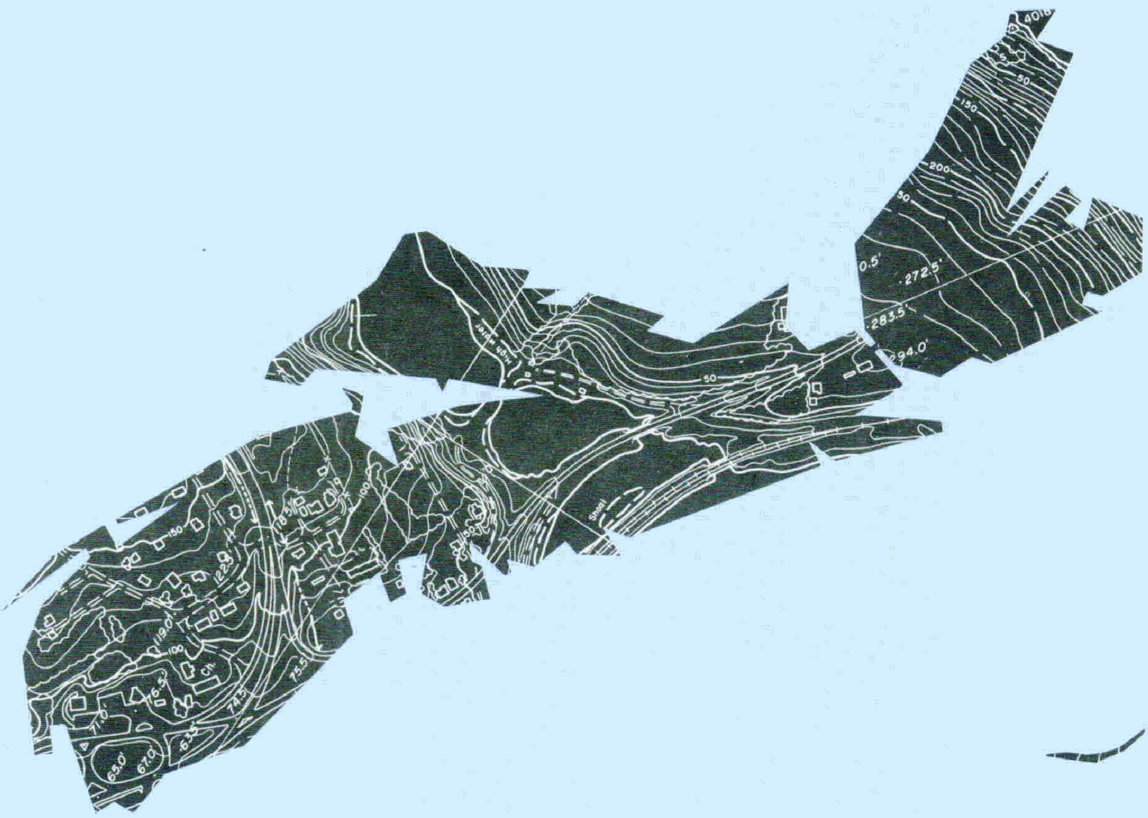
The NOVA SCOTIAN SURVEYOR



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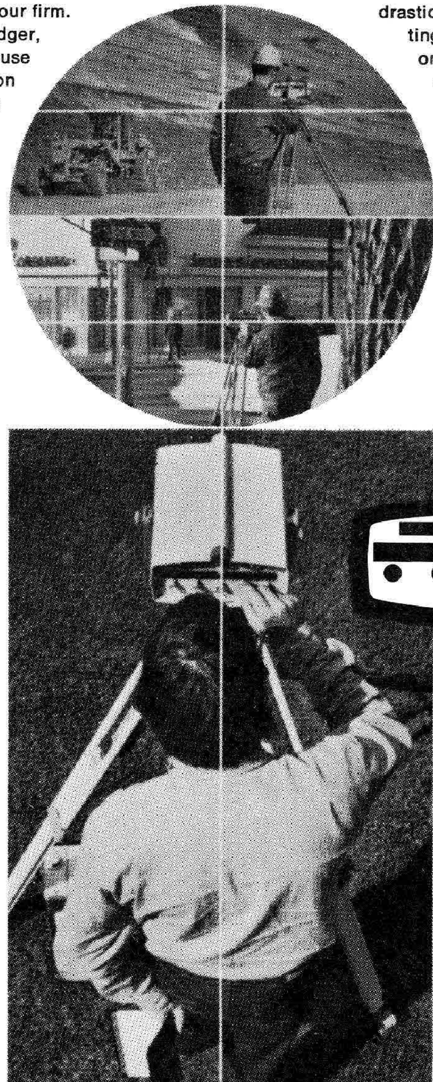

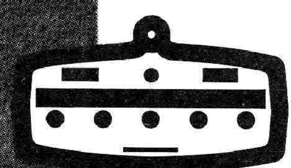

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James F. Doig
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TECHNICAL PANEL

"Surveying from Outer Space to Inner Space"

R.M. Eaton, D.E. Wells, L.A. Gale, Moderator G.E. Streb
Panel presentations are included in this issue

- C O N T E N T S -

Views, expressed in articles appearing in this publication are those of the authors, and not necessarily those of the Association.

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- EXTRACTS FROM -

"THE JUDICIAL FUNCTIONS OF SURVEYORS"

Mr. Justice Cooley

Michigan Supreme Court

When a man has had a training in one of the exact sciences, where every problem within its purview is supposed to be susceptible of accurate solution, he is likely to be not a little impatient when he is told that under some circumstances he must recognize inaccuracies, and govern his action by facts which lead him away from the results which theoretically he ought to reach. Observation warrants us in saying that this remark may frequently be made of surveyors.

In the State of Michigan, all our lands are supposed to have been surveyed once or more, and permanent monuments fixed to determine the boundaries of those who should become proprietors. The United States as original owner, caused them all to be surveyed once by sworn officers, and as the plan of subdivision was simple, and was uniform over a large extent of territory, there should have been, with due care, few or no mistakes; and long rows of monuments should have been perfect guides to the place of any one that chanced to be missing. The truth unfortunately is that the lines were very carelessly run, the monuments inaccurately placed; and, as the recorded witnesses to these were many times wanting in permanency, it is often the case that when the monument was not correctly placed it is impossible to determine by the record, with the aid of anything on the ground, where it was located. The incorrect record of course becomes worse than useless when the witnesses it refers to have disappeared.

It is, perhaps, generally supposed that our town plats were more accurately surveyed, as indeed they should have been, for in general there can have been no difficulty in making them sufficiently perfect for all practical purposes. Many of them, however, were laid out in the woods; some of them by proprietors themselves, without either chain or compass, and some by imperfectly trained surveyors, who, when land was cheap, did not appreciate the importance of having correct lines to determine boundaries when land should become dear. The fact probably is that town surveys are quite as inaccurate as those made under authority of the general government.

It is now upwards of fifty years since a major part of the public surveys in what is now the State of Michigan were made under authority of the United States. Of the lands south of Lansing, it is now forty years since the major part were sold and the work of improvement begun. A generation has passed away since they were converted into cultivated farms and few, if any, of the original corner and quarter stakes now remain.

The corner and quarter stakes were often nothing but green sticks driven into the ground. Stones might be put around or over these if they were handy, but often they were not, and the witness trees must be relied upon after the stake was gone. Too often the first settlers were careless in fixing their lines with accuracy while monuments remained, and an irregular brush fence, or something equally untrustworthy, may have been relied upon to keep in mind where the blazed line once was. A fire running through this might sweep it away, and if nothing were substituted in its place, the adjoining proprietors might in a few years be found disputing over their lines, and perhaps rushing into litigation as soon as they had occasion to cultivate the land along the boundary.

If now the disputing parties call in a surveyor, it is not likely that any one summoned would doubt or question that his duty was to find, if possible, the place of the original stakes which determined the boundary line between the proprietors; however, erroneous may have been the original survey, the monuments that were set must nevertheless govern, even though the effect be to make one-half quarter section ninety acres and the one adjoining but seventy; for parties buy or are supposed to buy in reference to those monuments, and are entitled to what is within their lines, and no more, be it more or less........

While the witness trees remain there can generally be no difficulty in determining the locality of the stakes. When the witness trees are gone, so that there is no longer record evidence of the monuments, it is remarkable how many there are who mistake altogether the duty that now devolves upon the surveyor. It is by no means uncommon that we find men whose theoretical education is supposed to make them experts who think that when the monuments are gone, the only thing to be done is to place new monuments where the old ones should have been, and where they would have been if placed correctly. This is a serious mistake. The problem is now the same that it was before; to ascertain, by the best lights of which the case admits, where the original lines were........

It will probably be admitted that no man loses title to his land or any part thereof merely because the evidences become lost or uncertain. It may become more difficult for him to establish it as against an adverse claimant, but theoretically the right remains; and it remains as a potential fact so long as he can present better evidence than any other person. And it may often happen that, notwithstanding the loss of all trace of a section corner or quarter stake, there will still be evidence from which any surveyor will be able to determine with almost absolute certainty where the original boundary was between the government subdivisions.

There are two senses in which the word extinct may be used in this connection: One of the sense of physical disappearance; the other the sense of loss of all reliable evidence. If the statute speaks of extinct corners in the former sense, it is plain that a serious mistake was made in supporting that surveyors could be clothed with authority to establish new corners by an arbitrary rule in such cases. As well might the statute declare that if a man lose his deed he shall lose his land altogether. But if by extinct corner is meant one in respect to the actual location of which all reliable evidence is lost, then the following remarks are pertinent:

1. There would undoubtedly be a presumption in such a case that the corner was correctly fixed by the government surveyor where the field notes indicated it to be.

2. But this is only a presumption, and may be overcome by any satisfaction evidence showing that in fact it was placed elsewhere.

3. No statute can confer upon a county surveyor the power to "establish" corners, and thereby bind the parties concerned. Nor is this a question merely of conflict between State and Federal law; it is a question of property right. The original surveys must govern, and the laws under which they were made must govern, because the land was bought in reference to them; and any legislation, whether State or Federal, that should have the effect to change these, would be inoperative, because disturbing vested rights.

4. In any case of disputed lines, unless the parties concerned settle the controversy by agreement, the determination of it is necessarily a judicial act, and it must proceed upon evidence, and give full opportunity for a hearing. No arbitrary rules of survey or of evidence can be laid down whereby it can be adjudged.

The general duty of a surveyor in such a case is plain enough. He is not to assume that a monument is lost until after he has thoroughly sifted the evidence and found himself unable to trace it. Even then he should hesitate long before doing anything to the disturbance of settled possessions. Occupation, especially if long continued, often affords very satisfactory evidence of the original boundary when no other is attainable; and the surveyor should inquire when it originated, how, and why the lines were then located as they were, and whether a claim of title has always accompanied the possession, and give all the facts due force as evidence. Unfortunately, it is known that surveyors sometimes, in supposed obedience to the State statute, disregard all evidences of occupation and claim of title, and plunge whole neighborhoods into quarrels and litigation by assuming to "establish" corners at points with which the previous occupation cannot harmonize.

It is often the case that where one or more corners are found to be extinct, all parties concerned have acquiesced in lines which were traced by the guidance of some other corner or landmark, which may or may not have been trustworthy; but to bring these lines into discredit when the people concerned do not question them, not only breeds trouble in the neighborhood, but it must often subject the surveyor himself to annoyance and perhaps discredit, since in a legal controversy the law as well as common sense must declare that a supposed boundary line long acquiesced in is better evidence of where the real line should be than any survey made after the original monuments have disappeared.......

The mischiefs of overlooking the facts of possession must often appear in cities and villages. In towns the block and lot stakes soon disappear; there are no witness trees and no monuments to govern except such as have been put in their places, or where their places were supposed to be. The streets are likely to be soon marked off by fences, and the lots in a block will be measured off from these, without looking farther. Now it may perhaps be known in a particular case that a certain monument still remaining was the starting point in the original survey of the town plat; or a surveyor settling in the town may take some central point as the point of departure in his surveys, and assuming the original plat to be accurate, he will then undertake to find all streets and all lots by course and distance according to the plat, measuring and estimating from his point of departure. This procedure might unsettle every line and every monument existing by acquiescence in the town; it would be very likely to change the lines of streets, and raise controversies everywhere. Yet this is what is sometimes done; the surveyor himself being the first person to raise the disturbing questions.

