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COMMUNICATIONS TO THE MOON AND PLANETS

By

DR. EBERHARDT RECHTIN

THE RADIO CLUB OF AMERICA, INC.

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The Radio Club of America

ORGANIZED FOR INTERCHANGE OF KNOWLEDGE OF THE RADIO ART, THE PROMOTION OF GOOD FELLOWSHIP AMONG THE MEMBERS THEREOF, AND THE ADVANCEMENT OF PUBLIC INTEREST IN RADIO.

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PROCEEDINGS OF THE RADIO CLUB OF AMERICA

Volume 42 April, 1966 No. 1

COMMUNICATIONS TO THE MOON AND PLANETS

By

DR. EBERHARDT RECHTIN
Assistant Director of the Deep Space
Instrumentation Facility
Jet Propulsion Laboratory, Pasadena, California

I want to tell you something tonight about space technology before it becomes obsolete. Our technology goes dramatically from five inch headlines to half an inch on the front page; only very shortly thereafter, it is down to a quarter of an inch on page ten. Not long after that stage, we are pleased to get a short statement once in a while in a back section of the paper.

Another measure of how rapidly our position dwindles in the public eye is the response of technical magazines to contributions dealing with our projects. When we first start out getting attention, the technical publications are hungry for any contributions about our project from any source. It isn't long before they limit their acceptances to submissions from the highest and most reputable authority concerned with the project but even that phase does not last for too long. Thereafter, acceptance depends upon the decision of a special papers review committee. Finally, we count ourselves fortunate to be remembered in an annual survey of the whole field.

Perhaps the best index I have found is the way my daughters are treated in elementary school. Their presence in the student body inevitably led to my giving talks at their school to the engineers of the future. Space projects interest people of all ages but the kids in an elementary school can and do ask more intelligent questions than their parents. They understand more, they see more, they appreciate more and they look at fundamentals. For example, "What keeps the Echo balloon up?" was put to me by a very young elementary school student on one of my first ventures into the elementary school area.

For awhile after the initial dramatic phase of the project, the kids are heroes at school. As the novelty of the project wears off, they are what may be described as well respected. Finally, your kids are just kids. We are at that desirable stage now, as far as deep space projects are concerned.

Space Travel Becomes Respectable

I can remember ten years ago, when we talked about the practical engineering aspects of communication to the moon and to the planets, we could do so only with members of research groups actively working on space projects. The Defense Department even issued advice to keep space discussions among ourselves because space travel was not yet accepted as a sensible and plausible proposition by the general public.

Five years ago, when we had several satellites up and communication with them was already old hat, our data rate was not very high - eight bits per second or so. But the literature then was still full of statements that enormous powers and huge antennas would be needed aboard spacecraft for communications from the planets to earth.

By about three years ago, we demonstrated spacecraft with quite useful data rates transmitting from the area of the planet Venus, 50,000,000 miles away. We delivered all kinds of scientific information over that distance at about ten bits per second, which, only two years previous, was about the best we could do from the nearby moon. Then, about eight months ago, we sent live television pictures from the moon and broadcast them to the American public over its TV networks. The frame rate was about one picture per second and the home reproduction was quite acceptable.

About four months ago, we sent good quality facsimile pictures back from the planet Mars at a data rate of about ten bits per second, which serves as a useful lowest limit. The Mars pictures were sent at a distance of 100,000,000 miles. You will see some of these pictures tonight.

We can foresee television feeding directly into our TV networks from the moon with standard American broadcast quality within ten years and we may be able to do a great deal better than that. By that time, we shall be able to get five kilobits per scan from Mars, good enough for sending good facsimile pictures continuously for high grade continuous surveillance of the planet at distances up to 250,000,000 miles, which is its maximum distance from earth at the far side of the sun.

Outer Space Communications and Navigation

At the same time that we have been developing our data communications capabilities, we have been working on navigation and guidance techniques in order to be able to put our spacecraft where we wish. When we started out, we considered our ICBM accuracies quite good. Radio guidance systems which would put down an ICBM within a mile of the target at 5,000 miles were regarded as extremely precise with a performance of one part in 5,000.

About three years ago, we put a spacecraft within 500 miles of the aiming point at 35,000,000 miles. Two years ago, we put a spacecraft on the moon within a few miles of the target at a distance of 240,000 miles. On the planet Mars, we came within a few hundred miles of the target point at 100,000,000 miles.

To put it in another way, our guidance techniques have gone from about one part in 5,000 to one part in 100,000. We are now about to do one part in a million. In the next decade, we can expect this to be routine. This will enable us to go accurately to Mars and when we are there, to control an orbit around the planet with great precision continuously from stations here on earth. We will be able to alter their orbit to put our probes wherever we wish.

Successful Techniques are Simple

A curious thing about this whole space development is that now that we have learned how to do it, the techniques employed look remarkably simple. We sometimes wonder where all the controversy came from along the way. This is probably the classic record of most developments; once you know the answer and demonstrate it, most people can say the solution found is quite straightforward and obvious.

We have learned two fundamental theorems from pioneering in space, two principles that have stayed firmly with us. The first one is that before the flight, the results are unexpected. The second is that after the flight, the result is obvious.

These two precise engineering theorems can be ignored by designers only at their very great peril. They tell us obviously how to build a space telemetry systems. The results must be unexpected before you put the system into use.

Applied to spacecraft design, the first theorem can be carried to great lengths in defining the tolerances and specifications of what to expect, the uncertainties to be encountered and the dire undefined problems that must be faced. You must also be prepared to face the application of the second theorem after you have demonstrated the success of your project, the fact that all the non-participating experts will say everything was obvious all along.

You must not be discouraged when you successfully place a spacecraft in the vicinity of Mars and transmit and produce pictures showing what Mars really looks like, that the armchair experts will say that we told you that it was going to be that way; we all knew it was going to be that way and all the trouble you went to was hardly worth the effort.

We could write a script for an imaginary project from beginning to end, complete with what everyone will say at each stage. It would be a pleasure to watch this being played out in the real world, step by step, as it goes along with an actual project.

It is amazing how many people said that the Van Allen belts were really obvious and that craters on the surface of Mars were of course to be expected.

Reliability on Deep Space Projects

In space technology, we have been most fortunate to have faced the minimum number of false starts. There have been a minimum number of errors in conceptual design and in the basic systems concepts. The communications have fortunately proved very reliable. We have yet to have a significant failure with the moon probes and with planetary space probes. Because of this, we have been able to tell what happens with the rest of the spacecraft system.

A really good criterion for a space communication system design proposes that the communication system must work even after everything else has conked out. You will see that theorem illustrated tonight in a variety of ways. Our fortunes have been far better than those of our notably less successful competition. We will now show you slides of photographs made and transmitted from space which demonstrate, in a way, the answers in the back of the book of space exploration problems. I will not go into detail of how we made these pictures -- the methods used are fairly straightforward. (Laughter). However, it is good to see what happened.

