Early geophysical practice — the BMR instrument collection

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The Bureau of Mineral Resources, Geology and Geophysics was formed in 1946. It replaced the Mineral Resources Survey (1942-46) whose forerunners were the Aerial Geological and Geophysical Survey of Northern Australia (AGGSNA) (1934-1941) and the earlier Imperial Geophysical Experimental Survey (IGES) (1928-30). The notably large BMR geophysical achievement has used a wide variety of geophysical and allied measuring apparatus, much of which was placed in storage as its effectiveness declined. The collection has been further enhanced by direct donation from exploration companies and joint international programs.

One hundred and ten artefacts from the collection were recorded, along with details of origin and use where known. Reference is made to early literature describing many of the objects.

This account provides a general overview of the collection.

Introduction

This account summarises a collection of 19th and 20th century geophysical instruments that has been assembled in Australia during the past eighty years or so. This collection has resulted from the wide range of geophysical programs conducted by the Bureau of Mineral Resources, Geology and Geophysics (BMR) since 1946. The holdings have been extended by the addition of equipment presented to the Bureau by exploration companies and by overseas co-operative agencies. Additional sources such as these have provided the collection with equipment of much earlier origin than the 1940s. The collection is a significant part of Australia's technological heritage.

It is BMR policy to add outdated equipment to the collection which is housed in warehouse storage at the Commonwealth Government Store, Oaklands, NSW. This particular location is excellent for storage—industrial pollutants are absent and the stores are well managed and supervised at all times.

In May 1977 the bulk of the collection was studied and recorded by some members of the Department of Geophysics, University of New England under guidance of the author who represented the National Sub-Committee for Engineering Heritage of the Institution of Engineers, Australia, and who was at that time a member of that Department.

One hundred and ten items, or sets of items, were uncrated, examined, photographed, and recorded on cards for purposes of further study and research. Recording procedures used were in line with those considered for adoption for moveable artefacts by the I E Aust Engineering Heritage Sub-Committee.

Following the initial cataloguing process some preliminary research was conducted on the artefacts by the author, being confined to general comment rather than of any specific relevance to past BMR programs. The original set of cards is held by the author; a copy being provided for use by BMR staff.

At the time of preparation of this summary members, present and past, of the BMR had begun research on the relevance of the artefacts to BMR history. The detailed and more complex description of the collection will eventually be published as a BMR Record under the title 'The BMR Historic Geophysical Apparatus Collection'. Table 1 summarises the collection holdings.

Literature on history of earth sciences

Many of the artefacts have origins in other countries of the world. Appreciation and understanding of the collection, therefore, must be gained by study of global literature.

Geophysics is itself a multi-disciplinary subject; the BMR collection reflects certain facets. In reviewing the literature the terms of reference were kept broad so as not to lose perspective.

Early texts of direct relevance are rare, most 19th century and early 20th century earth-science work being discussed instead in books on natural philosophy, electrical engineering and the like. Walker (1913), however, reviewed the latest in seismological technique at the time when Milne died. The life and work of Milne on the Isle of Wight, England is the subject of a small study by Herbert-Gistar & Nott (1974). Early use of the pendulum in determination of gravity force is the topic of a detailed history by Lenzen & Multhauf (1965).

Wartnaby (1957) published a brief historical survey and catalogue of exhibits in the then existing Seismological section of the Science Museum, London. (This section has now been incorporated into an extensive new gallery of Geophysics and Oceanography opened February, 1977.) This study includes a 51-entry bibliography on seismology from 1702-1954 along with descriptions of 45 sets of equipment held by the Museum. Wartnaby (1972) has studied the works of John Milne and Robert Mallet for a doctoral thesis, this following his previous M.Sc. thesis on the only work of Milne. Descriptions of the new Science Museum, London gallery (which includes material relevant to Australian history) are available in McConnel (1976, 1977).

A commemorative issue of 'Timebreak' (Geo. Space Corp., 1971) explored the development of reflection seismology in exploration. The history of early seismic exploration method was published by Mintrop (1930). Dobrin (1960) includes a brief history of geophysical method, as does Jakosky (1950).

