DEPARTMENT OF NATIONAL DEVELOPMENT
Secretary: RW Bosell

DIVISION OF NATIONAL MAPPING
Director: BP Lambert

TECHNICAL REPORT No. 7

AUSTRALIAN ANTARCTIC TERRITORY

FRAMNES MOUNTAINS - DEPOT PEAK

TELLUROMETER TRAVERSE

November 1965 - January 1966

by

M. J. Corry B. Surv., L. S., M. I. S. Australia.

NMP/67/019

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FOREWORD

by Director of National Mapping.

Field survey work of all kinds on the Antarctic continent has shown increasing emphasis on intensive activity in the summer months, achieving large volumes of work in a short time, with ample numbers of fully trained personnel and maximum use of air transport.

However, transport still depends largely on helicopters, with short range and voracious appetites for fuel. As the survey areas extend further from the coast into remote areas, some logistic effort must be spread over the year. The weeks of autumn provide the opportunity for emplacement of food and fuel dumps, and much useful field work may be done in spring, while ship access to the continent is still prevented by ice.

This report describes such an operation south of Mawson in the spring of 1965, by which tellurometer traverse control for mapping was extended from the coast across the ice cap to the northernmost rock feature in the Prince Charles Mountains region.

Mr. Corry was attached to the Australian National Antarctic Research Expedition, wintering at Mawson in 1965. The survey party left Mawson in early November and started operations at Mt. Twintop on 20th November. The survey was completed by 5th January and the party returned to Mawson on 10th January, 1966.

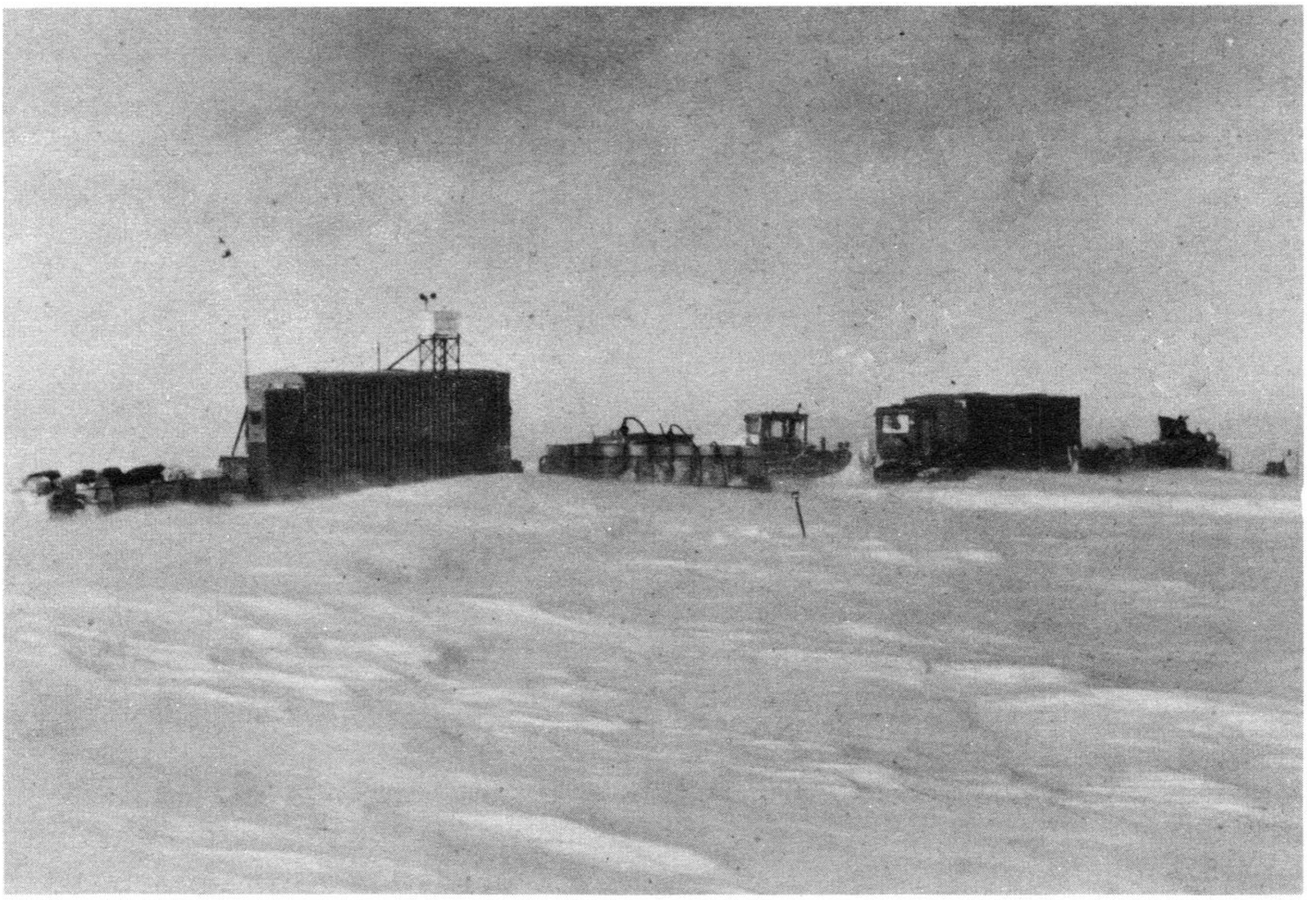
1. INTRODUCTION :

Following the successful helicopter-supported Tellurometer traverse of about 300 miles westward from the Framnes Mountains to Mount Mueller, Kemp Land, January-February, 1965 (Division of National Mapping Technical Report No. 5) a start was made on another important project; a Tellurometer traverse from Mount Twintop, in the Framnes Mountains, to Depot Peak, the most northerly rock outcrop in the extensive Prince Charles Mountains Region. Long-term planning was for this traverse, of some 100 miles, to be the first major link in a chain of traverses through the Prince Charles Mountains, designed to provide adequate control for the 1: 250,000 scale mapping of this region and to provide a framework of permanent marks for accurate measurement of ice movement.

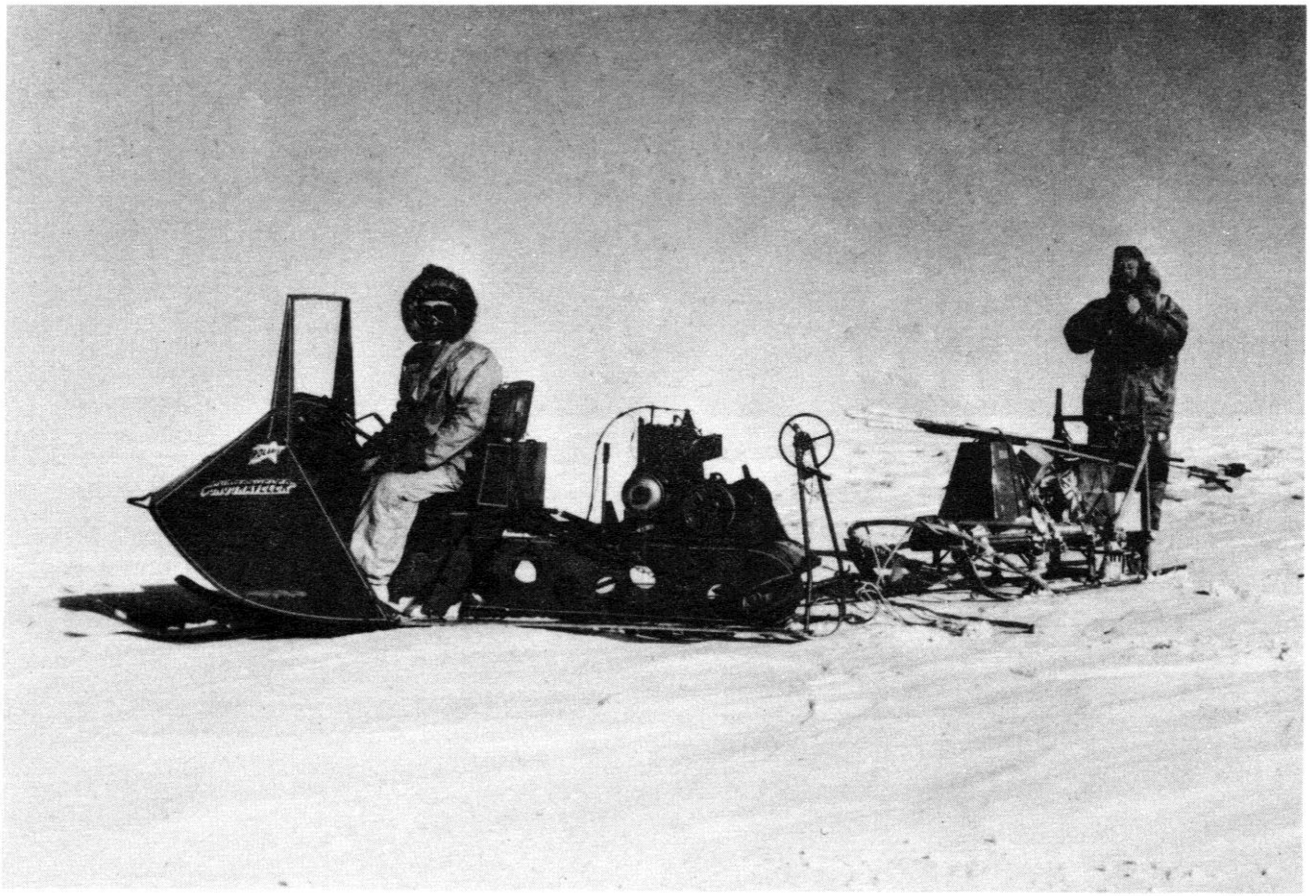
It was realised that the execution of the Mount Twintop - Depot Peak traverse would not be easy, because it would have to be a series of short legs across the undulating ice sheet without benefit of intermediate mountains to provide elevation for the Tellurometer.

