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Record No. 1970 / 22

Preliminary Tests of the EM 16 Prospecting Equipment at Captains Flat,

New South Wales 1968

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ILLUSTRATIONS

SUMMARY

Preliminary tests of the Ronka EM16 prospecting equipment were conducted in the Captains Flat area, NSW, using the transmission from the v.l.f. radio station on North West Cape, Western Australia. The area was found to be generally unsuitable for testing the equipment because the strike of the country is approximately parallel to the direction of the primary field.

Some agreement was noted between the v.l.f. anomalies and the results of previous electromagnetic (Turam) surveys but, in general, the v.l.f. anomalies showed little resemblance to the normal type of anomaly expected from a sub-surface conducting body, and could not be interpreted satisfactorily. Surface conductors such as swamps appeared to have a marked effect on the v.l.f. profiles. The results were inconclusive with regard to the possible depth penetration of the method.

1. INTRODUCTION

The v.l.f. radio station NWC on North West Cape is part of a worldwide network of communications stations established by the United States Navy. The very low frequency (v.l.f.) of operation (22.3 kHz) allows the radio signals to penetrate the ocean depths for communication with submerged submarines.

In October and November 1968, a three-week survey was carried out in the Captains Flat area to evaluate the Ronka EM16 prospecting equipment, which utilises the electromagnetic fields radiated by the v.l.f. radio stations. Many such stations exist, but the EM16 is only sufficiently sensitive to receive the North West Cape station for reliable survey work. In south-east Australia the signal is very strong, and it seems likely that this would be so over the entire continent.

In the Captains Flat area, known electromagnetic anomalies delineated by Sedmik (1965) were investigated, as well as the area around the abandoned Lake George Mine. Several areas were also suggested by the Electrolytic Zinc Company whose co-operation and assistance are gratefully acknowledged.

In the Bollard area the grid laid down by Sedmik (1965) was located, and the stations were re-occupied. In all other areas the grid laid down by the Electrolytic Zinc Company was used. A plan of traverses surveyed with the Ronka EM16 is shown in Plate 1.

2. EQUIPMENT

General description

The EM16 prospecting equipment is basically a radio receiver for detecting the electromagnetic fields radiated by the v.l.f. radio stations. The frequency of operation of these stations lies in the range 15-25 kHz. The equipment is tuned to the appropriate frequency by means of a plug-in unit. Two plug-in units are accommodated, and a switch to select either one allows consecutive readings to be taken using two different stations.

The equipment is light (1.1 kg), and simple to operate. A normal reading under good conditions is taken in about 15 seconds, so that surveying speed is high. Battery life is claimed by the manufacturers at about 200 hours. The instrument has no warm-up period and may be switched off between readings, so that very long battery life may be expected.

Two readings are obtained, one from an inclinometer (the in-phase reading), and one from a potentiometer dial (the quadrature reading).

Principles of operation

The signal produced by the radio station is vertically polarised (i.e. the electric vector is vertical and the magnetic vector is horizontal and concentric round the station). Under normal conditions of propagation over a uniform earth, no vertical magnetic field will be detected.

In the discussion which follows, reference to a coil will imply reference to the axis of that coil.

Consider the resultant of the uniform horizontal electromagnetic field, and the secondary field due to a buried conductor. At any point the secondary field will usually be out of phase with, and inclined to, the primary field. The resultant will be a rotating vector, which describes an ellipse of polarisation in the plane of the primary and secondary fields.

In the special case where the azimuth of the secondary field is the same as that of the primary, then the ellipse will be in the vertical plane. A detecting coil oriented perpendicular to the ellipse will observe no signal. A coil along the major axis will detect a maximum signal and one along the minor axis will detect a minimum, which will be zero only if the secondary field is in phase with the primary. Note that the maximum signal will not be in phase with the primary signal unless the secondary phase lag is zero, or the secondary field is 90° out-of-phase with and perpendicular to the primary field.

In the more usual case where the primary and secondary fields have different azimuths, the plane of the ellipse will be inclined. Consider the ellipse generated by the projection of the inclined ellipse onto the vertical plane through the major axis. In the following discussion this will be the ellipse referred to.

The EM16 contains two mutually perpendicular coils in the form of an inverted T. When held in normal operating position, one coil (the "reference" coil) is horizontal and the other (the "signal" coil) is vertical.

The signal coil is series tuned and the reference coil is shunt tuned to the desired frequency. This introduces 90° phase difference between the two signals. The output from the signal coil is amplified and mixed with a local oscillator signal to give a fixed beat frequency of about 1500 Hz which is detected with earphones. The output from the reference coil is controlled by the quadrature potentiometer.

In operation, the azimuth of the field is first obtained by turning the signal coil to the horizontal and rotating in the horizontal plane. When the coil is perpendicular to the field, the signal in the earphones is minimum.

The instrument is then oriented such that the reference coil is horizontal and in the azimuth of the field. The quadrature potentiometer is set at zero and no reference signal is detected. The signal in the earphones is minimised by tilting the signal coil (keeping the reference coil in the plane containing the field azimuth) and the inclination of the major axis of the ellipse of plarisation may be read from the inclinometer attached to the case.