Suppose, for example, a particular village street has been located by acquiescence and use for many years, and the proprietors in a certain block have laid off their lots in reference to this practical location. Two lot owners quarrel, and one of them calls in a surveyor that he may be sure that his neighbour shall not get an inch of land from him. This surveyor undertakes to make his survey accurate, whether the original was, or not, and the first result is, he notifies the lot owners that there is error in the street line, and that all fences should be moved, say one foot to the east. Perhaps he goes on to drive stakes through the block according to this conclusion. Of course, if he is right in doing this, all lines in the village will be unsettled; but we will limit our attention to the single block. It is not likely that the lot owners generally will allow the new survey to unsettle their possessions, but there is always a probability of finding someone disposed to do so. We shall then have a lawsuit; and with what result?

It is common error that lines do not become fixed by acquiescence in a less time than twenty years. In fact, by statute, road lines may become conclusively fixed in ten years; and there is no particular time that should be required to conclude private owners, where it appears that they accepted a particular line as their boundary, and all concerned have cultivated and claimed up to it..Public policy requires that such lines be not lightly disturbed, or disturbed at all after the lapse of any considerable time. The litigant, therefore, who in such a case pins his faith on the surveyor, is likely to suffer for his reliance, and the surveyor himself to be mortified by a result that seems to impeach his judgment.

Of course, nothing in what has been said can require a surveyor to conceal his own judgment, or to report the facts one way when he believes them to be another. He has no right to mislead, and he may rightfully express his opinion that an original monument was at one place, when at the same time he is satisfied that acquiescence has fixed the right of parties as if it were at another. But he would do mischief if he were to attempt to "establish" monuments which he knew would tend to disturb settled rights; the farthest he has a right to go, as an officer of the law, is to express his opinion where the monument should be, at the same time that he imparts the information to those who employ him, and who might otherwise be misled, that the same authority that makes him an officer and entrusts him to make surveys also allows parties to settle their own boundary lines, and considers acquiescence in a particular line or monument, for any considerable period, as strong, if not conclusive, evidence of such settlement. The peace of the community absolutely requires this rule........

It is not long since that, in one of the leading cities of the State, an attempt was made to move houses two or three rods into a street, on the ground that a survey under which the street had been located for many years had been found on more recent survey to be erroneous.

From the foregoing it will appear that the duty of the surveyor where boundaries are in dispute must be varied by the circumstances:- 1. He is to search for original monuments, or for the places where they were originally located, and allow these to control if he finds them, unless he has reason to believe that agreements of the parties, express or implied, have rendered them unimportant. By monuments in the case of government surveys we mean, of course, the corner and quarter stakes: blazed lines or marked trees on the lines are not monuments; they are merely guides or finger-posts, if we may use the expression, to inform us with more or less accuracy where the monuments may be found. 2. If the original monuments are no longer discoverable the question of location becomes one of evidence merely. It is merely idle for any State statute to direct a surveyor to locate or "establish" a corner, as the place of the original monument, according to some inflexible rule. The surveyor, on the other hand, must inquire into all the facts; giving due prominence to the acts of parties concerned, and always keeping in mind, FIRST, that neither in his opinion, nor his survey, can be conclusive upon parties concerned; SECOND, that courts and juries may be required to follow after the surveyor over the same ground, and that it is exceedingly desirable that he govern his action by the same rights and rules that will govern theirs. On town plats if a surplus or deficiency appears in a block, when the actual boundaries are compared with the original figures, and there is no evidence to fix the exact location of the stakes which marked the division into lots, the rule of common sense and of law is that the surplus or deficiency is to be apportioned between the lots, on an assumption that the error extended alike to all parts of the block........

It is always possible, when corners are extinct, that the surveyor may usefully act as a mediator between parties and assist in preventing legal controversies by settling doubtful lines. Unless he is made for this purpose an arbitrator by legal submission, the parties, of course, even if they consent to follow his judgment, cannot, on the basis of mere consent, be compelled to do so, but if he brings about an agreement, and they carry it into effect by actually conforming their occupation to his lines, the action will conclude them. Of course, it is desirable that all such agreements be reduced to writing: but this is not absolutely indispensable if they are carried into effect without.

Mr. Editor:-

The foregoing is an excerpt from the article "The Judicial Functions of Surveyors" by Mr. Justice Cooley of the Michigan Supreme Court. We have used this excerpt for several years as a hand-out to our surveying students.

The article by Mr. Justice Cooley appears as Appendix "A" to *The Theory and Practice of Surveying*, J. B. Johnson and L. S. Smith, 17th Edition, 1914. I suspect the article itself was written earlier than that - the first edition of this book appeared in 1886.

Most of what is said seems to me to be as valid today as it was then.

- J. F. Doig, Principal,
Nova Scotia Land Survey Institute.

The following papers

were presented at

a panel discussion entitled

SURVEYING FROM OUTER SPACE TO INNER SPACE

panel members:

D. E. Wells

*L. A. Gale

R. M. Eaton

Moderator: G. E. Streb

Annual Meeting

The Association of Nova Scotia Land Surveyors

9:30 a.m. November 6, 1971

Holiday Inn, Dartmouth, Nova Scotia

* *Mr. Gale's paper was not available at the time this issue went to press. It will be presented in our next issue.*

- SATELLITE SURVEYING -

by

D. E. Wells*

1. INTRODUCTION

It is often said nowadays that we have entered the satellite era. Let me confirm that statement with some statistics (NASA, 1-71). The launching of Sputnik 1 just over 14 years ago (on October 4, 1957) has been followed by over 1000 more launchings, which have placed over 5500 trackable objects into orbit around the earth. Of these about half survive, the rest having "decayed" or crashed to earth. The surviving objects include about 500 satellites still in orbit, however, most of these are inactive or dead satellites. I would guess that there are only about 100 still active satellites currently in orbit. In recent years there have been just over 100 new launchings per year.

What are all these satellites used for? We are most familiar with the few dozen manned satellites which have orbited the earth, and more recently the moon. We also hear frequently of the communications satellites which interconnect the world's T.V. networks, for which there is a tracking station at Mill Village, Nova Scotia, and currently a Canadian satellite under development. Occasionally we hear that many if not most of the satellites are so-called "reconnaisance" (or spy) satellites.

I would like to discuss another use for some of these satellites which I believe will provide one of the major impacts of the satellite era. For the first time man, either as an astronaut or using electronic instrumentation as his eyes and ears in an unmanned satellite, is now able to stand off from the world and look back on it objectively. The psychological impact of this is evident in the often quoted remarks of astronauts who claim new insights from viewing the earth as a whole from the perspective of space. There are more concrete examples of what I mean. I will mention only three: Satellites like Canada's Alouette have looked at the whole ionosphere and discovered the hitherto unsuspected Van Allen radiation belts. Geophysical satellites have made it possible for the first time to discover just what shape the earth's gravity field (the geoid) has on a global basis. Weather satellites can monitor meteorological conditions over the entire continental areas, providing a big picture in which the thousands of measurements made from the ground can be placed in context.

In broad perspective, a surveyor could be defined as one whose profession it is to look at the world, make measurements, and analyze and display what he has measured. It is therefore only natural that there should be applications in surveying for satellites. I will restrict myself to mentioning only three, which will comprise the remainder of this talk. They are:

a) the prospects for mapping from satellite photography

b) the World Survey Control Network of the U. S. National Geodetic Survey

c) geodetic control using Doppler satellite observations. I will only briefly discuss the first two applications, and will include some recent results obtained here in the Atlantic Provinces using the third application.

2. Mapping from Satellite Photographs

The most obvious difference between photographs taken from satellites and those taken from aircraft is that the satellite is 10 to 100 times higher than

* *Bedford Institute, on educational leave at University of New Brunswick.*

aircraft. Assuming the aircraft and satellite cameras have similar focal lengths, this means a larger area is covered by a single photograph, and also that the photographic scale is smaller. It is reasonable to expect that satellite photography would be useful for small scale mapping but not for large scale mapping. Estimates of the largest scale of original mapping which might be possible from satellite photography range from 1:250,000 [Petrie, 1970] to 1:50,000 [Doyle, 1971].

Another difference between satellite and aircraft is that the aircraft vibrates and causes atmospheric turbulence, and the satellite does not. Also the tilt of the camera axis can be controlled much more accurately in a satellite than in an aircraft. The satellite is, therefore, a somewhat better camera platform.

I will mention some of the problems of flight-planning and data recovery for satellite photography.

Flight planning for a satellite is more complicated than for an aircraft. For example, as Figure 1 shows, the usual satellite orbit is elliptical. This means that the satellite height above the earth, and therefore the photographic scale and coverage will vary. Therefore, it is important that photographic satellites be kept in as circular an orbit as possible.

Another factor is the angle between the orbit plane and the equator, called the orbit inclination. For an orbit as shown in Figure 1 the polar latitudes will never be crossed by the satellite. It is necessary that the satellite pass over the poles (that is, the inclination angle is 90°) if worldwide coverage is desired.

A third problem is how high to make the orbit. For low orbits (say 150 km) the scale is larger, but the satellite travels about 100 times faster than an aircraft, causing loss of resolution due to image movement. At high altitudes the velocity is lower, but there is loss of resolution due to small scale.

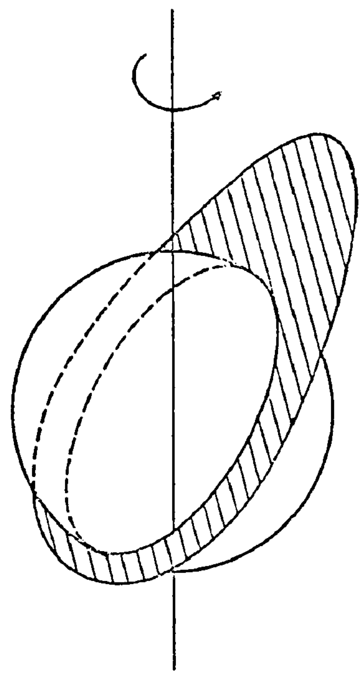

Figure 1

The most difficult problem is to ensure overlapping coverage. At 150 km altitude the satellite orbits the earth every one and one-half hours. During this time the earth will have rotated by about 17.5°, so that the satellite photographs strips which are separated by about 2000 km. at the equator. It is possible (but difficult) to plan an orbit which, over a period of a few days, will photograph overlapping sets of strips [Petrie 1970].

Turning to data recovery, there are three systems which have been used. Weather satellites use television cameras to record the image, and transmit the data as a T.V. signal to a ground station. A second method, used by Lunar-Orbiter in mapping the moon is to record the image on film, develop the film inside the satellite, scan the developed film, with a T.V. camera and transmit the data as before. The third possibility, used by most Russian and U.S. spy satellites, is to bring the film itself back to earth, either by ejecting film cartridges in small sub-satellite re-entry vehicles or by bringing the whole satellite down after a useful life of, say a few weeks. Only this last method provides adequate photographic quality for topographic mapping.

One last important point is that the photogrammetric processing of satellite photographs is possible only using the most expensive of photogrammetric machines; that is computer-controlled analytical plotters (for example the OMI AP-2 and AP-3).

An example of mapping from satellite photography are three 1:250,000 maps of the Phoenix area (U.S. Geological Survey 1970); the standard line maps and two versions of photomaps prepared from photographs taken on Apollo 9, in March 1969. In several areas there is mismatch between the photo and the line map, and checking against large scale maps has shown the errors to be in the line maps. Also the photo image shows additional cultural features added since the line map was revised [Doyle, 1971].

3. The World Survey Control Network

We now consider what happens when we keep the camera on the earth and use the satellite merely as a beacon to be photographed against the star background. This method, called photogrammetric satellite triangulation, is being used by the U.S. National Geodetic Survey in establishing the World Survey Control Network [Schmid, 1970; Jones, 1971; Bonford, 1971]. The satellites used were Echo 1 (in orbit 1960-1968), Echo 2 (in orbit 1964-1969) and Pageos (in orbit since 1966), all of which are reflecting balloon satellites of 30 to 40 metres diameter at altitudes of 1000 to 5000 km.