The traverse was planned to be carried out in the late spring. Four fuel and food depots were established in the previous autumn; at Mount Twintop (40 miles south of Mawson); at a position 30 miles south of Mount Twintop; in the vicinity of Depot Peak, and near Stinear Nunataks, some 40 miles south of Depot Peak.

The traverse was carried out successfully, although extremely bad weather and lack of time prevented the intended closure back to Mount Twintop. Of the thirty-eight days required to complete the traverse only twelve were suitable for survey work. On only four of these twelve days was it possible to work throughout the day.



Tractors, caravans and sledges parked during blizzard. *Photo by M. J. Corry*



Polaris Sno-traveller and dog sledge with survey equipment. *Photo by M. J. Corry*

2. PERSONNEL

The nine members of the field party were drawn from the 1965 wintering party at Mawson and consisted of the following:

B.C. Woinarski	- Leader.
M.J. Corry	- Surveyor.
P.J. Gordon	- Radio Technician; Assistant to Surveyor.
D.B. Carter	- Electronics Technician; Assistant to Surveyor.
J. McGhee & K.D. Watson	- Mechanics.
P.J. McGrath	- Radio Operator
P.A. Bensley	- Carpenter.
M.A. Poulton	- Weather Observer.

3. TECHNICAL EQUIPMENT

Two Tellurometer Model MRA3 units with a cathode ray tube readout were used for distance measurement and a Wild T3 theodolite for the traverse angles. Two Wild T2 theodolites were used in conjunction with the T3 theodolite for simultaneous vertical angles.

Three light portable towers, as described in 9.5.3., were used for angular work.

4. TRAINING OF PERSONNEL

As only one qualified surveyor was available to carry out the traverse, it was necessary to train other members of the wintering party in survey work, especially in the operation of a theodolite for simultaneous vertical angles and in the operation of the Tellurometer. Fortunately, the Radio Technician had had limited experience with a theodolite and, with his experience in the operation of electronic equipment, he was able to master the procedures very quickly, especially the Tellurometer. The theodolite took longer to master and some trouble was experienced in the early part of the traverse although considerable theodolite practice had been carried out at Mawson prior to departure. The radio operator also was trained in the use of the instruments but was never required to operate them. The electronics technician, being the surveyor's principal recorder, quickly picked up the routine and towards the end of the traverse was of considerable help by being a third person competent in the operation of the theodolite and tellurometer. Excellent work was turned in by both technicians.

5. VEHICLES

Australian National Antarctic Research Expeditions have not had aircraft based at Mawson since 1960, therefore ground transport had to be used throughout the operation and the traverse party had to be self supporting whilst in the field.

The following vehicles were used on the traverse; Two Caterpillar D4 tractors (each hauling three or four sledges); two Porsche Snow Tracs and one Polaris K95 Sno-traveller with a small dog sledge.

Caterpillar tractors have been proved in polar regions, particularly by Australia and the United States. The D4 model, with water-cooled diesel engine rated at 32 hp. and developing 50 hp at 1600 rpm, is capable of pulling loads up to 15 tons under suitable conditions. The standard transmission has five forward gears and one reverse gear, giving a maximum speed of approximately 7 miles per hour. Fuel consumption is approximately 1 mile per gallon and the special 24 inch wide track gives a rather high ground pressure of 5 lb per square inch.

The Snow Trac is a light, tracked scout vehicle claimed to be capable of carrying 1100 lb and towing another 1100 lb. The 4 cylinder air-cooled Porsche engine is rated at 60 hp Transmission is standard, with four forward and one reverse gear, and has an extremely low ground pressure of ¾ lb per sq. in. Fuel consumption varies from 1½ to 7 miles per gallon, and a top speed of 20 m.p.h. can be attained in satisfactory conditions.

The Polaris is a motorised toboggan powered by a 9½ hp air cooled petrol engine. It features an automatic transmission which drives a pair of chains separated by a number of cross bars which provide the traction. The weight of the engine and transmission is applied to the cross bars whilst the rest of the vehicle is carried by two wooden skis. Steering is by means of two metal skis at the front of the wooden skis.

The Polaris had been untested in plateau conditions, although favourable reports on it had been received from other countries. On the traverse, the performance of the Polaris exceeded all expectations.

One Snow Trac did not reach Mt. Twintop, being completely out of commission with a seized wheel bearing. The other Snow Trac was very useful provided it was handled with care, but it, too, broke down completely near the end of the traverse.

The tractors, with their usual relatively trouble-free performance, proved to be good support vehicles but were hampered by the heavy snow conditions. However, on the traverse, their slow rate of progress was not an important factor.

6. TRAVERSING PROCEDURE

6.1 ORIGINAL PROPOSALS

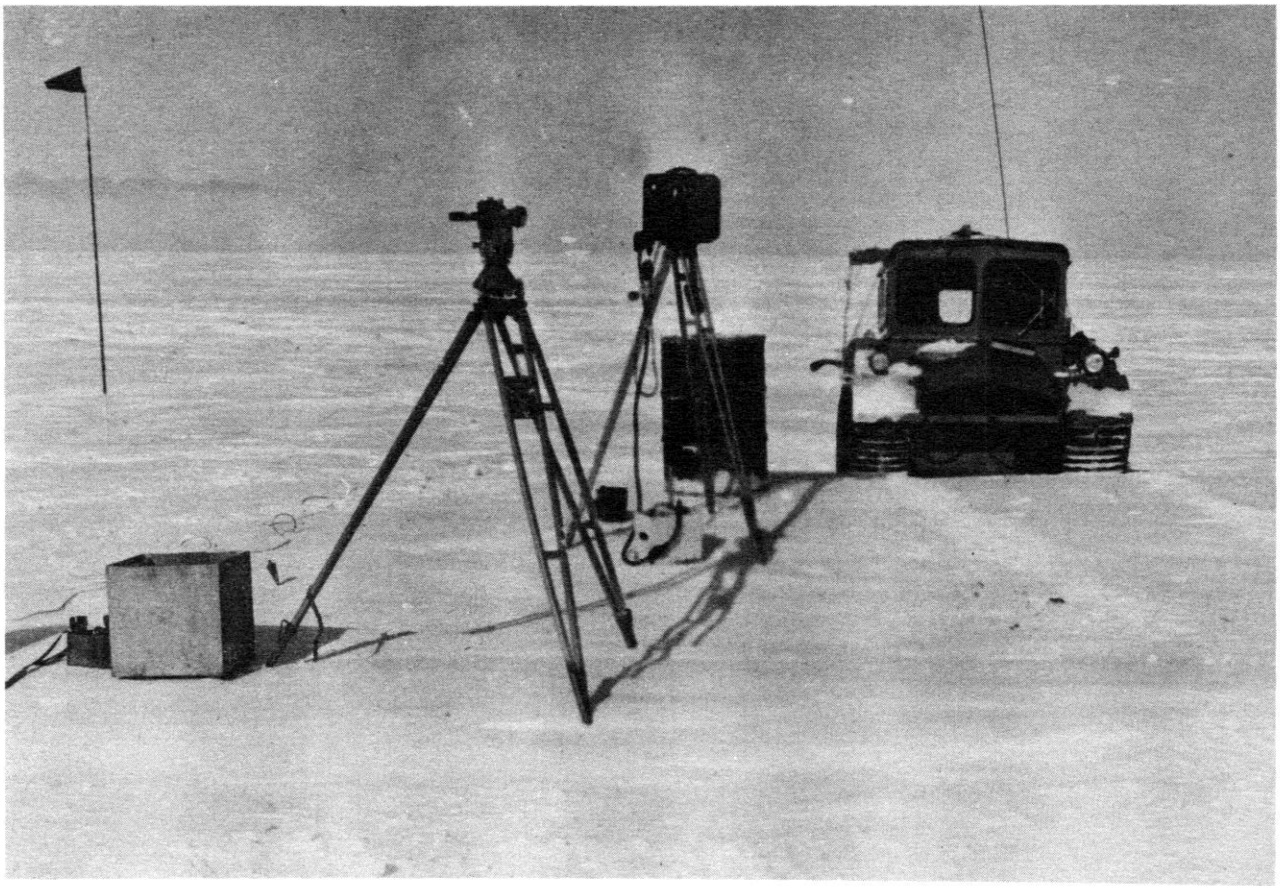
The original plan was to split the traverse team into three separate parties :-