The signal in the earphones will not normally be zero and the quadrature potentiometer is adjusted to give zero signal. The potentiometer is calibrated as the percentage of the total reference signal required to null the residual pickup in the signal coil. This gives the ratio between the minor and major axes of the ellipse of polarisation.

The tangent of the angle of inclination (multiplied by 100), and the ratio of minor to major axes are equated by the manufacturers to the vertical in-phase and out-of-phase field respectively. In the EM16 instruction manual it is not explicitly stated what the phase reference is, but the implication is that it is the primary field. This is not so. Consider the space vector diagram (Fig. 1) at the instant when the rotating vector is along the major axis of the ellipse. The vector M may be resolved into two vectors I_H (horizontal) and I_V (vertical) each in phase with M, and

$$\tan \theta = I_V/I_H$$

Now I_H will be in phase with M but not with either the primary or secondary fields. I_V is that portion of the vertical component of the secondary field which is in phase with M.

By similar reasoning Q_V is the vertical component of the secondary field 90° out of phase with the resultant M.

Now from Figure 1

$$N/Q_V = M/I_H$$

$$\therefore \quad Q_V = N . I_H/M$$

Thus the parameters determined by the EM16 are the components of the vertical field in phase and 90° out of phase with the total resultant field, expressed as percentages of the total field.

3. DISCUSSION OF RESULTS

Although many miles of traverses were read, and many anomalous readings were obtained, the results are not amenable to direct interpretation at this stage. The main problem is that the strike of the country is near-parallel to the field direction; with present experience, interpretation of this type of result is difficult. Interpretation of the results from the Captains Flat area may be possible when experience has been gained in other areas. Only one anomaly of the expected form (see Fig. 2) was obtained and this is in the Bollard area (Plate 5). Here the conductor strikes about 310° and the in-phase component gives the expected cross-over, at about 700E. The position of the cross-over agrees well with that of the Turam anomaly obtained by Sedmik (1965). The anomaly is due to outcropping black slate. The quadrature component shows a cross-over at about 600E.

In the Gourlay-Hickey area, Traverse 100,000N coincides roughly with Traverse 12,200S of Sedmik (op. cit.) and the Turam profiles are shown for comparison with the EM16 results (Plate2). The well defined Turam anomaly at 98,420E is due to a north-striking conductor and has not been detected by the v.l.f. equipment.

The EM16 anomaly between 98,900E and 99,500E, although not of the normally expected form, corresponds roughly with a very weak Turam anomaly. The form of the anomaly is perhaps caused by the large difference between traverse and field azimuths.

The gravity anomaly reported in this area by Sedmik (op. cit., Plate 17) occurs at 98,870E-98,970E. This is to the west of the EM16 anomaly, but in plan, the two anomalies are of roughly similar shape and may be caused by the same body.

The strong anomaly detected by both the Turam and EM16 methods near 100,000E is associated with a fence and telephone line. The Turam anomaly is probably associated with the fence and/or telephone line but the EM16 anomaly is alomost certainly caused by the telephone line alone, because in other areas, N-S trending fences have had little effect on the EM16 readings.

In the Golf Course area two traverses were read in the N-S direction (parallel to the strike). Part of these traverses is shown in Plate 3. Perhaps the most interesting feature is at 97,200N where an E-W fence cuts the traverse and a large narrow anomaly is obtained. However there is also a much broader anomaly which is indicated by the general displacement of the profiles on either side of the fence. To determine whether such an effect could be produced solely by the fence, a traverse was read across a fence in a area towards Bungendore (Plate 6). The results show that the effect of the fence is noticeable only out to a distance of about 400 ft (120 m) and there is no general displacement of the profiles. It is therefore considered that the much broader anomaly at 97,200N is not attributable to the fence and is probably caused by some geological feature.

The area covered by Traverses 101,000E and 101,200E is open grassland which has a tendency to be swampy. It is tentatively proposed that many of the anomalies shown in Plate 3 may in fact be caused by surface water. This is in part borne out by some detailed traverses around 99,700N, some of which are shown in Plate 4. In this area the outline of the anomalous zone follows quite closely the outline of swamp.

The differences between the values of profile 101,200E in Plates 3 and 4 are due to inaccuracies in re-location of the stations. In the initial reading of the traverse, pacing was used to locate the stations, but during the detailed gridding a tape was used.

As yet no information as to the depth penetration of the method has been obtained, and this must be a major aim of the testing to be continued in Tasmania and Western Australia.

4. CONCLUSIONS

The EM16 prospecting unit is light and easily readable. In Australia only the North West Cape station can be received with sufficient reliability for routine surveying.

The tests in the Captains Flat area were inconclusive owing to the parallel relationship between the primary field and the strike of the country.

Evaluation of the method as a geophysical tool should continue particularly with emphasis on the determination of the depth penetration and the effects of surface conductors such as creeks and swamps.

5. REFERENCES

SEDMIK, E.C.E., 1965. Captains Flat metalliferous geophysical survey, NSW, 1960. Bur. Min. Resour. Aust. Rep.. 96.