Other early texts on geophysics include Davison (1921), Davison (1927), Ambronn (1928), Gutenberg (1929), Rothe (1930), Wien & Harms (1930), Shaw (1931), Imamaru (1937), Leet (1938), Heiland

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(1940), Nettleton (1940), Byerly (1942), Rayleigh (1945), Dix (1952), Landsberg (1952), and Eve & Keys (1956).

Specific histories compiled include Weatherby (1940) on seismic prospecting, Eckhardt (1940) on gravity method for oil search, and Rust (1938) on electrical methods.

The Royal Society arranged a London exhibition in 1925. Its report, Royal Society (1925) includes descriptions of geophysical demonstrations by Sir Napier Shaw, FRS (Solar and Terrestrial Radiation and Meteorology), Capt. C. J. P. Cave (Cloud photographs), C. Chree, FRS and C. S. Wright (Terrestrial Magnetism and Atmospheric Electricity), and H. H. Turner, FRS and J. J. Shaw (Seismology).

Turning to works more specific to Australian history it will be found that little exists. History of Australian science studies are embryonic, there being no definitive work yet completed. Hoare (1975) provided a brief account of science since Cook's first voyage to Australia in the 1760s. A little depth into geophysical endeavours in meteorology and astronomy of the 1800s is available in the published correspondence compiled as a chapter of a work by Mozley-Moyal (1976). Introductory sections on meteorology and astronomy give some useful information on magnetic data and observatory programs. Source documents held in libraries throughout Australia can be located using a guide to manuscripts by Mozley (1966). The Adolph Basser Library of the History of Australian Science, Academy of Sciences Building, Canberra holds extensive historical science material.

Wood (1966) reviewed the early weather and astronomical observatories of Sydney, Melbourne, Adelaide, Perth, Riverview College, and Mount Stromlo, and describes past events of Government and University groups since settlement—1780s up to 1966. Wood begins his account with the comment that James Cook came to the then vaguely known Australasian region to observe a transit of Venus at Tahiti in 1769. Cook also performer valuable magnetic and marine charting at such a standard of precision that many of his charts were not bettered for nearly two centuries. Cook's voyages are described in a popular style by R. and T. Rienits (1968). Day (1966) reviews the development of Australian geophysics since the earliest settlement to about 1950.

An historic sea voyage made a century later, that of the *Challenger* of 1872-1876 (Linklater, 1972), also provided some geophysical measurements in the Australasian region. The emphasis, however, was mainly on exploration of the depths of the oceans. In 1914 the annual meeting of the British Association was held in Australia. Howarth (1931) provided a brief report of visitors' activities. A more detailed account was published in the Report of the British Association for 1914, p. 679.

Cooks' magnetic measurements had been preceded by those of Bligh and Hunter in 1787-1789, and earlier still by Tasman in 1642. Green (1972) provides a short account of magnetic measurements of the 1840s, including the operations of the short-lived magnetic program of the Rossbank Magnetic Observatory of Hobart Town.

Early accounts of geophysical method being used in exploration for minerals, water, and oil include Aplin (1926), and Hautpick (1928)—who discussed the methods being adopted at that time, suggesting their

GRAVITY

—Askania, Oertling, torsion balances 1920
—Thyssen gravimeter 1920
—Holweck-Lejay inverted pendulums 1955
—North American marine set 1955

MAGNETISM

—Kew-pattern dip circles 1920
—Sharpe low-precision dip circle 1955
—Kew-pattern magnetometers of British, German, US origin 1910
—Sharp personal torsion magnetometer 1965
—Earth-inductors of German origin 1920-50
—Vertical and horizontal force variometers of British and German design 1930-50
—Proton precession magnetometer 1950
—Magnetometer calibrators 1930-50

RADIOACTIVITY

—Portable geiger counters of Australian, Dutch, Canadian, British and U.S. design 1955
—Portable scintillometers of Canadian, U.S. design 1955
—Electronic scaling units and amplifiers of British, Australian design 1955
—Airborne scintillometers of Canadian, British design 1955
—Borehole logging set 1955
—Sample assay units 1955

