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TWO METHODS OF GRAVITY TRAVERSING WITH HELICOPTERS

by

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SUMMARY

The Line and Cell methods of gravity traversing with helicopters are described and compared. Flight plans using the Line method are shown for two four-mile areas; flight plans using the Cell method are shown for one of these four-mile areas.

The comparison of the methods suggests that, although it may involve slightly longer total flight time to cover a four-mile area, the Cell method offers substantial advantages over the Line method.

1. INTRODUCTION

In the past, the Bureau of Mineral Resources has used the Line method of gravity traversing with helicopters. It has been proposed that the Line method be replaced by the Cell method. This Record describes and compares these two methods of gravity traversing with helicopters.

2. FLIGHT PLANNING

The basic survey grid should be placed on a map showing the centres of the aerial photographs. At present the Bureau of Mineral Resources uses a seven-mile square grid. This grid spacing was chosen because one station per 50 square miles was considered the most economic density for a regional gravity coverage of Australia that could be completed within a reasonable time. A gravity survey with such a spacing would be expected to detect any anomaly with gravity relief exceeding 5 mgal and with length greater than 10 miles, although additional stations may be necessary to define the anomaly clearly.

In planning a flight the following times are assumed:

Landing of helicopter	1	minute
Take-off of helicopter	1	"
Flying time per mile between stations	1	"
Readings taken by geophysicist	6	"
Lunch (long flight only)	30	"
Refuelling (long flight only)	30	"

The main points to remember when planning a flight are:

(a) Maximum use must be made of the helicopter.

(b) Whenever the helicopter is in the air it should be traversing.

(c) The geophysical observer should not be traversing for long periods, as his efficiency towards the end may diminish very rapidly.

(d) Flights long enough to require refuelling and lunch time have an unproductive hour added to them.

(e) Because of (a), (c), and (d) above, it has been found that the best type of flight arrangement consists of two traverses, each of 5 to 5½ hours duration, in a day.

(f) It is best to plan in advance for a number of flights that have a range of elapsed times.

There should be at least one accurately levelled survey station in each traverse to enable reasonable accuracy in determining altitudes, also each traverse should be tied-in to adjacent traverses on each side (Plate 1).

If possible, all flight planning should be completed before the party moves into the field. The flight planning should never be less than a week in advance of the flight; this is the minimum period needed by the draughtsmen to prepare photographs and to check the flight plan properly.

3. METHOD OF FLYING

Two methods of flying traverses have been considered; viz. the Line method and the Cell method (Plate 1), both of which are described below.

Line method. Traverse lines should be run east-west to avoid unnecessary resetting of the gravity meter, and should contain loops of no more than seven intervals each. (See Fig. 1). To facilitate the planning of shorter flights, the operating base camps should be placed as near as possible to the central longitude of the area to be flown. From any one base camp, flights should be planned having a wide range of elapsed times, e.g. from $3\frac{1}{2}$ to 6 hours. When using this arrangement, if the helicopter is unserviceable for part of a day, suitable flights can be chosen to best utilise the remainder of the day.

Plates 2, 3, and 4 are examples of flight-planning maps. The Brighton Downs four-mile area (Plate 2) was flown by one helicopter; the Mackunda four-mile area (Plates 3 and 4) has been planned for two-helicopter operations, but has not yet been flown.

Brighton Downs four-mile area. The following table shows elapsed and flying times for this area which was flown in 1961. See also Plate 2.

Flight No.	Elapsed Time		Flying Time		Comments
	hr	min	hr	min	
141	10	00	6	00	Ex Davenport Downs
142	10	00	6	00	Ex Davenport Downs
144	6	54	3	42	Transit flight from Davenport Downs to Brighton Downs
145	7	24	3	56	Flight from Brighton Downs to Maneroo H.S. and return to Brighton Downs.
146	8	30	4	36	As above
147	8	54	4	54	Ex Brighton Downs
148	7	12	4	00	Ex Brighton Downs
	4	36	3	12	

Flights 141 and 142 are examples of the type of flight which should be avoided if possible, for the following reasons:

(a) One hour of the elapsed time is unproductive.

(b) Toward the end of a long flight the geophysicist will become tired; therefore he will more likely to make mistakes and his efficiency will decrease.

(c) Flight 141 was not tied-in to Flight 142 because there was insufficient time to complete the area properly.

These flights would have been more effective if the base from which they were flown had been nearer the 141° 45' meridian.