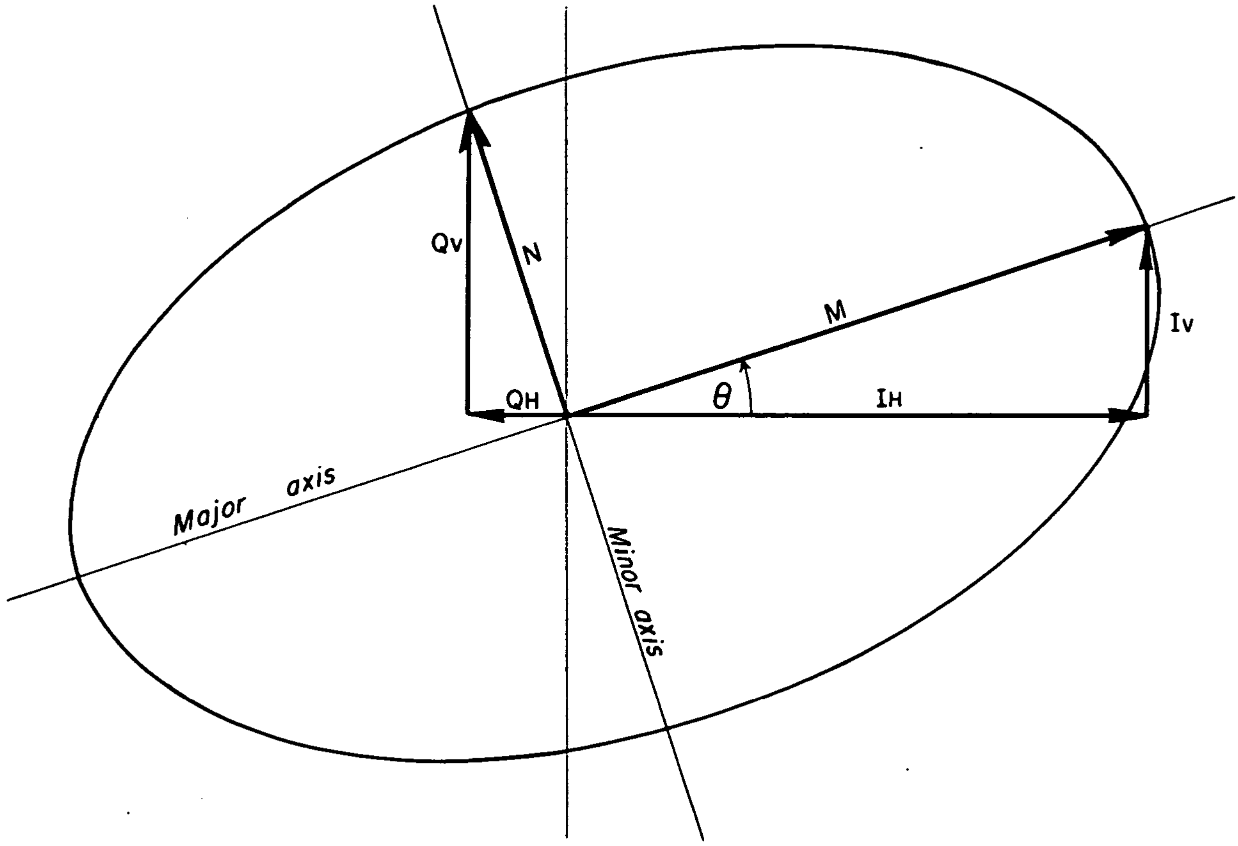


Fig. 1 SPACE VECTOR DIAGRAM