SEISMIC

—Cambridge Inst. Soundranging set with telephones 1920
—BMR long-period seismographs 1960
—Mid western reflection set for marine use 1955

POSITION

—Aneroid altimeter 1950
—Observers magnetic compasses 1935
—NML Straight line flight indicator 1950
—Theodolites 1930-40

TIME INTERVAL

—Landis observatory master clock
—Synchronome slave clocks 1910-50
—Chronometers in gymbals 1880-1960

ATMOSPHERIC PARAMETERS

—Dust samplers and observing kit 1920-1955
—Recording barograph 1900

SOLAR RADIATION

—Spectro-helioscope (part only) 1950
—Jordan sunshine recorder 1900

ELECTRICAL INSTRUMENTS

—Toepfer, Askania, Cambridge optical-lever galvanometers 1910-30
—Quadrant mirror electrometers 1900
—Weston voltmeter and ampmeter 1905, 1930
—Weston multimeter
—Ionisation tester
—Sullivan-Griffith bridge 1950
—L and N potentiometer 1950

RECORDERS

—Light spot photographic 1930, 1960
—Cambridge Vibrograph 1940

PROSPECTING EQUIPMENT

—EM Compensator 1950
—Ratiometer 1950
—ABEM Slingram & Turam 1955
—SP Voltmeters 1950

Table 1. Summary of the collection.
(Dates given indicate approximate decade only)

increased use in Australia as a means to boost the then ailing mining industry.

The definitive early work on the relevance and application of geophysical method in Australia was that of the Imperial Geophysical Experimental Survey. This study (Broughton-Edge & Laby, 1931), was made to establish the value of geophysical methods in Australian conditions, not to discover profitable geological materials. This survey was a prime factor in the later creation of the BMR in 1946.

The Bureau of Mineral Resources today maintains five geophysical observatories in which geomagnetic and seismic equipment are operated; Dooley (1958) has compiled an account of the history of the Toolangi (Victoria) observatory.

Gravity measurements have been made since the 17th century, so it is not surprising that they were made in Australia from its earliest settlement. Dooley & Barlow (1976) have published an extensive account of gravity measurements made in Australia since 1819, providing details of instrumentation through the many references cited. Figure 1 shows an early Oertling gravity torsion balance of the collection.

Assessment of the collection

Australian professional science in the 19th century follows a pattern more like that of the USA for, compared with Europe, very little physical science was practised. Records reveal that some scientific instruments were in use throughout the land, but it seems little has survived from the 19th century.

Prior to the structured work of government agencies, which began in the 1930s, geophysical work was scattered, uncoordinated and poorly documented. As a consequence historians must re-discover the past.

The BMR Collection is the most extensive assembly of historic geophysical apparatus in Australia. All other national sources combined would add little more to its scope. It is hoped that the collection will be made more available to the public, for it presents a significant amount of national activity in the more modern era of earth sciences.

The collection is lacking in originals and replicas of epoch-making designs of overseas and to a lesser extent local origin. A balanced collection would need items that represent the earlier works of such people as Tasman, Cook, the Challenger Expedition and the Threlfall gravity meter. The collection is a most worthy basis for expansion, if acquisition becomes possible.

Notable artefacts from the Australian viewpoint include several Australian-made equipments, the range of radioactivity measuring sets, and several pieces that have important associations with early scientists in the region. Figure 2 is an early etching of the dip needle design commonly known as the Kew pattern.

The collection appears to possess little of global importance. Much of what is held is similar to holdings of the larger Northern Hemisphere science museums (Sydenham, 1977). It is, however, important to realise that this collection is as valuable to the nation of the future as it is to us immediately.

Historical geophysical instruments elsewhere in Australia

A small number of early geophysical instruments are extant in other Australian collections. More research

Figure 1. Oertling torsion balance, c 1915.