Flights 145 and 147 were tied-in together but at the edge, not in the centre, of the area covered by the flights. The tie-in between Flights 145 and 147 would have been more effective if it had been made between the centre loops which are only loosely controlled.

Flight 144 is an example of a transit flight being planned as a productive (although slightly too long) flight.

Mackunda four-mile area. The following table shows elapsed and flying times as planned to conform with the flight plan on Plate 3.

Flight No.	Elapsed Time		Flying Time		Comments
	hr	min	hr	min	
149	3	50	2	20	Ex Old Cork
150	4	18	2	42	Ex Old Cork
151	4	38	2	56	Ex Old Cork
152	5	18	3	18	Ex Old Cork
153	6	50	3	44	Ex Old Cork
154	6	10	3	46	Ex Old Cork
155	3	22	2	04	Ex Middleton
156	7	52	4	18	Ex Middleton
157	4	58	3	10	Ex Middleton
158	4	50	3	14	Ex Middleton, transit to Kynuna.
173	1	52	1	20	Ex Old Cork, transit to Middleton.
174	1	16	1	02	Ex Old Cork, transit to Middleton.

These flights were well planned, although 153 and 156 were slightly too long. As with the Brighton Downs area, there was a tendency to place ties at the edge of the four-mile area instead of at the middle of the traverse. However, this was overcome in most cases by the traverse Flights 173 and 174 which acted as tie-flights; Flight 152 was only flight not adequately tied-in to the others.

It will be noted that the Mackunda four-mile area (Plate 3), was planned for two-helicopter work (hence the two traverse flights between Old Cork and Middleton), whereas the Brighton Downs four-mile area was planned for one-helicopter operation. However, the gravity survey of the four-mile area Mackunda had to be changed to one-helicopter operation part way through, after one helicopter became permanently unserviceable. The work in the Brighton Downs area was also affected by this breakdown, viz. one traverse had to be cut out, and Flight 148 had to be replanned to end at the top of the four-mile area. It must be emphasised that the alterations necessary were only slight in spite of the major change in operations, and the time involved in flight-planning the area early in the survey was not wasted.

Cell method. The idealised layout for the Cell method is illustrated in Figure 3 of Plate 1, which shows a four-mile area divided into six cells, each a half-degree (35 miles) square. The position of the main base will depend upon the configuration of the group of four-mile areas to be covered. Fly-camps are situated at the centres of adjacent blocks of four cells.

Each cell is covered by four loops from the sub-base at its centre. The elapsed time for each loop being approximately two hours, the 35-mile square can be covered in one day's flying. The loop that includes the fly-camp will be flown either second or third to enable the helicopter to be refuelled at the fly-camp.

In two-helicopter operations the helicopters should operate in adjoining cells, both for safety and to enable a continuous block of area to be completed for computations and thus permit quick follow-ups if necessary.

An example of how this method could be applied in practice to the Mackunda four-mile area is included (Plate 4). The difference in flying times between the Line and Cell methods is small (32 hr 02 min for the Line method and 34 hr 58 min for the Cell method), even though the positions of the camps and the station layout were chosen to suit the Line method, and were not those that would have been best for the Cell method.

Because the four loops in a cell close on the same point, it is not necessary to fly them all at the same time; thus, to make use of any available time, flights with elapsed times of 2, 4, 6, and 8 hours are possible. Another advantage of the Cell method would be seen if a traverse were interrupted. With the Cell method, the loops completed prior to the interruption would not have to be re-flown.

4. COMPARISON OF THE LINE AND CELL METHODS OF TRAVERSING

Accuracy of altitudes

The low accuracy of barometric heights has caused some concern in the previous helicopter gravity surveys, the estimated standard deviation being roughly 20 ft. This figure is made up of errors due to poor diurnal control and to poor barometer performance.

In the Line traverse method, the diurnal curve is measured at the base camp, and is assumed to be correct for the whole traverse, which commonly extends up to 100 miles distant. This assumption would rarely be true. With the Cell traverse method, using two helicopters in adjacent cells, it will be possible to set up a triangulation system with barometers at the fly-camp and at each cell-centre. An examination of these three diurnal curves would enable the passage of pressure fronts and the attitude of isobaric planes to be noted and to some extent allowed for.