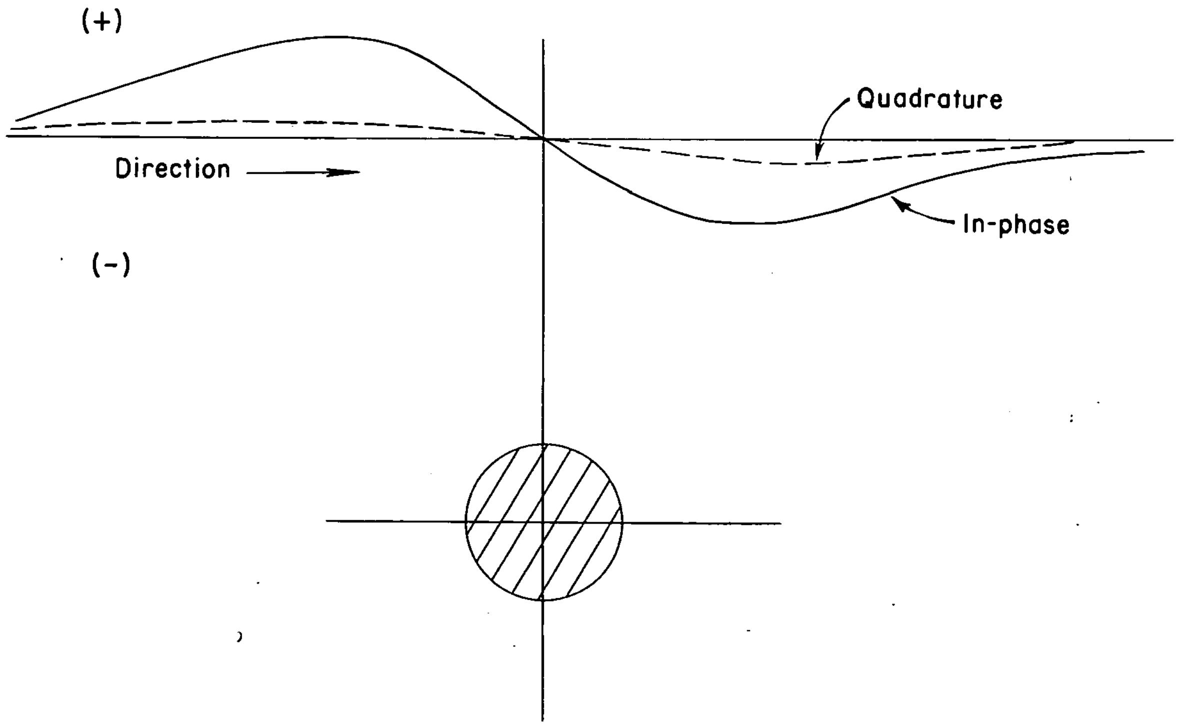