(a)Forward party in Snow Trac: Navigation, reconnaissance, station marking and provision of a target for horizontal angles.,

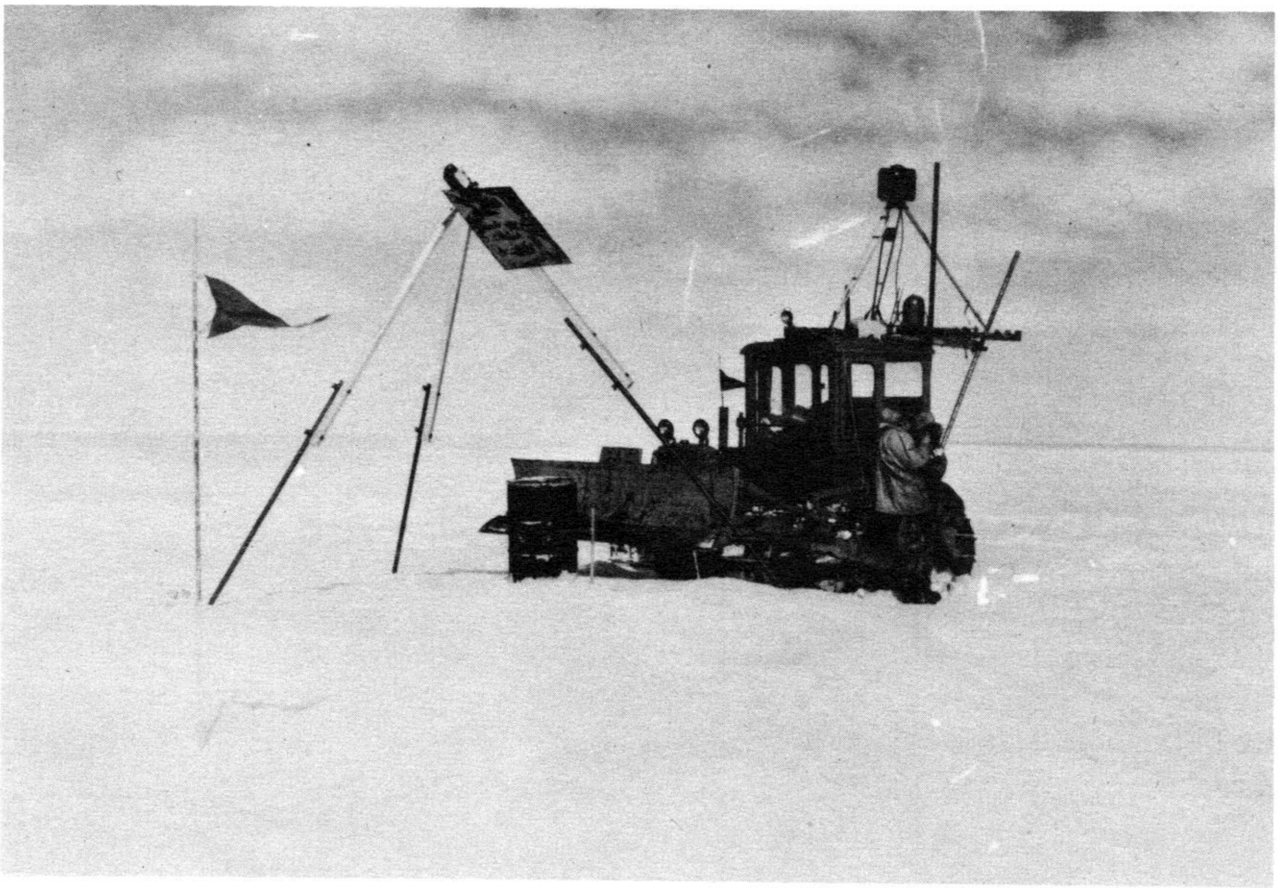
(b)Centre party, using elevated instruments on roof of tractor: Horizontal angles, simultaneous reciprocal vertical angles and Tellurometer measurement to rear party, and camera operation for terrestrial photographs.

(c)Rear party, using elevated instruments on Snow Trac: simultaneous reciprocal vertical angles and Tellurometer measurements to centre party, and provision of back target for horizontal angles.

Assuming a station interval of about four miles, it was felt that in a twelve hour day three legs could be measured. The tractor trains and caravans would comprise the centre party and all three parties would return to the tractor trains upon completion of the day's work. Preferably, the two trains were not to be split up during the day, thus the manpower requirements were eight or nine men.



Sno-Trac, Tellurometer and theodolite at station NM/S/90 *Photo by M. J. Corry*



Portable metal beacon and elevated Tellurometer on caterpillar tractor. *Photo by M. J. Corry*

6.2 FIRST MODIFICATIONS TO PROCEDURE AT MT. TWINTOP

Two separate parties left Mawson to rendezvous at Mt. Twintop. The advance party of four men, using the two Snow Tracs, established three permanent survey beacons in the Framnes Mountains for use during the horizontal angle measurements at Mt. Twintop. They also measured by Tellurometer the distance between Anniversary Nunataks and Mt. Twintop. This was done in conjunction with the second party who had brought the tractor train to Mt. Twintop. (The survey work carried out in this region formed part of the triangulation of the Framnes Mountains commenced in previous seasons).

The following problems arose at the Mt. Twintop rendezvous :

(a) the weather and soft snow were considerably delaying the progress of the tractors. The Mawson to Mt. Twintop journey normally a two day trip, had taken eight days. Snow conditions in places had necessitated the use of two tractors in tandem which caused extremely slow progress.

(b) one Snow Trac was completely out of commission and neither time nor vehicles could be spared to obtain replacement parts from Mawson.

The only alternative was to use the Polaris Sno-traveller and the half-sized dog sledge (which had been taken along as the spare vehicle) and hope that this arrangement would suffice.

6.3 SECOND MODIFICATION TO PROCEDURE

After the initial two or three legs the following points had arisen :

(a) The Polaris had exceeded all expectations and its only drawback was the restricted load carrying capacity of the small Nansen dog sledge.

(b) The terrain was much more undulating, with broad snow valleys, than was expected. Although virtually dictating station location it was found that in the majority of cases the instruments could be set up directly on the snow surface without loss of performance. Time was saved by not having to erect and dismantle the towers.

(c) The tractors were still making extremely slow progress and they could not afford the time to stop for survey measurements if satisfactory progress was to be made each day.

6.4 TRAVERSING PROCEDURE AS FINALLY ADOPTED

Consideration of these factors led to the following general procedure being adopted for the remainder of the traverse, although at times it was varied according to the circumstances.