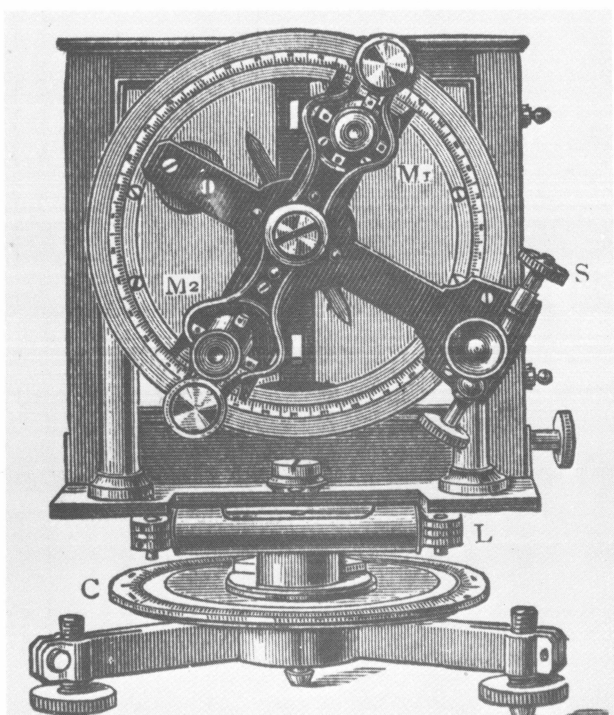

Figure 2. Kew-pattern dip-circle (Mullineux-Walmsley, 1910).

is needed to provide an exhaustive list; the following provides an indication.

The Science Museum of Victoria, Melbourne, has some of the instruments used in the original Melbourne Observatory. These include galvanometers from the 1840s, a sunshine recorder, and an 1880s three-component seismograph.

The Department of Geology, Melbourne University, is to donate a small collection of exploration apparatus (including an early gravity meter) to the BMR holdings.

The Basser Library of Australian Science, Canberra has custody of radio apparatus used in early Antarctica magnetosphere research.

Relics from the Sydney Observatory, the Bureau of Meteorology, and the Department of Health were presented to the Museum of Applied Arts and Sciences, Sydney. These include meteorological instruments, galvanometers and recording barographs and thermographs of the 1900 era.

Another source of early equipment is University Departments concerned with Physics, Earth Sciences, and Engineering. These have yet to be studied, but it is apparent that a considerable amount of obsolete field equipment has gone to these institutions from commercial companies who no longer had use for it.

General comment on instruments of the collection

An IEAust. code number was assigned to each article, a label being attached to items recorded. Most items also possess a BMR vocabulary code that shows their relationship to the general inventory. A card was completed for each item. These were then sorted in groups on the basis of the physical variable that the apparatus measured. Table 1 summarises the collection and should be consulted when reading the following comments.

Gravity force

Torsion balances. Torsion balances originated and were used in the 1900-1930 period following the success of the Eotvos balance (designed in the late 1890s) in geophysical exploration for oil. Their relative fragility, sheer size, and slow operation eventually led to a decline in use. They were used to determine gravity gradients and curvatures of equipotential surfaces, not the absolute value at a station, and were capable of detecting 10^{-13} gm force differences. They made use of opto-mechanical transducer principles.

The collection contains Askania and Oertling torsion balances, and a Thyssen gravimeter known to have been used in oil search in Australia and Indonesia.

Pendulums. The development of pendulum measurements of gravity began in the 1600s. By the 19th century absolute measurements were made by this method. Early in the 20th century the nominal 0.5 m (and shorter) pendulum apparatus was introduced into exploration geophysics. This development has been researched in depth by Lenzen & Multhauf (1965), who reported the progress to about 1920. Dooley & Barlow (1976) have published an account containing the pendulum measurements made in Australia. The most recent use in Australia was with the multiple instrument systems of the Russians in 1974. Pendulum absolute gravity measurements are rapidly being displaced by the thrown-mass laser interferometer of absolute determination, the grid being filled in by relative measurements made with spring-mass instruments.

The collection contains a complete field system for using the inverted pendulum of Holweck-Lejay design. This system was used by Shell (Queensland) Development Pty Ltd in southern Queensland in 1940-42 (Dooley & Barlow, 1976).