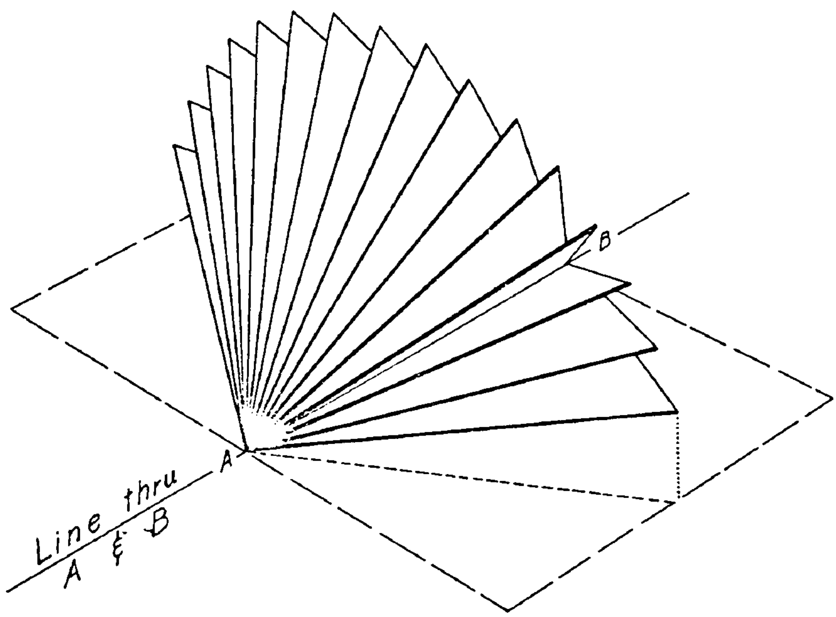

Figure 2

The satellite is photographed simultaneously from two ground stations A and B (see Figure 2). Knowing the time of the photographs precisely, and knowing the star right ascensions and declinations, the satellite right ascension and declination as seen from both stations A and B can be determined from the photographs. If two events are recorded, one on each side of AB, the direction of the chord AB can be computed as the intersection of the two planes containing A, B and the satellite. If more than two events are recorded (for example there are 16 in Figure 2) then a least squares adjustment for the direction AB can be made.

The World Net consists of 45 stations distributed around the world interconnected by 125 lines. Between 1966 and 1970, 1700 events were observed to obtain the direction of each of these lines.

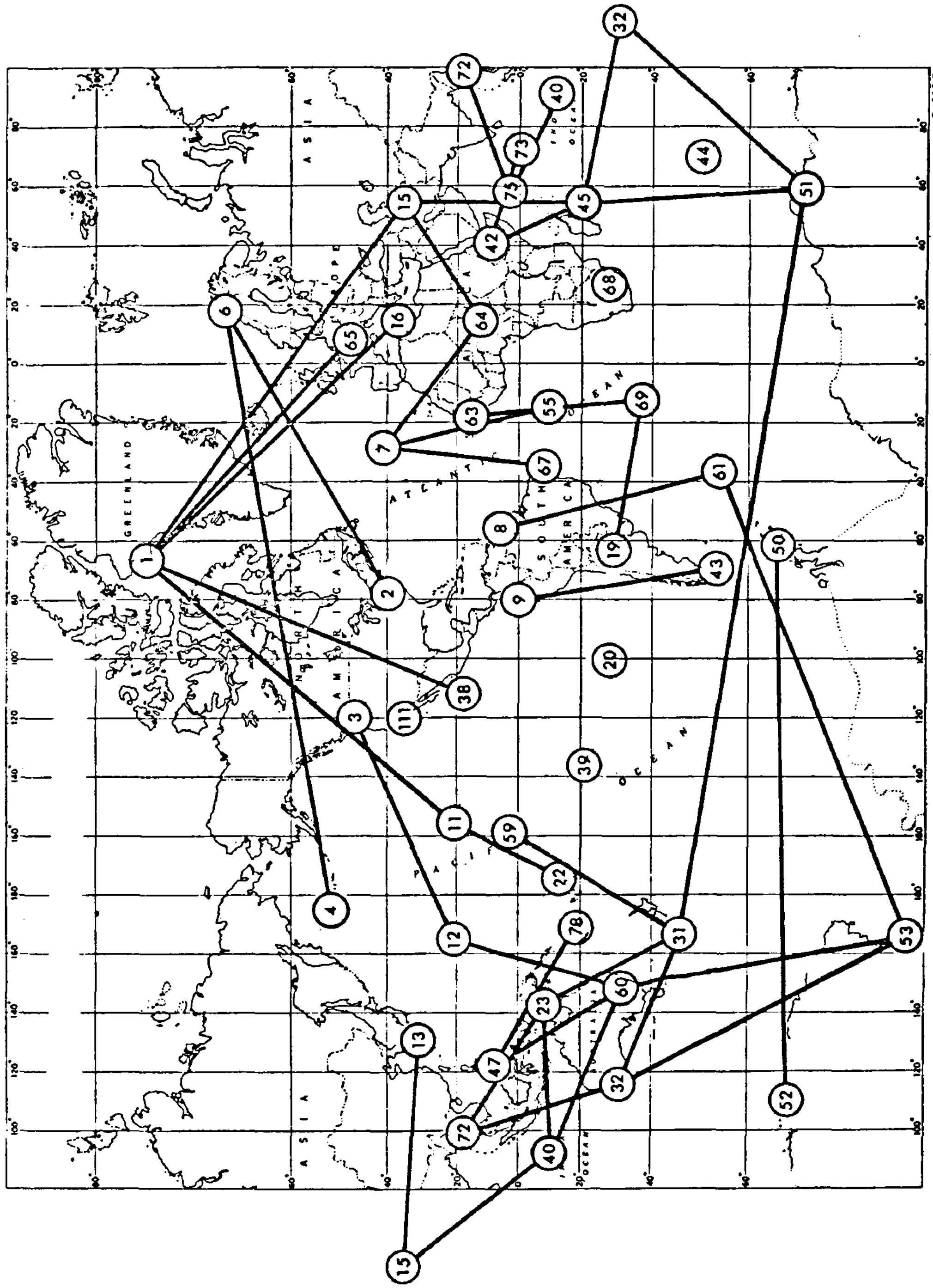

Figure 3

The initial results of the data reduction and computation are expected one year from now. The expected RMS errors in station coordinates is about four metres. This World Net is merely a geometrical polyhedron whose vertices are the 45 stations (Figure 3). As such, the scale of this polyhedron must be provided separately. Four baselines have been measured to about one part per million to provide scale. Referring to Figure 3, these baselines connect stations 32 and 60 in southern Australia, 2 and 3 across the U.S., 6 and 16 down through Europe, and 63 and 64 across Africa.

Canada has no World Net station, however, observations for densification of the World Net for North America are almost complete. Canada has eight stations in this densification net, three of which are in Atlantic Canada, at Halifax, Nova Scotia; St. John's, Newfoundland; and Goose Bay, Labrador.

4. Geodetic Control from Doppler Satellite Measurements

In contrast to the geometrical satellite geodesy used to determine the World Net, there is a second way in which satellite observations can be analyzed, called dynamic satellite geodesy. In this case both the fundamental problems of geodesy are solved; the coordinates of the observing stations are determined relative to the centre of gravity of the earth (rather than relative to each other as in the geometric model), and a global description of the gravity field of the earth is obtained. This can be done because the motion of near-earth satellites is influenced mainly by the gravity field, and so perturbations in satellite orbits can be related perturbations in the gravity field. Numerous observations are required from a few dozen stations around the world if a complete dynamic solution for both station coordinates and gravity field is to be made.

One system which incorporates dynamic satellite geodesy is the Transit system, also called the U.S. Navy Navigation Satellite System [Wells, 1969].

This system uses the Doppler principle (Figure 4). As the satellite passes over a ground station, a stable radio frequency broadcast by the satellite is Doppler shifted as it is received by the ground station, exactly the same way that the train whistle we hear seems to change in pitch as the train goes by. This change in frequency over a two minute interval (say T1 to T2 in Figure 4), is directly related to the change in the station-to-satellite distance over the same interval (S2 - S1). Thus the Doppler system really is a distance - difference measuring system. Therefore, if we know the satellite's coordinates, we can solve for the ground station coordinates from three or four two-minute Doppler measurements, and a single satellite pass typically consists of between five to eight such measurements.

Knowing the satellite's coordinates is where the dynamic geodesy comes in. The U.S. Navy maintains the Transit system by making a full dynamic solution and then on the basis of the results, predicting the satellite orbit up to 12 hours in advance. This predicted orbit is transmitted to the satellite and stored in the satellite memory and radioed down to the user with the Doppler frequencies.

Figure 5 shows some results, about three years old, of tracking about 50 satellite passes at the Bedford Institute, and computing a separate receiver position from each pass. The surveyed antenna position and the mean satellite position are different because they are referred to different geodetic datums [Wells and Krakiwsky, 1971].

The Transit system was originally intended for use at sea. Since the ship is moving, each pass must be computed separately. Also the Doppler effect depends on relative velocity between satellite and receiver, and therefore, is affected by the motion of the ship. The ship's velocity therefore must be accurately known to use this system. However, when we use the system on land, we are not moving, and it makes sense to combine all our Doppler observations into one solution, thereby greatly increasing the redundancy of the solution.