The First Lunar Probe

The first lunar probe stood one foot high and weighed eleven pounds. The total weight allowed for communications equipment was one pound. It was launched back in 1960. We thought that probe was something. It was truly a probe since it sent back ten bits of information per second. It did not get very close to the moon, unfortunately; its closest approach was about 25,000 miles away from it. Consequently we did not learn much more than how to begin.

The guidance system consisted of spinning weights. That was the Pioneer probe, the first one that ever flew. It was not such a remarkable achievement but it will serve to show how fast space technology has progressed from its pioneering beginning.

The antenna installation used to receive the signals radiated by the Pioneer satellite was taken wholesale from the radio astronomers, who had been building large and reasonably precise structures. The dish was 85 feet across. The mount design was based on astronomical requirements. It is an equatorial or polar mount, quite convenient for space probes, where probes look more like stars than rapidly moving objects in the sky, such as earth satellites or missiles.

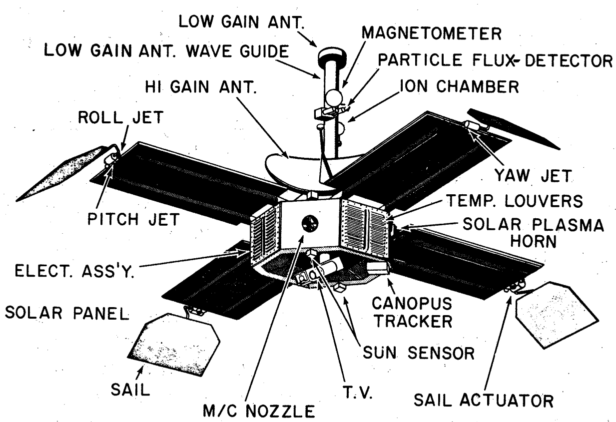

Fig. 1 - The Mariner Mars outer space probe of 1964, showing the principal components

Later Space Probes

The Mariner Mars probe, shown in Figure 1, indicates where we stand today and illustrates many of the components used in current space technology in a more or less standard way. The large wing-like things are solar cell panels. They produce several hundred watts of power from the sun, which is stored and used in the hexagonal center section of the structure. The strange looking post on the top is the low gain antenna. It is a truncated parabola.

The spacecraft is completely stabilized. One stabilization system keeps one axis pointed toward the sun and thus holds the solar panels properly oriented to generate the maximum power from the sun.

The other stabilization axis is pointed at a star roughly out of the plane of ecliptics so that we have what amounts to an orthagonal reference system.

The spacecraft depends upon its sensing system to maintain its stabilization. This activates small gas jets, the pitch jet and the yaw jet. These jets are very small with very little gas in them, a total of about 10 pounds, which is enough to last for four years in space.

These jets occasionally squirt small jets of gas, about once every half hour. This is sufficient to keep the spacecraft stabilized to about one half a degree at all times on the two different axes. The spacecraft is thus locked, if you will, to the sun and to a star.

The fact that it is so stabilized means that the high gain antenna on it is a practical communication tool which may be accurately beamed toward the earth.

The little Pioneer, which I showed you previously, was simply a spinning device. The gain achieved by the antenna was very small, in the order of 5 or 6 DB. The antenna gain on the stabilized spacecraft can easily be 20 or 30 DB.

The amount of power that can be gathered by the large solar panels, which stretch fifteen feet from wing tip to wing tip, is considerably greater than the half pound of batteries that we had on the first moon shot.

The flat shaped sails on the outside are an interesting addition to the guidance and control system. Sunlight exerts pressure on any device in space, where there are very few other influences. This pressure of light is sufficient to upset the spacecraft if the center of gravity is not exactly right. These sails literally sail the craft through space. The little sails move as the sunlight comes in, thereby correcting any small imbalances in the system and they keep the spacecraft pointing into the wind, so to speak. The forces are extremely small but if allowed to keep pushing the spacecraft off center for any length of time, would upset it. The sails contribute materially to space flight stability.

The illustration also shows the Canopus tracker. The camera mounted in the spacecraft took pictures of Mars as it went by and sent them back to earth, transmitting through the high gain antenna. The transmitter had a power level of ten watts continuous.

This spacecraft represents an abrupt jump from the very simple small device to a completely stabilized machine within a very few years. I use the word machine in its true sense because this spacecraft accomplishes its tasks automatically in response to commands sent to it from the earth.

The next illustration shows one of the more important facets of doing business in deep space. DSIF stands for Deep Space Instrumentation Facility. The installations shown are Goldstone, Cal., Cape Kennedy, Fla., Madrid, Spain, Johannesburg, South Africa, Woomera and Canberra in Australia. These stations are so located that a spacecraft, once out of the immediate vicinity of the earth, can be kept in quite continuous contact.

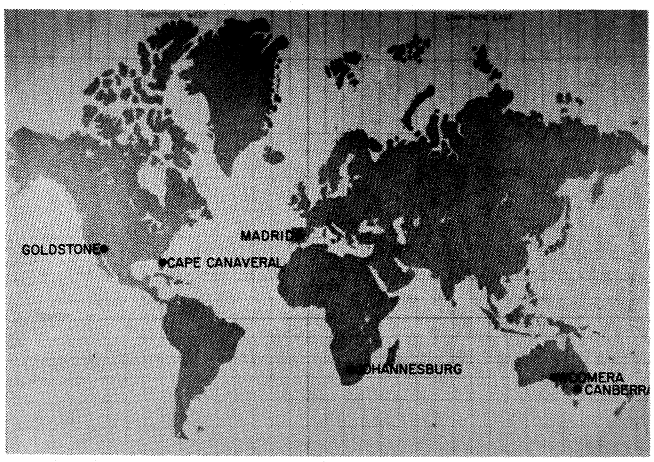

Fig. 2 - Deep Space Instrumentation facilities are distributed longitudinally around the world to maintain continuous contact with space probes

Importance of Continuous Operation

Continuous space probe operation has turned out to be quite important, far more important than we originally believed. When the spacecraft is completely stabilized, it receives solar energy continuously, converts the solar energy into electricity, transmits information continuously at the same power level, employs a guidance and control system that operates in the same sustained fashion. The output of the spacecraft is accumulated on the earth by a set of stations that must maintain continuous contact with the spacecraft throughout its mission. This continuous operation turns out to be the most important factor in maintaining the reliability of the entire system.

When you consider that the Mars mission had to fly for nine months in a hostile environment with no chance of repair, that it then worked perfectly at the end point, transmitting all of its pictures and that it did everything else we asked of it, you have successfully confronted a very severe reliability problem in the basic design of the whole system.

There are two ways in which the reliability problem could have been faced. We considered both approaches originally and, after extensive study, decided upon one of them. In this selection, we were indeed quite fortunate because the discarded approach does not work. The one we selected does.