The survey was conducted by two survey parties, working independently of the tractor trains, which were able to proceed at their own rate. However the trains kept in the vicinity of the area where the survey observations were being conducted.

The two survey parties were assigned the following tasks :

(a) Front party with Polaris and sledge: Reconnaissance, station marking, vertical angles and Tellurometer measurement back to the centre party, and provision of forward target for horizontal angles.

(b) Centre party with Snow Trac: Horizontal angles, vertical angles and Tellurometer measurements to front party, and terrestrial photographs.

The back marker for horizontal angles was usually a drum, or a cane, which had been placed previously by the centre party prior to leaving that station.

7. RECONNAISSANCE

Previous reconnaissance reports had mentioned the existence of ice domes and other undulations on the plateau which could be used as traverse stations. During the Autumn depot laying trip, a look-out had been kept for these undulations, but the prevailing conditions of poor visibility prevented adequate reconnaissance of the terrain. It was decided, therefore, to follow the longer but proved route from Mt. Twintop to near Depot Peak, rather than proceed direct to the latter feature.

Time and conditions did not permit a reconnaissance before the commencement of actual survey measurements, although this was very desirable. Reconnaissance turned out to be one of the troublesome parts of the traverse, for the following reasons:

(a)The forward party had not had any previous experience of this type of work.

(b)The lack of reliable communication between the centre and forward party. The radios supplied were too bulky and heavy and had a limited range, using voice communication, unless an elaborate aerial system was erected. It was not practicable to use the Tellurometer communications system, mainly because their batteries had to be conserved for line measurements, there being no re-charging facilities on the Polaris.

(c)The actual difficulty of telling, on a fair y flat featureless terrain, exactly where the best station locations were, especially with regard to best visibility from the previous station. Even more difficult was the gauging of the forward sights from the proposed station site.

Generally speaking, the centre party tried to move up to the next station as quickly as possible, so that the Snow Trac could be used as a large marker to clearly indicate the position of the station to the reconnaissance party. If possible, the centre party also tried to follow the progress of the reconnaissance party through a theodolite. If the proposed forward station was seen to be in an unsatisfactory position, the reconnaissance party was advised by Tellurometer, but usually the new forward site was accepted. Tellurometer contact was made either on previously arranged schedules or, if the theodolite had been used to follow the progress of the reconnaissance party satisfactorily, contact was made as soon as the reconnaissance party had set up their Tellurometer. As the traverse progressed, the reconnaissance improved considerably with the experience gained and consequently lines of better lengths were measured.

The total length of the traverse was 101.4 miles, from Mt. Twintop to Depot Peak. Sixteen stations were established on the snow. Of all the lines with both terminal points on the snow, the longest was 8.4 miles and the shortest 1.2 miles, with an average of nearly 4.5 miles.

8. STATION MARKING

The station mark used on the snow was a bamboo cane approximately four feet long and a little over an inch in diameter. A Sipre ice drill was used to place the cane in the snow to a depth of two to three feet, the top foot of the cane was painted "dayglo" orange for easy recognition.

At approximately ninety degrees to the backsight, and exactly thirty feet from the station mark, a bamboo cane was placed each side of the station. These canes protruded seven to ten feet above the surface. One cane was painted red with a red flag, whilst the other was black with a black flag. This scheme was used to distinguish the survey station from the other trail markers. For the relatively short legs a cane was also placed in line with the station marker, and for the longer lines a fuel drum was used. Sometimes both cane and drum were used.

The two side canes allowed easy recognition of the station, this being particularly important when searching for it as a backsight for horizontal angles and then more than one drum or cane (the remainder being trail markers) were visible in the same general direction.

The two terminal stations at Mt. Twintop and Depot Peak were marked and surmounted by permanent beacons. The eccentric marks in both cases were rock pitons surrounded by a ring of rocks.

9. ANGLE MEASUREMENT

9.1 THEODOLITE PERFORMANCE

Optical work proved to be the greatest source of trouble experienced on the traverse, due to its great dependence on suitable weather and surface conditions. When the instrument was set up on snow, the tripod legs were driven hard in, to reduce sinking to a minimum. The Wild T3 theodolite gave almost trouble-free service and was a delight to use. In the majority of cases, the forty times magnification was used, although in bad conditions reduced magnification was found to be more satisfactory. The only troubles experienced with the instrument were stiffness and stickiness towards the end of the traverse and, on one occasion, when the light path to the horizontal circle failed completely, but this proved to be only temporary. However, it was noticed that the junction of the main circle readings in both the horizontal and vertical circle positions was not clear, the lines being permanently slightly out of focus. Such was not the case with the Wild T2 theodolites which likewise gave good service but of course were not in the same category as the Wild T3.

Theodolites when used on the Snow Trac roof were relatively stable, provided care was taken, but trouble was experienced on the one occasion that the instrument was set up on top of the tractor. In these cases, it was necessary to make the connection to the station mark by use of the theodolite and tape.

9.2 ANGLE READINGS

The procedure of double readings, whereby two separate pointings of each target are taken in succession before proceeding to the next target or changing face, was used. This procedure had been adopted in Australia for use with Wild T3 theodolite (with its half scale micrometre) on geodetic work for several years. As well as utilising to the utmost the requirement that the micrometres of Wild T3 theodolites must be read twice in order to obtain the correct number of seconds, the procedure of double readings had the following advantages even when using the Wild T2 theodolites :

(a)Quicker reading was possible, as half the pointings only required a quick movement of the slow motion screw. This resulted in less searching for small targets in featureless terrain; an important consideration.

(b)Quicker comparisons between successive readings were possible. This was particularly important for inexperienced observers and recorders, especially if refraction was constantly changing in vertical angle observations.

Typical ice station, showing station mark, drum, identifying canes and survey equipment. *Photo by M. A. Poulton*

Angle observations on ice sheet, using Wild T3 theodolite *Photo by M. J. Corry*

9.3 HORIZONTAL ANGLES

The Wild T3 theodolite was used throughout the traverse except once, when trouble was experienced with lighting of the horizontal circle. Generally, two sets of three double zeros to second order standard (range between the 24 readings not to exceed eight seconds) were obtained. More readings were taken if this range was exceeded.

9.4 VERTICAL ANGLES

In every case, simultaneous reciprocal angles were obtained, usually with the Wild T3 at one end and a Wild T2 at the other. The usual number of readings was four double pairs, that is sixteen pointings. Sometimes, in bad conditions, only three double pairs (the minimum requirement) could be observed.

9.5 TARGETS

The various targets tried were :

9.5.1 DRUMS:

Drums, of the forty four gallon size, were generally used for the backsights for horizontal angles. These were very good for the longer legs of five miles and over. Contrast with the snow was improved by painting the drums black, but this rapidly increased the ablation rate. Canes placed to the side were still needed to distinguish the black drums from the yellow trail drums.

9.5.2. BAMBOO CANES

These were painted black with the exception of the lower portion which was painted white to reduce ablation. Bamboo canes proved ideal for short legs. On days of good visibility, canes could be utilised for the longer legs (up to eight miles) if the high powered eyepiece of the theodolite was employed. Often a drum and a cane were used together in conjunction; the drum for recognition and the cane as the target.

9.5.3 TRIPOD AND THEODOLITE

This target was used mainly at the forward station and was found to be good in reasonable conditions. If conditions were not satisfactory a Tellurometer (being larger than the theodolite) was used, and if necessary a person would stand directly behind the instrument to improve the sighting. In bad conditions, however, this arrangement was not always satisfactory and the portable beacons had to be used, but the limited carrying capacity of the Polaris sledge prevented their general use.

9.5.4 PORTABLE TOWERS

Previous accounts of Tellurometer work over snow had all stressed the need for elevation of instruments, particularly Tellurometers, in order to maintain a satisfactory station interval of about four miles.

With this in mind, construction was started at Mawson, during the winter, of three lights, portable towers for this purpose. Because of the scarcity of suitable materials these took the form of tripods, one being of wood and the others of aluminium and piping. It was hoped that these towers could also be utilised as beacons by strapping a three foot square sheet of aluminium on top of the structure. Unfortunately, tests at Mawson showed that the fourteen feet long legs were too unstable for theodolite work, although satisfactory for the Tellurometer. Because of this, two racks, suitable for holding the tripods securely onto vehicle roofs were, manufactured and found to be satisfactory provided care was taken.