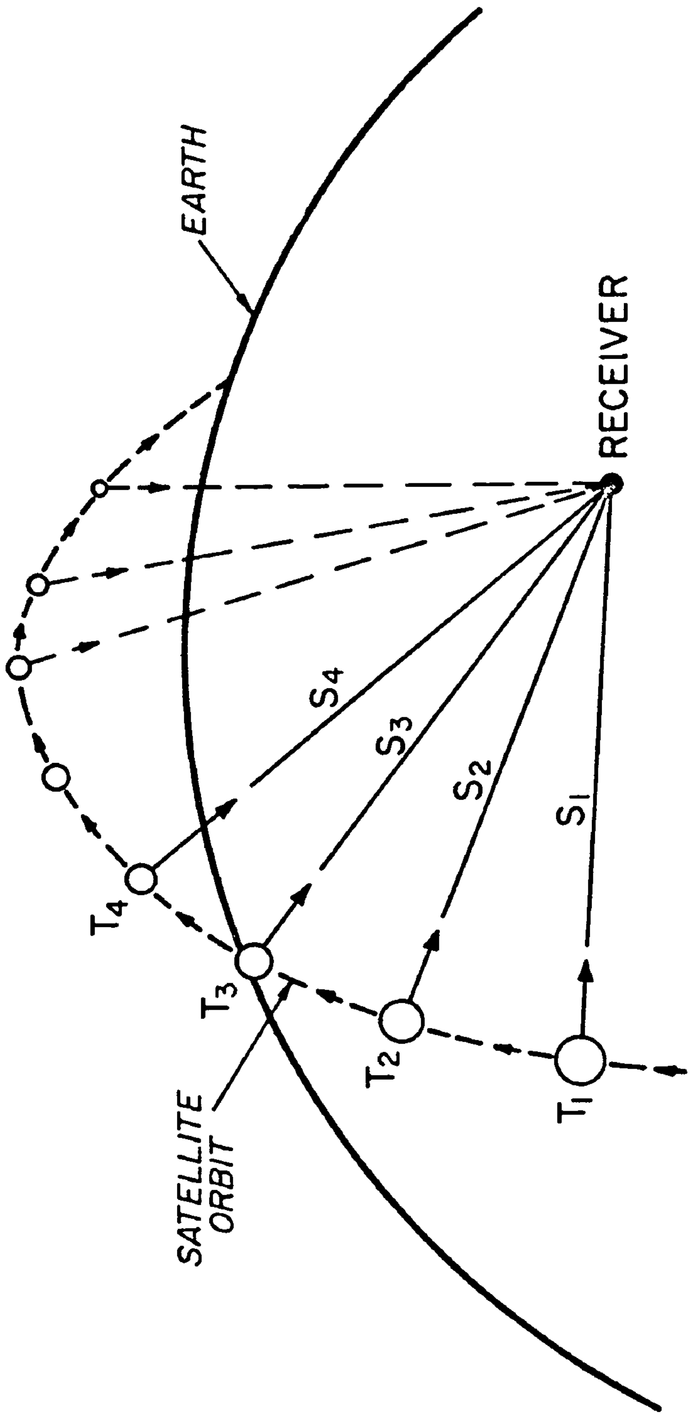

Figure 4

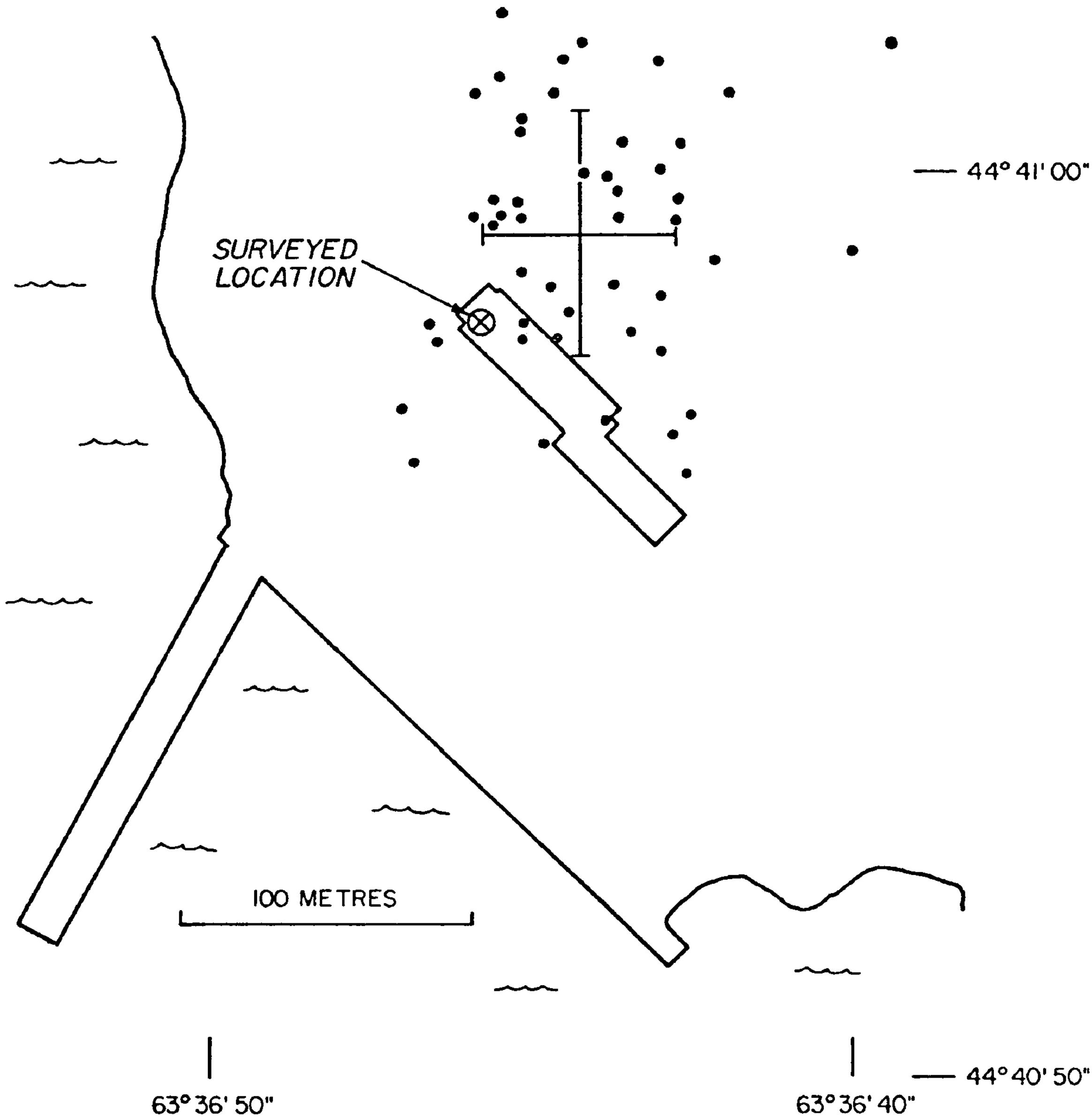

Figure 5

In the fall of 1970 the Bedford Institute, the University of New Brunswick Surveying Engineering Department, and Shell Canada cooperated in a joint project to test the feasibility of using the Transit system for geodetic control on land. Several receivers were distributed around Atlantic Canada for a two week period to collect Doppler satellite pass data. Three of these receivers were located near the three World Net densification stations mentioned earlier (Halifax, St. John's and Goose Bay). A fourth receiver was located in Fredericton.

Since then we have been processing the data from these four receivers in several different ways, analyzing the internal consistency of the results, and comparing them to both conventional geodetic control co-ordinates and to preliminary World Survey Control Net densification co-ordinates. Four significant indications can be drawn from the results of this work [Krakiwsky et al, 1972].

When observing from one tracking station at a time our results indicate a repeatability of within five metres can be achieved.

Better results can be obtained by tracking simultaneously from two stations. This is because some of the sources of error produce similar effects at tracking stations separated by distances of up to 1000 km. (the satellite orbit height). This method of tracking has been called "translocation", and is best evaluated by comparing the interstation spatial distances computed from the Transit data with the interstation spatial distances computed from the best available set of coordinates for the tracking stations. For our stations the best available co-ordinates are those resulting from the Maritime Scientific Adjustment (MSA), a recent readjustment by the Geodetic Survey of Canada of horizontal control networks in Canada [Pinch, 1971]. The agreement between the Transit and MSA interstation spatial distances for the six lines connecting our four stations averaged 1.9 parts per million times the interstation distance, with a worst case of 3.6 parts per million. This indicates that the performance of the Transit system, using the translocation technique, compares favorably with competing first order geodetic control measuring systems.

When the MSA coordinates were replaced by the first order North American Datum (NAD) geodetic coordinates for the four stations, the agreement was degraded to an average of 7 parts per million, and worst case of 15.5 parts per million. This indicates that both the Transit and MSA coordinates have higher internal consistency than the NAD coordinates, for the four stations we have studied at least.

Lastly, when the Transit interstation distances are compared with the interstation distances computed using preliminary satellite triangulation coordinates, the agreement is 6, 1 and 11.5 parts per million times the distance for the three lines connecting the three World Net densification stations we occupied. It is encouraging that there is such good agreement between two totally independent satellite-based systems, one based on the photogrammetric determination of absolute directions in space using star coordinates as reference, and the other based on the measurement of the Doppler shift of radio signals using a dynamic satellite geodesy solution for the earth's gravity field to compute reference satellite coordinates.

5. Conclusions

We have considered just three of the possible applications of satellites to surveying. All three provide advantages over other methods, but the three differ in their economic feasibility. There are at present only very limited plans for experiments in cartographic mapping from satellite photography. Currently, thematic and synoptic mapping from satellite photography is of much more interest [Gregory, 1971]. The World Net field work is essentially complete and final results will be forthcoming during the next few years. It appears the Doppler satellite system is here to stay and will be maintained by the U.S. Navy, and can provide geodetic control to first-order accuracy, making it the satellite system with the greatest potential value for surveyors in the future.

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Figure Captions

FIGURE 1. Elliptical near-earth satellite orbit

FIGURE 2. Method of photogrammetric satellite triangulation [from Jones, 1971]

FIGURE 3. Stations in the World Survey Control Net [from Jones, 1971]

FIGURE 4. Method of Doppler satellite positioning [from Wells, 1969]

FIGURE 5. Doppler satellite results at Bedford Institute [from Wells, 1969]

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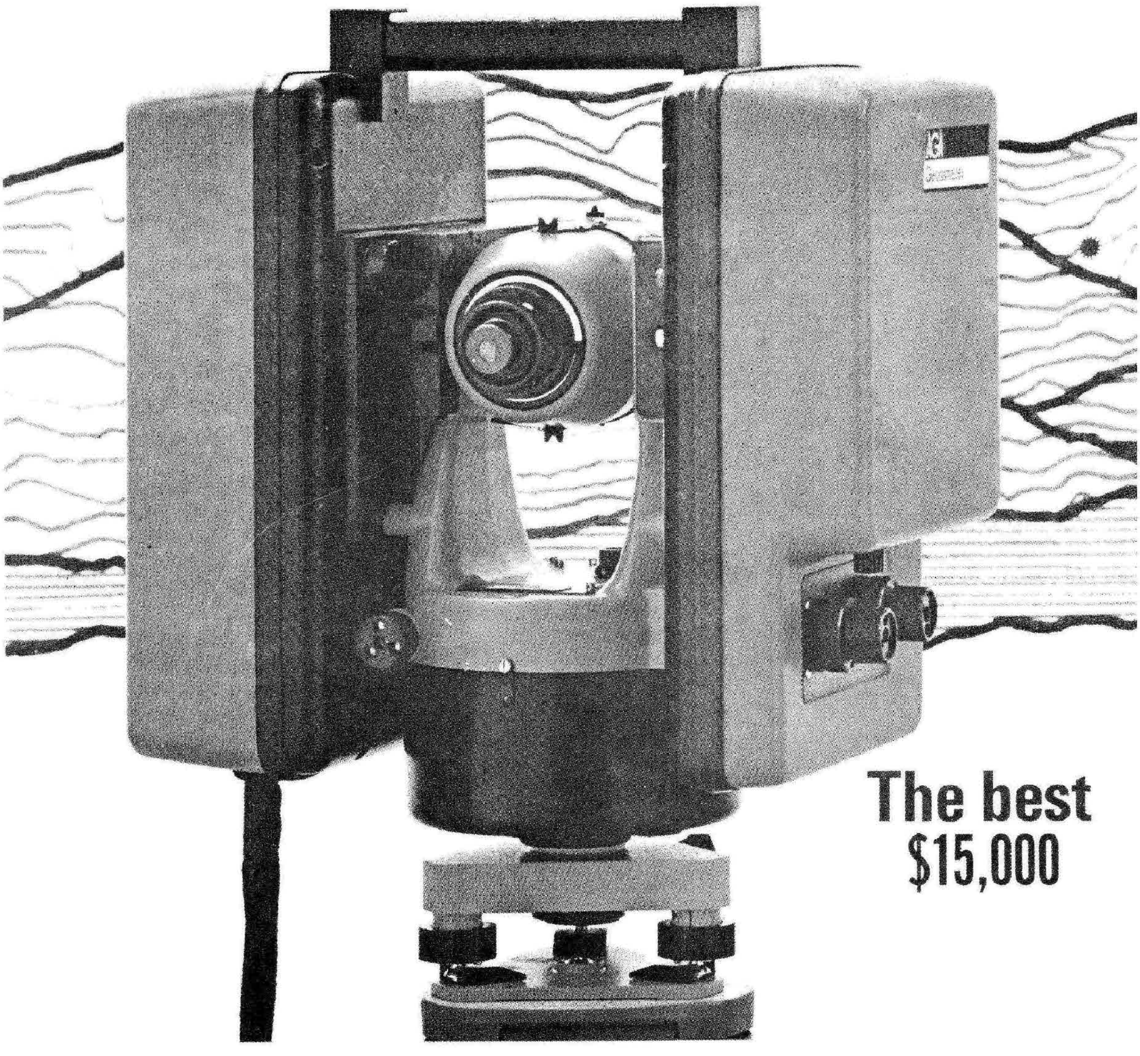