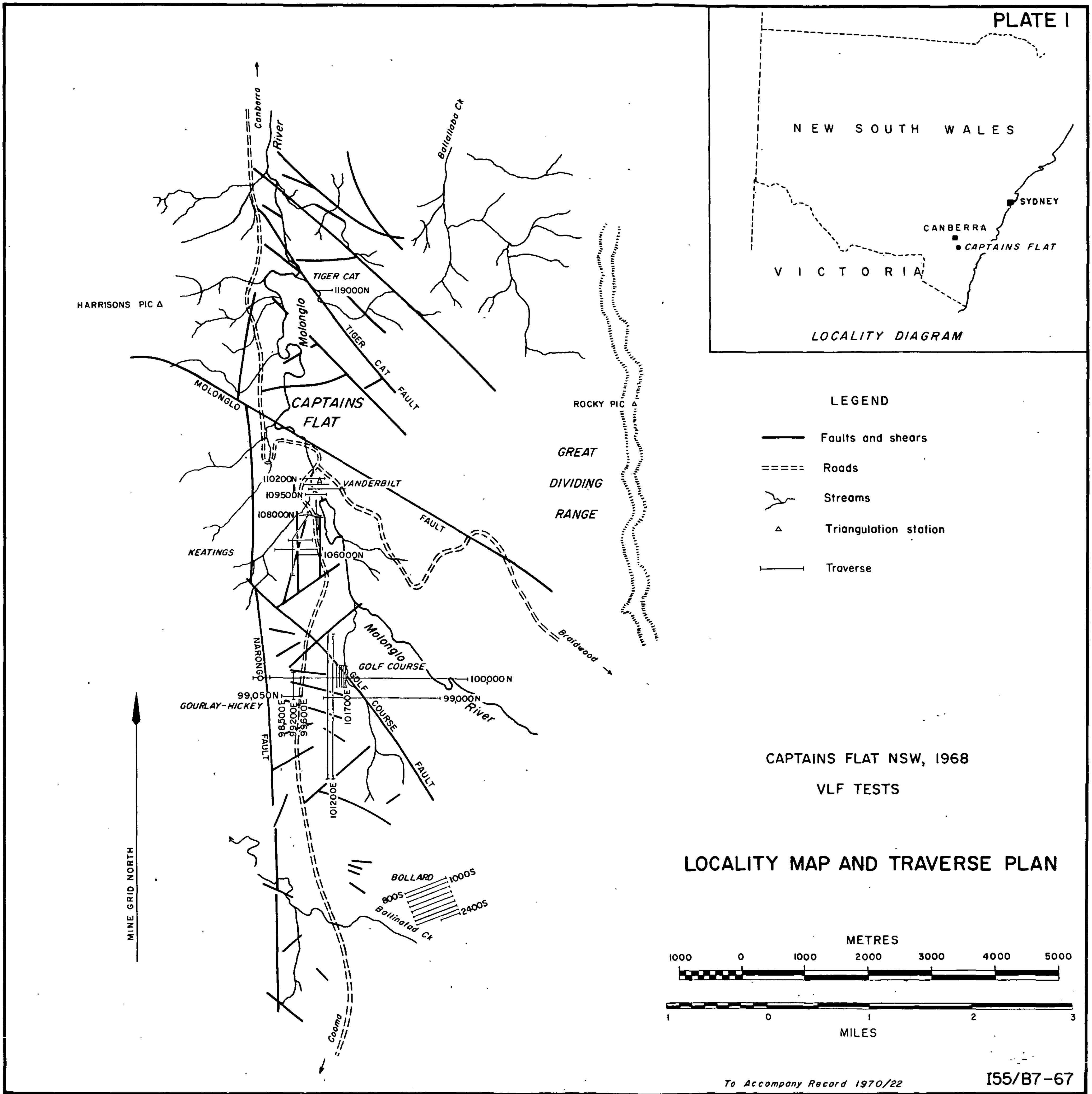
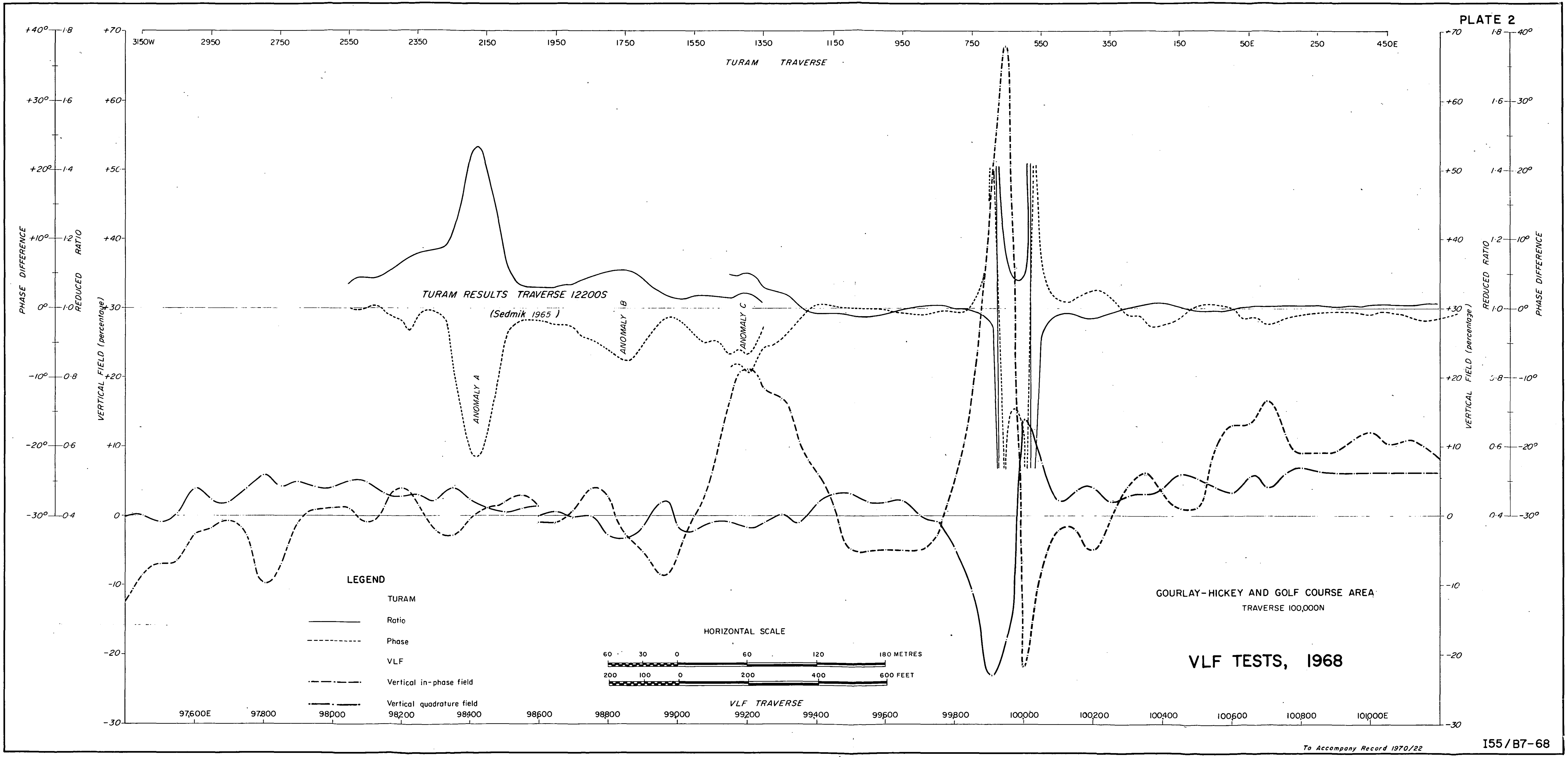