The reason that it works depends upon an important theorem in reliability: if something is working, don't fix it. Or to put it in another way, if a thing is working, it will probably continue to work. And again, don't change anything in good operating condition.

In a spacecraft on a prolonged mission, continuously stabilized for operating in a relatively stable environment, nothing much is happening. So the electrons keep busily about their work because there isn't much going on that might disrupt things.

The other approach to reliability is based on the proposition that shelf life in electronics is very much longer than operating life. This makes it logical to allow the spacecraft to go to sleep for most of the time and put its system to work only intermittently. This makes it operate under shelf life conditions for most of the time; it is called up into action when you need it for as short a period of activity as possible. You then need only one ground station to talk to providing you time the operations to periods when it is within range of the receiving station. The whole system is then designed for minimum operating time at conveniently spaced intervals and for maximum operation on a shelf life basis.

This is the technique the Russians used and it is the one that does not work. When you look at a plot of failures versus operating time, there is a strong correlation with such events as filling the rocket with liquid oxygen, sudden temperature changes, sudden mechanical changes and the frequency of failure.

In a spacecraft environment, suddenly changing its thermal environment from one of simple tumbling to one of being kept in a fixed position relative to the sun, is a material first order contribution to reliability of performance. This is a difficult proposition to prove analytically but it does turn out that reliance on a continuous transmission and a continuous operation of all functions of the spacecraft is a very strong ingredient toward the success of the spacecraft that have gone to the moon and particularly those that have journeyed to the planets.

Figure 3 shows a modern and permanent station, the Echo station at Goldstone, California. The antenna is the familiar 85 foot dish. This is

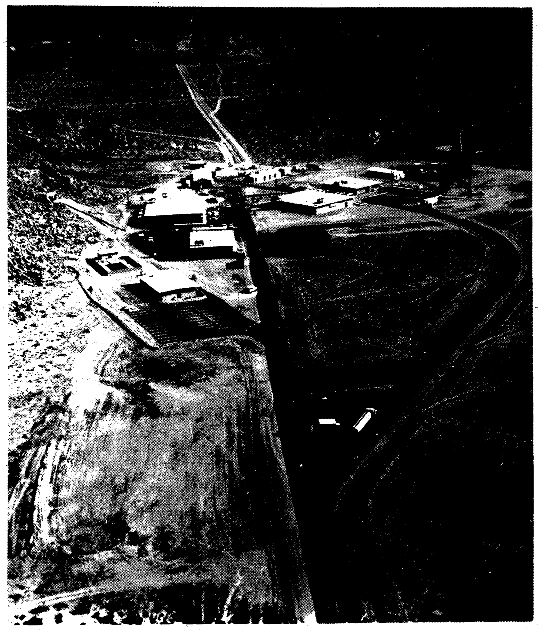

Fig. 3 - The Echo Station, located at Goldstone in the California desert

typical of the stations we have around the world. It is in the desert, a most convenient place for an activity like this. Many of our stations are located in desert country because no one wants to live there. This makes it very quiet in the radio frequency sense so that we can successfully operate high sensitivity stations.

DEEP SPACE INSTRUMENTATION FACILITY

PARAMETER	1961	PLANNED (1962 - 1970)
LONGITUDE SPACING OF STATIONS	120°	120°
ANTENNA DIAMETER (m)	26	26 AND 70 (APPROX)
LISTENING FREQUENCY (mc)	960	2295 ±5
LISTENING SYSTEM TEMP (°K)	2000	<50
TRANSMITTING FREQUENCY (mc)	890	2115 ±5
TRANSMITTING POWER (kw)	10	10 AND 100
PRINCIPAL FLIGHT MISSIONS	LUNAR UNMANNED	LUNAR & PLANETARY MANNED & UNMANNED
TYPICAL COMMUNICATION SERVICE	LUNAR SLOW-SPEED FACSIMILE	TELEPHONY, LUNAR TV PLANETARY FACSIMILE

Fig. 4 - Present and projected deep space instrumentation facilities and their capabilities

Figure 4 shows our progress graphically to 1961 and projections out to 1970. The upper curve is a figure of performance based on the signal to noise ratio which we can achieve in a one cycle band. We have attained a factor of 10 to the fifth power for about 2,000 hours so far and there is as yet no sign of reduction in our rate of progress.

We are going to digital format not particularly because of its communication efficiency but because of the problems of storage and computation. We are simply deluged with data. When we say deluged with data, our friends at the Goddard Space Center are inclined to laugh. What do you mean by deluged? You are getting eight bits per second from outer space. We are getting 200,000,000 bits per day. We have warehouses of tape requiring analysis.

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The balance of Dr. Rechtin's splendid address was devoted to the showing of slides, some of which are shown here as Figures 5, 6, 7 and 8. Following the slides, Dr. Rechtin fielded a large number of questions, a few of which have been abstracted below. Speaker's names and their questions are not given because the microphone on the speaker's table was out of range.

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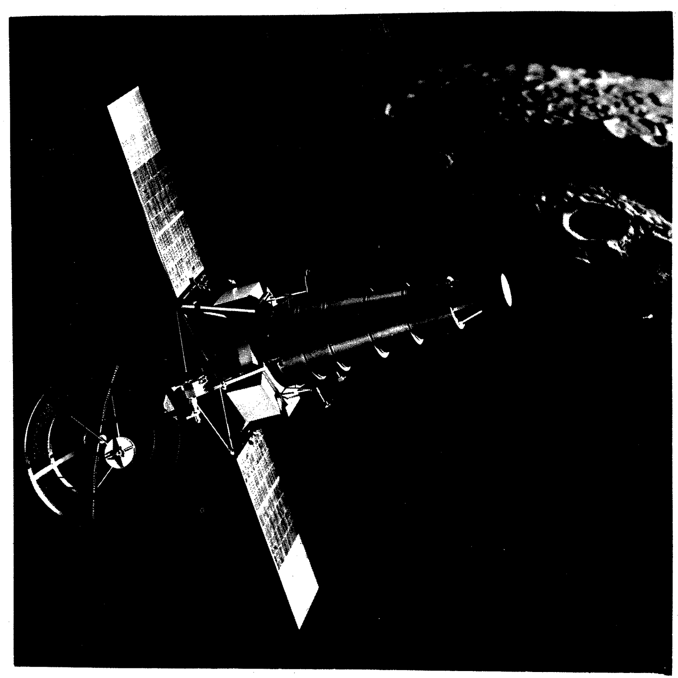


Fig. 5 - The Ranger moon probe, which obtained numerous revealing close-up pictures of the moon