Marine gravity. The BMR, in 1957, purchased a complete North American system for conducting gravity surveys in coastal areas. A deck-mounted hoist unit is used to lower an assembly to the sea-floor. This latter unit houses a spring-mass gravimeter, and can be levelled and read from aboard ship. The gravimeter itself was not recorded, not being in the store inventory. The Bureau possesses a number of spring-mass gravimeters.

Earth's magnetic field

Dip needles. The dip of a compass needle was noticed in earliest times. By the time James Cook made his Australian voyages in the 1760s dip-needle devices had become quite sophisticated. The Kew (Observatory) pattern originated in England. It incorporated opposing optical viewers for precise reading of the vertical angle, and was in common use at the end of the 19th century. Mullineux-Walmsley (1910) gives a description of its use and a fine etching of a unit similar to those of this collection. Dip circles are still used for low precision surveys, the Sharpe instrument of the collection being a relatively modern example.

One of the dip circles was previously owned by Sir Douglas Mawson.

Absolute magnetometers. Commonly known as theodolite magnetometers, these were used to determine declination D and horizontal force H, and—depending

Figure 3. Carnegie Institution of Washington magnetometer equipment, c 1900.

on accessories, inclination I by the earth induction principle. H was determined by the very tedious method of oscillations and deflections. Gauss, in 1832, appears to have been the first to use the dynamic method for H determination.

Mullineux-Walmsley (1910), and Glazebrook (1922, p. 533) provide etchings and lengthy descriptions of the use of the Kew pattern (Elliot) magnetometer systems.

The DTMCIW—illustrated in Figure 3—and Bausch units are American equivalents. These instrument systems provide magnificent examples of the skill of mechanical and optical instrument-makers in the 1900 period.

The equipment sets in the collection were used at Watheroo Magnetic Observatory, and for field observations throughout Australia, SE Asia and SW Pacific. They were passed to BMR when the Watheroo Magnetic Observatory was transferred from the Carnegie Institution of Washington to the Commonwealth in 1947.

Earth inductors. In 1831 Faraday, after many years of experimental frustration, observed and identified the conditions wherein electricity is generated by interaction with magnetic field. Within days he demonstrated that a loop rotated in free space generates a voltage potential because of the existence of the earth's field. In 1853 Weber used this principle quantitatively to determine the absolute value of the earth's field.

Earth inductors were in common use by 1900; the Askania unit of the collection was still marketed in 1969, for complementing total intensity proton-magnetometer measurements by the determination of inclination to $\pm$ 0.3 arc minutes.

A trial, made in Europe by Logachev in 1936, sought to use the earth inductor as magnetometer for airborne surveys. The sensitivity of 1000 gamma available to him was, however, far from adequate for such purposes.

Variometers. The instruments of the collection are commercial forms of Schmidt's 1915 magnetic field balance. An H form magnet is balanced on knife edges, and is read by visual observation of an optical lever. The instrument principle can be arranged to measure either the vertical or the horizontal component of the earth field. An adjustment exists that enables the absolute field at a station to be balanced, so that variations from station to station can be determined. Telford & others (1976) describe the operation and theory of the balance: instrument orientation with respect to the field components being measured is a critical parameter and so these instruments are supplied wtih magnetic compasses. They are inexpensive and reliable, and can provide a resolution of 10 gamma. Operation, however, is tedious, attributing to their eventual decline in usage, especially for horizontal component determination. Hilger and Watts, for example, discontinued sales of new instruments (models SGI, SG2) before 1960.

The age of the variometers held ranges from 1935 to 1955.

Proton or nuclear precession. The phenomenon of nuclear magnetic resonance was quantified around 1945. The principle enabled magnetic field strength to be measured by a new procedure. Varian and Packard, in 1954, developed a new form of total field instrument which became known as the proton precession magnetometer. Advantages were that it was little more than a bottle of water, a coil and electronic circuitry; sensitive; self-calibrated, with absolute measurement to within 1 gamma; and that it did not need specific orientation or stationary working. It did, however, require a ls integrating time between observations.