The towers proved to be most satisfactory as beacons, especially in the poorer visibility conditions and in the isolated cases where the stations were not intervisible at ground level. In the latter case, on short lines, sights were made directly to the upright at the top of the beacon, which had previously been centred accurately over the station mark. For the long legs to the traverse terminal points located on rock, a portable beacon was erected over the mark at the station situated on the snow and several fuel drums welded together were erected nearby. This arrangement served to distinguish the beacon from strastrugi which, when viewed from a distance, had an appearance similar to a beacon.

9.5.5 HELIOGRAPHS AND LAMPS

Although these would have been quite useful, especially on days of drift, the problem of sighting to an obscured object did not warrant their use.

9.6 ENVIRONMENT INFLUENCES

On this traverse, as in all polar regions, external influences on angle measurement were of a peculiar nature. Some of the important ones were :

9.6.1. SCINTILLATION

This generally occurred over cooling snow, as a characteristic of increasing temperature gradient and decreasing mass balance of the air. Experience gained on this traverse showed that it could occur at any time, but usually did so in the early to mid-evening. The direction and strength of the wind did not seem to affect its occurrence. The effect was quite frustrating as the image of the target appeared to move at random or break up completely.

9.6.2. ATMOSPHERIC REFRACTION AND MIRAGE

Abnormal inverse refraction occurred on four occasions on legs over the snow. This was determined by simultaneous reciprocal angle measurement and usually occurred around midday. About five or six hours after noon, the refraction showed a general tendency to increase positively and the maximum reading of the coefficient of terrestrial refraction was +0.501 whilst the minimum was -0.092. No trouble with the total refraction of the light beam was experienced.

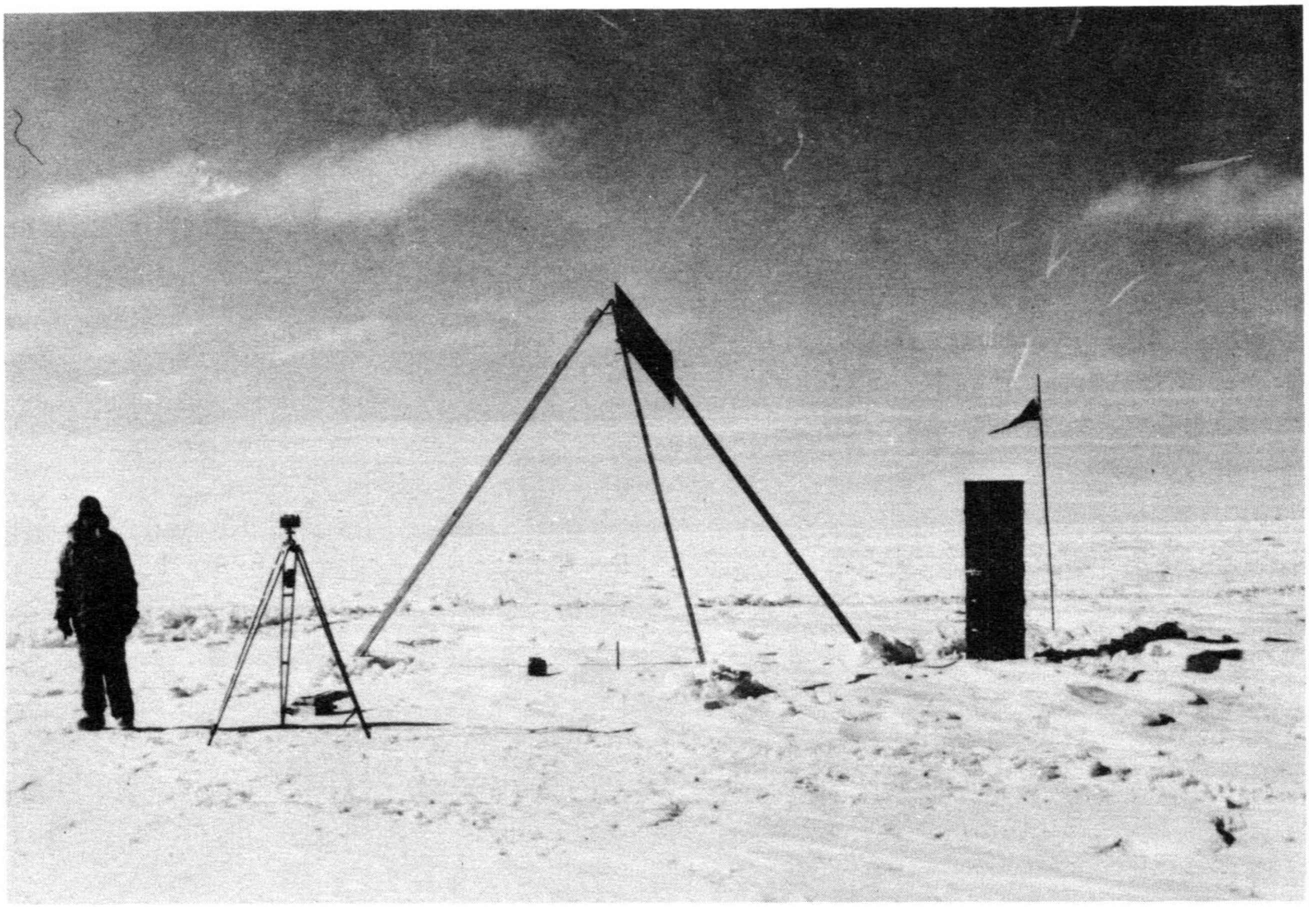
Doubts had been raised in the past regarding the reliability of vertical angles taken close to the snow surface. A test was made over a leg of about three miles where two simultaneous reciprocal angles were observed, the measurements being three weeks apart. Although inverse refraction existed in the first measurement and normal refraction was present in the second, the calculated height differences agreed to about an inch. On the basis of this it could be said that a reliable height determination can be obtained using vertical angles provided:

(a)The angles are observed simultaneously at each end.

(b)The lines are relatively short, preferably not longer than eight miles.

Another factor, although probably unimportant, could have been the fact that both stations were on similar terrain, e.g. the tops of broad snow ridges with broad valleys between.

Horizontal refraction was not apparent on the plateau, but when observing at Mt. Twintop to the first ice station 18 miles away, a movement of ten seconds was noticed between three sets, each of twelve readings, taken over an hour. A fourth set observed next day gave a value very close to the mean of the previous day’s work.



Portable beacon and drum beacon at station NM/S/95 *Photo by M. J. Corry*

Snow drifts around vehicles after blizzard *Photo by M. J. Corry*

9.6.3. TOPOGRAPHY

The region is undulating and consists of broad snow ridges and valleys; thus, the station locations were virtually determined by the terrain. On several of the snow ridges it was necessary to elevate the instruments, because the breadth of the ridge prevented good visibility from instruments set only five feet above the surface.

9.6.4. OBSERVER AND CHILL

As every member of the traverse party had spent the previous nine months at Mawson, the observers were acclimatised, but persistent winds of about twenty knots made observing unpleasant, and temporary frostbite, especially around the nose, was experienced on several occasions. Care had to be taken when using the theodolites, to avoid breathing on the instrument and causing fogging. Normal windproof mittens were worn with a woollen undermitten and silk instrument gloves. With practice it was possible to operate the instruments without loss of accuracy.

9.6.5. WEATHER IN GENERAL

The presence of much soft snow caused delays of several days, waiting for it to be either blown away or consolidated. At times the ground drift was light enough for easy travel, but too thick for survey operations, thus hindering progress. Elevating instruments and targets to a height of ten feet resulted in little improvement and heliographs and lamps could not be used because of sighting difficulties caused by the drift.

Whiteout conditions proved extremely favourable for angle observations to high contrast targets, but movement of vehicles was prevented in these conditions because of the safety factor. The semi-whiteout conditions gave nearly the same high contrast, but vehicles were able to move provided care was taken. The latter conditions were used to advantage on several occasions.

10. DISTANCE MEASUREMENT

10.1 TELLUROMETER PERFORMANCE

Generally, a trouble-free run was experienced with the Model MRA 3 Tellurometers, the only trouble being a faulty headset and dirty contacts on the main function switch. Spare headsets, a necessity for polar work, were carried and the dirty contacts were cleaned with carbon tetrachloride. Initially, trouble was experienced with the icing up of the headset mouth pieces caused by condensation. A small plastic bag stretched over the mouthpiece was an efficient means of preventing condensation and did not affect clarity of speech.

