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Dear Members,

It is useful from time to time to look behind the scenes of map-making and consider the procedures of survey by land and sea. This is the theme of our Annual Symposium. For example, how often have we admired and perhaps coveted De Bry's map of Virginia, published in the first volume of the famous *Voyages*, 1590. The map was based on John White's watercolour "La Virginea Pars", surveyed 1585 to 1586 with the help of Thomas Harriot. The truly remarkable achievement of the original survey was brought home to me when I was conducted in early April on a tour of the Carolina Outer Banks and Roanoke Island. Battered by wind and rain as I darted in and out of the car, I recalled the tell-tale shipwrecks along the Banks in De Bry's portrayal of the arrival of the Englishmen, 1585. I was very relieved not to be in a boat at sea. The adjoining mainland comprises many miles of water-logged woodland and even now seems quite a wilderness. It is obvious that White and Harriot would not have been able to achieve anything like such an accurate and extensive survey but for the help of the Carolina Algonquian Indians. That the Indians accompanied and presumably guided the English surveying party we know from their amazed comments on the mathematical instruments ("the works of gods", as they saw them), which are recorded by Harriot in his *Briefe and true report*, 1588. Perhaps I should add that my expedition on the track of the Roanoke colonists of 1585 to 1587 followed the excellent International Sir Walter Raleigh Conference held at the University of North Carolina, Chapel Hill, 27 & 28 March 1987. The event was organised by Dr. H. G. Jones and co-sponsored by America's Four Hundreth Anniversary Committee, the National Humanities Center, the North Caroliniana Society, together with the University.

To return to the theme of our conference, I commend to you the papers by Andrew David, J. R. Smith and O. A. W. Dilke which appear in this issue. A further two by Yolande Hodson and myself are reserved for the next. We have given a specially nautical flavour to the proceedings with Admiral "Steve" Richie, Past President of the International Hydrographic Bureau, speaking at the Dinner, and Rear-Admiral Roger Morris, trhe Hydrographer, opening the Map Fair. They will no doubt remind us of the vicissitudes of survey at Sea. Captain Cook wrote "Was it not for the pleasure which naturally results to a man from his being the first discoverer even was it nothing more than sand or shoals this kind of service would be insupportable especially in far distant parts like this, short of provisions and almost every other necessary."

Members interested in Cook's voyages may like to know of an exhibition "Captain Cook Hero of the Pacific," which is on display at Penshurst Place, near Tonbridge, Kent, from 28 May to the 27th September 1987, under the auspices of the Viscount and Viscountess De L'Isle.

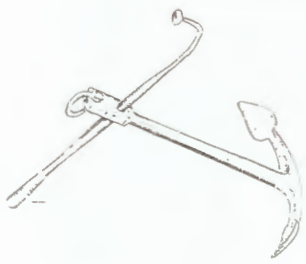
This summer is notable for a number of conferences. The Society for the History of discoveries will be coming to London on 3 to 5 September, holding its first annual conference in Europe (see the separate note of invitation). This is dovetailed with the 12th International Conference for the History of Cartography, to be held in Paris, 7 to 11 September. Our IMCoS fifth Annual International Symposium in Jerusalem, Haifa and Acco follows, 25 to 28 October 1987. Meanwhile at Morelia in Mexico, the International Cartographic Association will be meeting from 12 to 21 October. The ICA Standing Commission on the History of Cartography will be holding sessions both in Paris (on 7 September) and

Morelia. The Commission looks forward to making available shortly the volume *Cartographic Innovations* which is being published by the Map Collector Publications and is the outcome of the Commission's first project.

Finally, I would like to say how much I am enjoying being your President since I took over last Autumn, and to thank most warmly the officers of the Society and all others who have helped with the Symposium. We also extend our thanks to the Science Museum for providing an admirable venue.

DR HELEN WALLIS OBE
IMCoS President

CHARTS



Susanna Fisher

Spencer, Upham, Southampton SO3 1JD, England.
Tel: (048 96) 291

THE SOCIETY FOR THE HISTORY OF DISCOVERIES

Members are warmly invited to attend the meeting of the above Society which will be held in the British Library on **Thursday 3 September** from 10 am to 4 pm. It will be followed by a Reception in the King's Library and a Private View of the Exhibition of The City in Maps from 6 to 7.30 pm. Members will be most welcome at either or both events: thje Registration Fee for the Conference is £10, and tickets for the Evening Reception and Private View are £12.

For fuller details and registration forms please apply *not later than 10 August* to Dr Helen Wallis c/o The Map Library, Great Russell Street, London WC1B 3DG *enclosing a stamped addressed envelope measuring approximately 9 in x 4½ in.*

NOTES FROM THE CHAIRMAN

I would like to welcome all our members, their guests and other visitors to the 1987 London Symposium, Annual Dinner and Map Fair.

The theme of this year's Symposium is "The Science of the World of Maps" which is being held in the appropriate setting of the Science Museum. We are very fortunate in haveing such excellent speakers as Professor Oswald Dilke, Yolande Hodson, James R. Smith and our own President Dr Helen Wallis. I am sure those attending will appreciate listening to their expertise in the subjects chosen. Stuart Jackson will be the Symposium Chairman and Co-Ordinator of the day's events.

We have decided on a change of venue for the Annual Dinner which is being held in the Refectory, The Sherfield Buildings, Imperial College, just adjacent to the Science Museum in Exhibition Road. This year's dinner is being arranged by our Membership Secretary, Caroline Batchelor with Peter her husband in support. The Annual Dinner is a well established event where collectors can meet one another in a relaxed atmosphere. We are fortunate to have as our 'Guest of Honour' and speaker, Admiral G. S. Ritchie CB. DSC, FRICS.

I would like to thank Douglas Adams and Stephen Luck of Tooley Adams for inviting all the delegates attending the Symposium and exhibitors at the Map Fair to a reception being held at their premises on Friday evening, 19th June.

The Map Fair as usual will be at the Forum Hotel on Sunday 21st June. The hotel has been recently refurbished. This year we are pleased to welcome many new exhibitors especially those from overseas.

The Map Fair will be formally opened at 11 am. by Rear Admiral Roger Morris, F.R.I.C.S., F.R.G.S., Hydrographer to the Royal Navy.

Plans are well ahead for the Israel Symposium. Eva Wajntraub hopes to be present at the fair to take bookings.

You will read a summary of the AGM in this journal and a note that the Society continues to grow and fulfils its role providing an international forum for those interested in cartography.

On behalf of our organising committee I welcome you to London and hope you will enjoy your stay.

My final thanks go to the IMCoS committee and many others who have helped to make the Symposium and Map Fair possible.

MALCOLM YOUNG
IMCoS Chairman

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Cover illustrations courtesy of Jonathan Potter Ltd

LONDON SYMPOSIUM MAP FAIR EXHIBITION & ANNUAL DINNER

We would like to thank the Directors of the Science Museum for allowing us to use their Lecture Theatre and other facilities.

Also our Speakers:-

ANDREW DAVID: Lieutenant Commander, Royal Navy Hydrographic Department, Ministry of Defence.

OSWALDE DILKE: Professor Emeritus, University of Leeds

YOLANDE HODSON: Formerly senior research assistant, the British Library. Hon. Secretary of the Charles Close Society.

JIM SMITH: ARICS, FRGS. Principal Lecturer in Land Surveying, Portsmouth Polytechnic.

DR HELEN WALLIS: OBE, FSA. Recently retired Map Librarian of the Biritsh Library. President of IMCoS.

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DR HELEN WALLIS OBE
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& many others who have assisted in many different ways.

We hope you all have an enjoyable Weekend

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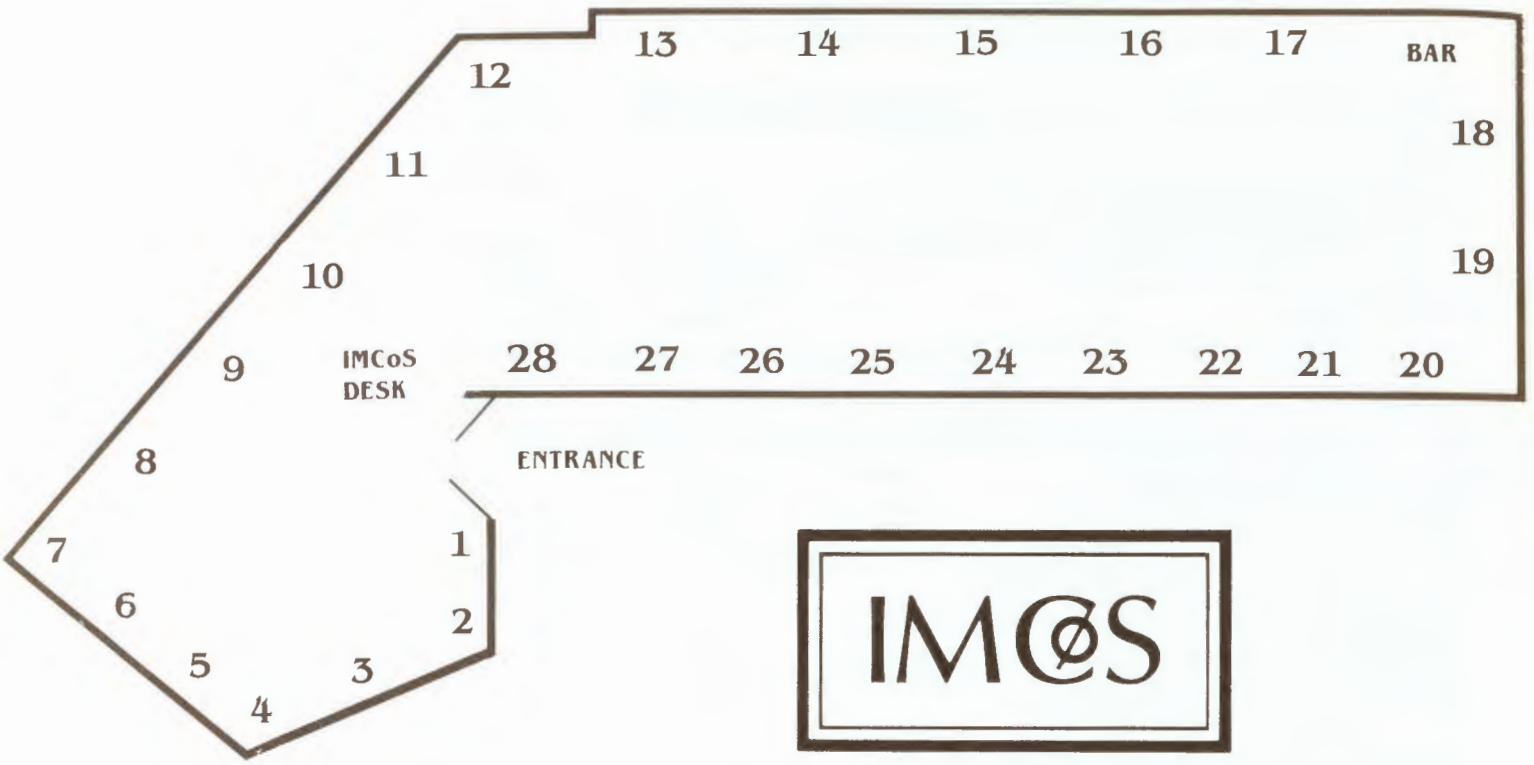
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3.	Mercbook
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8.	Avril Noble
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20.	Chas E. Goad
21.	Susanna Fisher
22.	Richard Arkway
23.	Alfieri
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28.	Brendan Moss