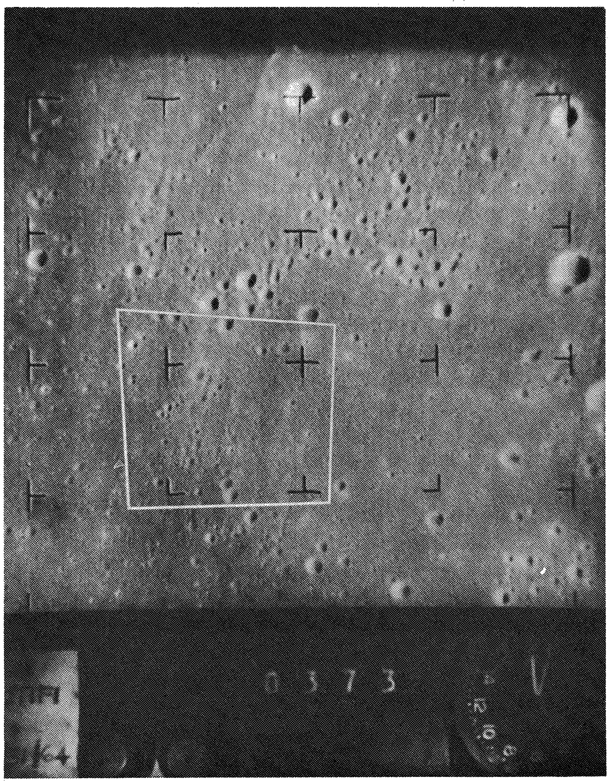


Fig. 6 - Composite Ranger moon map, showing size of a single frame

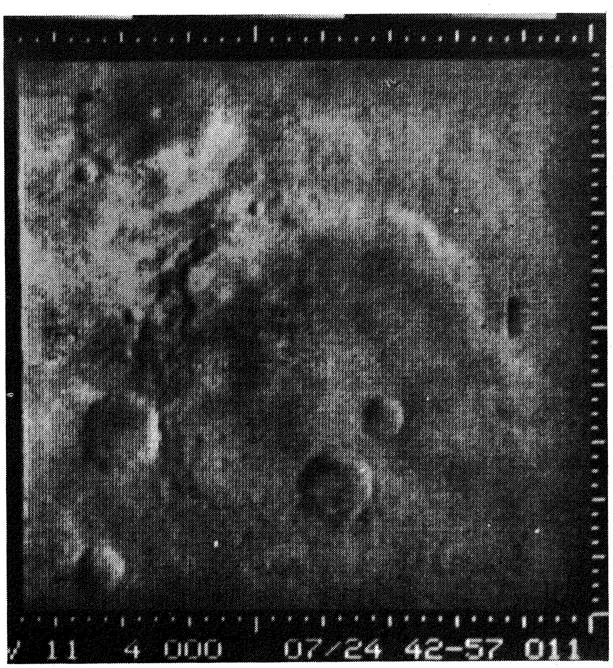


Fig. 7 - A revealing picture of the surface of Mars, showing a similarity with moon surface features

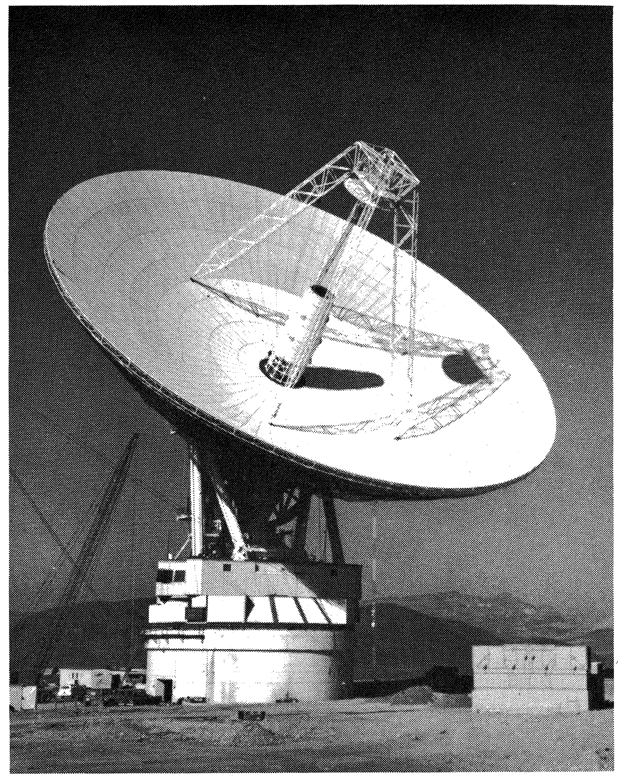


Fig. 8 - Deep space tracking radar with 210 foot dish now nearing completion

Meteorites

Meteorites are a real danger to spacecraft. Most of the dust and debris that a spacecraft encounters is at a close proximity to the earth. We are not quite sure why this is so. A theory frequently advanced is that the earth gathers the debris in its journey through the solar system. It then goes into orbit around the earth and then slowly disintegrates and falls to the earth's surface.

As we go further out, the density is very much lower but it is still significant.

When we went out to Venus, the spacecraft was quite severely hit several times. That particular spacecraft was an early one and it had typical early electronic problems. For a time, it caused us considerable anxiety. The signal received on the earth sensor was erratic. For a time it looked as if we would be unable to accomplish the mission.

You know how we solve that kind of problem on earth. We kick the thing. We could hardly manage that under the circumstances but outer space found a way for us. Along came a rock. It smashed into one of the solar panels and disrupted everything on the space probe. All the power systems were joggled; everything happened at once. Then the spacecraft's communications came back on the air and worked perfectly from then on.

Dust

We are seriously concerned with the outer space dust problem. If we planned to take the dust cap off the camera lens early in the flight, bombardment by dust, the effect of cosmic rays and whatever else to which the lens would be exposed, might seriously degrade the pictures. There was no experience on which to base the best possible trade-off between early and last minute removal of the lens cover. We did not know whether or not we would have serious attitude disturbances near the planet which might not be correctable because of the time lag in controlling the spacecraft at such great distances. With close timing of lens cap removal just prior to picture taking, we would run the risk of having our camera inoperative because of attitude problems, at the very moment that we might otherwise be able to get our best possible pictures.