Erratic barometer behaviour will be more easily detectable with the Cell method, owing to the repeat readings at the same station (Cell-centre). Some of the Askania microbarometers that are in use suffer a type of air-travel fatigue but it is hoped that this will not apply to some new instruments ('Mechanisms') currently being tried out.

With the Cell method of flying and using Mechanism instruments and satisfactory Askania instruments, it is felt that accuracies of 5 ft in altitude differences less than 500 ft are possible.

<u>Accuracy of observed gravity</u>

An estimate of the gravity-meter drift is obtained by comparing repeated readings at certain stations. Using the Line traverse method, the first repeat within the traverse is made with an interval of one and a half hours between readings; subsequent repeats are made at intervals of 1 hour 45 minutes between readings. When the Cell method is used, a repeat is obtained every one and a half hours, at the same place (the cell-centre), and a triple repeat is obtained at the fly-camp, thus giving much better control for the construction of a drift curve.

<u>Anomalous results</u>

The results of an individual Line traverse are very hard to analyse as they give a profile rather than areal coverage, and therefore trends and anomalous results are difficult to assess. With the Cell method a first assessment is somewhat easier, as any gravity station within the area has enough other stations around it to enable a geophysicist to assess whether a high or low gravity value is an interesting anomaly or possibly a misreading. If a follow-up flight is desirable, it can often be planned for and done on the next day, thus reducing the number of long transit flights and the re-sorting of photographs that often have to be done with the Line traverse method.

<u>Interrupted traverses</u>

Sometimes a traverse has to be interrupted for one of several reasons including helicopter breakdowns, instrument faults, navigation errors, and adverse weather conditions. When this happens on a Line traverse it may be necessary to reject all observations made, because of lack of drift control and ties-ins. This may commonly involve a loss of up to two hours' flying time; it may possibly be as much as three and a half hours. However, with the Cell method the lost time would usually be less than one hour, with a maximum of one and three quarter hours.

Radio control

Using the Line traverse method, radio control between helicopter and base is quite commonly a problem as it has to be maintained over distances of up to 100 miles, and for half the traverse time, of over 50 miles. Using the Cell method, the maximum distance of the helicopter from the base radio would be 40 miles in the case of a fly-camp base or 20 miles for a cell-centre base; thus there will be more reliable communications with the Cell method.

Safety

If the observer in a helicopter is unable to locate a proposed station whilst on a Line traverse, the helicopter may have to return to the main base, thereby usually wasting all the flying time already done on that traverse. On a Cell traverse, the observer is less likely to lose his way, because his photographs cover an area (the cell), rather than a thin strip as in the case of the Line traverse. However, if the observer does 'lose his way' then the operator at the cell-centre base can be informed by radio to send up a smoke signal or flare that will be readily visible for forty miles. Thus the helicopter can return to the base with a maximum loss of about two hours flying time, and with a chance of completing the rest of the work in the day.

With two helicopters working in adjacent cells, one could always be called off traverse for rescue operations in the event of a failure of the other helicopter; such an operation would be quicker and cheaper than on Line traverses, where it is much harder, and often impossible, to have two helicopters in reasonably close to each other.

Flying conditions

All flying personnel have found helicopter traversing to be extremely strenuous, and their efficiency and awareness deteriorate rapidly on flights involving an elapsed time greater than 5 to 5½ hours. Using the Cell method and two observers per helicopter, each observer need only fly two loops, and then act as the cell-centre base operator for the other two loops, thus giving a maximum elapsed time of about four hours per observer. Even if one observer had to fly all four loops in the day, the cell-centre would provide the most suitable stop-over for lunch, and the extra assistance available for refuelling would allow more time for the observer to relax and recover efficiency. Using the Line method, it is usually impossible to restrict all flights to less than 5 to 5½ hours elapsed time, and long flights will always be necessary.