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INTERNATIONAL MAP COLLECTORS' SOCIETY
1987 ANNUAL SYMPOSIUM
SATURDAY 20 JUNE 1987

THE SCIENCES OF THE WORLD OF MAPS

For most of us, our interest in maps may be aesthetic, historical or even commercial, but rarely scientific. Yet without the development over many years of several branches of science, neither the making of maps nor their usage, hence their basic purpose and very existence, would be as we know them.

This Symposium examines some fascinating aspects of several of the relevant sciences in the entirely appropriate setting of the Science Museum.

9-45 REGISTRATION

10-15 INTRODUCTION
Helen Wallis

10-20 CHARTING THE SEAS
Andrew David
The invention of the octant and the chronometer in the 18c revolutionised surveying techniques at sea. The scientific approach to chart making adopted in the latter half of the century by Cook in Newfoundland and the Pacific, and by the two Mackenzies around the British Isles, led to the comprehensive surveys of Australia by Flinders and of North West America by Vancouver around the turn of the century. The first Admiralty chart was published in 1800: chart making had come of age.

11-00 SURVEYING THE LAND
Yolande Hodson
The evolution of topographical surveying techniques and equipment was speeded by the impetus of military necessity and led to the mapping of Cassini in France, Roy and the Ordnance Survey in Britain, Rennell in India, and of the American Revolutionary War.

11-40 MEASURING THE EARTH
Jim Smith
Modern geodesy can be said to have its origins in the expeditions to Peru and Lapland that finally determined that the earth is not an exact sphere and is, in fact, oblate. The 250th anniversary of those expeditions is now being celebrated. Brief comments are given on the recorded measures of the figure of the earth up to 1735, and then details of the two major expeditions that included many famous scientific names and resulted in the "flattening" of the earth.

12-20 EYES IN THE HEAVENS
Helen Wallis
Terrestrial globes represent our world as their makers would have expected it to appear, had they been able to view it from the heavens. Celestial globes depict the sphere of the heavens as it would appear from outside the universe. Now satellites record the earth with precision from out in space. The long history of globe making contrasts with the rapid and recent history of the satellite in the scientific depiction of the globe. Globes were first made in ancient Greee and China, but the years from c. 1500 to 1800 were the great age of globe making, achieving the highest degree of artistry and craftsmanship.

1-15 LUNCH
Participants are free to make their own arrangements

2-30 EXPERIMENTS IN ROMAN SURVEYING
Oswald Dilke
How the use of replicas of Roman surveying instruments made for the Wakefield Schools Museum Service was tested, by surveying a 2-iugera (0.504 ha) plot. The discovery of the relative simplicity of this type of surveying and its comparative accuracy when checked against modern methods of survey.

3-15 CLOSE OF SYMPOSIUM
The galleries of the Science Museum will be open to participants until 6-00. To enable everyone to organise their time so as to fit with their individual interests, detailed guides, notes and leaflets are provided. Particularly relevant are the galleries on Navigation, Mapmaking and Surveying, Astronomy, and Exploration.

NOTES ON SPEAKERS

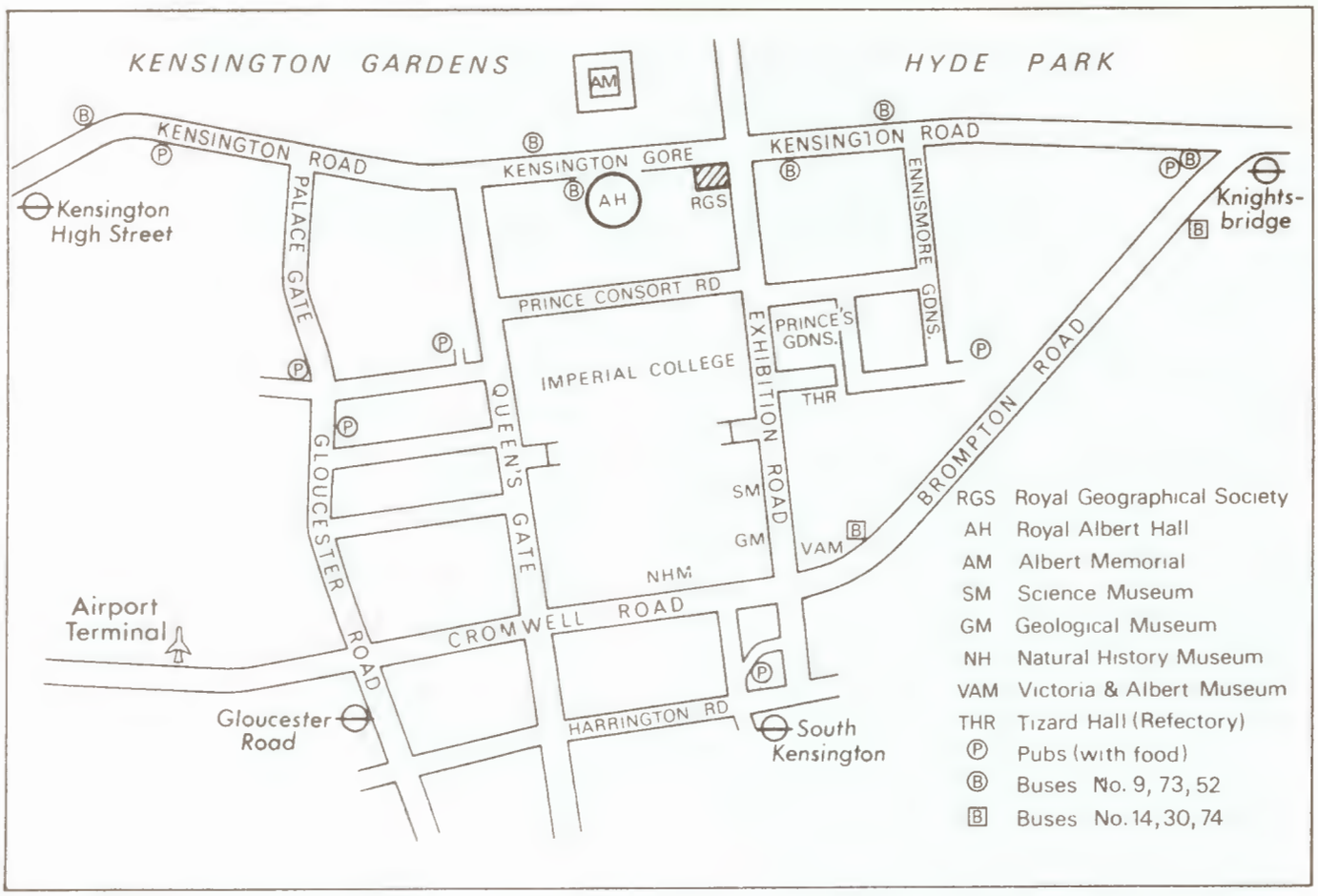
ANDREW DAVID joined the Royal Navy in 1943. Specialising as a hydrographic surveyor in 1947, he has carried out surveys in many parts of the world, latterly as a Lieutenant Commander. From 1961 to 1985 he served in the Hydrographic Department of the Ministry of Defence, with special involvement with the department's archives. He has published a number of articles relating to Admiralty charts and other historical matters and is at present preparing for publication by the Hakluyt Society a fully illustrated catalogue of the charts and coastal views drawn on Cook's first voyage.

PROFESSOR OSWALD DILKE, Educated at Stowe School and King's College, Cambridge.
Postgraduate Student at British School in Athens, 1938-9.
Intelligence Corps, 1940-46.
Lecturer in Classics, Hull University College, 1946-50.
Lecturer in Humanity, University of Glasgow, 1950-67 (1961 and 1962 seconded as Professor of Classics, Rhodes University).
Professor of Latin, University of Leeds, 1967-80 (Emeritus from 1980).
Visiting Professor in Classics, Ohio State University, 1969.
Fellow of Accademia Latina, Rome, since 1975.
Publications include:
The Roman Land Surveyors, 1971.
The Ancient Romans: how they lived and worked, 1975.
Roman Books and their Impact, 1977.
Greek and Roman Maps, 1985.
Contributions to The History of Cartography, Vol. 1, ed. B. Harley and D. Woodward, 1987.