Fig. 2 TYPICAL EM16 ANOMALY DUE TO A CONDUCTING SPHERE



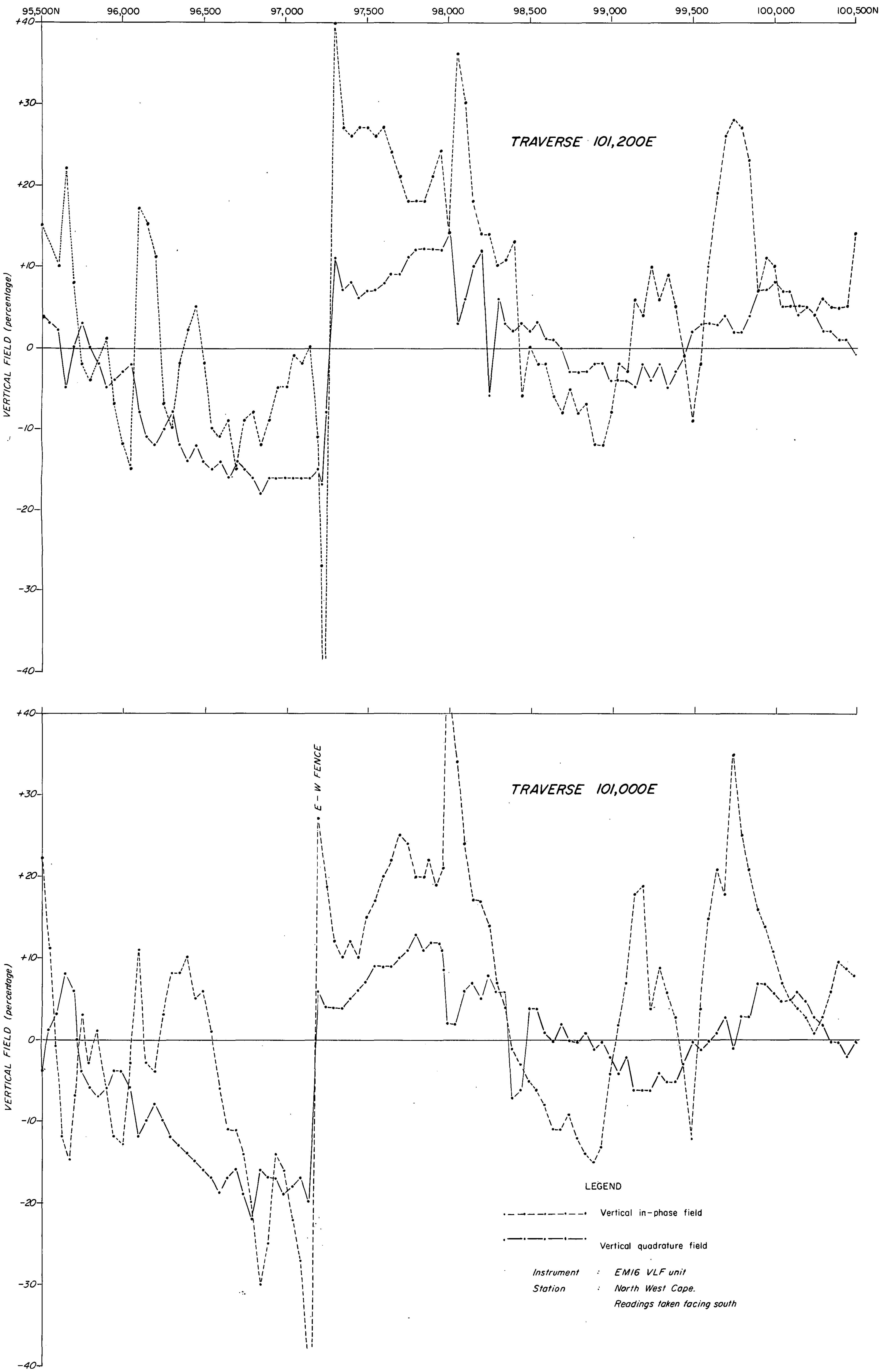
(Based on I55/B0-39)

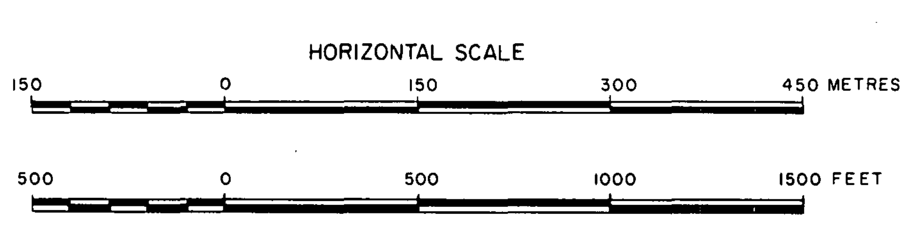


CAPTAINS FLAT 1968

To Accompany Record 1970/22

I55/B7-68





GOLF COURSE AREA

TRAVERSES 101,000E & 101,200E.