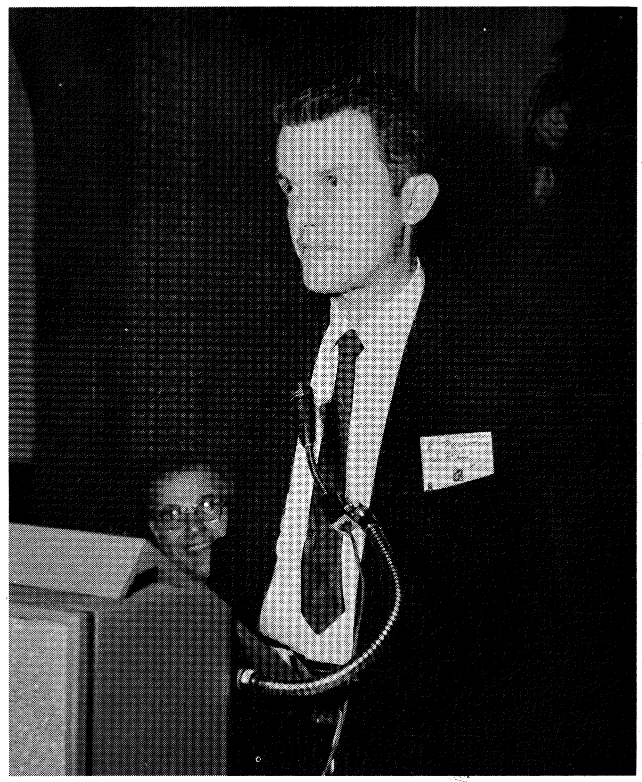
The only proof that we picked the right moment to remove the lens cap is the fact that we came out all right. We analyzed the received pictures for graininess due to dust on the lens. Remember that we were measuring micro-meteorite intensity all through the flight. We simulated the effect of the observed dust in the laboratory; the results caused us continuous concern. Everyone to the director of the laboratory sat in, pondering the problem. We finally made the decision to take off the lens cap in mid-flight because we had so many other problems, such as the possibility that dust specks might affect the attitude controls, etc. We traded off the risks in removing the lens cap earlier to leave us free to concentrate on many other questions requiring last minute solutions.

Stabilization Sails

The sails were experimental and we did not know how effectively they would function in deep space. Hence we provided the gas jets to permit remote navigation of the spacecraft. If the sails could stabilize the craft without the aid of the gas jets, no net expenditure of power would have been required other than that used to control the position of the sails. It turned out that one of the sails had to be positioned at the limit. This can be corrected in future designs. The effect of the sails was to increase the potential life of the gas system from one to four years of operation.

In the future, with careful design to attain accurate weight balance of the spacecraft, it should be possible to achieve attitude stabilization at least in the free fall mode, relying on the sails alone. The problem is quite different when we are turning on a rocket motor, for example. But this affects a small interplanetary spacecraft for only a few minutes out of a total space flight.

DR. EBERHARDT RECHTIN DISCUSSES DEEP SPACE PROJECTS AT RADIO CLUB BANQUET



Dr. Eberhardt Rechtin, Assistant Director of the Deep Space Instrumentation Facility of the Jet Propulsion Laboratory of the California Institute of Technology, addressing the 56th Annual Banquet of the Radio Club

Marked by a great speech by an outstanding space scientist and by the award of the coveted Armstrong Medal to one of our most popular and faithful members, the 56th Annual Radio Club Banquet at the Seventh Regiment Armory in New York on November 19, 1965, will long be remembered in the annals of the Club.

Our president, Jerry B. Minter, extended the Club's greetings to members and their guests, Frank Shepard acted as a genial Master of Ceremonies, John H. Bose made the award and read the Citation for the Armstrong Medal to Ernest V. Amy, quoted in full below.

Introduced by Frank Shepard, Dr. Eberhardt Rechtin, Assistant Director of the Deep Space Instrumentation Facility of the Jet Propulsion Laboratory, delivered the address of the evening, dealing with communications to the moon and the planets. It proved to be a pleasant mixture of authoritative scientific information, philosophy and humor, a compellingly interesting presentation on the practical aspects of deep space navigation and telemetry. The address is abstracted in a separate article, taken from a tape recording made of Dr. Rechtin's speech.

Dr. Rechtin appeared through the good offices of Dr. Robert C. Seamans, Jr., Deputy Administrator of the National Aeronautics and Space Administration, a position to which he was promoted from that of Associate Administrator, during the course of the negotiations with your Editor, acting as a member of the Banquet Committee.

The 1965 Banquet Committee worked under the chairmanship of Wilson Aull and included members Amy, Batcher, Felix, Houck, McMann, Sr., and Minter.

CITATION ON THE OCCASION

of the

AWARD OF THE ARMSTRONG MEDAL

to

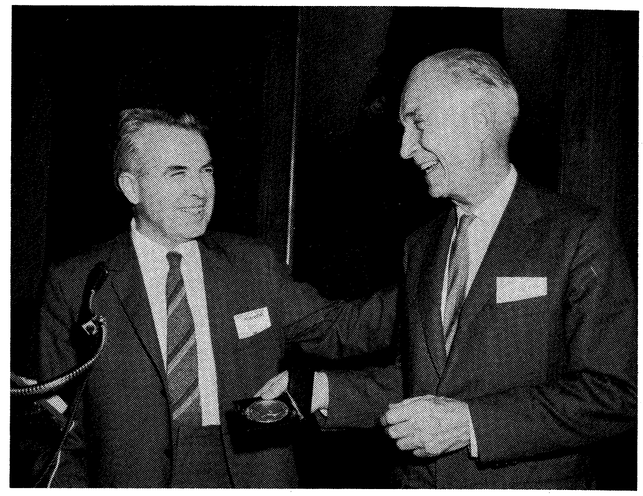
ERNEST V. AMY

Our medalist is a radio pioneer in the true sense of the word. Both as an amateur and as a professional, his efforts have advanced the communication art.

As an amateur, he was active in the organization of this Club, the oldest radio club in the world. A charter and life member, he served either as an officer or as a Director since 1911. He designed and constructed the antenna for the 1BCG transmitter which sent the first radio message ever to be received across the Atlantic Ocean on short waves.

Professionally, he pioneered in the development of early vacuum tube transmitters for commercial marine use, and was active in the design and installation of high power short wave transmitters and directional antennas. His developments of many basic wide-band and noise-reducing antenna systems have resulted in over 30 U.S. patents to his credit. The growth of FM and TV broadcasting in large cities was greatly enhanced by the multicoupler master antenna systems he helped develop.

With all these accomplishments, perhaps his greatest contribution is the inspiration his example has furnished to his colleagues in this exciting art.



Frank King accepts the Armstrong Medal in behalf of his associate, Ernest V. Amy, from Radio Club president, Jerry B. Minter

RADIO CLUB OF AMERICA TO MOVE TO NEW QUARTERS AT GENERAL SOCIETY OF MECHANICS AND TRADESMEN

After many years at 11 West 42nd Street, the Radio Club of America will move its headquarters to a room provided by the General Society of Mechanics and Tradesmen of the City of New York at its building at 20 West 44th Street, New York, N.Y.

Our vacated quarters were made available to us by Ernest V. Amy and Frank King, who not only provided space for the Club's use but also rendered numerous services, such as answering and forwarding mail, maintaining mailing lists and distributing the Proceedings and preparing and issuing Club meeting notices.

The General Society of Mechanics and Tradesmen held its first formal organization meeting on November 17, 1785, over 181 years ago. It maintains and operates the famous Mechanics Institute, a free technical school meeting the needs of the building trades, founded in 1820. More than 100,000 students have attended the Institute since 1900 and it has trained more men for the building construction industry than any other institution in the nation. Electric and electronic technology and mathematics are among the subjects taught at the Institute.