YOLANDE HODSON, Formerly Senior Research Assistant at the Map Library, British Library. Contributor to 'A History of the Ordnance Survey' and author of several papers on British military mapping. Currently cataloguing the Duke of Cumberland's collection of military maps at Windsor Castle. Hon. Secretary of the Charles Close Society for the Study of Ordnance Survey Maps.

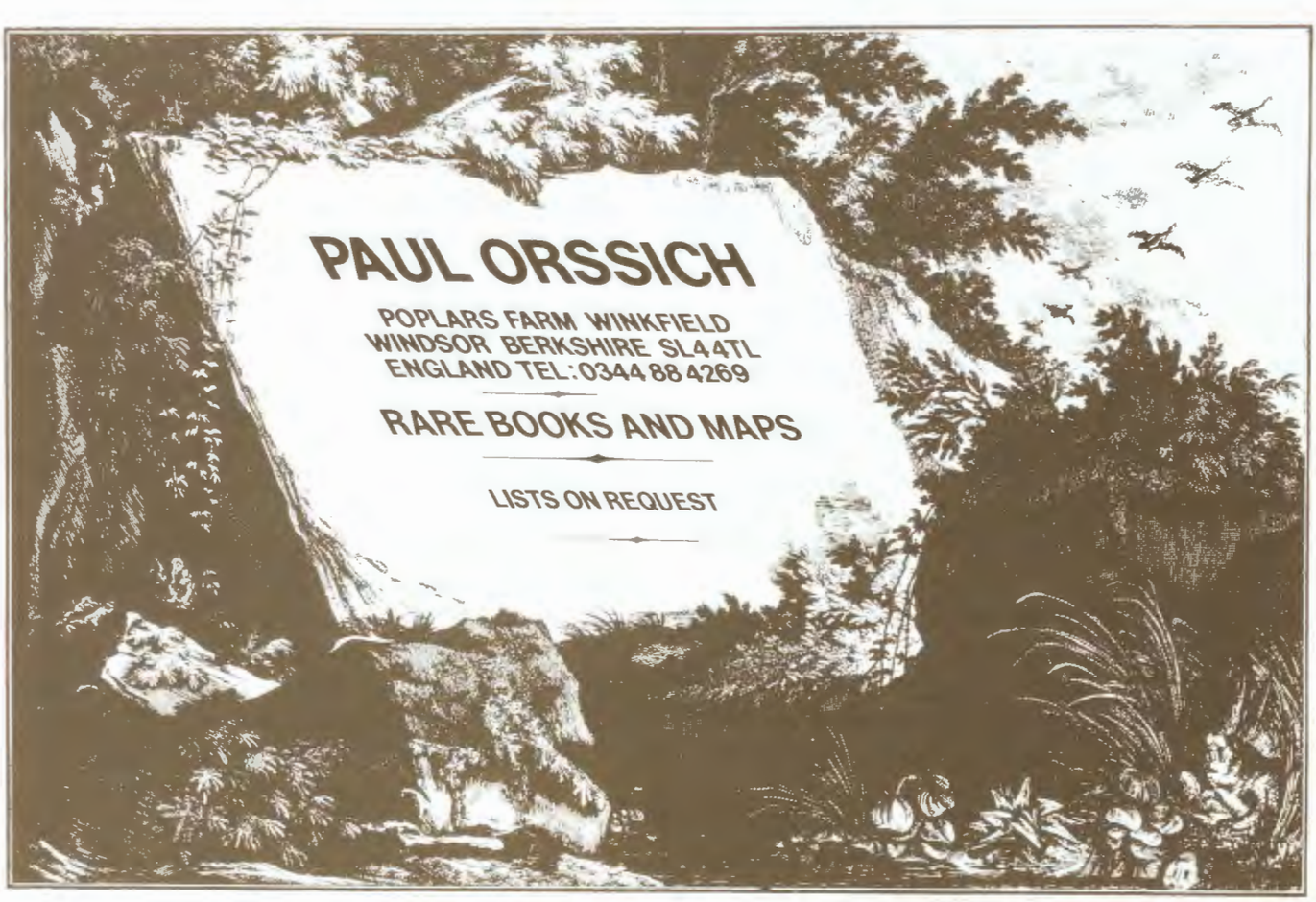
JAMES (JIM) SMITH ARICS FRGS, Principal lecturer in land surveying, Department of Civil Engineering, Portsmouth Polytechnic, where he has been since 1968.
Previously with the Opencast Executive of the NCB; The Hertfordshire County Council; West Nigeria Government and the Mapping and Charting Establishment, Feltham.
Member of the Land Survey Divisional Council of the Royal Institution of Chartered Surveyors since 1967. Chairman of its Technical Advisory Committee.
Member of the Editorial Advisory Group for the RICS Journal 'Land and Minerals Surveying'.
Secretary to Commission 6 (Engineering Survey) of the International Federation of Surveyors (FIG), since 1979.
Member of BSI and ISO committees relevant to site surveying since 1971. Author of numerous papers on land surveying topics and of a book 'From Plane to Spheroid' due to be published early 1987.

DR HELEN WALLIS OBE FSA MA D. Phil (Oxon) Hon. D. Litt. Hon. FLA FRGS recently retired as Map Librarian of the British Library (1973-86), previously Superintendent of the Map Room of the British Museum (1967-73). President of IMCoS. Chairman of the Standing Commission for the History of Cartography of the International Cartographic Association Chairman of the Society for Nautical Research. Past President of the British Cartographic Society. Author of the Roxburghe Club Edition of the Boke of Idrography of Jean Rotz, 1981, and numerous other works and papers on the history of cartography. Now preparing a history of globe making and the use of globes in Great Britain.



SM: Marks the entrance in Exhibition Road to the Science Museum. The Symposium takes place in the Lecture Theatre on the Ground Floor.

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CHARTING THE SEAS 1750-1800

by Lieutenant Commander Andrew David, Royal Navy
formerly of the
Hydrographic Department, Ministry of Defence

'The Lives and Fortunes of Sea-faring Persons, in great Measure, depend on the Accuracy of their Charts'
Murdoch Mackenzie Senior, 1750

There was a great improvement in the standard of hydrographic surveying in the latter half of the eighteenth century. This was due partly to the availability of better navigational instruments and partly to the scientific approach adopted by surveyors such as the two Murdoch Mackenzies and Graeme Spence in the British Isles and by James Cook, Samuel Holland and J.F.W. Des Barres in North America.

The octant, which was invented in 1731, enabled angles up to 90° to be measured accurately at sea, thus enabling navigators and surveyors to obtain their latitude to within a few miles by a meridian altitude of the sun or a star. An improved version of this instrument was introduced in 1759, which could measure angles up to 120°. This was the first sextant and it enabled longitude to be determined to an accuracy of perhaps 45 minutes of arc by observing the angular distance between the moon and the sun or star, a method known as lunar distances. After the successful trial of the chronometer on Cook's second voyage (1772-1775) the surveyor was able to determine his longitude even more accurately. The sextant also proved to be most useful to hydrographic surveyors, enabling them to measure horizontal angles accurately at sea for the first time. It could also be used on land, being more portable and, according to Murdoch Mackenzie Senior, generally more accurately and minutely divided than a theodolite. (i)

The first charts of the British Isles based on a rigid system of triangulation were published in 1750 from Murdoch Mackenzie Senior's survey of the Orkney Islands, carried out between 1742 and 1749. Mackenzie described the method he used in some detail. Beacons were first erected on the summits of all prominent hills and features. A base about 4 miles long was then measured on a frozen lake and its bearing observed with a magnetic needle and converted to a true bearing by applying magnetic variation. Theodolite angles were then observed from both ends of the base to various beacons, and the distances and bearings between them computed. The resulting triangulation was then laid down on a plotting sheet. Mackenzie next observed angles from selected stations into all headlands, points, bays, houses and other prominent features and these too were laid down on his plotting sheet. He then proceeded to walk round the coastline, drawing in by eye the true shape of the headlands and sketching in the remaining coastline, noting the nature of the foreshore as he went along. Boats were then positioned over rocks and shoals, which were then 'shot-up' from shore marks. When Mackenzie had completed the coastal topography in this manner, he went round the coast in a boat taking soundings, paying particular attention to the vicinity of rocks and shoals and in navigable channels. The nature of the bottom was also obtained. Mackenzie does not relate how he fixed the position of his soundings, but it was probably by compass bearings from the boat. Sailing directions were compiled, tidal streams observed and coastal views drawn, all of which were embodied in his atlas. (ii) Subsequently Mackenzie was commissioned by the Admiralty to survey

the west coast of the British Isles and the whole of Ireland. By 1770 he had reached Carmarthen Bay and there his survey ended. His charts were published in two folio atlases, issued in 1774 and 1776.

In retirement Mackenzie published "A Treatise of Maritim Surveying", the first comprehensive manual of hydrographic surveying in the English language. In his manual Mackenzie proposed an instrument he called a station pointer for plotting two simultaneous horizontal sextant angles, thus enabling the surveyor to obtain his position at sea by resection. Using it, a skilled surveyor could now fix and plot his position accurately on his field board at frequent intervals.