The Bureau, realising the potential of this new device, decided to construct units for its own use. This was prior to commercial sale of satisfactory field devices. Two units, now without sensors, exist in this collection, along with the airborne towing bird.

Calibrators. Magnetometers can be calibrated either by placing them in a uniform magnetic field of known value, or by observing their response to suitably placed permanent magnets. The former method is precise when the field is produced by electrical current in coils placed in the Helmholtz arrangement.

This collection includes a coil and current source combined, a current calibrating bridge, and a unit made for, or with, a flux-gate magnetometer.

Radioactivity

In 1896 Bequerel reported the existence of radioactive emanations from uranium compounds. Two years later Villard identified the more penetrating gamma rays. Interest in radioactive materials became of fundamental importance to modern science in general, but the demand for radioactive materials was not great until the 1940s when war and then the peaceful uses of radioactivity provided a demand for ores.

First detectors were leaf electroscopes and visually observed scintillation setups. In 1908 Geiger, working with Rutherford, devised an ionisation chamber detector which was later improved by Müller in 1928. Availability of the vacuum tube amplifier enabled sensitive detectors of radioactivity to be devised. By the late 1940s large-scale interest existed in inexpensive portable prospecting Geiger-Müller tube devices. The development of the photo-multiplier in the late 1930s enabled more sensitive measurements to be made by the scintillation method. Thus by the time that the boom in demand for radioactive ores arose around 1950, adequate technology existed for its rapid detection. Survey was either by hand-held ratemeter (using Geiger or scintillation detectors), airborne detector (only scintillometers sufficed), or by well-logging.

The Bureau was heavily committed in the 1950s with this form of search. To assist the program a wide range of equipment was purchased from Australia, UK (mainly through contractors to AERA, Harwell), Holland, Canada and the USA. A geiger counter, manufactured in Melbourne, is shown in Figure 4.

Radioactivity measuring instruments make use of counting of electrical impulses generated by the discrete nuclear process. The time-rate of counts generated is a measure of radioactivity strength. Thus, many units are termed ratemeters.

The collection strongly reflects the derivative nature of Australian technology, and the range of countries from which detection equipment was obtained for use in simple prospecting, in sample assay, and in airborne survey.

Seismic method

Laboratory seismic recording of earthquake activity began with mechanical recording methods, such as Milne's of around 1895. In 1904 Galitzin added electromagnetic transduction, thereby obtaining greatly increased gain and avoiding the restriction for recording from the energy available in the signal. In 1917 Mintrop's mechanical seismic recorder was applied to exploration needs, and by 1921 reflection seismic pros-

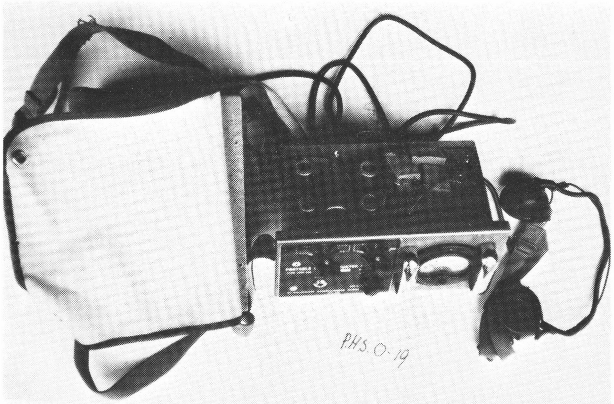

Figure 4. Austronic, Melbourne, geiger counter c 1952.