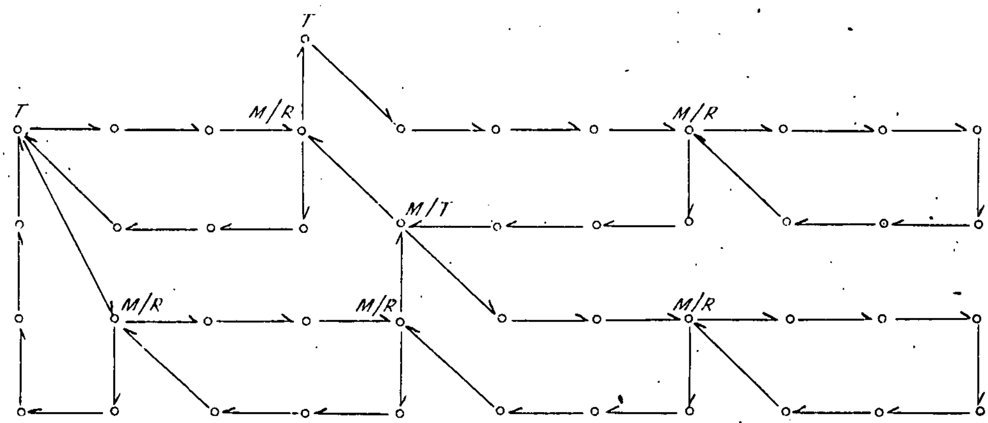
5. CONCLUSIONS

The Cell method of gravity traversing with helicopters appears to offer substantial advantages over the Line method from all aspects, with the exception that the total flight time involved to cover a four-mile area is slightly longer. However, considering the extra length of 'follow-up flights' when using the Line method, the Cell method could be expected in practice to take about the same time to complete a four-mile area.

PLATE I.