The survey of the British Isles was continued by Mackenzie's nephew and namesake Murdoch Mackenzie Junior, who surveyed the Bristol Channel, most of the south coast of England and part of the Thames Estuary between 1770 and 1787, when he was succeeded by his cousin and former apprentice Graeme Spence. The first recorded use of the station pointer was in 1774 during a survey of the north coast of Kent, carried out by Murdoch Mackenzie Junior with the assistance of Graeme Spence, who later wrote "the water work was surveyed by sextant angles between the several fixed objects on land and no compass bearings were used to fix or protract the work". (iii) The wealth of detail on this survey, particularly soundings, demonstrates the significant advance in hydrographic surveying achieved by the introduction of the station pointer. It could however only be used in conjunction with marks which had been accurately fixed and plotted on the surveyor's field board. Compass bearings continued to be used by surveyors to fix the position of soundings in most surveys.

In North America the need for accurate maps and charts became apparent during the Seven Years War. In 1758, the day after the fall of Louisburg, James Cook, the Master of HMS "Pembroke" was sent ashore, where his curiosity was aroused by the behaviour of a man carrying a small square table, supported by a tripod. Every now and again the man set his table down so that he could squint along it in various directions, after which he made notes in a pocket book. Cook discovered that this person was Major Samuel Holland, who was engaged on making a plan of Louisburg and its encampments. Cook expressed a keen desire to be instructed in the use of the plane table, which took place the following day. Subsequently Holland was invited on board the "Pembroke" to meet Captain Simcoe, who had also expressed a wish to see this novel instrument. This chance meeting with Holland seems to have encouraged Cook to carry out a survey of Gaspe Bay the following month. Cook's survey, published by Mount and Page in 1759, is the earliest known example of his work; the original survey has sadly not survived.

The British fleet, including the "Pembroke", spent the winter of 1758-9 in Halifax Harbour where Holland was stationed. Whenever he could be spared, Holland spent his time on board the "Pembroke", where he and Cook constructed a chart of the St Lawrence River in the great cabin, under the supervision of Captain Simcoe, mostly from plans in Admiral Durrell's possession. The resulting chart was sent post haste to England, where it was immediately engraved by Thomas Jeffreys and copies sent back to Halifax prior to the fleet sailing for Quebec in 1759. That same winter, again under Captain Simcoe's eye, Cook studied spherical trigonometry and astronomy from the works of Charles Leadbetter, so that he could be better qualified to carry out further surveys. Cook told Holland, when the two met in London in 1776, that the "Improvements, and Instructions he had received on board the "Pembroke" had been the Sole Foundation of the Services he had been enabled to perform". (iv)

At the end of the Seven Years War, Cook was appointed to carry out hydrographic surveys in Labrador and Newfoundland since accurate charts were needed to safeguard British fishery interests in these waters, following the peace treaty with France. Between 1763 and 1767, Cook surveyed most of the west and south coasts of Newfoundland. A little of Cook's survey methods can be gleaned from his logs. (v) Starting his survey on the north coast of Newfoundland, he "went into the Bay Sacre, Measured a Base Line and fix'd Flaggs on the Different Islands, &c". (vi) Other bays and harbours in Newfoundland were surveyed in a similar manner. However it would have been totally impracticable for Cook to triangulate the whole of the coast of Newfoundland and Labrador. He therefore had to use less rigorous methods for most of his survey. However he would have landed on all prominent headlands and observed theodolite or sextant angles from them to adjacent headlands and other prominent features, observing at the same time magnetic bearings by azimuth compass. He would also have obtained the latitude of some of the headlands by means of meridian altitudes and observed for magnetic variation from time to time. Then knowing the difference of latitude between the two headlands and the true bearing between them he could, if necessary, calculate the distance from one to the other. However this method would only be reasonably accurate if the headlands were roughly north/south. Cook could also measure a base by a method called 'sound ranging'. A gun fired from one headland would be observed from another, and the time interval between the flash and the report measured. Then using the speed of sound through the air (1142 feet per second), the distance between the two headlands could be calculated. Cook probably obtained longitude by observing the occultations of the moons of Jupiter, since his survey was carried out before the introduction of either lunar distances or the chronometer. However in 1766 he obtained the longitude of the Burgeo Islands by observing an eclipse of the sun, which brought him to the attention of the Royal Society. The positions of the soundings taken by Cook were fixed by cross bearings taken by magnetic compass, the only method open to him. Thus while Cook was able to base small parts of his survey on rigid systems of triangulation, for the remainder he was forced to adapt his methods to fit the terrain. Much of the skill of surveyors of the eighteenth and nineteenth centuries was in making similar compromises. How well Cook succeeded in Newfoundland is clear from the many people who have attested to the accuracy of his charts. A later surveyor, Captain H.W. Bayfield, when resurveying Red Bay on the coast of Labrador wrote in his journal on 9th August 1833 "Cook's Plan of this Bay as well as of Chateau Bay is excellent." and again on the west coast of Newfoundland he wrote on 27th June 1835 "I found Cook's Survey of Cod Roy Isl'd, Cape Anguille & coast adjacent extremely accurate . . .". (vii)

In 1764, Holland was appointed Surveyor General of the Province of Quebec and the Northern District of North America. His primary task was that of a land surveyor. He did however carry out extensive and accurate surveys of the coastlines under his jurisdiction. Holland had for a time the assistance of HMS "Canceaux", Lieutenant Henry Mowat, for offshore work. Some of his surveys however carry notes stating that for lack of naval assistance the shoals and soundings could not be completed. Bayfield also commented on Holland's work, writing, "Of the various charts of the St Lawrence which have hitherto been in use, those of Major Holland, re-published by Des Barres in 1778, are the least inaccurate, yet the least in general use". (ix)

J.F.W. Des Barres, a flamboyant character, was a former army officer employed by the Admiralty to carry out hydrographic surveys in North America.

Cook and Des Barres probably met in Halifax in the winter of 1758-9 and it is known that when Cook was Master of HMS "Northumberland" he assisted Des Barres in carrying out a number of surveys. Later, while Cook concentrated on Newfoundland, Des Barres worked in the Gulf of St Lawrence and Nova Scotia and down the eastern seaboard of what is now the United States. Des Barres's surveys, incorporating those of Holland and others, were published as "The Atlantic Neptune" in 1777, with further issues up to 1781. No two issues are identical, but 182 separate charts and coastal views have been identified in the collection in the National Maritime Museum. Des Barres described his survey methods in some detail in a letter to Lord Colville (viii), which shows that they were very similar to those used by Murdoch Mackenzie Senior and Cook. Whilst Des Barres's charts were a great advance on their predecessors, their quality did not measure up to Cook's work in Newfoundland. Bayfield in particular was very critical, pointing out that there were numerous "errors and omissions" in Des Barres's charts and in particular "the soundings are generally incorrect". (x)

Cook's survey work in Newfoundland came to an end in 1768 when he was appointed in command of HMS "Endeavour" to carry a scientific party from the Royal Society to Tahiti to observe the transit of Venus, after which he was to explore the South Pacific. On all his Pacific voyages Cook had to use less rigorous survey methods than those he had adopted in Newfoundland, particularly for his surveys of New Zealand and Australia. Cook realised that it was more important to explore as great a length of coast as possible with a reduced degree of accuracy rather than exploring in detail a shorter length, leaving large portions of the coast unexplored. To do this, Cook adopted a procedure known as a running survey, described by John Robertson in one of the standard navigational manuals of the day. According to Robertson, in order to make the necessary observations it was necessary either to anchor or lie to as steadily as possible, and . . .

> Then while the vessel is in a stationary situation, take, with the azimuth compass, the bearings in degrees of such points of the coast, as form the most material projections, or hollows; write down these bearings, and make a rough sketch of the appearance of the coast, observing carefully to mark the points whose bearings were taken with letters, for the sake of reference. (xi)

Successive 'ship stations' were occupied about every 10 miles, when the same procedure was carried out, the distances between stations being obtained by log. The work was plotted as the survey progressed and adjusted whenever it was possible to obtain the ship's latitude by a meridian altitude of the sun. Soundings were taken and inked in on the ship's track to complete the picture. Cook's technique, combining the survey procedures he used in Newfoundland with those advocated by Robertson, produced surprisingly accurate charts of New Zealand and Australia, bearing in mind the short length of time he spent on the coasts of these two countries.

On his third voyage, Cook delegated much of the survey work to William Bligh, the Master of the "Resolution". Bligh's running survey of the North Pacific is of a similar accuracy to those carried out during Cook's first two voyages. Bligh had few opportunities to carry out extensive survey later in his career, but he was instrumental in passing on his skills to Matthew Flinders, whose surveys of Australia carried out at the turn of the century made a significant contribution to the development of that country. Cook also passed on his hydrographic skills to George Vancouver, whose monumental running survey of the North-west coast of America was perhaps the greatest hydrographic survey carried out in the eighteenth century.

The skills of these eighteenth century surveyors set a standard in chart making for their successors in the nineteenth century to follow. It is perhaps no co-incidence that 1800 saw the publication of the first Admiralty chart, which later that century was to become a byword of reliability, when navigators were said to put their faith in God and the Admiralty chart.

NOTES

(i) Murdoch Mackenzie, Senior, "A Treatise of Maritim Surveying" (London 1774), pp. 28-29.
(ii) Murdoch Mackenzie, "Orcades or a Geographic and Hydrographic Survey of the Orkney and Lewis Islands" (London 1750).
(iii) G. Spence, "Nautical Descriptions of the Banks and Channels in the Thames Estuary" (1804).
(iv) Contained in a letter, dated 11 January 1792, from Holland to Governor Simcoe, son of Captain Simcoe; Metropolitan Toronto Library manuscript.
(v) Public Record Office, Adm 52/1263 (seven books).
(vi) R.A. Skelton, "James Cook Surveyor of Newfoundland" (San Francisco 1965), p. 14.
(vii) Ruth McKenzie (ed), "The St Lawrence Survey Journals of Captain Henry Wolsey Bayfield", Vol I (Toronto, The Champlain Society 1984), pp. 256 and 349.
(viii) Public Record Office, Adm 1/482, letter dated May 1765.
(ix) W.H. Bayfield, "Sailing Directions for the Gulf and River St Lawrence . . ." (London 1837), p. 2.
(x) Ibid.
(xi) J. Robertson, "The Elements of Navigation", 2nd edition (London 1764), p. 460.