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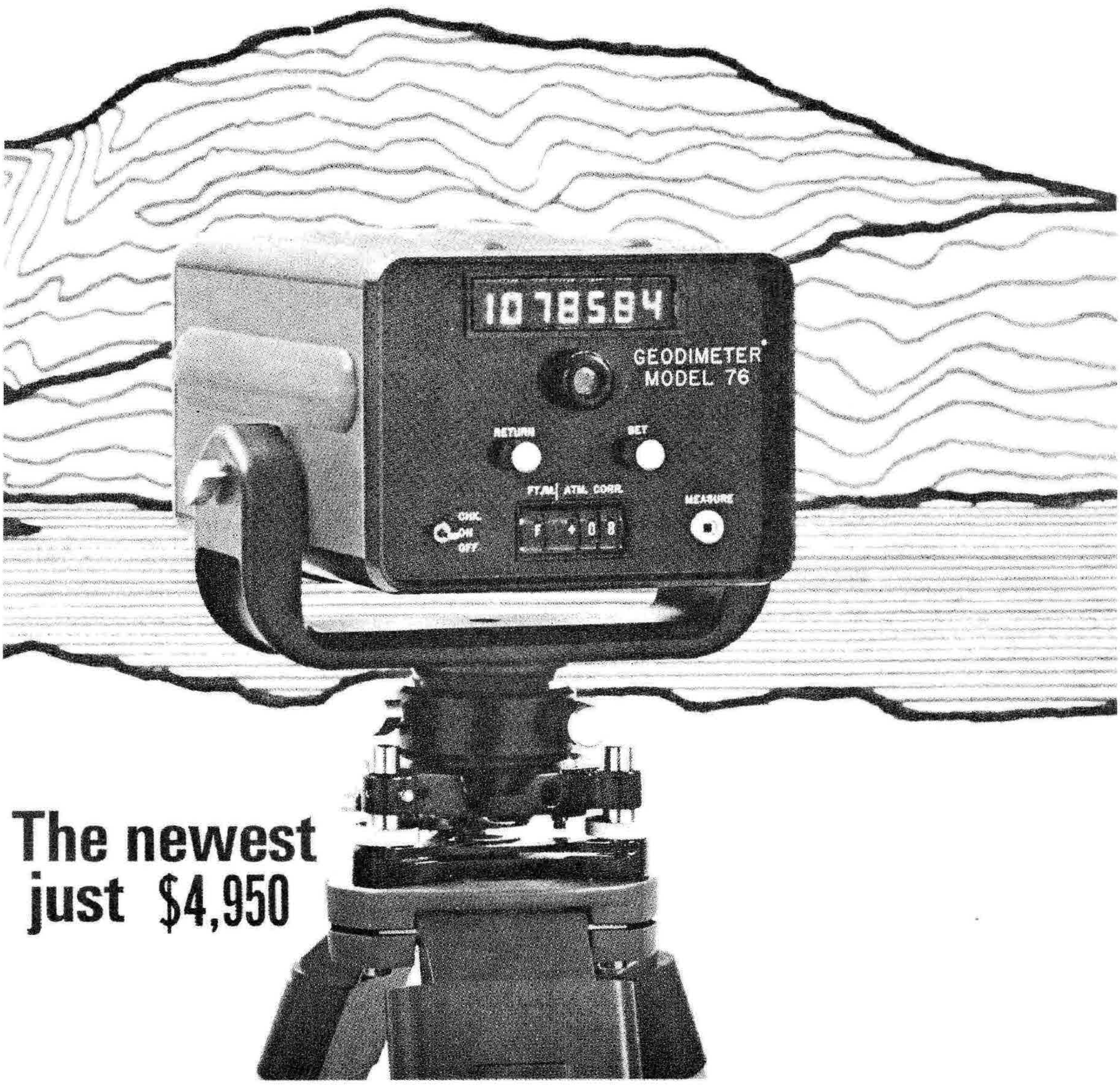

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- RADIO WAVES AND SOUND WAVES - FOR POSITIONING AT SEA

By

*R. M. Eaton**

INTRODUCTION

Until a few years ago, the surveyor who had to work at sea did his best to behave as though he was still on land. Within sight of shore he fixed by resection, using a sextant, which has mirrors, so that he could sight two objects simultaneously. If he had to go beyond the horizon he extended a network of taut-moored buoys to seaward, fixing them by sextant triangulation and taut-wire distance measurement. Taut-wire was the hydrographer's chain; a huge reel held hundreds of miles of single-strand piano wire. One end was anchored to the seabed close inshore where he could fix by the land, and then the wire was paid out astern over a measuring sheave as the ship steamed down the line of buoys. These floating control points were used for the detailed survey, allowing a slightly different position depending on which way the tide was running, until a storm blew them away or an irate fisherman got his nets tangled in them.

Then, in the mid 1950's, the radio-navigation methods originally developed in World War II to guide bombers and invasion barges over hundreds of miles became sufficiently refined to give survey accuracy, rather than just hitting the right beach. At about the same time our interest in the seabed began to go beyond just being sure it was deep enough for navigation; we began to think of resource surveys and scientific studies. In 1957 the Canadian Hydrographic Service began to survey the whole of the Gulf of St. Lawrence, using a Decca Survey chain. This year there are probably a dozen geophysical survey vessels on our continental shelf, all using radio and acoustic waves to find out where they are. *Baffin*, for instance, was mapping bathymetry and the earth's gravity and magnetic fields on the Flemish Cap, 350 nautical miles eash of Newfoundland.

Now 350 miles is a long line to measure in one hop. A land surveyor might ask why we make things so difficult for ourselves; why don't we extend our control seaward from the coastline in an orderly manner, using towers or seabed markers? Well, the only place I know where there are enough towers to do this is the Gulf of Mexico, and since a tower which is to stay in place for even a short time will cost millions of dollars, we will have to wait for the oil companies to put them up for us. Seabed markers are being used more and more, but because the sea is opaque to light waves and radio waves, the only method we have of 'seeing' the beacon on the bottom is by sound, which travels very well in water. Unfortunately, there is a snag. The sea is not a uniform mass of water, the same from top to bottom; it is strongly layered, being generally warmer at the top than at the bottom. Consequently, sound waves are strongly refracted. They are bent towards the colder water, and so if you are trying to 'see' a seabed marker at some distance, your interrogating sound waves will be refracted downwards and may hit the seabed before they get anywhere near the marker (Fig. 7). The range at which seabed beacons can be detected in the relatively shallow waters of the continental shelf is no more than a mile or two; much less in early summer when water layering is strongly developed.

Another method of acoustic navigation uses Doppler sonar to look at the seabed and measure how fast you are moving over it. The echoes returned from objects which you are steaming towards will be higher pitched than the transmitted signal, due to the same Doppler effect that makes the pitch of a train's whistle high as it approaches a station and then drop sharply as it passes through. Accurate Doppler-shift measurements, tied into the ship's gyro, give ship's velocity over the seabed.

**Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth, Nova Scotia.*

PRINCIPLE OF MEASUREMENT

The basis of all these methods, except Doppler sonar, is to measure ranges from the ship to two or more beacons in known positions. This is done by transmitting a radio wave or sound wave, which triggers the beacon into responding, and timing how long the response takes to get back to the transmitter. Knowing the velocities of radio waves over the earth's surface (about 299,650 km/sec), and of sound waves in water (about 1500 m/sec), you find that range equals roughly 150 km/msec return travel time for a radio wave, and 0.75 m/msec for a sound wave. Note that very high timing precision is needed for radio wave ranging. Note also that the velocities I quoted are approximate; for precise work you must take care to estimate them as closely as possible. The residual error from a careful estimate of radio wave velocity is about 20 metres at 200 to 500 km range.

The simplest method of time measurement is to transmit short bursts, or 'pulses', of waves, and to arrange that the leading edge of the pulse transmitted from the ship's 'master' transmitter starts a clock count, and the leading edge of the return pulse from the 'slave' beacon stops it. Unfortunately, it is physically impossible to transmit an absolutely sharp, wall-sided pulse. In addition, distortion during propagation through the atmosphere and during processing by electronic circuitry alters the shape of a signal, so that the return pulse from the slave is not quite the same shape as the one transmitted by the master. Consequently, it is difficult to identify the leading edge of the pulse exactly, and this 'pulse-matching' method gives a fuzzy sort of time count. For a radio wave it is correct to about $\pm 1\ \mu$sec, the equivalent of ± 150 metres, and this is the best resolution of a radio-navigation system such as Loran-A; however, the situation is much better in acoustic ranging; the timing accuracy is only about ± 6 msec, but due to the much lower velocity of sound in water this is the equivalent of $\pm$ 2 metres.

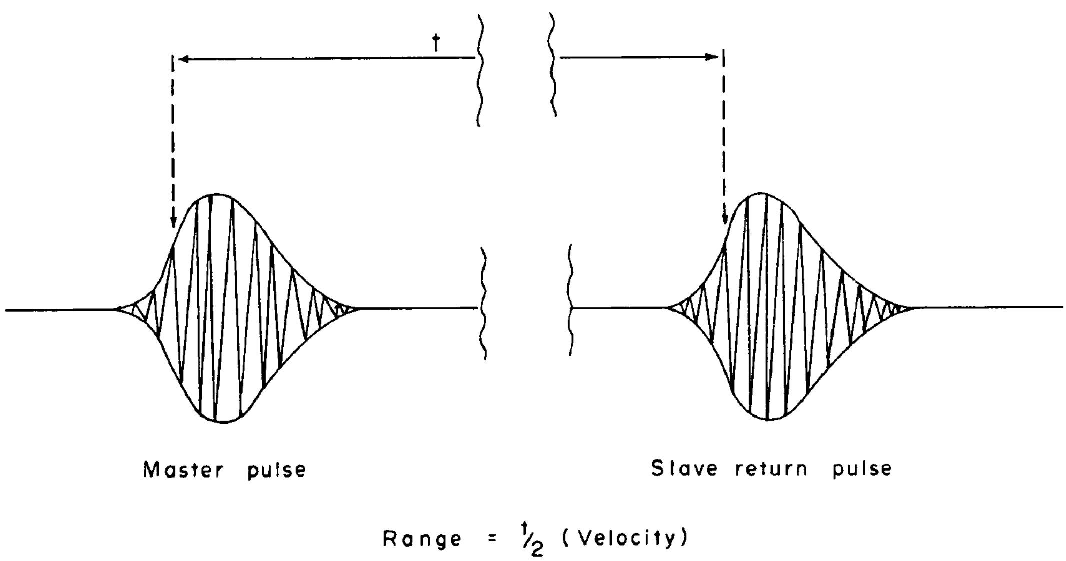


FIGURE 1 - CYCLE MATCHING

(Note that the timing accuracy by no means represents the overall system accuracy. Timing contributes just one of several range errors, and the geometry of the ranging position lines amplifies all these in the fix error).

A great improvement in radio-ranging is achieved by identifying one particular cycle of the radio wave within the pulse, and making the measurements on that. Loran-C, a long range radio navigation system using 'cycle-matching', has a timing accuracy of about $\pm 0.05\,\mu sec$, equivalent to ± 6 metres. Figure 1, illustrates cycle-matching time measurement on the master and slave pulses diagrammatically.