The Radio Club of America is highly honored and it is proud to be associated with this distinguished organization and its widespread and effective educational work.

RIGHT SUBJECT, WRONG WRITER

DAVID SARNOFF, By EUGENE LYONS.

HARPER & ROW
372 pp. $6.95

Lyons' biography of our Honorary Member (1926) should be of great interest to all Radio Club members, but it turns out to be something that we can take or leave. It has several faults, any one of which would be, if not fatal, at least disabling. One is that Lyons stands in too much awe of his redoubtable subject. A biographer may have an inner feeling of inferiority - the subject is usually a greater man than the biographer - but he must keep it out of his writing. He must be dedicated to his task, which is to show the man as he is, warts and all, as the saying goes. He needs something of the ferocity of Goya, who once drew a revolver on a nobleman who objected to the way Goya had painted him. He painted the Empress Maria Luisa and made her look like an imperious old bitch - but it was a great painting and she knew it. If someone did that in words for Sarnoff, I am sure he would appreciate it, after he got over the initial shock of seeing himself as a serious and informed writer sees him.

Then,Lyons, is not a radio man, and he has had to take most his material at secondhand. He could have overcome that handicap had he researched hard enough and been as skeptical and hardboiled as it is the business of a good reporter to be. Perhaps he tried but, if so, he didn't make it. Thus he repeats the accepted story of Sarnoff's role in the Titanic disaster of 1912. That account, though probably by now impossible to dislodge from the annals of American industrial history, is more in the realm of legend than of fact. If Lyons had gone to the sources, or let someone do the research for him (he is a senior editor of Reader's Digest) he could have got at the facts of this not unimportant episode in the Sarnoff saga.

This review grew partly out of a conversation with Ernest V. Amy and Frank King - of course I am solely responsible for the content. Ernest complained that the book mentioned only a few engineers - top-flight men like Alexanderson, Goldsmith, De Forest, Fessenden, Armstrong, etc. - and none of the second-string technical people without whom even a great administrator like Sarnoff could not have created an industry - or rather a congeries of industries. The point carries some weight, but the fact that the managers get as short shrift as most of the engineers. George F. McClelland gets only a single index entry and that is in connection with an anecdote. When Sarnoff found out that the National Broadcasting Company followed a discriminatory hiring policy, he called McClelland, the Vice-President and General Manager, to his office, and pointing to an employment application form, spoke as follows:

"George, this certainly is not aimed at Catholics, since you're a Catholic. It can't possibly be aimed at Jews, since I'm a Jew. Why do we discriminate against the poor Protestants?"

It is a typically effective Sarnoff crack and makes a good story but in a comprehensive book, McClelland deserves better than this. He was the first commercial broadcasting sales manager at WEAF, the pioneer commercial radio station, and became vice-president and general manager of the National Broadcasting Company when it was formed. He died a suicide, a victim of the intestine wars of NBC and his effort to found a third radio network before the time was ripe. His opposite number in RCA, Charles Popenoe, is not mentioned at all. Many people whom I considered important suffer the same neglect. But there is a reason for these omissions. After about 1930, Sarnoff moved in a rarified corporate atmosphere where he just could not afford to give much time to anyone outside of the Rockefellers, the Luces, the Owen D. Youngs and people like that. Those were the names he dropped if you got to see him after the divide, and he was not dropping them just for effect; he was trying to tell you what his life was like now.

I can't be enthusiastic about a job poorly done from either a Lytton Strachey or an Emil Ludwig standpoint (one a good intellectual biographer, the other a good popular one), still, I am not advising against buying the book. It contains some facts that I did not know, such as that it was through Louis Kirstein, the department store magnate of Boston and New York, that Sarnoff met Joseph P. Kennedy, a meeting which resulted in the founding of Radio Keith Orpheum Corporation and the RKO motion picture studios in Hollywood. And, for us who knew Howard Armstrong, there is a fair, objective account of the lethal conflict between Armstrong and Sarnoff. They were great, both of them; they were friends and colleagues for many years. Finally, external circumstance, their own individual strength, and the genius which animated each, drove them into enmity. Or was it only misunderstanding? For now both AM and FM serve the nation - and neither serves it surpassingly well from the standpoint of high American culture. The reconciliation does not makes Lyons' book a good one, but perhaps it should make us more tolerant of its imperfections.

Carl Dreher

Proceedings of The Radio Club of America

1959 to 1965, inclusive

Year	Volume	Number	Title of Paper	Author
1959	35	1	General Review of Missile Telemetry	Dale Samuelson
			An Account of the Discovery of Jupiter as a Radio Source	Dr. K. L. Franklin
		2	Problems of Ballastic Missile Defense	W. H. Hutchins
1960	36	1	The Evolution of Radio	Hugo Gernsback
		2	Golden Jubilee Anniversary Number	
1961	37	1	Super Regenerative Pulse Radar	Frank H. Shepard, Jr.
			The Writing of Radio History - A Project for the Radio Club of America	I. S. Coggeshall
		2	The CBS NetALERT - A System for Network Signalling	A. A. Goldberg, A. Kaiser, D. Vorhes
		3	The Anatomy of an Electronic Typer	Walter Hladky
		4	A New Method of Accurate Frequency Measurement	Harry W. Houck, Norman Gaw
1962	38	1	The Dynaquad, A Solid State Electronic Switch	C. E. Atkins
		2	Philips Telegraph Switching Systems	E. R. MacMillan
		3	Simplified Automation	Ralph H. Batcher
1963	39	1	The Teleglobe Pay TV System	Ira Kamen
		2	The Importance of Reliability and Maintainability of Electronic Devices	S. R. Calabro
		3	New York's Modern Fire Communications Center	N. J. Reinhardt, A. Dettori
1964	40	1	Portable TV Tape Recorder	F. J. Haney, R. L. Pointer
			N. Y. Fire Communications Center, Part 2	N. J. Reinhardt, A. Dettori
		2	Optimizing High Frequency Telegraph Transmission	Walter Lyons
		3	Whales, Porpoises and Sonar	William E. Schevill
		4	Directory, 1964 — Members of the Radio Club of America, with brief biographies	
1965	41	1	The Modulated Optical Alarm System	Samuel M. Bagno
		2	The Oscar Amateur Satellite Program	Nicholas K. Marshall
			Educasting Systems	Ira Kamen
		3	Computer-Produced Movies	Kenneth C. Knowlton
			Application of Time-Diversity to Multi-Link Data Transmission	Walter Lyons

MEASUREMENTS'
"FAMOUS FIRSTS"

1939 MODEL 54 STANDARD SIGNAL GENERATOR—Frequency range of 100 Kc. to 20 Mc. The first commercial signal generator with built-in tuning motor.

MODEL 65-B STANDARD SIGNAL GENERATOR—This instrument replaced the Model 54 and incorporated many new features including an extended frequency range of 75 Kc. to 30 Mc.