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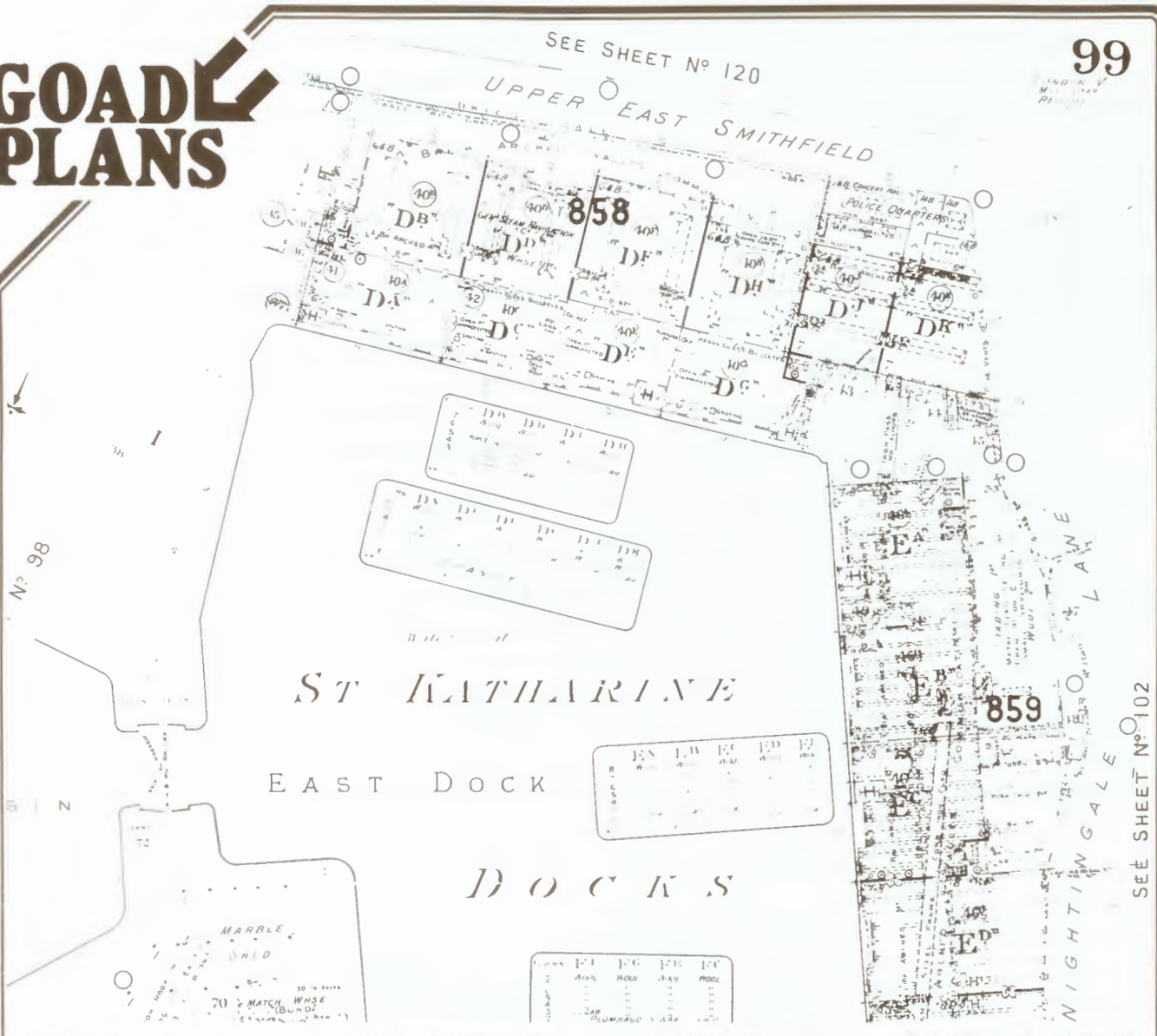
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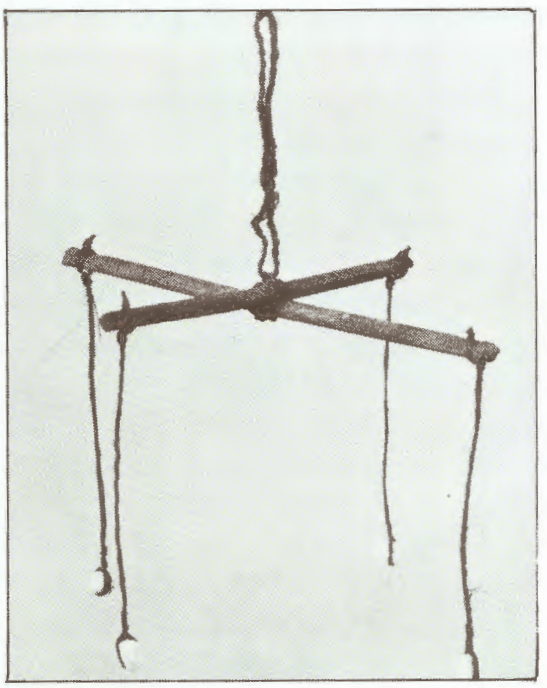
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GRAECO-ROMAN SURVEYING INSTRUMENTS

by O.A.W. Dilke

We have three sources for our knowledge of instruments used or thought to have been used by surveyors in the Greek and Roman world: artefacts preserved or partly preserved; ancient reliefs showing instruments; and descriptions or allusions in ancient treatises. It is also possible to deduce what instruments were used in preparing maps, plans or blue-prints. Among the more interesting in the last category is the recently interpreted series of architectural incised drawings to scale at the temple of Apollo at Didyma in Asia Minor.

Sighting instruments were, to the best of our knowledge, (a) three types of cross: the surveyor's cross; the simple ancient cross-staff; and the cross-staff with angle bracket; and (b) the dioptra. Although the nomenclature of the first three is not certain, the first was probably called in Greek *asteriskos* ("little star") and the second in Latin *stella* ("star"), while it is the third that was probably known as *groma*.

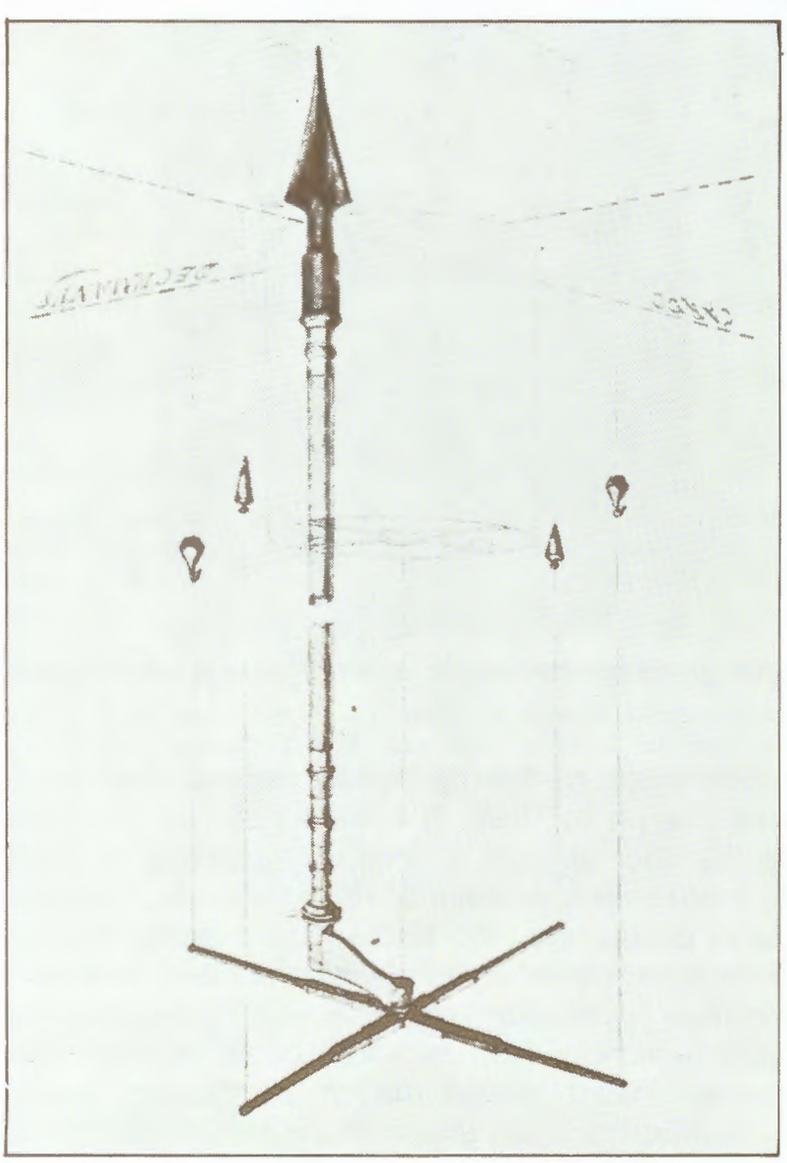


Asteriskos *(surveyor's cross) of the Ptolemaic period, found in the Fayyûm, Egypt.*

A very simple *asteriskos* of the Ptolemaic period, 3rd-1st century BC, was found in the Fayyûm, Egypt, in 1899. It consists of two pieces of palm-leaf rib dovetailed and tied together at right angles with palm fibre cord, which served also to suspend the instrument. At each of the four ends, though not preserved, were plumb-lines and plummets. We know that a *stella* was used by Roman surveyors, because it appears in stylised form on two reliefs. The first is the tombstone of L. Aebutius Faustus at Ivrea (ancient Eporedia), north Italy. It is of the 1st century AD and describes him as a freedman, *mensor* and *sevir*, and his wife as a freedwoman. Freed slaves under the Empire constituted a large percentage of the qualified artisan class. *Mensor*, literally "measurer", means any type of surveyor, while *sevir*, literally a member of a committe of six, is a title of distinction conferred by the local authority for services rendered. In this case

the local authority was the Roman colony of Eporedia, which is known to have had its territory centuriated. On the tombstone the surveyor's cross is shown detached from the staff, and two out of four plumb-bobs are also shown separately. The second of these memorials is a small one found at the Porta Nocera necropolis, Pompeii, in 1956. This stele of Popidius Nicostratus, of the 1st century AD, has a relief of the staff surmounted by a surveyor's cross in plan. The metal parts of what is thought to have been a similar instrument were found at Pfünz, near Eichstätt, Bavaria. It consisted of a rigid iron cross with a hole at the intersection, each of the four arms being turned downwards at right angles and with a nail at each end, perhaps to hold a square wooden frame. The iron staff fitting through the hole is only 35.5 cm. long, so may have been made to insert into a pointed wooden base.