Whilst the cathode ray tube gave satisfactory representation of the received signal, the mechanical part of the measurements proved to be slow and rather unsatisfactory in the conditions. It is understood that the cathode ray tube assembly will be replaced by a dial type digital read out which should be more efficient and easier to operate.

10.2 POWER SUPPLY

Checks on battery current during the winter had indicated a rather high value. The normal battery leads were replaced by heavier duty leads of approximately three times the capacity. Sponge rubber lined carrying boxes were manufactured, as well as steel boxes which protected the headsets from damage. Provision was made to allow tapping of vehicle batteries in case the normal Tellurometer battery failed.

The heavier battery leads proved to be a decided advantage and no appreciable voltage drop was experienced, even when operating through a twelve foot lead from the Snow Trac. The internal nickel-cadmium batteries supplied for the Tellurometer were not used, as it had been found previously that these had a rather limited capacity in Antarctica.

Two 40 ampere hour lead-acid batteries were used. They were satisfactory, being sufficient for at least two full measurements before recharging. If required, the Snow Trac battery could be utilised as a spare for the centre party. Unfortunately, the Polaris did not use a battery and with its limited carrying capacity and the shortage of suitable batteries, a spare could not be carried by the forward party.

10.3 ANCILLARY EQUIPMENT

Thermometers having a range of -40°F to +60°F were fitted to the Lambrecht-Assman psychrometers in place of the conventional thermometers which had a lower limit of -10°F.

A special battery charger, which normally ran off a 240 volt AC supply and which was used for charging the internal nickel-cadmium batteries of the Tellurometer, was modified to permit it to be used in conjunction with a small generating set.

Initially the small T.A.S. generator model PG200, which had been used previously with success on the Kemp Land survey, was used for recharging, but due to its small output and fuel capacity only one battery at a time could be charged. The generator eventually broke down, then the welder carried by the tractor train was used for charging, and although uneconomical it was satisfactory for the remainder of the traverse.

Battery failure in the field occurred twice. On both times it was found that the failure was caused by an oversight in charging and not due to the battery itself. An oversight on the traverse was the failure to take a hydrometer and thus no reliable idea of the state of the batteries could be obtained.

10.4 OPERATION

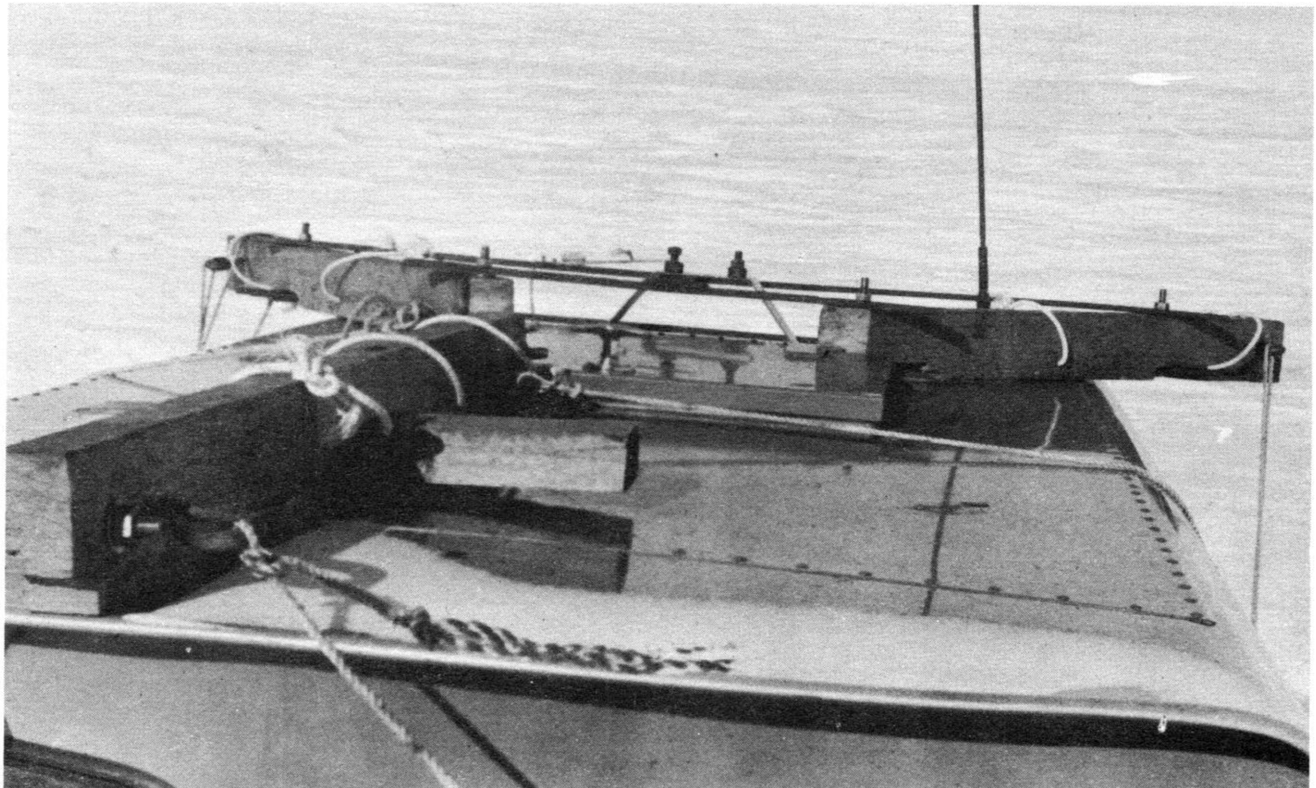
For most of the traverse the Tellurometers were operated with the tripod on snow, but on some occasions elevation of the instrument was necessary even though stations were intervisible at normal eye level. In these cases, the AGC reading (a measure of the incoming signal strength) would be only about five units with the instrument set up on the surface, but above thirty units when one of the instruments was elevated, thus giving the necessary signal strength required for measurement. The Tellurometer with the forward party could not be elevated except by means of a portable aluminium tower. Fortunately, the need to do this arose on only one occasion, with fairly satisfactory results.

Wild T2 theodolite tripods were used with the Tellurometers; with their longer legs they were better for the purpose than T3 tripods, (The normal Tellurometer tripods were not available for use on this traverse).

Due to the absorption of the indirect, ray, very little ground swing was experienced; usually the amplitude was under one millimicrosecond. A complete cycle of swing could not be developed, even utilising the full frequency range of the instrument. After the first few lines, the fine measurements were made on nine or ten cavities, situated approximately 20 Mc/s apart.

Sno-Trac and camp at Mount Twintop

Photo by M. J. Corry



Adjustable rack for holding tripods on vehicle roof.

Photo by M. J. Corry

10.5 MEASURING PROCEDURE

Because of the limited time factor, the usually constant atmospheric conditions during the two hours spent at each station and the limited capacity of the batteries, the following procedure was generally adopted :

(a)With the surveyor at, the master end and the assistant surveyor at the remote and on cavity setting 040, contact was made at a pre-arranged time or when the remote instrument was visually observed through the theodolite set up at the master end (see section 5).

(b)After the initial contact, such preliminaries as direction tuning was done. The remote end then moved down to the lowest cavity used for fine readings and contact was re-established.

(c)The instruments were allowed to warm up while the atmospherics were read. (Almost ten minutes was required for the oven lamp to start cycling).

(d)When the atmospherics readings were completed and the oven lamp had started cycling, a set of coarse readings was taken by the surveyor and checked for ambiguities.

(e)A set of fine readings was then taken by the surveyor.

(f)Another set of coarse readings was taken by the surveyor and checked for consistency with the previous results.

(g)Atmospherics were again read before the two instruments interchanged functions, i.e., the hitherto remote end became the master station.

(h)Contact was re-established and a set of coarse readings was taken by the assistant surveyor. The readings were transmitted to the surveyor (via the Tellurometer speech link) who checked them fcr ambiguities and consistency with the previous readings.

(i)A set of fine readings was taken by the assistant surveyor.

(j)A final set of atmospherics was read.