1940 MODEL 58 UHF RADIO NOISE AND FIELD STRENGTH METER—With a frequency coverage from 15 Mc. to 150 Mc. This instrument filled a long wanted need for a field strength meter usable above 20 Mc.

MODEL 79-B PULSE GENERATOR—The first commercially-built pulse generator.

1941 MODEL 75 STANDARD SIGNAL GENERATOR—The first generator to meet the need for an instrument covering the I.F. and carrier ranges of high frequency receivers. Frequency range, 50 Mc. to 400 Mc.

1942 SPECIALIZED TEST EQUIPMENT FOR THE ARMED FORCES. WORLD WAR II.

1943 MODEL 84 STANDARD SIGNAL GENERATOR—A precision instrument in the frequency range from 300 Mc. to 1000 Mc. The first UHF signal generator to include a self-contained pulse modulator.

1944 MODEL 80 STANDARD SIGNAL GENERATOR—With an output metering system that was an innovation in the field of measuring equipment. This signal generator, with a frequency range of 2 Mc. to 400 Mc. replaced the Model 75 and has become a standard test instrument for many manufacturers of electronic equipment.

1945 MODEL 78-FM STANDARD SIGNAL GENERATOR—The first instrument to meet the demand for a moderately priced frequency modulated signal generator to cover the range of 86 Mc. to 108 Mc.

1946 MODEL 67 PEAK VOLTMETER—The first electronic peak voltmeter to be produced commercially. This new voltmeter overcame the limitations of copper oxide meters and electronic voltmeters of the r.m.s. type.

1947 MODEL 90 TELEVISION SIGNAL GENERATOR—The first commercial wide-band, wide-range standard signal generator ever developed to meet the most exacting standards required for high definition television use.

1948 MODEL 59 MEGACYCLE METER—The familiar grid-dip meter, but its new design, wide frequency coverage of 2.2 Mc. to 420 Mc. and many other important features make it the first commercial instrument of its type to be suitable for laboratory use.

1949 MODEL 82 STANDARD SIGNAL GENERATOR—Providing the extremely wide frequency coverage of 20 cycles to 50 megacycles. An improved mutual inductance type attenuator used in conjunction with the 80 Kc. to 50 Mc. oscillator is one of the many new features.

1950 MODEL 111 CRYSTAL CALIBRATOR—A calibrator that not only provides a test signal of crystal-controlled frequency but also has a self-contained receiver of 2 microwatts sensitivity.

1951 MODEL 31 INTERMODULATION METER—With completely self-contained test signal generator, analyzer, voltmeter and power supply. Model 31 aids in obtaining peak performance from audio systems, AM and FM receivers and transmitters.

1952 MODEL 84 TV STANDARD SIGNAL GENERATOR—With a frequency range of 300-1000 Mc., this versatile new instrument is the first of its kind designed for the UHF television field.

1953 MODEL 59-UHF MEGACYCLE METER—With a frequency range of 420 to 940 megacycles, the first grid-dip meter to cover this range in a single band and to provide laboratory instrument performance.

1954 FM STANDARD SIGNAL GENERATOR. Designed originally for Military service. The commercial Model 95 is engineered to meet the rigid test requirements imposed on modern high quality electronic instruments. It provides frequency coverage between 50 Mc. and 400 Mc.

1955 RADIO INTERFERENCE MEASURING SET. An aperiodic noise meter useful to 1000 Mc.

1956 MODEL 505 STANDARD TEST SET FOR TRANSISTORS. A versatile transistor test set which facilitates the measurement of static and dynamic transistor parameters.

1957 RADIO FIELD STRENGTH AND INTERFERENCE MEASURING SET. A tuned radio interference and field strength set covering the frequency range of 150 Mc. to 1000 Mc.

1958 MODEL 560-FM STANDARD SIGNAL GENERATOR—First successful FM Signal Generator using solid state modulator.

1959 MODEL 700 FREQUENCY METER—A completely new concept of frequency measurement. An instrument capable of direct and continuous reading to one cycle in 25-1000 Mc range.

1960 MODEL 139 TEST OSCILLATOR—A compact, versatile, and portable instrument for rapid and accurate alignment of I.F. circuits in all types of radio receivers.

1961 MODEL 760 STANDARD FREQUENCY METER—An accurate, simple to operaate, direct read-out, portable instrument designed for servicing two-way mobile radio equipment.

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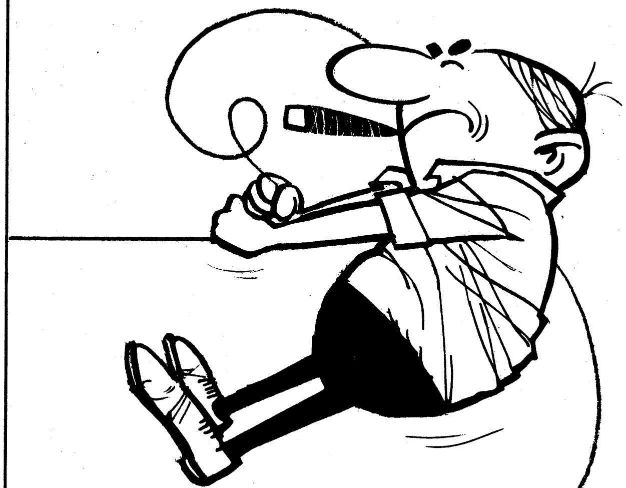