Despite the multiple evidence of these simpler types, the likelihood is that none of these was what the Corpus Agrimensorum, which assembled treatises on Roman land surveying, calls *groma* or more generally *ferramentum*, "iron instrument". Instead this may have been the type of cross-staff with angle bracket whose metal parts were found at Pompeii in 1912. The central part of its cross was of rigid iron, so has been preserved; it originally enclosed four wooden arms. Four plumb-bobs from it, in two differently shaped pairs, are preserved. Under the cross was an angle bracket, whose curved iron supports are extant. The base of this bracket fitted into a bronze collar set into the top of a



Reconstruction by M. Della Corte of the groma *found at Pompeii.*

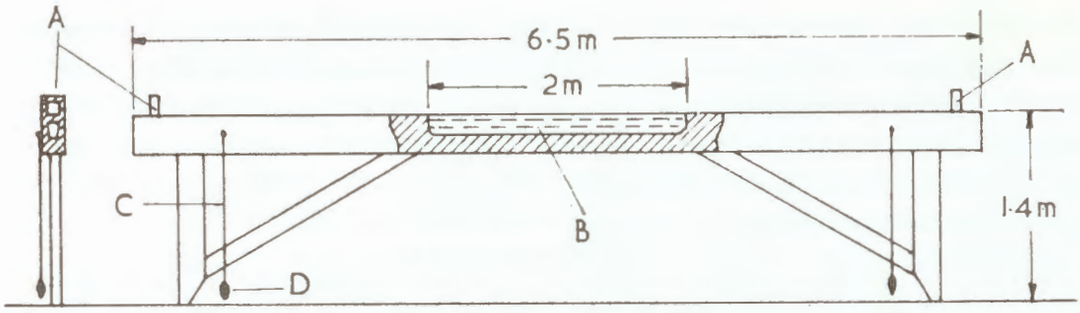
wooden staff; only the fluted iron shoe of this is preserved. The height of the staff is not known, but may have been about 2 metres. The object of the angle bracket was probably twofold: (a) to enable the iron shoe to be fixed in the earth surrounding a centuriation stone, so that the point of origin would be under the intersection of the arms; (b) it enabled the *groma* to be more flexible, since sighting was not obstructed by the staff.

The *groma* is frequently mentioned in the Corpus Agrimensor and a later name for *agrimensores* (literally "land measurers") is *gromatici*. In addition, we are told that there was in Roman army camps an area known as *locus gromae*, "place of the *groma*". Whether this instrument was used for other forms of Roman surveying, such as road, aqueduct, building and town-planning, is uncertain. It was particularly suitable for the squares or rectangles of land apportionment known as *centuriae*. The commonest size of these was 20 × 20 *actus*. The *actus*, literally "a driving", originally denoted the distance that oxen pulling a plough would be driven before turning, and as a measure it was 120 Roman feet. The commonest measure for the Roman foot was 29.57 cm., so 2,400 Roman feet, the usual length of a side of a *centuria*, amounts to 709 m 68, or slightly less under the late Roman Empire. Actual measurements on the ground vary between 703 and 711 m. The unit of area for land was the *iugerum* (0.252 ha.); 2 *iugera* formed a *heredium* ("heritable plot"), but this went out of use early as a unit of measurement; and 100 *heredia* formed a *centuria*. Hence the standard "century" was not quoted as 100 *heredia* but as 200 *iugera*.

Our knowledge of Greek sighting instruments comes from a comparatively late source, Hero(n) of Alexandria, the mechanical engineer and inventor, who probably wrote in the 1st century AD. He claimed not to have invented his *dioptra* but to have perfected it, and indeed Alexandria had been in the forefront of Greek mathematics ever since its foundation. Despite a gap in his text, we can with the help of a manuscript sketch reconstruct it as a sophisticated instrument either for surveying or for astronomical observation. The base could serve equally well for the *dioptra* as for a leveller. By means of two worm-gears engaging in toothed wheels, the orientation and elevation could be finely adjusted as the technician took his sights across the circular revolving table which formed the upper part of the instrument. It is perhaps not surprising that, although Vitruvius guardedly recommends the use of the *dioptra* for the levelling of water-channels, it is nowhere mentioned in the writings of the Roman land surveyors. Presumably it would have been too heavy and complicated for their specific purposes in the field.

Ancient levelling equipment was based on water-levels or on a combination of these and plumb-lines. The Romans used a Greek instrument, not Hero's but what was known as a *chorobates*. Vitruvius viii.5.1 describes this as being about 20 Roman feet long, and as having a water-channel 5 feet long in the centre. Alongside the legs were plumb-lines and plummets, and lines drawn across the cross-struts showed if the plumb-lines were upright. At the same time, by sighting from one end to the other, one could see whether the water was at the same level at each end. Vitruvius maintains that a slight curve on the water surface, due to the curvature of the earth, was unimportant. The drawbacks of the *chorobates* were that it was very cumbersome and did not measure gradients.

The land surveyors used as a measuring-rod the *decempeda* or *pertica*, a wooden rod 10 Roman feet (2 m 95.7) long. The word *pertica* literally means pole, and the now obsolete English perch takes its name, though not its measurement of 5½ yards, from it. Metal end-pieces of the *decempeda* have

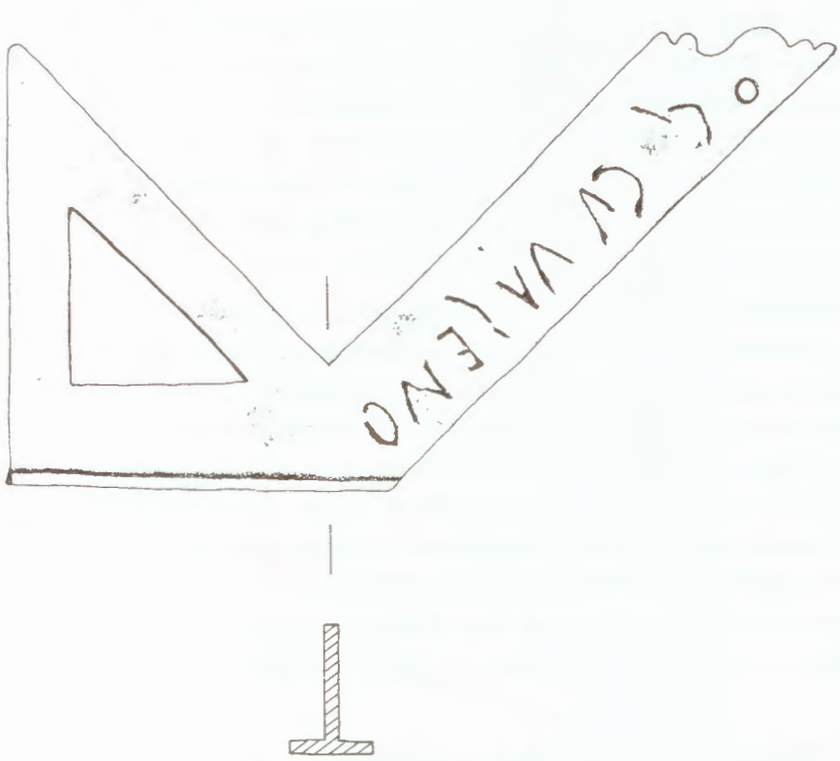


Reconstruction of a chorobates. *The suggested measurements do not correspond to those of Virtruvius.*

been found at Enns, north Austria, and at Pompeii. For longer distances Hero mentions the use of waxed ropes, such as may be seen on dynastic Egyptian wall-paintings. For shorter distances a one-foot ruler was used, sometimes one that folded in two: examples have been found in bronze, iron, bone and horn. A pattern of the standard foot was kept at the temple of Juno Moneta on the Capitoline Hill in Rome, which served also as a mint; hence the foot was called *pes monetalis.* Regional variants were a Ptolemaic foot of 12½ Roman feet and a *pes Drusianus,* used in Germany and parts of Gaul, of 13½ Roman feet.

In addition to measuring-rods, land surveyors needed stakes, so that the assistant could by fixing them in the ground help the surveyor to sight a straight line. Either these stakes or specially cut ones could serve the *cultellatio,* literally "cutting with a knife", i.e. "step-levelling" to obtain the horizontal equivalent.

