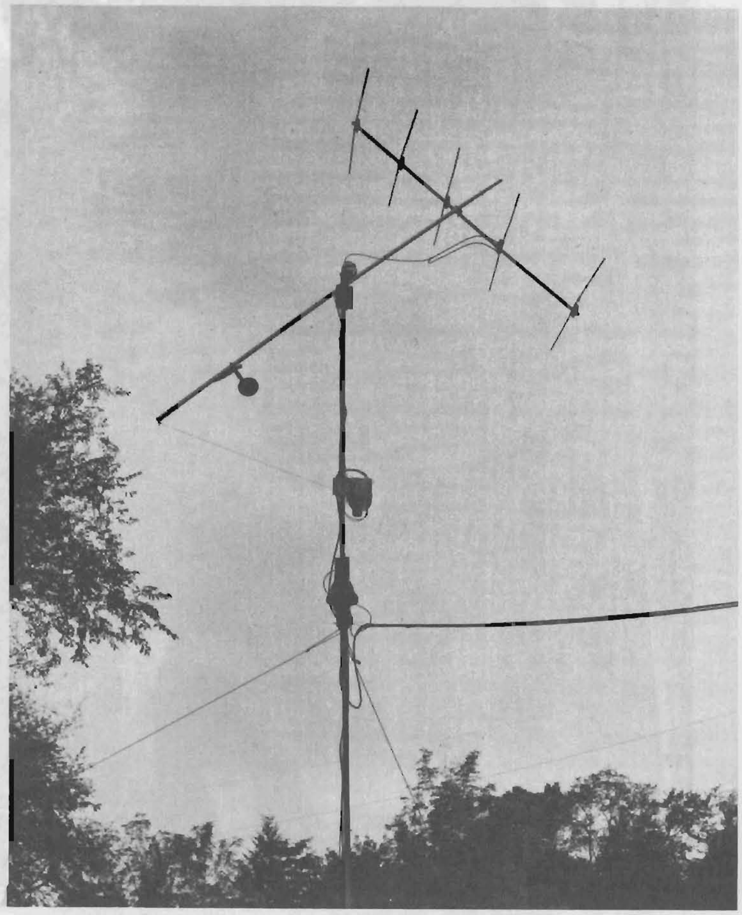
The word satellite has been in our vocabulary for a long time, but it has not meant much to children until October, 1957. Now, even eight year olds can get excited about them, especially when they can listen to them first hand.

One day I came in to find two of my children, Connie and Roby, intently listening to Explorer IV. After the path was worked out from a recording made from the other receiver, they were thrilled to discover that the satellite had passed overhead at a height of 615 miles, heading Northeast.

In the picture, Roby is tuning the receiver while listening to the signals on a loudspeaker, and Connie is listening with earphones. What they are hearing are the modulation signals for Explorer IV. that appear on side two of the record.

In order to receive the best possible signals from U.S. satellites, the antenna should be in the open. To accomplish this, it is mounted on a 25 foot pole in a field about 150 feet from the receiving and recording room. This means that there has to be a 150 foot long cable to carry the signals from the antenna to the receiver. If this were done at 108 megacycles, more than half of the signal would be lost in the cable. Since the transmitters in the satellites send out very little power to begin with, every method possible should be followed to preserve the signal that is picked up by the Antenna. The cable looses much less if the frequency is lower. Mounted on the antenna pole is a box housing what is called a frequency convertor. Mrs. Fuller is pointing it out to the children in the picture and explaining its purpose.

This convertor receives the signals as they come from the antenna at 108 megacycles and changes them to six megacycles. Perhaps you have heard of beat-notes in sound. That is the pulsing that is heard when two tones are sounded simultaneously having nearly the same frequency. The pulsing frequency is the difference between the two frequencies and is called the beat frequency. In the convertor is an oscillator which generates a signal at a frequency of 114 megacycles. When this is "beat" with the incoming signal at 108 megacycles, a 6 megacycle beat frequency results. This beat frequency is then carried with very little loss by the 150 foot cable into the receiver which is tuned to 6 megacycles. So long as the frequency of the incoming signal does not differ widely from 108 megacycles, the receiver can pick up the resulting beat by simply tuning it around 6 megacycles. For example, to receive the 108.030 megacycle signals, the receiver is tuned to 114-108.030=5.970 megacycles.



Receiving satellite signals is much different from receiving ordinary broadcast stations. Transmitters for regular radio stations may put out 50,000 watts which are picked up by receivers usually within a distance of 25 miles. At night, of course, they can be heard from much greater distances, but not reliably. On the other hand, satellites carry very feeble transmitters. This is done to make the batteries last as long as possible. When rocket techniques are further advanced, atomic power supplies will be used which will make it possible to use much greater power and for indefinite length of time. Just now, however, every weight saving device must be used.