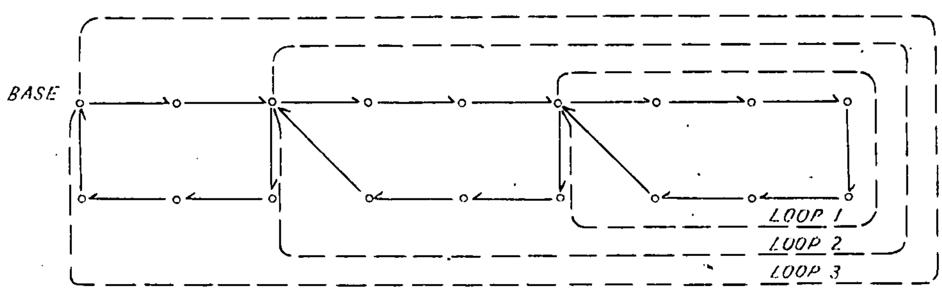
LINE TRAVERSE METHOD

FIG. 1



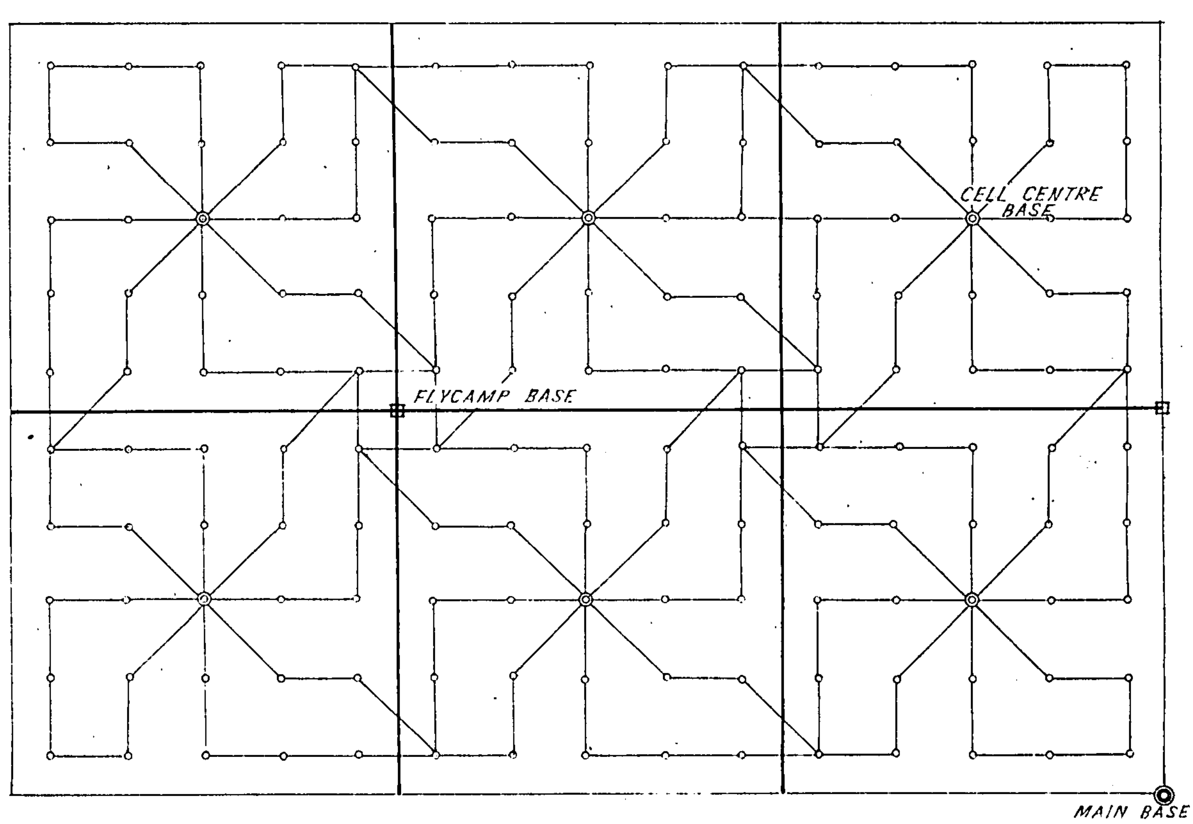
LINE TRAVERSE CONTROL

FIG. 2



CELL TRAVERSE METHOD (4-mile map area divided into six cells)