Various set-squares (*normae*), mostly used by building surveyors, have been discovered. One such, bearing the name of its owner, was found in Watling Street, Canterbury, in 1978. Compasses and dividers were not uncommon, and there is in the British Museum a pair of proportional compasses with a ratio of 2:1, which may perhaps have been used in map-making. Hyginus Gromaticus

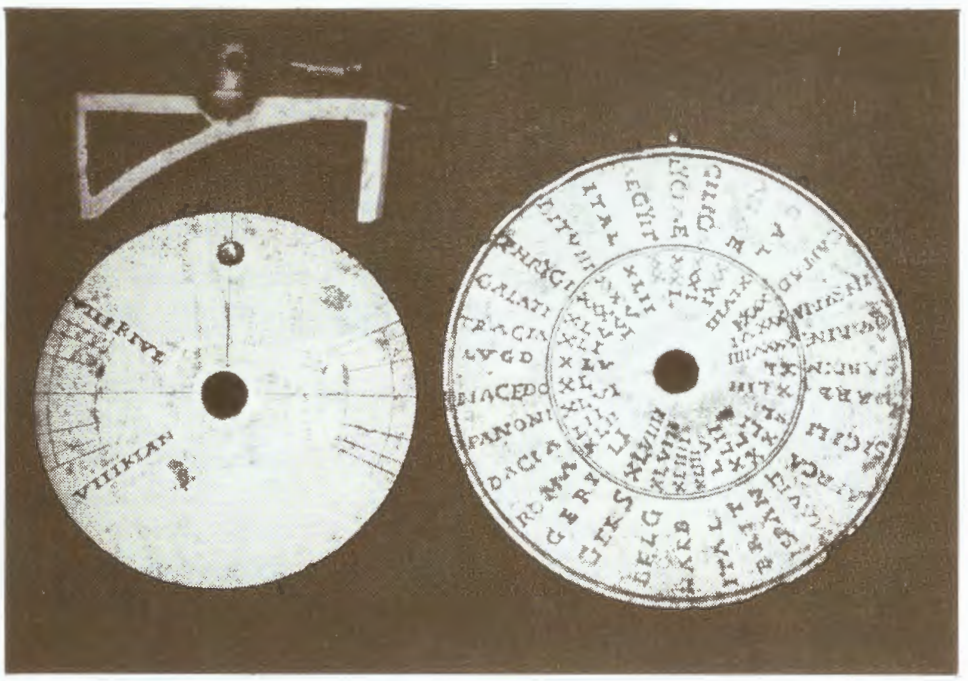


Roman norma *(set square) found in Watling Street, Canterbury.*

tells us that it was the duty of land surveyors to make two copies of a survey map of every area centuriated by them, one to be kept locally and one to be deposited in the Tabularium, record office, in Rome.

For orientation the gnomon was used, the usual procedure being to draw a circle round it, mark the points where the sun's shadow entered and left the circumference, join these points and bisect the line, when south would lie in a straight line from centre through the point of bisection. A more complicated method, involving solid geometry, is mentioned by Hyginus Gromaticus.

It was also possible to use the sundial to indicate south, as well as time. The workshop of Verus at Pompeii contained a rectangular ivory box, serving (a) to contain small objects, (b) when used with a small gnomon, as a portable sundial, (c) on one side, as a measure. It therefore seems likely that surveyors



Roman portable sundial, Oxford Museum of the History of Science: (a) gnomon, (b) face, with dates 8 days (inclusive) before January 1 and July 1, (c) reverse, with names and latitudes of provinces. The latitude figures, XXX-LX in tens, here not shown are on the obverse surrounding the face.

used also the vertical type of portable sundial probably invented in the 2nd century AD. A good specimen of this is to be seen in the Oxford Museum of the History of Science; it is said to have been found near Bratislava, and may be of the 3rd century AD. On the back are the mean latitudes of the provinces of the Roman Empire. From these, one position would be set on the front, for example 57° (as given) for the mean latitude of Britain, while another pointer would be turned to the correct season. Thereupon when facing the sun directly the gnomon would throw the sun's shadow more or less correctly on a curved hour recorder with six lines, for double use before and after noon.

Finally, the materials for writing up reports were mainly the wax tablet and stylus, used for notes, and the papyrus roll and ink for more permanent purposes, papyrus being replaced by parchment or vellum from the 3rd century AD. For survey maps, either the same materials were used, or if a more permanent material still was thought desirable, it was either bronze or stone. Bronze maps are mentioned in Greek and Roman sources, including the map of the Persian Empire quoted by Herodotus and the reference to the Rome record office. Many fragments of cadastral maps of the Roman colony of Arausio

(Orange) are preserved in stone, while those of the city plan of Rome, Forma Urbis Romae, are in marble. These have survived, while bronze was melted down, either when survey maps were regarded as obsolete or in the course of civil wars or barbarian invasions.

Although ancient treatises on surveying survived the Dark Ages, Roman surveying instruments did not. Nevertheless, there are obvious parallels between them and the *Italian squadro* illustrated in Ludovico Perini, *Geometria pratica* (Venice, 1757).

Suggested Reading

F. Blume, *et al.*, ed., *Die Schriften der römischen Feldmesser*, 2 vols. (Berlin, 1848-52 and reprint).

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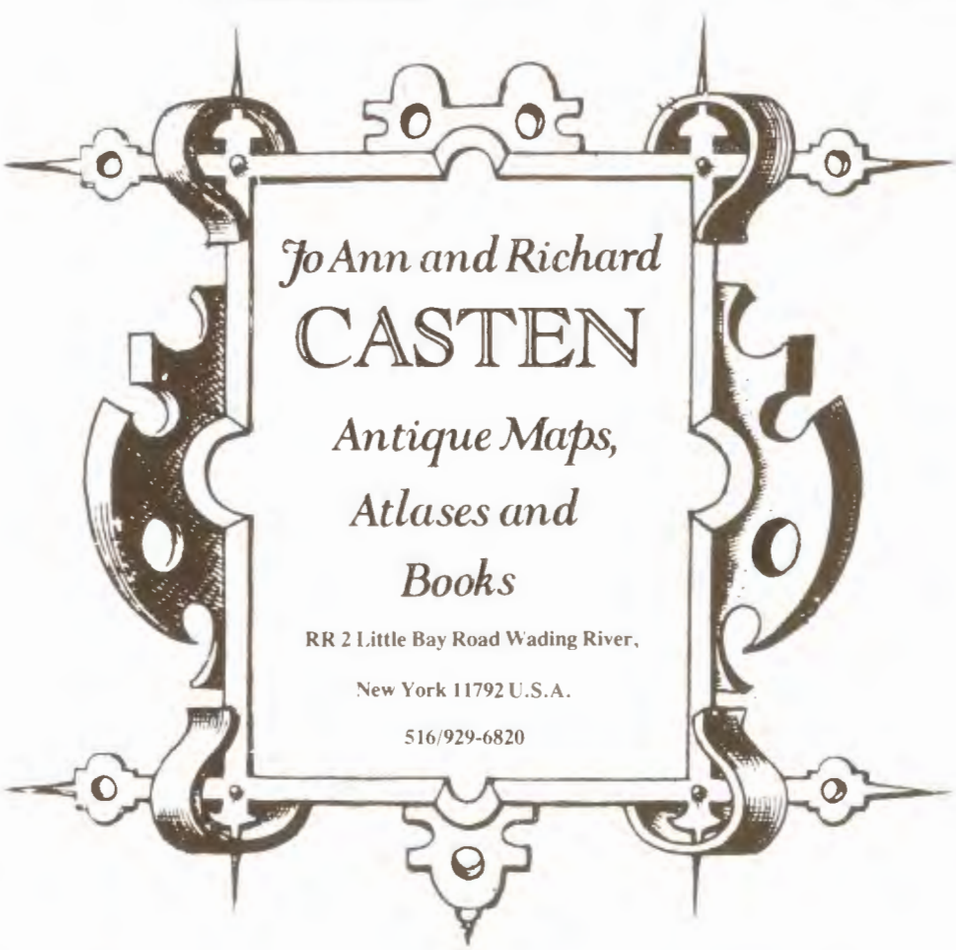
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THE FIGURE OF THE EARTH UP TO 1750

J.R. Smith, ARICS

Geodesy is closely tied to the figure of the earth and refinements in the parameters are a continuing pre-occupation of the geodesist. There is a constant requirement for improvements to keep in step with the ever increasing demands of science. Nowadays however satellites and computers are among the tools used and the investigator can be virtually office bound. What of the past and how did this branch of science have its modern beginnings?

If the starting point is taken as far back as the 9th century BC then one finds references to the earth as a convex disc, a short cylinder, a rectangle and various other shapes. It was not until Aristotle c.350 BC that there was a general belief that the earth was some sort of spherical shape.

It is not at all certain that the earliest suggestions of a sphere were based on anything more scientific than the idea of the time that since a sphere was considered to be the perfect shape so the earth must be that shape. Doubters still existed in the 6th century AD but as with the flat earth society, they were not given much credence.

The earliest estimate of the earth's size is credited to Aristotle with a value of 400,000 stade for the circumference. Little is known about the origins of the figure, whether it was measured or only a guess, whether it was Aristotle's or borrowed from some earlier observer, and even the length of the stade is open to doubt. In fact there were several values in different areas and at different times varying from the equivalent of 157 m to 210 m.

Eratosthenes

The best known personality of that period in the context of arc measurement was Eratosthenes c.200 BC. As with Aristotle, so again there is doubt expressed by some authorities as to whether or not the observations were his own or only reported by him. Aside from that doubt however, the work formed the basis of all arc measurements up to modern times. The principle of requiring the difference of latitude between two points on the same meridian, and the distance between those points survived 2000 years. However while the principle may have endured, the methods of evaluating the unknowns changed considerably.