The most extreme conditions thus far are presented by the Navy Vanguard satellite launched March 17, 1958. This satellite has a solar battery operated transmitter in it which produces five milliwats and goes out to a maximum distance of 2500 miles. This satellite can be heard on side 2 of the record. In order to receive this, a good antenna must be used which will collect in as much of the passing wave as possible. The antenna that we used is shown in the photograph. Crudely speaking, it acts like a telescope with a rather broad field of view. In the picture, it is pointing up at an angle of 45 degrees to the northeast. The antenna consists of five aluminum rods about four feet long arranged parallel to each other about 20 inches apart. The cable that carries the signal to the convertor is attached to the fourth rod from the top. This array of rods is mounted on a mast which is designed to rotate the antenna, so that it can point in any direction above the horizon. The motor for rotating the antenna around the compass points is the lowest object about halfway up the pole. Above this horizontal rotater is the motor for pointing the antenna up at any angle.

The device that tells the operator at the controls in the receiving room in what direction the antenna is pointing, is located further up the pole. You can also see the group of cables leading to the control room. They consist of a cable carrying the six megacycle signal, one for operating the horizontal rotater, another for the vertical rotater and a power line to bring 115 volt out to the convertor.

Such an antenna as this is said to have a gain of ten. That is, it is ten times more effective than a simple antenna would be. Putting it still differently, it makes the satellite transmitter appear to have ten times as much power as it really does. With more expensive and elaborate antenna systems, a very much greater gain may be realized. At Jodrell Bank in England, there is an antenna which is 250 feet in diameter which has a gain at these frequencies of about 25,000. Such an installation costs several million dollars.

There is another problem that might be of interest. As can be imagined, the receiver that is used to pick up the 6 megacycles signal from the convertor must be a very sensitive one. Now, there are radio stations broadcasting on just about every frequency. Six megacycles is no exception. At night when the signals from these stations are strongest, they tend to get into the receiver and interfere with satellite signals. Great care must be taken to see that everything is as well shielded as possible, even the cable that brings the signal from the convertor. We put this cable above ground about fifteen feet, but it really should go underground. The interference would be much less. During the day, we have absolutely no trouble, but at night there is some leakage, as we call it.

ROUTE OF THE SPUTNIK

From the diagram one can see how, as the globe revolved, the sputnik wove a kind of invisible cocoon of its trajectories round it, swathing nearly the whole of the Earth's surface from pole to pole.

Perhaps you would like to try your hand at calculating the velocity and distance of closest approach for one of the satellites. First, we need a little mathematics. For a moving body that is sending out a wave such as from the horn of an automobile or the radio signals from a satellite, if the body is far away and approaching, the frequency of the wave as detected by the listener is $F_A = F_O$ (C/C-V) where F_O is the true frequency, C is the speed with which the wave travels and V is the speed with which the body is moving toward the listener. This equation is true if the body is far away and approaching. For radio signals, C is 186,400 miles per second. Now if we know the true frequency and the apparent frequency F, we could calculate V. But we don't know F_O for sure so we need another fact. After the satellite has passed over head and is receeding far away on the other side, the equation is $F = F(C/C+V)$. Now if we divide one by the other, F_O will disappear leaving V as the only unknown.
$F_a/F_r = (C+V)/(C-V)$

After very careful measurements of the frequencies, we find that F_a=20,004,500 cycles and F_r=20,005,500 cycles. Now you can determine V, the speed of the satellite. See if you get my answer, V=4.66 miles/sec. or 16,776 mph. You can also calculate the speed of the car whose horn illustrated the dopplar shift phenomenon in the recording. A piano will help you find the frequencies F_a and F_r. Remember that the speed of sound is about 1120 feet per second or 760 miles per hour.

Once we have the speed of the satellite, it is calculated possible to find the distance to the satellite when it is closest to the listener. To do this accurately involves a very complicated process. An approximate answer can be obtained as follows: On record it was mentioned that we need to know the maximum rate of change of frequency. Suppose we call this P. The equation for the minimum distance is D_{min} $F_O V^2/PC$. This time, we must know the true frequency F_O. One way to get it rather closely is to find the mid frequency between F_a and F_r. Simply add them together and divide by two. $F_O = (F_a + F_r)/2$=20,005,000 cycles per second. V has already been determined. From the recording, we can find that the frequency changes about 400 cycles in one minute at its maximum change. In order to make the calculation, however, we must divide this by 60. P must be frequency change per second, not per minute. Hence, P=6.67 for this example. Substitute the numbers into the equation for D_{min} and see if you get the same answer I did; that is, D_{min} 349 miles.

It must be remembered that this simplified method ignores the fact that the satellite is going in a circular path. To take this into account requires rather complicated geometry and trigonometry. The answer as found by our system is correct to within a few per cent, however.