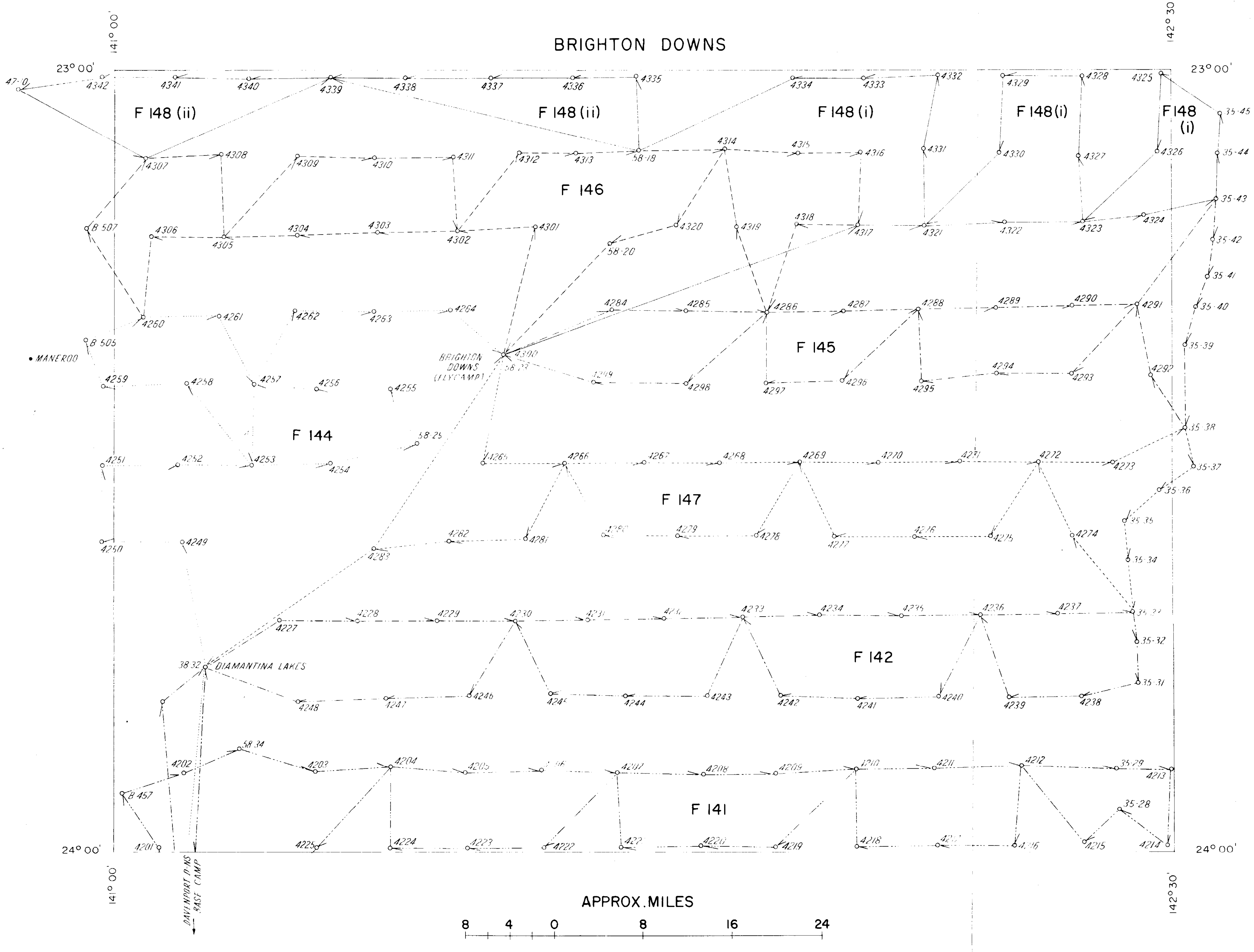
FIG. 3



CELL AND LINE METHODS, GRAVITY TRAVERSING

Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics G65-34

To accompany Record 1962/134



LINE METHOD FLIGHT PLAN

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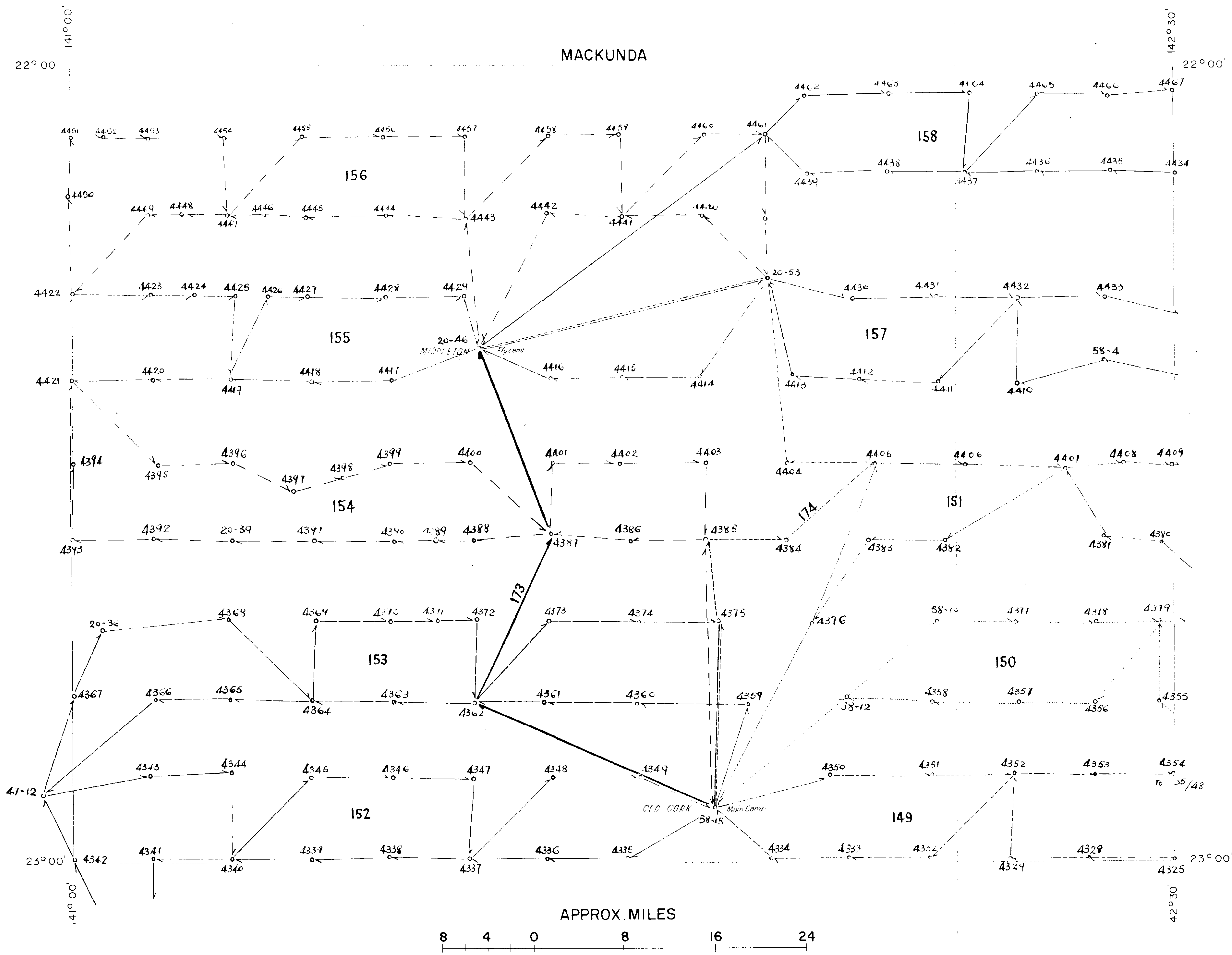
PLATE 3.