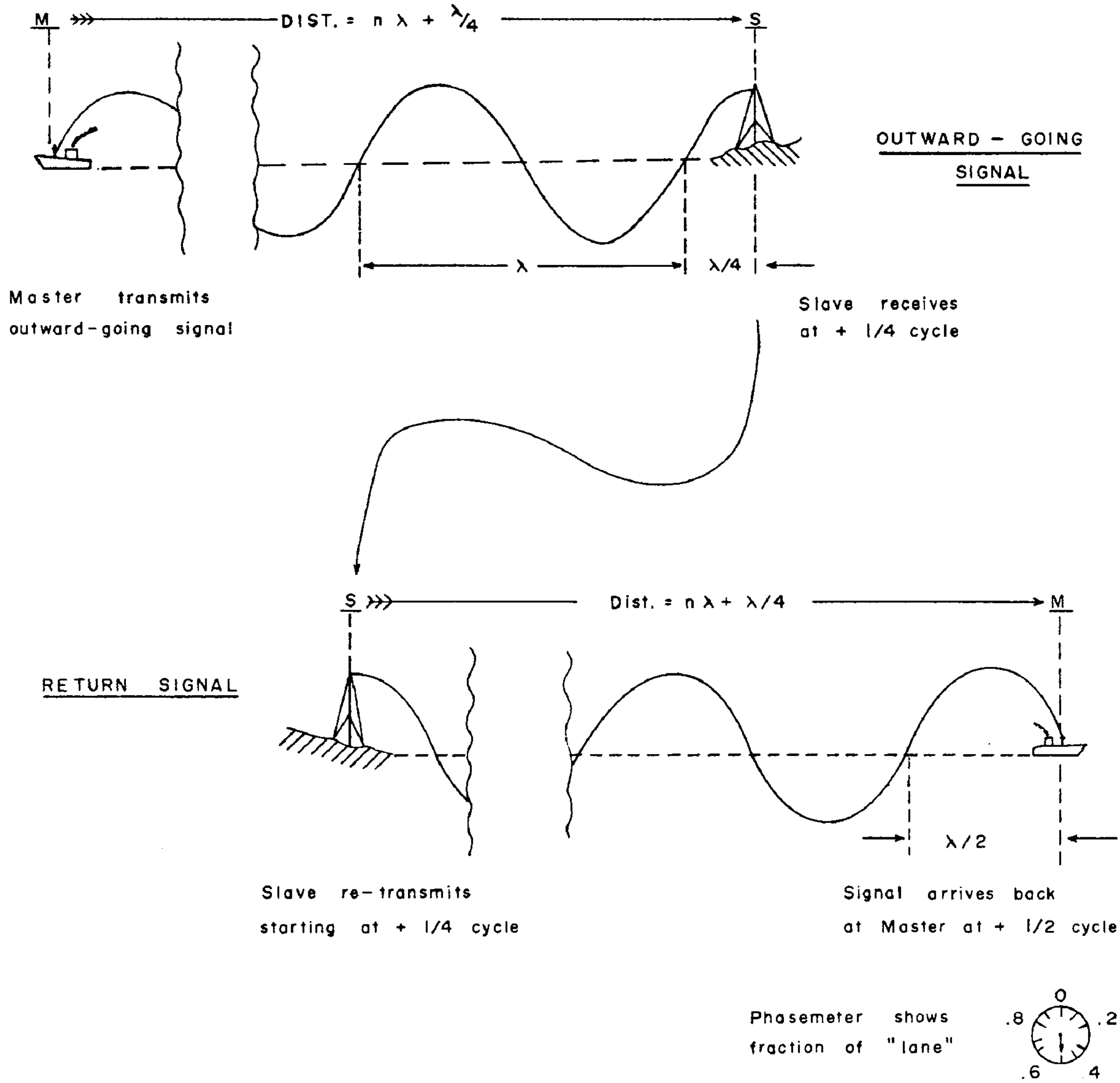


FIGURE 2 - PHASE COMPARISON

Cycle-matching is technically difficult to accomplish, and a simpler and more reliable method is used by the Decca Navigator systems. Both master and slave transmit continuously, instead of in pulses, and the slave is 'phase-locked' to the master so that it always re-transmits at the same point of the cycle that it receives from the master (the same principle is used in the Tellurometer). If the vessel carrying the master transmitter is initially at a range from the slave equal to a whole number of wave-lengths, the signal it receives from the slave will be in phase with its own transmission, i.e., the peaks and troughs of each signal will coincide exactly. As the range increases, the two signals will move out of phase (Figure 2), until eventually, when the range has changed by half a wave-length (or one 'lane'), they will be in phase again. A phasemeter measures the fraction of a cycle (lane) between the signals at the master, with a resolution of about 6 metres. The difficulty now is that although the phasemeter measures exactly where the ship is within a lane, it does not say how many whole lanes there are between the ship and the slave. To establish this 'lane count' the ship must start from a known position, such as a buoy, a seabed beacon, or a series of satellite fixes. Once the correct whole lanes are set in, the Decca will thereafter keep track of lanes gained or lost.

Unfortunately for Decca, a radio-wave reflecting layer, absent during the day, appears high up in the sky at sunset (Fig. 6). At long range the indirect travel-path via the reflecting layer often delivers more signal strength than the direct path over the earth's surface, and since the two path-lengths are different the two waves 'interfere' and the range measurement is lost. When this happens, the ship must return to the known position for a fresh start. Loran-C suffers from 'skywave' interference, but its signal is chopped up into pulses, and since groundwave travels a shorter path and so arrives earlier than skywave, the first part of the pulse will consist of groundwave alone. A range measurement made on this part will be free from skywave.

RANGE-RANGE AND HYPERBOLIC OPTIONS

So far all I have described is the measurement of one range. The information you want is the position of the survey ship and this is determined by the intersection of two range circles, as shown in Figure 3. (More than two shore stations are seldom used because of the high cost of radio transmitters). Acoustic positioning is similar in principle, but many seabed beacons are used, to extend the range. Note how strongly accuracy depends on the angle of cut of the position lines; along the inter-slave baseline, for instance, there is no fix at all. Note also that no slave can serve more than one master, so that the ranging method is restricted to a single user. (Current developments are modifying this restriction).

There is, however, a second option. If you take the master transmitter off the ship and put it ashore between the two slaves, and carry a passive time-difference receiver in the ship, you can measure the time difference between the arrival of the master signal and the slave signal. (The master transmission triggers the slaves to transmit, as before). The time difference can be converted to a distance-difference. A line along which the distance-difference has a given value happens to be a hyperbola; Figure 4 shows how hyperbolas for distance-differences of 0 and 40 km are constructed. A second distance-difference between the master and a second slave produces a second hyperbola, and the intersect-on with the first hyperbola gives the ship's position, as shown on Figure 4. Note that the 'lanes' of a hyperbolic lattice widen as they leave the baseline, magnifying the effect of position-line error. In addition, the angle of cut is generally weaker than in a range-range lattice. However, any number of users can operate passive receivers simultaneously, which is useful. This is the option used for the main Decca chains operated by MOT for commercial shipping; it is also used for inshore hydrographic surveys, when several shallow draught launches are deployed on the same survey.

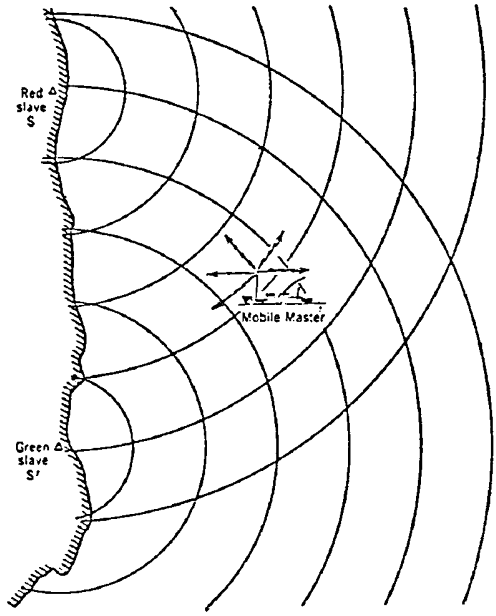


FIGURE 3 - RANGE-RANGE POSITIONING (from Bigelow, 1965)

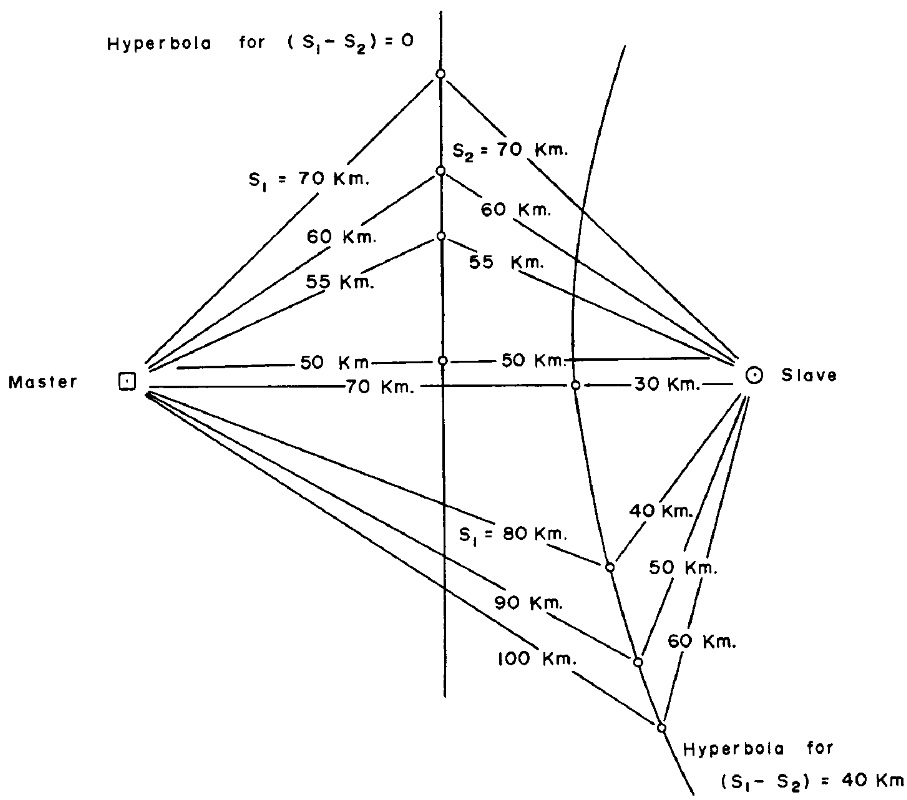


FIGURE 4 - CONSTRUCTION OF HYPERBOLAS

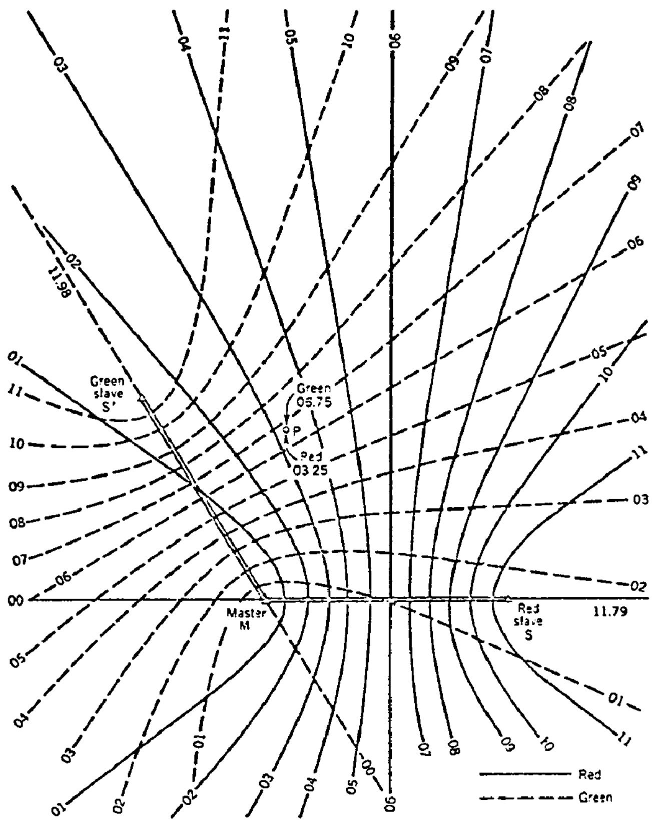


FIGURE 5 - HYPERBOLIC POSITIONING (from Bigelow, 1965)

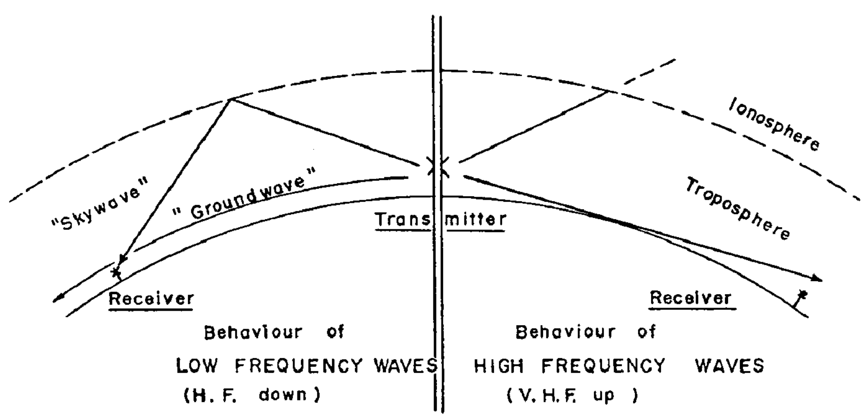


FIGURE 6 - RADIO-WAVE PATHS (after Wells, 1970)

PROPAGATION PECULIARITIES

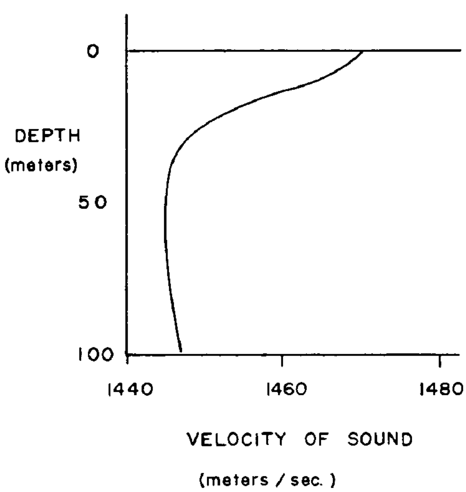
You may have looked out to sea from the water's edge one time and seen a ship quite clearly, but 'hull-down', with only her masts and upperworks visible, Looking back from seaward, a hydrographic surveyor balancing in a launch 12 miles offshore will just see the top of a 70-foot high lighthouse.