The above procedure saved time and conserved batteries. It also allowed the surveyor to exercise the maximum control over the operation and the assistant surveyor did not have to worry about technicalities such as checking for ambiguities. If the battery failed halfway through the readings, as happened in one instance, then all readings to this stage had been taken by the surveyor and thus probably had more reliability than if the operation had been conducted otherwise.

10.6 ATMOSPHERICS

10.6.1 TEMPERATURES

A Lambrecht-Assman psychrometer was used to obtain the dry bulb temperatures only. Instead of using the wet-bulb temperature to determine the humidity factor, a hydrograph was used. This was located in a meteorological screen on the roof of a living caravan which was always in the vicinity of the survey operations. The weather observer periodically checked this hydrograph with a psychrometer. Generally this proved to be a very satisfactory arrangement, there being no need to worry about freezing of the water used in wet-bulb determinations.

10.6.2 ATMOSPHERIC PRESSURE

Banks of three ex-aircraft altimeters, each being read to the nearest five feet, were used. These altimeters proved to be suspect as one bank showed a hundred feet difference between two altimeters, but unfortunately no reliable means of checking these altimeters was available.

11. GEODETIC BACKGROUND

11.1 ORIGIN

Both terminal points of this traverse were on rock and azimuth is held in the south using Peak 7 of the Stinear Nunataks for future extension.

Mt Twintop was connected previously to the origin, Bechervaise Island near Mawson. It is anticipated that a more accurate determination of the geographical position of Bechervaise I. station will be made in the near future using the Ney method currently being used in Antarctica by the United States Geological Survey.

11.2 ICE MOVEMENT

From observations taken in the past near Mawson, a movement of the ice sheet of approximately an inch a day is suggested for the region of the traverse. Because of this movement the positions of all traverse stations, as well as the measured distances and angles, are dependent on time. Hence all observations must be reduced to a reference time but in the absence of exact movement details it will be assumed, for the time being, that ice movement is negligible.

11.3 CONTROL AND CHECKS

In the future, when this traverse is re-run, it will be possible to determine the actual movement of each station over the period between the two traverses, and thus correct all observations for ice movement.

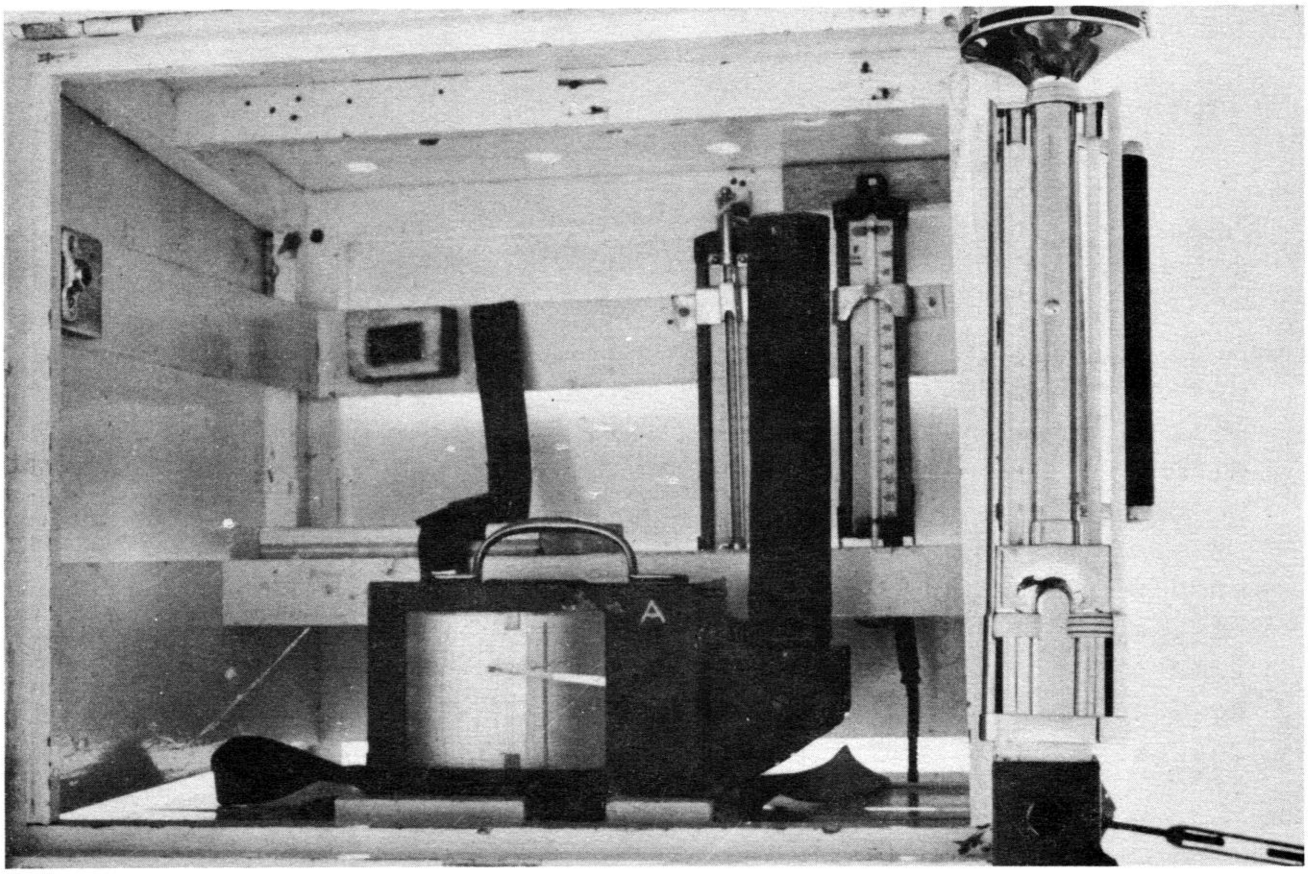
With the exception of one leg, Tellurometer distances were measured independently both ways and so a check was afforded on distance measurement. The repetition method described in section 7.2 afforded the check on angle measurement.

It was hoped to obtain extra control by taking an accurate astronomical fix at Depot Peak, but weather conditions prevented this work from being done. However when the southern extension of this traverse is carried out it should be possible to obtain this fix. Meanwhile an approximate position of Depot Peak is provided by a solar fix made in 1954 and this gave a check on gross error.

11.4 HEIGHTING

An interesting comparison has been made between the trigonometrical heights obtained on this traverse and those obtained by barometric methods along previous traverses. Barometric heights recorded during a 1954 traverse from Mawson direct to Depot Peak were found to be some 30 metres too high, whereas those recorded by a 1962 barometric traverse, along substantially the same route as that taken by the 1965 Tellurometer traverse, were found, by direct comparison, to be of the order of 50 meters lower than the trigonometrical heights. Comparison with other surface barometric heighting and aircraft radar altimeter heighting showed that the results obtained by the 1965 traverse probably represented a value very close to the mean of all observations taken in this region

Surveyor operating Tellurometer MRA 3 Mark 11 *Photo by M. A. Poulton*



Hydrograph and Lambrecht-Assman psychrometer *Photo by M. A. Poulton*

12. COMPUTATIONS

12.l TELLUROMETER DATA

All transmission times, dry bulb air temperatures, relative humidity, atmospheric pressure and instrument heights were taken directly from the field notes. The results of the corresponding simultaneous vertical angles with theodolite and target heights were also required.

12.2 REDUCTION FORMULAE FOR DISTANCE MEASUREMENTS

The basic formulae of

$$S = \frac{C_0\, t}{2n}$$

requires a knowledge of the refractive index(n) as well as the velocity of propagation of electro magnetic waves in vacuum (Co = 299,792.5 Km/s) and the transmission time (t) in order to determine the distance between the two instruments (S).

The refractive index is mainly a function of barometric pressure, air humidity and air temperature.

The formulae used for the calculation of "n" were :

$$(n - 1) = \frac{4730\ (P + E)}{459.7 + t}\ x\ 10^{-6}$$

$$E = \frac{8540\ e}{459.7 + t}$$

$$e = e'.0.000367P\ (t\text{-}t')\ (1+\frac{t'\text{-}32}{1571})$$

where t = Dry bulb temperature °F
t' = Wet bulb temperature °F
P = Barometric pressure in metres of Mercury
e = Vapour pressure
e' = Saturation Vapour pressure at t'

The corresponding depression (t-t') for each relative humidity was obtained from the Canadian Meteorological Branch Psychrometer Tables which are normally used to obtain the relative humidity from values of dry bulb temperature, wet bulb temperature and air pressure.