PLATE 3

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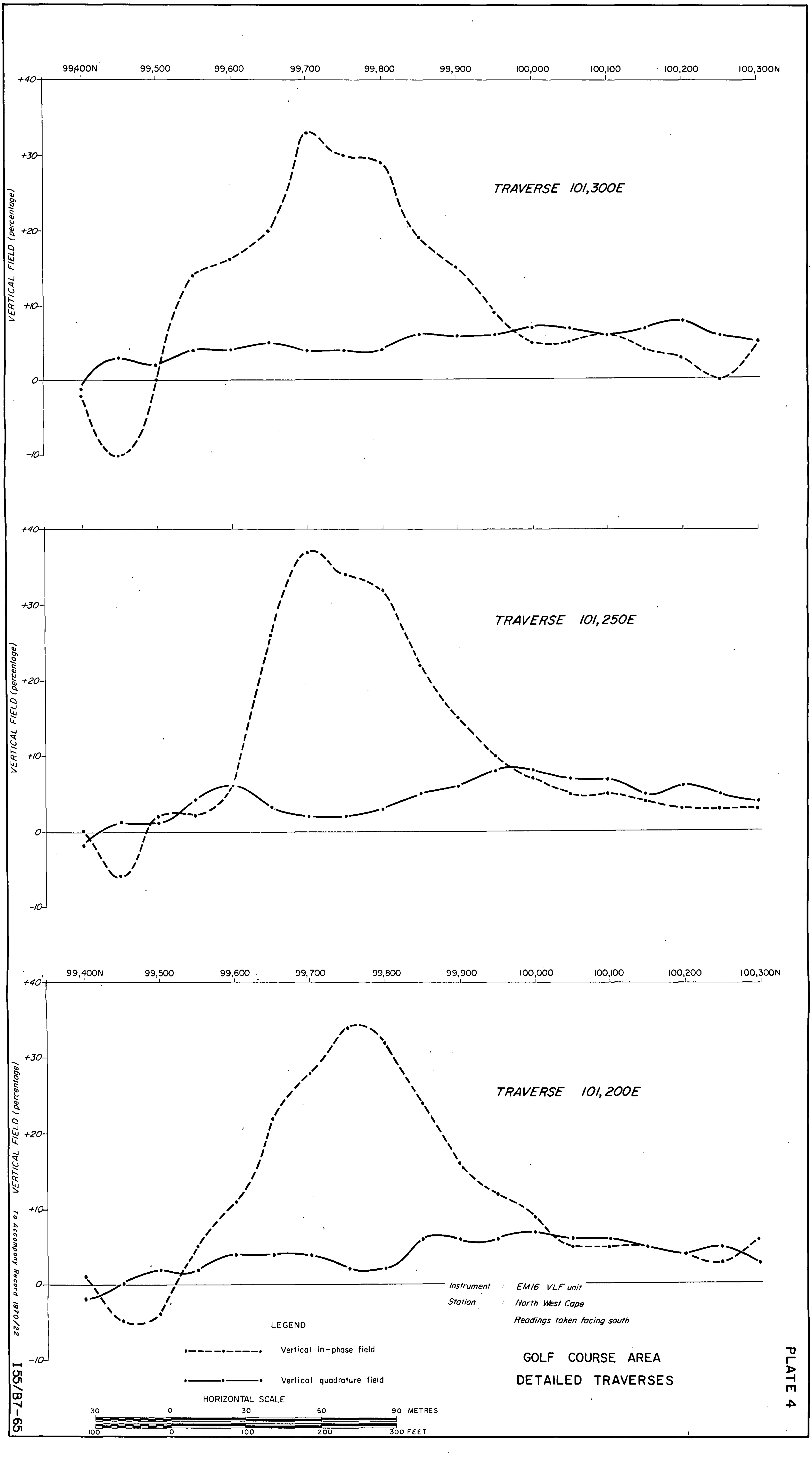
I55/B7-64


99,400N
99,500
99,600
99,700
99,800
99,900
100,000
100,100
100,200
100,300N
+40
+30
+20
+10
0
-10
VERTICAL FIELD (percentage)
TRAVERSE 101,300E
TRAVERSE 101,250E
TRAVERSE 101,200E
Instrument : EM16 VLF unit
Station : North West Cape
Readings taken facing south
LEGEND
Vertical in-phase field
Vertical quadrature field
HORIZONTAL SCALE
30 0 30 60 90 METRES
100 0 100 200 300 FEET
GOLF COURSE AREA
DETAILED TRAVERSES
PLATE 4
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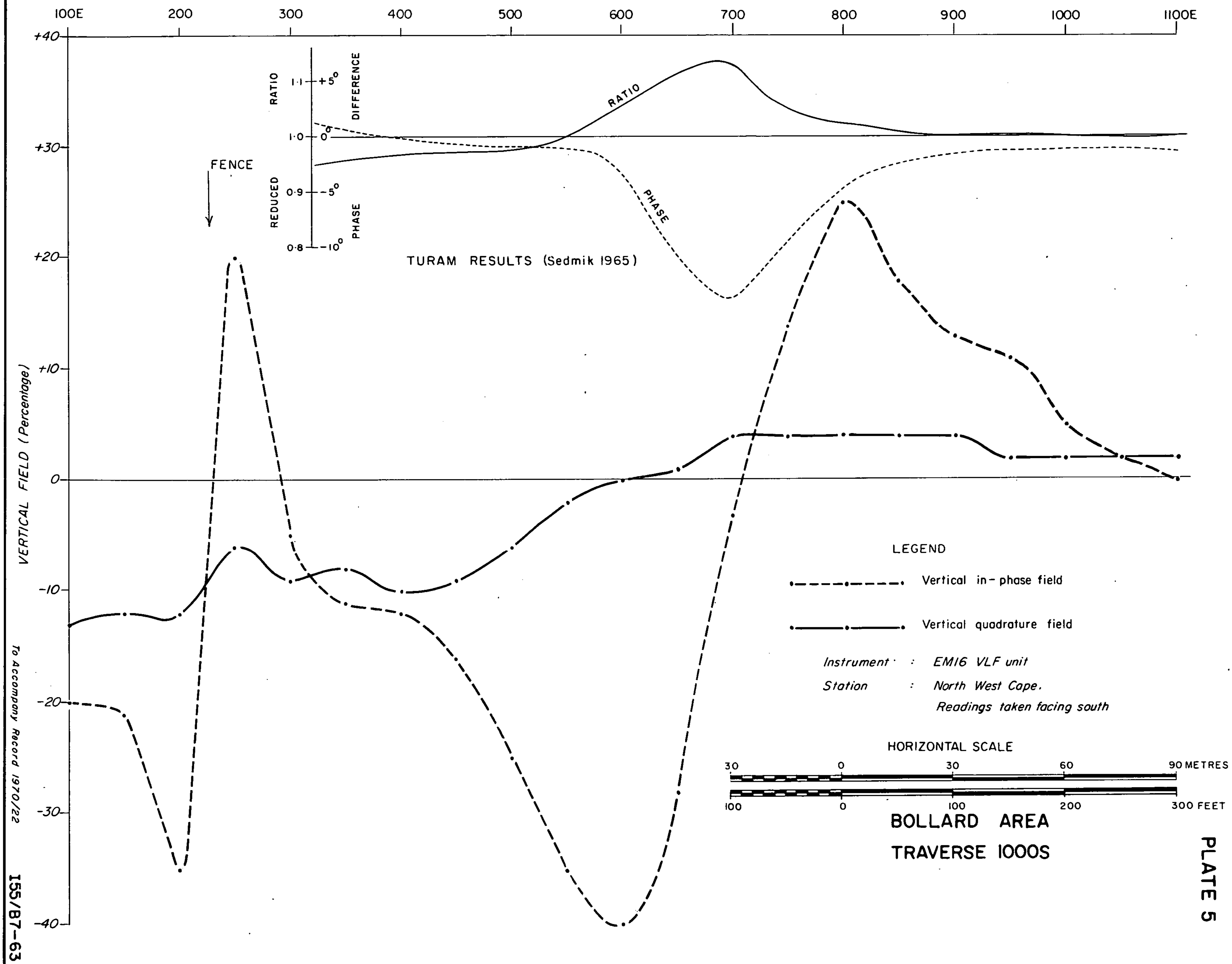
I55/B7-65