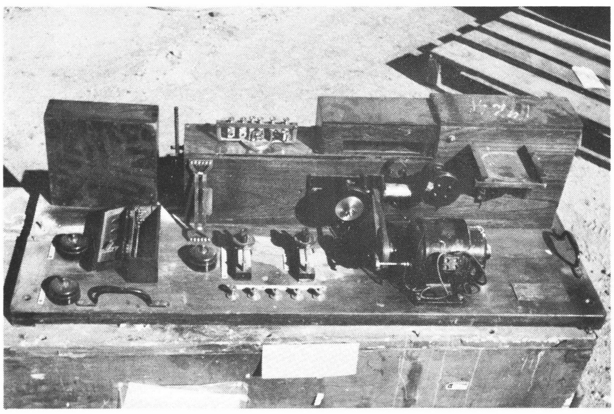

Figure 5. Recording and developing unit of Cambridge Instrument Co., sound-ranging equipment, c 1920

pecting was being used with great effect. Around this time military research was interested in the problem of ranging in on hostile big guns. Research into acoustic location was conducted from the 1914 period onward. An account of the techniques is given in Glazebrook (1923, p. 733). An internal publication of Cambridge Inst. Co. (1956) provides a photograph and brief description of the camera of the system. Figure 5 is a photograph of the camera and developing unit from the collection; this research significantly influenced early workers involved in the introduction of seismic exploration technique. The requirement for microphones with an unusually low and narrow band frequency acceptance response highlighted the need for geophones and galvanometers to be carefully matched.

The BMR Collection contains a virtually complete sound-ranging system dating from around 1916. The system was used in Australia by the Imperial Geophysical Experimental Survey (Broughton-Edge & Laby, 1931). It was reworked in 1941 with additions and alterations being made. Historically this is an important assembly, for it demonstrates one of the earliest uses of geophones, contains an example of the first-ever automatically developed photographic film-strip recording system, and contains such items of historic interest as an Einthoven string recorder, a tuning fork synchroniser, and a mercury-wetted relay.

In more recent times the BMR constructed observatory vertical seismographs. Two of these exist in the collection.

A complete marine seismic system has been preserved from the 1960 era. Only certain items of this were recorded here.

Related variables

Position location and control. Barometric pressure altimeters and magnetic compasses of flight origin exist in the collection. Especially interesting are straight-line flight indicators using electromechanical computing devices. These were produced at the National Standards Laboratory (now National Measurement Laboratory), Sydney around 1952. A unit is illustrated in Figure 6.

Time interval. A range of chronometers and a system of slave-master electric time keeping has come into the collection. Most of the items are from the Watheroo Magnetic Observatory. None are particularly important but the range covers a wide period of manufacture.

Atmospheric dust. Three items, two from the 1920 period, exist that enable samples to be taken and observed.

Atmospheric pressure. The recording barograph initialled R.F. (Richard Freres) is an interesting example because of the individually sealed capsules, and the use of a considerable tensioning mass that is applied to the aneroid capsule stack.

Solar radiation. The Jordan style sunshine recorder is identical with illustrations of 1888 models.

Electrical indicating instruments. Optical lever galvanometers used in conjunction with earth inductors exist. The quadrant mirror electrometers are typical of 1900 designs. These were used in the atmospheric electricity program at Watheroo from 1922 to the early 1950s. Various single and multi-purpose meters illus-