The Goff-Gratch formula for the saturation vapour pressure of ice, as tabulated in Smithsonian Meteorological Tables, was used.

The adopted procedure was to calculate separately the vapour pressure appertaining to each meteorological observation. The means of the temperature, vapour pressure and of all barometric pressures of the meteorological observations, taken before and after Tellurometer measurement (at both ends of the line), were then used in the given formulae for refractive index for the distance measurement under consideration.

A special programme enabled most of the calculation to be done by a Ferranti Sirius Computer. The input data required comprised transmission time, the corresponding dry bulb temperature, vapour pressure, atmospheric pressure, instrument heights and details of connections between eccentric marks and the station marks. An approximate latitude and azimuth of the line in question is required in order to obtain the sea level distance. If the height of the initial station is known accurately it is included in the data together with details of the corresponding simultaneous reciprocal vertical angle observations and the associated instrument and target heights. The output will give, in addition to the sea level distance between the station marks, the difference in height between the terminal points of each line, also the height of each station and the coefficient of vertical terrestrial refraction during the time the vertical angles were measured.

12.3 HORIZONTAL ANGLES

The only reductions required were in the few cases that eccentric stations were used. The eccentric corrections were computed by hand and checked, so that all horizontal angles were reduced to those appertaining at the station marks.

12.4 CO-ORDINATES

For the present the traverse is considered to be rigid, although this assumption is known to be incorrect on account of ice movement. (See section 11).

The geographical positions on the International Spheroid were calculated using Clarke's formula for medium lines. A programme for a C.D.C. 3600 computer had previously been written and required the usual input (latitude and longitude of initial station, azimuth to reference object, horizontal angle at each station, sea level distance between successive stations and details of the spheroid upon which the calculations are to be made). The output lists the following: Station number and name, angle at each station, latitude and longitude, difference between azimuth to next station and reverse azimuth, azimuth to next station, reverse azimuth from next station and sea level distance to next station.

CONCLUSIONS

The results of this traverse have showed that it is possible to run survey traverses over the ice sheet using ground transport only. However, when these traverses are extended into the mountain areas helicopters are virtually essential. Some logistics need to be improved; a vehicle faster than a D4 tractor and more reliable than the Snow Tracs is required, as well as more efficient radios equipment.

One indeed must thank the whole team on this traverse, especially those who were called on to carry out unfamiliar tasks. Gratitude is extended to the team who greatly assisted the traverse by laying fuel depots, and the remainder of the Mawson wintering party, who cheerfully shouldered the extra responsibilities and station tasks during the absence of the traverse party. Mention must also be made of the benefit derived from the experiences of previous wintering parties and the assistance of the Division of National Mapping, Department of National Development, and the Antarctic Division of the Department of External Affairs.

14. REFERENCES

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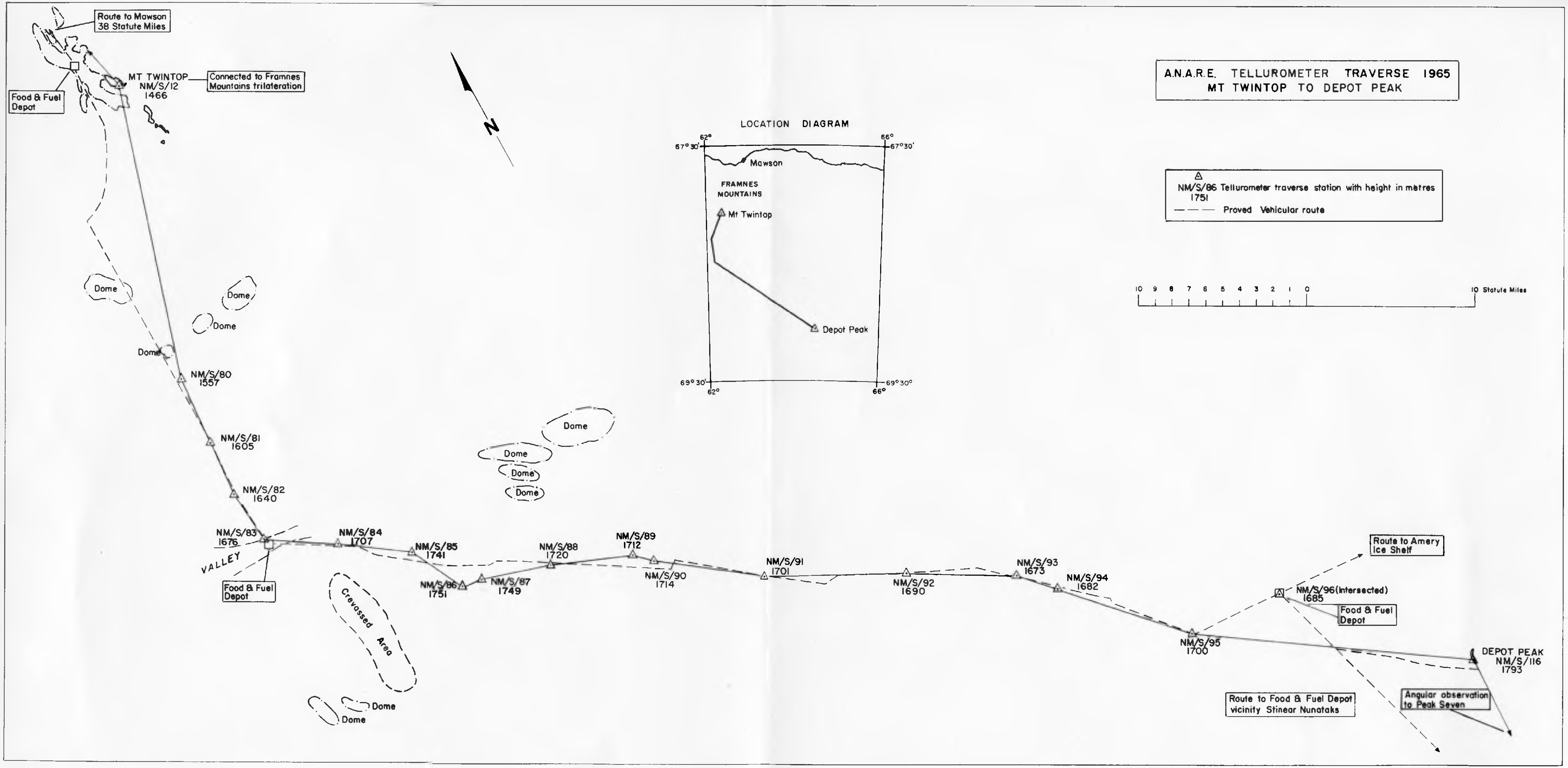
Photographs by M.A. Poulton and M.J. Corry.


A.N.A.R.E. TELLUROMETER TRAVERSE 1965
MT TWINTOP TO DEPOT PEAK
LOCATION DIAGRAM
62°
66°
67°30'
69°30'
Mawson
FRAMNES MOUNTAINS
Mt Twintop
Depot Peak
NM/S/86 Tellurometer traverse station with height in metres
1751
Proved Vehicular route
10 9 8 7 6 5 4 3 2 1 0
10 Statute Miles
N
Route to Mawson
38 Statute Miles
Food & Fuel Depot
MT TWINTOP
NM/S/12
1466
Connected to Framnes Mountains trilateration
Dome
Dome
Dome
Dome
NM/S/80
1557
NM/S/81
1605
NM/S/82
1640
NM/S/83
1676
VALLEY
Food & Fuel Depot
NM/S/84
1707
NM/S/85
1741
NM/S/86
1751
NM/S/87
1749
NM/S/88
1720
NM/S/89
1712
NM/S/90
1714
NM/S/91
1701
NM/S/92
1690
NM/S/93
1673
NM/S/94
1682
NM/S/95
1700
NM/S/96 (Intersected)
1685
Food & Fuel Depot
Route to Amery Ice Shelf
DEPOT PEAK
NM/S/116
1793
Route to Food & Fuel Depot vicinity Stinear Nunataks
Angular observation to Peak Seven
Dome
Dome
Dome
Dome
Crevassed Area
Dome
Dome