Radio-waves at radar and tellurometer frequencies (UHF up) behave much like light light waves; however, at lower frequencies they tend more to follow the curvature of the earth's surface (Fig. 6). And so if the survey area extends beyond the horizon visible from a shore station, you have to bring down the frequency of the radio system in order to get a radio-wave that will hug the earth's surface. Immediately there are two consequences:

1. More power is required to propagate lower frequency waves, and a bigger antenna is needed. So up goes the size of the transmitter station, and up goes the cost.

2. The wave-length increases, in inverse proportion to frequency, and since the error in a position line is to some extent a constant fraction of lane width, up goes the size of the error.

Sound waves are greatly affected by the characteristics of the water they travel through. Velocity, which is the parameter you need to know in order to convert sound-wave travel-times into distances, changes markedly with water temperature. It must always be measured on the spot, since the ocean is a dynamic system (too dynamic for those with weak stomachs) and its temperature is always changing. Temperature also changes from one depth to the next, as shown in Figure 7. Refraction on passing through the water layers bends all but vertical sound rays, and this means a slight correction must be calculated to find the true slant range. Much more serious than this, it imposes a maximum operating range for the acoustic system.



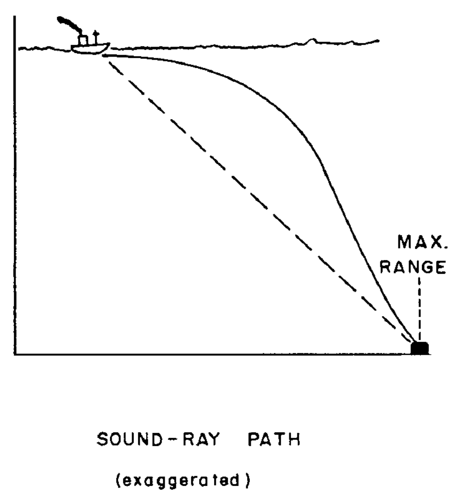


FIGURE 7 - SOUND-WAVE PATH

THE BEWILDERING CHOICE

The survey requirements, such as where you want to go; what accuracy you require; whether you can afford to close down at night, etc., impose certain limitations on the choice of positioning system. But there will usually be a number of approaches to any particular problem, sometimes with radical differences between them. For example, a geophysical outfit prospecting around Sable Island might decide to use Decca, with reference buoys for lane identification; or it might sacrifice accuracy for flexibility and opt for an integrated system involving satellite navigation and Doppler sonar.

Table 1 lists some of the alternatives. The detail shown has deliberately been kept to a minimum so as to give an overall picture, and should not be interpreted too exactly; for instance, an integrated satellite Doppler sonar system would cost much more than $8K + $12K, because a large computer would have to be programmed to tie the two together. Costs are rough estimates, intended to allow comparison between systems.

- TABLE 1 -

Continental Shelf Survey Systems
(Broad-Brush Treatment)

System	Transmitter Size	Frequency	Range	Method	Fix Accuracy	Approx. Cost per Month
SHORE-BASED:						
RPS (radar) Hydrodist (Tellurometer) etc.	100 lb	10,000 MHz	Line of sight	Range-range or Range-bearing	5 m	$ 6K
Hi-Fix Raydist Toran Lorac etc.	300 lb	2 MHz	200 km	Range-range or Hyperbolic	40 m	$10K
Decca	10 ton	100 kHz	500 km	Range-range	120 m	$50K
Loran-C	-	100 kHz	2000 km	Range-range	160 m	$15K
SEABED:						
Acoustic Beacons	500 lb	10 kHz	2-10 km, worldwide	Range-range	30 m	$10K
Doppler sonar	-	150 kHz	Continental Shelf	Velocity Measurement	300 m/hr	$ 8K
CELESTIAL:						
Sextant Fix	-	-	Worldwide	Position lines (if sky clear, 8-hourly).	3 km	$ 3K
Navigation Satellite	-	400 MHz	Worldwide	Computer Solution-(2-hourly)	500 m	$12K

Comments on some representative systems follow:

Inshore: Hydrodist

When you are close to shore you can behave like a land surveyor. You can put a Hydrodist (modified Tellurometer) Master in the boat, and the Remote ashore on a control point, along with a theodolite. Then you can fix by bearing and distance. As an alternative, particularly useful on the shores of Nova Scotia in summer when you can seldom see very far through a theodolite, you can double up the Hydrodist, with two masters on board, and two remotes ashore, and fix range-range.

Hydrodist is in the ultra-high frequency range (just above television), with wave-lengths measured in tens of centimetres. It is limited to line-of-sight, because radio-waves at that frequency travel in straight lines and do not follow the earth's curvature. As soon as you get out of sight of land you must look for an alternative.

Costal: Hi-Fix

If you come down in frequency to MHz (wave-length 150 metres), and increase in power from a battery to a thermo-electric generator, and in antenna size from a short stub to a 10-metre mast, you can get out to 200 km or more offshore before the signal gets too weak to be reliable. The maximum range of Hi-Fix over water has not been determined, but it is used regularly out to 150 km. We have been using Hi-Fix for eight years in hydrographic surveys by ship and launch in open seas, and by helicopter and hovercraft in the Arctic. It has proved reliable and convenient, and has become the mainstay of coastal surveys; the ship operates in deep water while the launches work on shoals and along the coastline, all on one hyperbolic chain. At present, it is being used by the survey ship *Kapuskasing* for surveys off Newfoundland and Northumberland Strait.

Setting up a Hi-Fix chain is not just a matter of erecting a mast and switching on. The patterns must be correctly zeroed by talking the slaves on from a receiver situated at a known point, and calibration is then carried out over the survey area, usually by shooting up a receiver in a survey launch by theodolite from shore control.

Since Hi-Fix uses phase-comparison, it can resolve the fraction of a lane in the distance to the slave, but cannot measure the number of whole lanes. Once the total lane-count has been established, by an independent fix, such as a theodolite intersection, a number of taut-moored reference buoys must be laid, and Hi-Fix lane reading of each found by steaming the ship close by. These buoys can then be used to reestablish the correct whole-lane reading after a transmission interruption.

Offshore: Lambda Decca

Hi-Fix will not cover all of the Gulf of St. Lawrence, and certainly not the Grand Banks, which extend more than 500 km from Newfoundland. So once again you must come down in frequency and up in power and antenna size. Decca Lambda has a small hut of equipment, and a 50-metre mast, and it takes three or four days to set a station up, plus another day to calibrate. Since the survey is now out on the high seas, and with luck there are no dangerous shoals, we can safely do all the work from a ship. We normally operate Lambda in range-range configuration, with the *Baffin*. She has been working on the Grand Banks and in the Gulf of St. Lawrence for several years. Last summer she took a trip to the Beaufort Sea, where she used the hyperbolic Lambda chain which the Polar Continental Shelf Project sets up annually for air, sea, and ground operations over the Arctic Ocean and the Archipelago of the Queen Elizabeth Islands.

Lambda Decca is the twin brother of the Navigational Decca Chains, which cover most of the Atlantic coast and Gulf of St. Lawrence from Cape Bonavista to

Fundy to Father Point. Apart from ship and aircraft navigation, Decca is used to control aerial photography and aeromagnetometer flight lines.

Decca is another phase comparison system and has the same ambiguity over lanes that occurs with Hi-Fix. Lambda Decca has a lower frequency 'lane identification' pattern that can be transmitted on command, but this is not reliable at long range or under bad atmospheric conditions, and so once again we lay buoys. The land identification system of the navigational Decca chains is reliable.

Anywhere on the Oceans: Acoustic Navigation

Because of its short range, navigation by interrogating seabed beacons will probably be limited to marking points on the seabed of particular interest, or to surveying small areas in great detail. The techniques are relatively new, and we are working on them at Bedford Institute.

"Integrated Systems"

The principle is analogous to a bearing and distance traverse tied into control points at intervals. At sea, the ship's gyro provides bearings, and distance is found from the ship's speed, measured either by an inertial system (if you are very rich indeed, like the U.S. Navy) or by Doppler sonar. Navigation satellite fixes provide the control for adjusting the accumulated error in course and speed measurement. A large computer keeps track of the data and produces up-to-the-minute position on demand. One such system is being operated on the Scotian shelf now.

Sea surveying is just an extension of the land surveyor's territory in this maritime province, and I expect that an increasing number of surveyors will 'go wet' as activity mounts on the continental shelf. I hope they will take full advantage of what experience we have gained at the Bedford Institute when this happens.

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Unfortunately, there is no comprehensive up-to-date reference on offshore surveying, but the following will help:

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COUNCIL REPORT - DECEMBER 4, 1971

The Complaints Committee reported three cases to Council: ONE, regarding practice of surveying by an unlicensed person; TWO, report by member of a misunderstanding with his client regarding surveying concepts; THREE,unprofessional ethics and conduct of a member reported by his client.

Ivan Macdonald, Chairman of the Technicians Certification Committee reported that he will be sending an information letter to the 128 technicians reported by the 1971 questionnaire.

Council voted that no delegate be sent to the International Meeting of the International Society of Photogrammetry being held in Ottawa during July 1972.

The scope of the technical papers for the 1972 Annual Meeting to be held in Sydney was decided.

Council agreed to continue the study of Association office space requirements.

W. S. Crooker reported on the meeting of the Legislative Committee with an A.P.E.N.S. Committee regarding amendments and additions to the Nova Scotia Land Surveyors Act. Council approved a motion to change the wording of Amendment #2 of the 21st Annual Meeting to make it more acceptable, and felt that Section 26 should be deleted.

Council moved that the date for the Special General Meeting which was to have considered the proposed changes in the Act approved in time to be presented to the Spring Session of the Legislature be March 11, 1972.

The following were accepted for membership in The Association of Nova Scotia Land Surveyors:

Allan Marshall Hunter - Windsor Junction
Victor E. Swinamer - Berwick
Brian Arthur Anderson - Louisdale.

The Secretary was requested to correspond with the Department of Highways regarding filing of right-of-way plans in Registry Offices.

No report from the Financial Committee as the Chairman was out of town.

No report from the Private Practise Committee as it has not yet met.

No report from the Editorial Committee as the Editor was not invited to attend.

James F. Doig, President,
The Association of Nova Scotia Land Surveyors.

Dear Sir:

As per your request of November 6th, I presented Mr. Gordon L. Nicholson with his certificate of Life Membership in the Association of Nova Scotia Land Surveyors on November 21st.

I spent some time chatting with Mr. & Mrs. Nicholson in the living room of their new residence on River Street in Stellarton and learned the following which might interest you.

Mr. Nicholson was born in Port Morien, Cape Breton, on June 18, 1899, and he attended college at North Eastern University in Boston, Mass., where he received a Bachelor of Science in Civil Engineering.

After this he spent nine years with the New York Central Railway and then worked for the Mexican State Railway.

Following this, he spent some time working for different contractors and was employed by the Dominion Steel and Coal Corporation in Cape Breton, and after this Mr. Nicholson returned to the U.S. where he worked again on construction work.

The Second World War came and because of the expansion of the Town, Pictou, N.S. needed an Engineer and Mr. Nicholson took the job. He worked in Pictou from 1944 - 1948, after which he worked a short time for the Town of New Glasgow, and then went to work for the Nova Scotia Department of Highways, where his responsibilities were that of Traffic Engineer and Special Jobs Engineer.