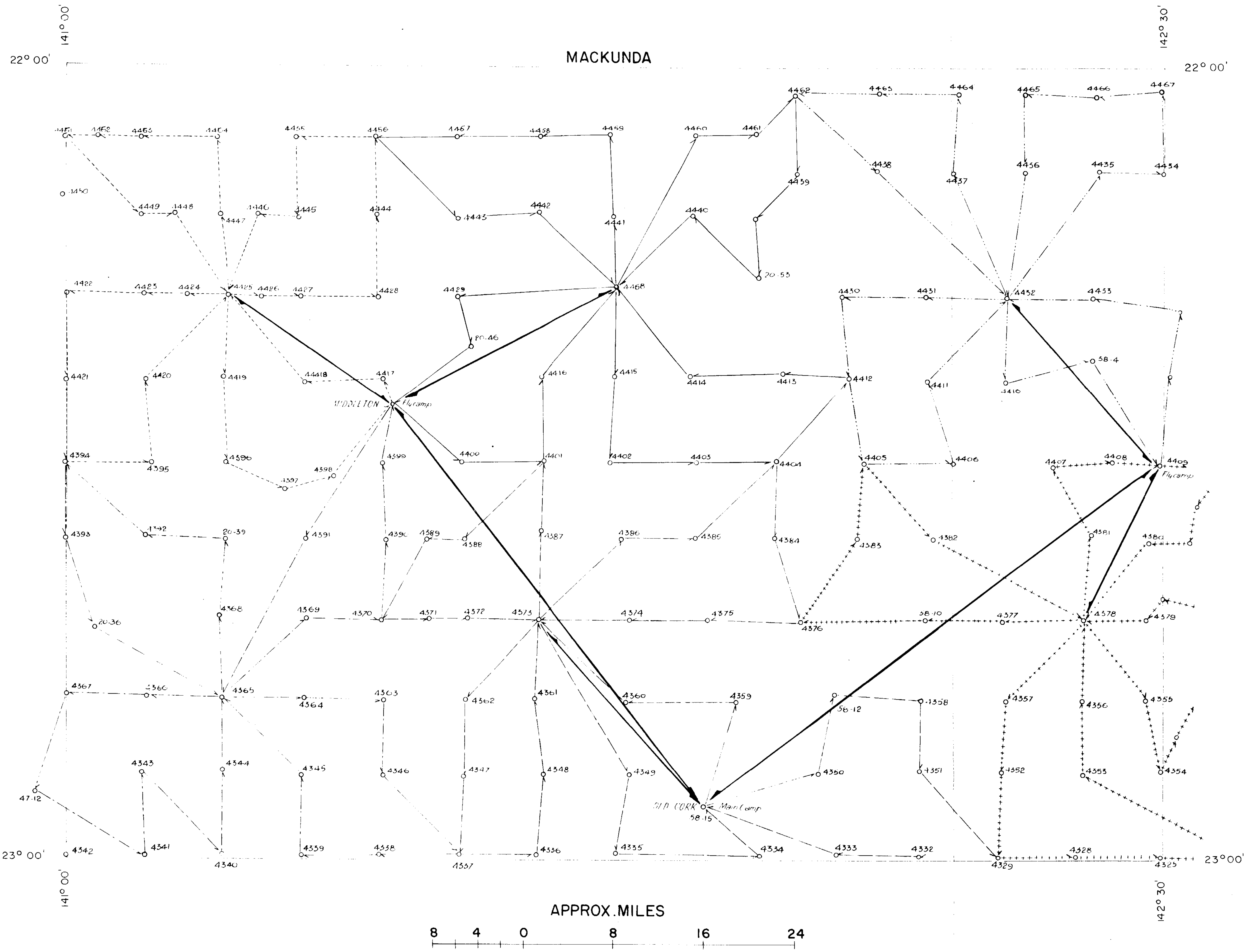


LINE METHOD FLIGHT PLAN

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 65-38

To accompany Record No 1962/134

PLATE 4.



CELL METHOD FLIGHT PLAN