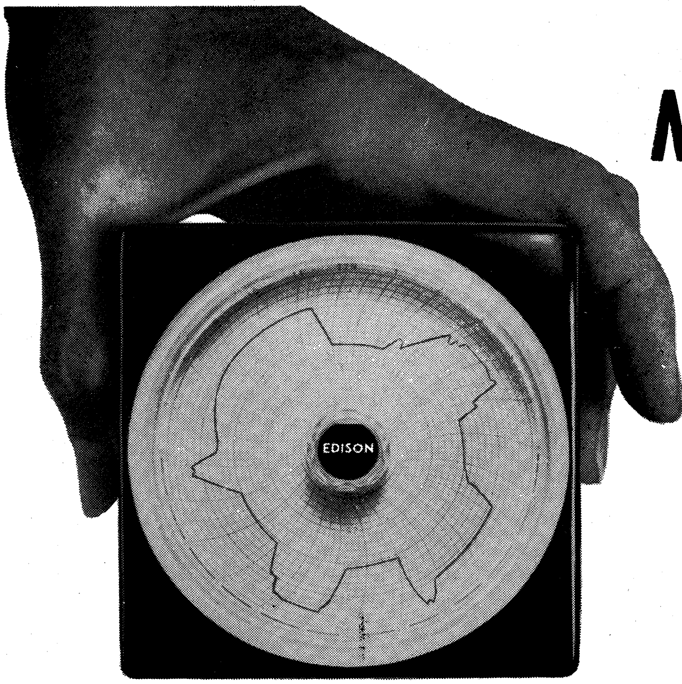

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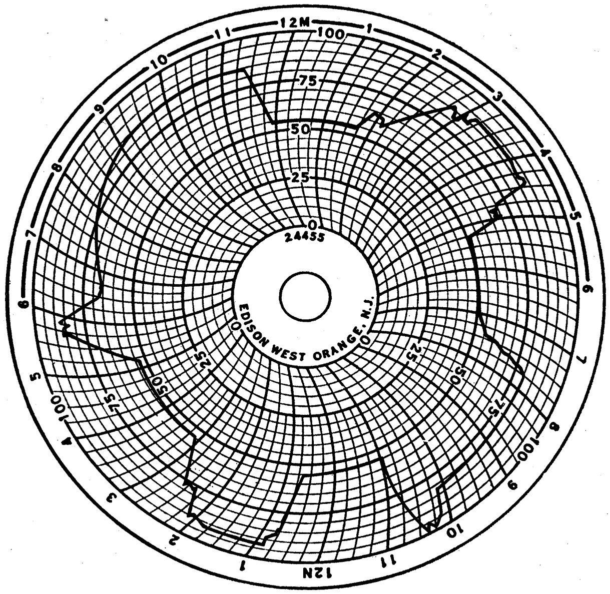

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- REPLACES METERS OR INDICATORS
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- JUST 3¾″ x 3¾″ x 3″

Now you can take advantage of a new, economical means of recording any variable that can be converted to an electrical signal. Thanks to Omnicorder, you need no longer rely on meters or indicators, even where cost factors or space restrictions would ordinarily dictate the use of these instruments.

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Omnicorder's simple, inexpensive construction assures dependable operation and a long, maintenance-free life. Four types of meter movements are available to measure a wide range of AC and DC electrical quantities, ranging from thermocouple outputs to currents as high as 100 amperes. No amplification is ever required, even for signals as low as 10 microamps.

For complete information on this rugged, maintenance-free Omnicorder, write for Catalog 3057.

Stylus operates through this slot. The measuring system is sealed off from any careless tampering.

Zero Set Screw: Adjustment is made when measuring system is not printing and when the circuit to be recorded is disconnected.

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TROPO

CANADA

Province of British Columbia, Canada — focal point of a pioneering tropo scatter communications system connecting Alaska, British Columbia, and the Continental United States.

In creating this system, prime contractor Lenkurt Electric Company of Canada, Ltd., a GT&E subsidiary, selected internationally-proven tropo scatter radio relay equipment by REL.

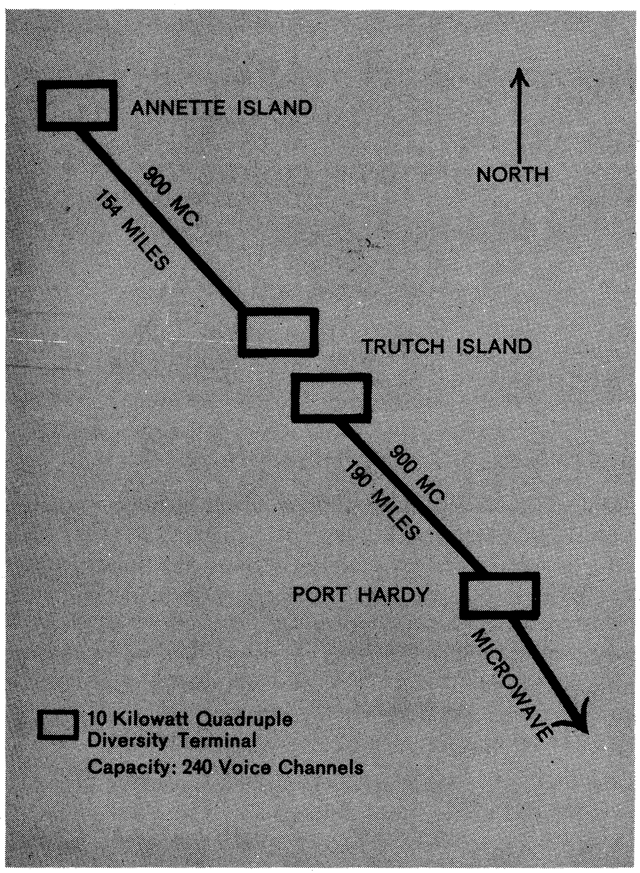
Operated by the British Columbia Telephone Company and the Alaska Telephone Corporation, also GT&E subsidiaries, the privately financed system spans 344 miles in two giant leaps to provide a totally integrated commercial telecommunications network.

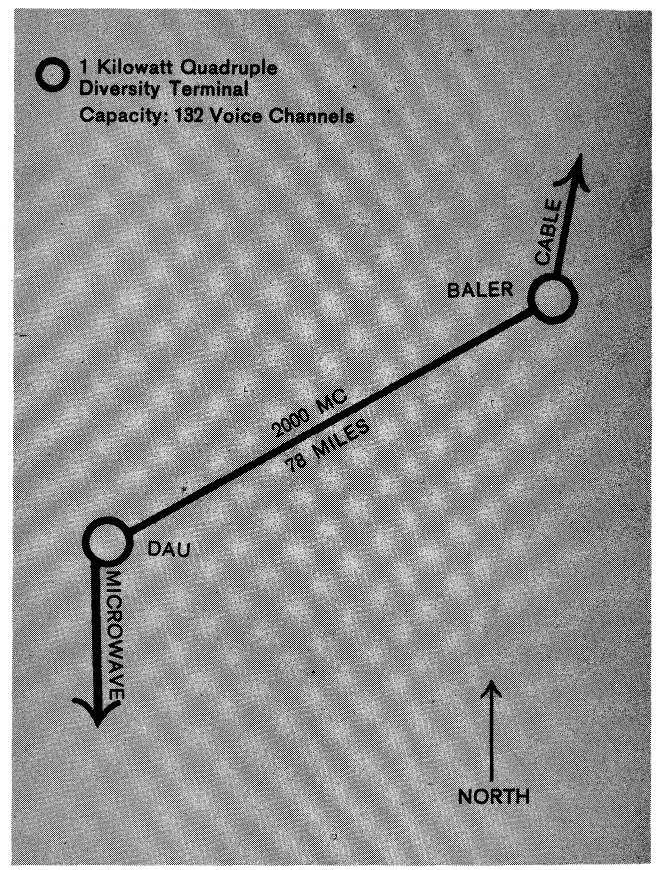
PHILIPPINES

Island of Luzon, Philippines — focal point of a tropospheric scatter system that provides a vital link in telecommunications between the Island Republic of the Philippines and the Continental United States.

Here again GT&E, through its Lenkurt International Division, selected radio relay equipment from REL — world leader in tropo scatter.

Operated by the Philippines Long Distance Telephone Company, the 132-channel system spans undeveloped mountain terrain to provide an economical and reliable communications link with international submarine cables to the United States.





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