Mr. Nicholson retired from the Department of Highways for the third time in 1967.

Both Mr. & Mrs. Nicholson are very spry and in good health and he now enjoys a woodworking hobby, and has a basement well equipped with all the necessary hand and power tools for the job. I had the pleasure of seeing some of his work which was beautiful.

Mr. Nicholson is a charter member of the Association of Professional Engineers and holds a Life Membership and a 50 year Membership Certificate in that Association.

Also, Mr. Nicholson attended the organization meeting of the Provincial Land Surveyors Association.

It would seem to me that the Land Surveyors could not have picked a better candidate for Life Membership.

I feel that I have all the times and places correct, but if not, I hope Mr. Nicholson will forgive me.

Thank you.

Yours very truly,

I. J. Osmond.

NEWS ITEMS -

Approximately 35 delegates and wives from Nova Scotia attended The Canadian Institute of Surveying 65th Annual Meeting at Quebec City during February.

Clarke Beattie attended as Councillor for Nova Scotia, and Al Daykin as Councillor-at-Large. While in Quebec City James Doig, President of The Association of Nova Scotia Land Surveyors and Walter Servant attended a meeting of the Special Committee on Survey Technician Education and Certification at which time the function of this committee was transferred to the C.I.S.

Also at this time a meeting was held by the Provincial Survey Presidents with Robert Feetham as Chairman, who presented a formula for the formation of a National Council of Land Surveyors which would consist of representation from each of the Provincial Land Surveyors Associations.

The Theme of the C.I.S. meeting was "The Role of the Surveyor in Modern Society, with subjects of special Maritime interest such as marine surveys, their purpose and methods, and who should make them, underwater pipeline survey problems and also, a panel discussion on the effects of designated control areas on legal surveys in the Maritimes, chaired by Walter Servant.

The C.I.S. Meeting coincided with the Annual Quebec Carnival, so for social activities in addition to the "Boustifaille du bon vieux temps, casse-croute et danses carnavalesques", we were able to see the ice monuments and the beautiful Night-time Carnival Parade.

At the official closing of the meeting lovely Mary Doig, daughter of President J. F. Doig and Mrs. Doig presented a beautiful bouquet of roses to Mrs. Simard, wife of the outgoing President of the C.I.S. Among other awards was a presentation to George Bates in recognition for his efforts of so many years of providing enjoyment at the C.I.S. Annual Meetings with his "kilted parades and other activities" which he always conducted with such quiet dignity and delicate decorum.

Contratulations go to Ed Rice for his recent promotion within the Maritime Telegraph and Telephone Company. Unfortunately it has meant his transfer to New Glasgow from Halifax where he has been so active with the Association of Nova Scotia Land Surveyors, especially as the Association Secretary-Treasurer. We are sure though that Ed will find Association activities in the New Glasgow area. His family will be joining him after school closing in June.

Henry Langley formerly with J.A. McElmon and Associates has joined the National Harbours Board in Halifax.

Garnet Clarke who has been assisting Ed Rice as Secretary has now taken over the complete duties of Secretary-Treasurer of the Association.

MUNICIPAL MAP INDEX..The third edition of the Municipal Map Index has been published by the Nova Scotia Department of Municipal Affairs. Copies are available at $2.50 from the Department of Municipal Affairs, P. O. Box 216, Halifax, Nova Scotia.

This list includes maps available from the Provincial Government Departments, mainly Municipal Affairs, Highways and Lands and Forests.

It was recently announced that under the Maritime Provinces Surveying and Mapping Program the Provincial Offices will be combined; the Administrative Offices to be in Fredericton, Engineering Offices in Amherst, Land Titles Offices to be in Halifax with the Control Surveys and Mapping personnel going to Charlottetown.

OBITUARY -

The death of Arthur Morse Foster, 85, of Bridgetown was recently reported. He had practised surveying for approximately 60 years, principally in Annapolis County. He was a member of the Association of Nova Scotia Land Surveyors and had been made a Life Member in 1971.

LAW AND HUMOUR

Though most people may regard land title searching as a pretty dull business, here is an allegedly true story of one attorney who has not lost his sense of humour.

While searching the title to a proposed land site in Louisiana, a Big American corporation delved as far back as 1803. Not satisfied with this, a legal advisor wrote for evidence as to prior titles. He received the following reply from a Louisiana attorney:

"Gentlemen:

I note your comment upon the fact that the record of title sent to you as applying to the lands under consideration dates only from the year 1803; and your request for an extension of the records prior to that date.

Please be advised that the government of the United States acquired the territory, including the tract to which your enquiry applies, by purchase from the government of France, in the year 1803. The Government of France acquired title by conquest from the Government of Spain. The Government of Spain acquired title by discovery by one Christopher Columbus, a resident of Conos, Italy, traveller and explorer, who by agreement concerning the acquisition of title of any lands discovered, travelled and explored under the sponsorship and patronage of Her Majesty the Queen of Spain. And the Queen of Spain had verified her arrangements with and received sanction of Her title by consent of the Pope, a resident of Rome, Italy, and an ex-officio representative and vice-regal of Jesus Christ. Jesus Christ is the Son and heir apparent of the Almighty God, from whom he received His authority, and the Almighty God made Louisiana."

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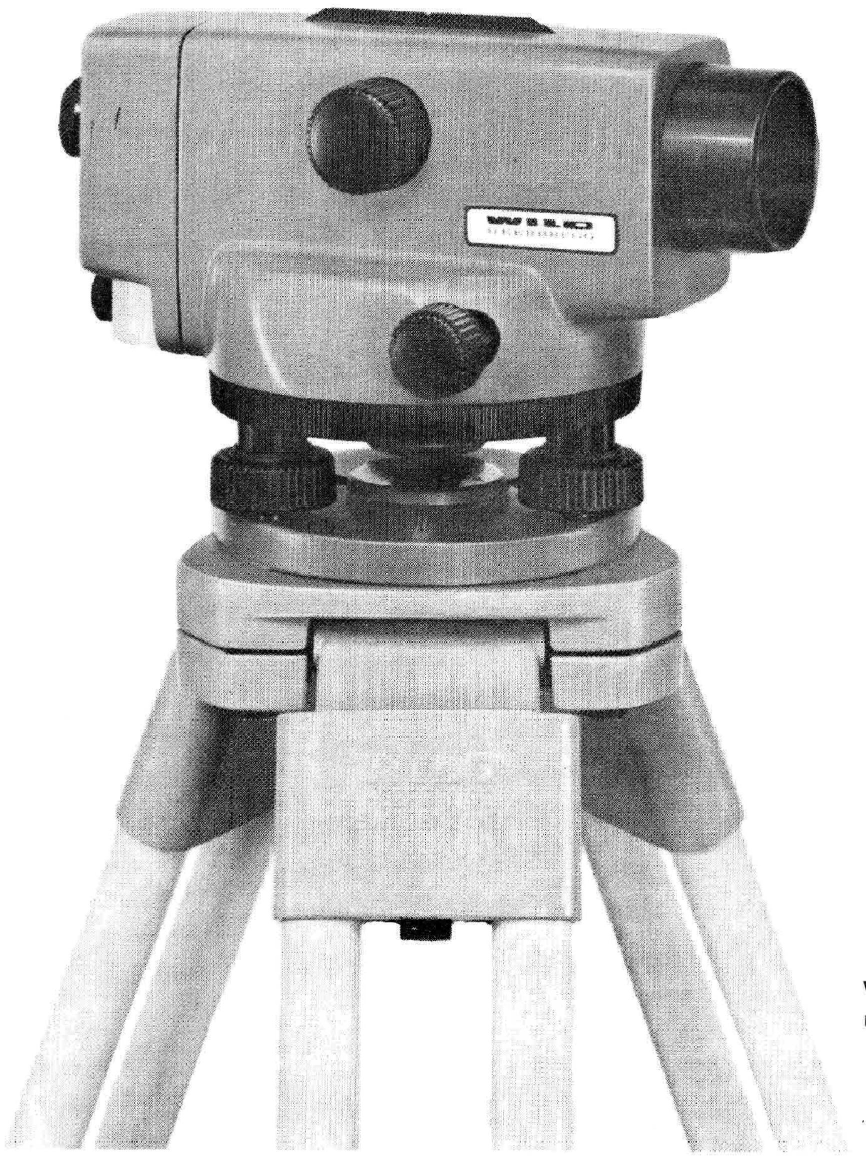

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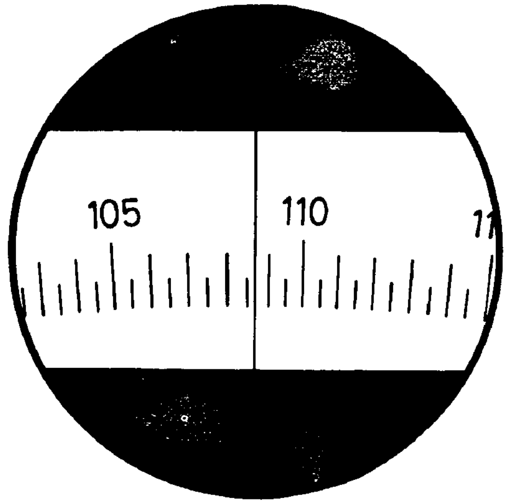
Reading example (108.7°; 108.7°)



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- **Horizontal circle with reading eyepiece, circle setting to any value**

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Technical Data

Standard deviation for 1 km/ 1 mile double run levelling	±2 mm	±0.008 ft
Heighting accuracy with a 50 m/150 ft sight	within 1.0 mm	0.003 ft
with micrometer	about 0.2 mm	0.0005 ft
Telescope	erect image	
Magnification	23×	
Clear objective aperture	36 mm	1.42 in
Field of view at 100 m/ft	3.15 m	3.15 ft
Shortest focussing distance	1.0 m	3.3 ft
Multiplication constant	100	
Additive constant	0	
Tilting range of compensator	±15′	
Setting accuracy	±0.5″	
Sensitivity of circular bubble	8′ per 2 mm	
Horizontal circle (metal)	400^g or	360°
Diameter	91 mm	3.59 in
Graduation interval	50^c or	30′
Reading by estimation	5^c or	3′

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Stock No.			kg	lb
336 406	1	Wild NAK1 Engineer's Automatic Level, 400^g,	2,3	5,7
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		with adjusting pin		
		or		
336 405	1	Wild NAK1 Engineer's Automatic Level, 360°,	2,3	5,7
		in plastic container,	1,3	2,9
		with adjusting pin		
312 985	1	Tripod GST00, with telescopic legs	3,8	8,4
		Tripod accessories: 1 plastic cover, 1 hexagonal key		
		or		
305 009	1	Tripod GST10, with telescopic legs	6,0	13,2
		Tripod accessories: 1 plastic cover, 1 pouch with plumb bob and hexagonal key		

Optional Accessories

	Parallel Plate Micrometer GPM2, with counterweight, in case
199 886	Measuring range 10 mm
175 155	Measuring range 5 mm
175 156	Measuring range 0.5 in
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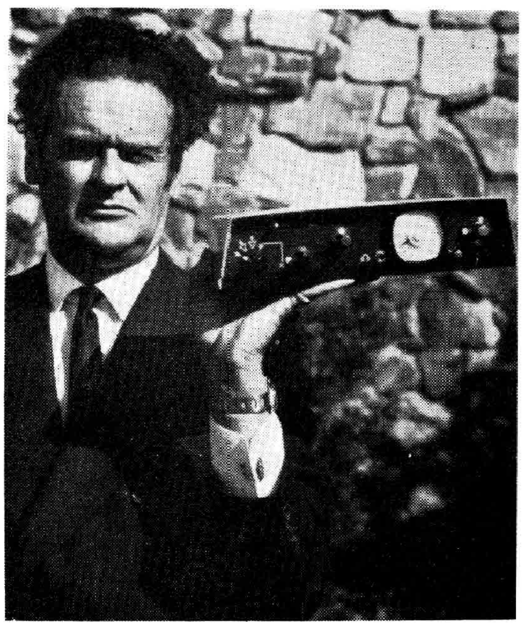

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