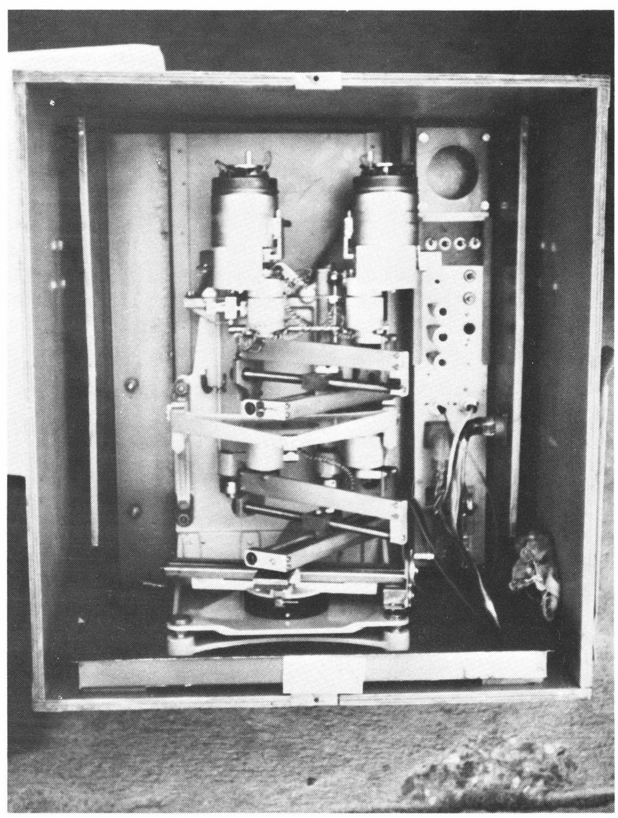

Figure 6. Straight-line flight indicator Mk 2, designed and constructed by the CSIRO Division of Electrotechnology, c 1950 (now NML).

trate the evolution of indicating instruments from pre-1900 to the 1950s.

Bridges. The units are relatively modern, dating from the 1950 period.

Recorders. Various kinds of signal recorder are represented.

The collection contains mechanically driven systems, for use with optical-lever devices requiring photographic recording.

The Cambridge Universal Vibrograph recorder, manufactured in 1944, and of design originating in 1925, records ground vibrations by means of a stylus that presses on celluloid film.

Prospecting equipment

At the time of the visit to the Oaklands store in May 1977, the collection did not include any items of electrical or electromagnetic prospecting equipment. Several such items have since been added. They include an early ratiometer (used in the potential drop ratio method) and EM compensator system, built by BMR to the basic design of original instrumentation used by the Aerial Geological and Geophysical Survey of Northern Australia; several early sets of Slingram and Turam equipment manufactured by the Electrical Prospecting Company of Sweden (ABEM); and various voltmeters used for self-potential surveys.

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Storage and retrieval systems for the Reference Minerals Collection and the Georgina Basin Project

Eugene L. Smith

Introduction

Two major information storage and retrieval systems now in operation at the Bureau of Mineral Resources—the Reference Minerals Collection Index and the Georgina Basin Project Data Base—are based on INFOL. The first system, used in progressively indexing mineral specimens in the BMR Museum, has been in operation 5 years and will continue indefinitely. The second system, designed for a specific field project, has been in operation for 4 years and has a finite life. The systems are run through CSIRONET on the Cyber 76 computer.

INFOL (described in detail in CSIRO Division of Computing Research Manuals) is a generalised information storage and retrieval system designed to create, maintain, and interrogate a file of information. Basically, it is a free-field language which allows items of information of variable length to be written in plain English. It does not require the use of 80-column coding forms; data are stored in a compressed form—blank fields and non-significant blanks in the data do not take up storage space; complex search strategies are possible; and the report generators are flexible. Output may be obtained as a written report on visual display units, paper or microform, or as input for other computer applications.

The major phases of an INFOL system are ESTABLISHMENT, INTERROGATION, UPDATE, and BOOKKEEPING. During the ESTABLISHMENT phase a *file* (i.e., a list) of *elements* (e.g., mineral specimens) consisting of a number of *items* (identification and descriptive information) is created. The file can then be interrogated or updated. Retrieval criteria can apply to items or sub-items—testing for the existence or non-existence of data, or testing relational criteria. The file may be updated by adding new elements; removing existing elements; adding, removing or changing items; or adding or changing sub-items. BOOKKEEPING occurs automatically at certain stages of INFOL operations. It gives information essential for specifying report formats.

The Reference Minerals Collection index

The Reference Minerals Collection housed in the Bureau of Mineral Resources Museum contains over 20 000 mineral specimens and has a growth rate of about 1000 specimens per year. Approximately half of the specimens are from private collections purchased by the Australian Government. The collection contains about half the known mineral species, and is maintained as a reference for BMR personnel and other research workers. It also provides specimens for display.

Because of the size, growth rate, value, and uses of the collection, a computer system to facilitate its effective management and accessibility was started in 1973. It now contains information on 6953 mineral specimens.

Figure 1 is an example of a completed coding sheet. Each element (in this case, mineral specimen) on the file contains up to 24 items of identification and descriptive information. The first item is a unique integer used to identify and index each element. In the case of the Minerals Index, it is the registered number of the mineral specimen.