BOLLARD AREA

TRAVERSE 1000S

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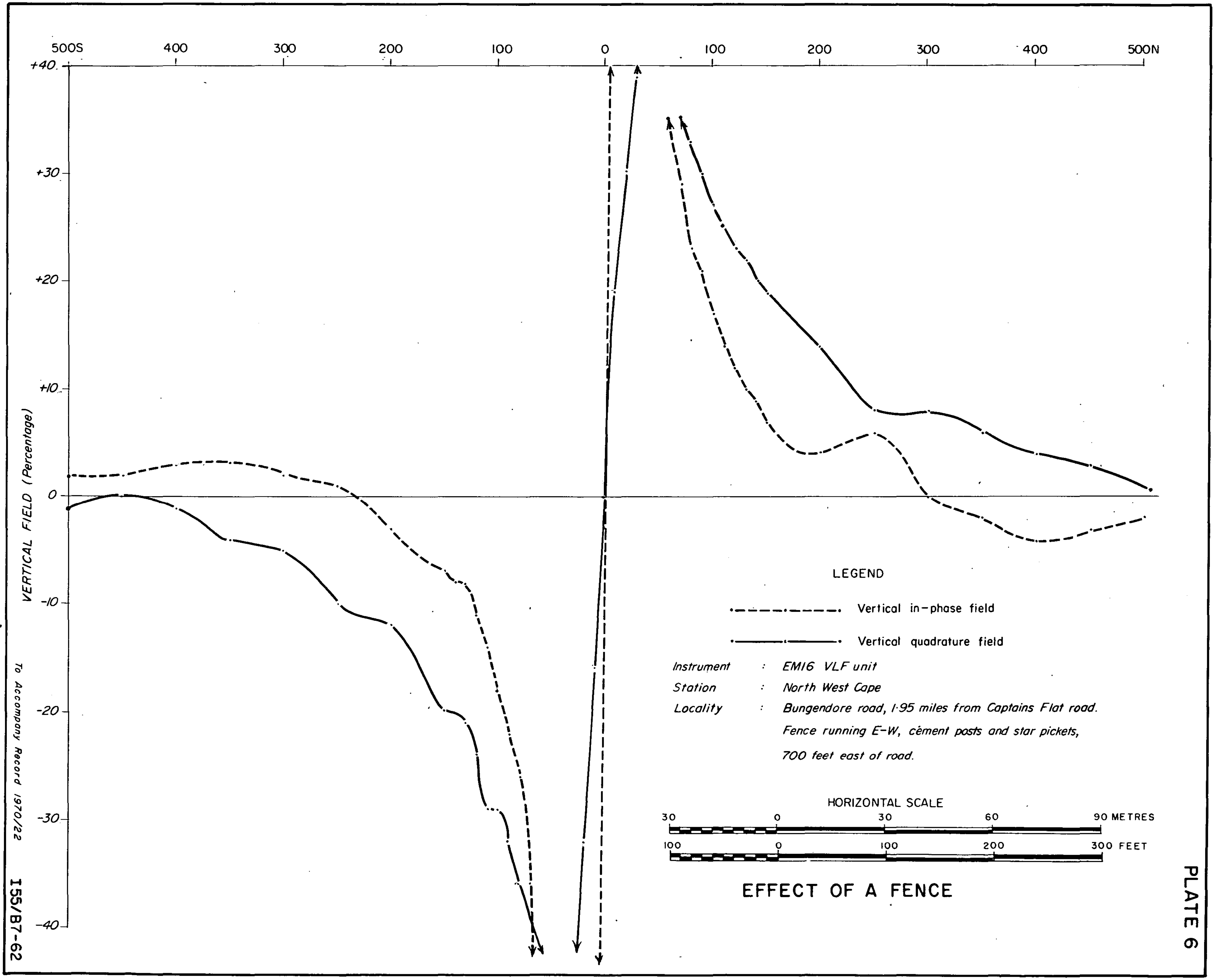
PLATE 5



EFFECT OF A FENCE

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PLATE 6