The angular length of the arc is generally reported in terms of the angles of elevation of the sun at the summer solstice at Syene and at Alexandria. That at Syene was based on the heresy that at the solstice the sun shone directly into a deep well and gave no shadow. That at Alexandria was measured using a scaphe, or hemispherical bowl with central stylus or gnomon casting a shadow onto graduations inside the bowl. In theory fine, but obviously peppered with sources of error.

The linear length of the arc is variously referred to in terms of travellers estimates, in terms of camel days journey or as a figure supplied by the Royal Road Surveyor. Whilst neither can be considered of great worth it is surprising how constant the speed of a camel is over long distances. Analysis on several expeditions in different regions each gave values near to 2½ British miles per hour or around 100 stade per day's travel.

From his results of 7° 12′ and 5,000 stade he calculated the circumference as 250,000 stade; a figure he modified by +2,000 stade to make it readily divisible by 60!

Posidonius

After Eratosthenes the next measure (or estimate) was by Posidonius who was Head of the Stoic school. During his many travels he is said to have noticed that from Rhodes the star Canopus just touched the horizon whereas at Alexandria its meridian altitude was 7½° (= ¼ of a sign of the zodiac). The distance of 5,000 stade from Rhodes to Alexandria could only have resulted from mariners estimates irrespective of which value of the stade was used.

The calculated circumference is then 240,000 stade. Errors of over 2° were inherent in the angular value of the arc in addition to a longitude difference of the same order.

I Hsing

After the Mediterranean, interest turns to China. Around 724 AD the Buddhist monk I Hsing was responsible for a meridian line through China. It stretched for 11,400 li (about 5,700 km) on the 114°E line. He used 8 ft high gnomons and the lengths of the shadows they cast to check the long held belief that for every 1,000 li one travelled north or south the shadow length changed by 1 Chinese inch. Actually it was found to be nearer to 4 inches.

There were 9 (or 11) gnomons depending on how much credibility is placed on the remoter points. Even so serious doubts have been cast on the validity of the observations and it woud appear that some of the values were possibly extrapolated rather than measured. The accepted result was for 1° = 356.39 li (= 157.52 km).

Al Mamûn

About 820 AD the Caliph Al Mamûn, who was later to found an observatory in Baghdad, requested his astronomer to measure an arc on the Plain of Sinjar (near Baghdad). In fact there would appear to have been 3 or 4 such measures although the various accounts are somewhat confusing.

It is suggested that the method used was for there to be two measuring parties who started from a central point. One party then went northwards and the other southwards until each had gone 1° according to its astronomical observations. This they did by periodically observing the altitude of Polaris until the value had changed by 1°. One of the few portable instruments for such work at that time could have been the astrolabe.

As for the linear distance, so there is once again confusion as to how it was determined. One reference says that ropes were used, another that horses were used and yet a further one that it was by wooden rods. Whichever it was the results are given as 1° = 56⅔ Arab miles (or 111.07 km) although there is also some uncertainty as to the length of the Arab mile.

Fernel

There is no further recorded measurement until 1525 when Jean Fernel observed an arc from Paris to Amiens. He began by observing the meridian altitude of the sun near Paris by using a triquetrum and then travelled north towards Amiens until he judged that he had covered the equivalent of 1°. This had taken him 4 days but the arc was a little less than a degree and he had to travel on again to achieve his target. The distance between the terminals he derived from the 17,024 revolutions of a carriage wheel. The length found for 1° was 68 Italian miles 95¼ paces (111.29 km).

Up to this time the distance between the terminals was in every case measured directly by some means or other.

Snellius

Triangulation arrived in the 16th century. Although the idea was first suggested in 1533 by Gemma Frisius the scheme shown in the diagram he supplied with his writing was not observable. He did however put forward various principles relating to observing that still maintain today.

The first observations were probably those by Tycho Brahe in Denmark but for a chain of any importance one must refer to Willibrord Snellius and his work in Holland around 1620. His is the name also connected with the first use of resection. In a publication at the time he considered himself as the Dutch successor to Eratosthenes.

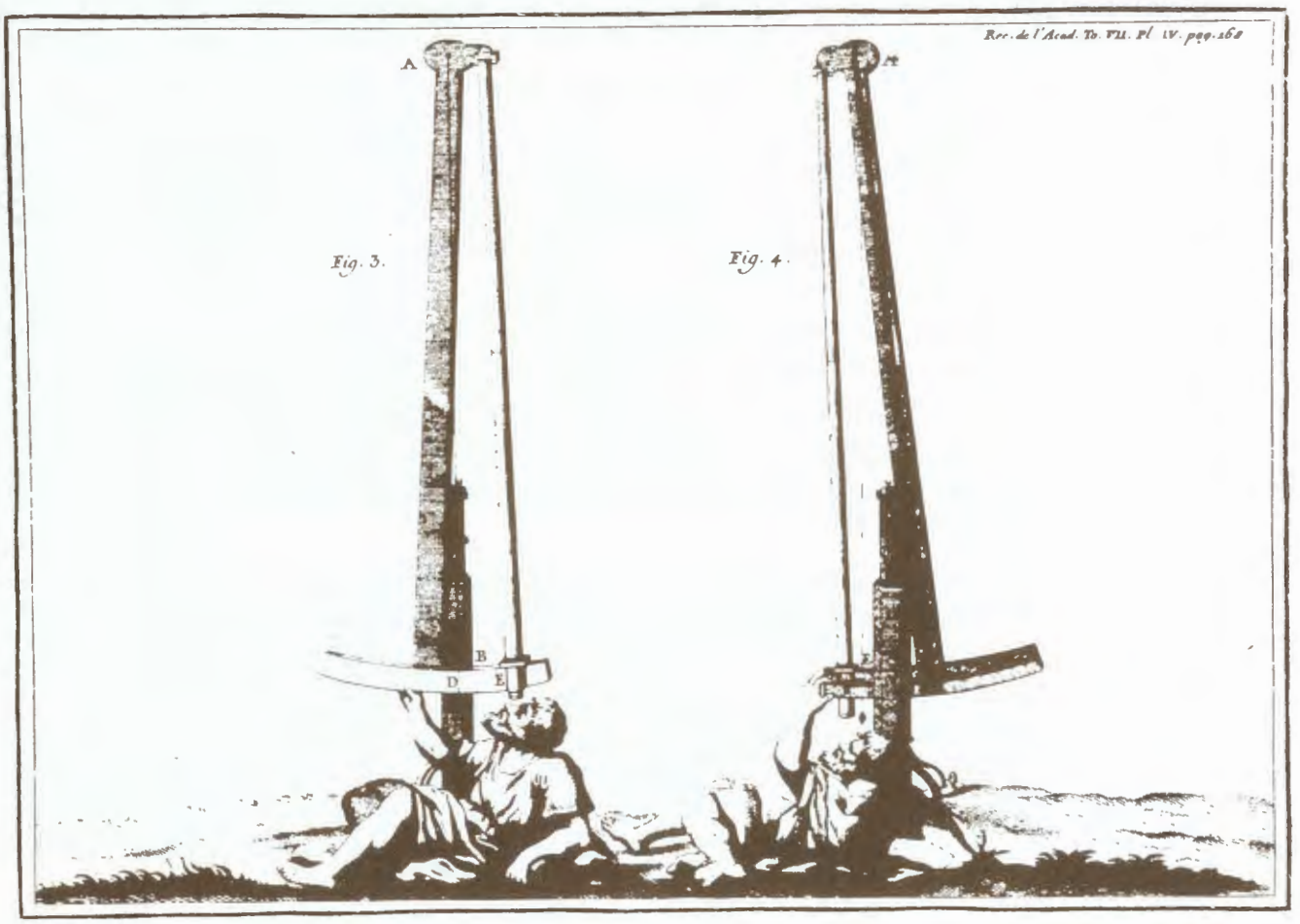
Besides observing a triangulation chain he also incorporated the use of base extension figures. He had 5 base lines that were measured with a chain but all were short – ranging from 393 to 1,780 m.

For the latitudes and azimuths Snellius used an iron quadrant of some 5½ ft radius. The arc was 1°11′ and the mean of his results gave 1° = 28,500 Rhynland perches. (= 107.29 km)

Norwood

Ten years after Snellius, Richard Norwood made the first recorded arc measure in England but instead of using triangulation he reverted to measuring the arc length directly. Whether or not he would have known of the work of Snellius is uncertain.

In 1633 he used a 5 ft radius sextant to observe the meridian altitude of the sun at the Tower of London. Two years later he made similar observations at York. The difference in latitude was calculated as 2°28′ but no apparent corrections were applied for changes in declination, refraction or parallax.



The zenith sector was used to make astronomical observations to obtain differences of latitude.

The distance was measured with a chain of 99 ft and some pacing with allowance made for deviations from a straight route and for slope.

The result was 1° = 367,196 English feet. (= 111.87 km)

Riccioli and Grimaldi

An Italian attempt at arc measurement in 1645 was doomed to failure by lack of appreciation of the effects of refraction. The Jesuits Riccioli and Grimaldi used triangulation to determine the distance between two elevated points. However they then determined the vertical angle of each point from the other and from them derived a value of 19′ 25″ for the arc length.

The calculated length of 1° was about 64,000 Bologna paces (119.82 km) but this is normally rejected in any serious discussion of the figure of the earth.

Picard

L'Abbé Jean Picard, who helped found the French Academy of Sciences in 1666, observed an important triangulation in 1668 between Paris and Amiens. He employed 17 triangles to connect two baselines over an arc of 1°23′. The bases were of 5,663 toise (11,037 m) and 3,902 toise (7,605 m) and were measured with wooden rods each 2 toise (3,898 m) long.

For the angles he used a 38 inch radius quadrant and for the astronomical observations a zenith sector of 10 ft radius and limb of 18°. The result was 1° = 57,060 toise (111.21 km)

The controversy

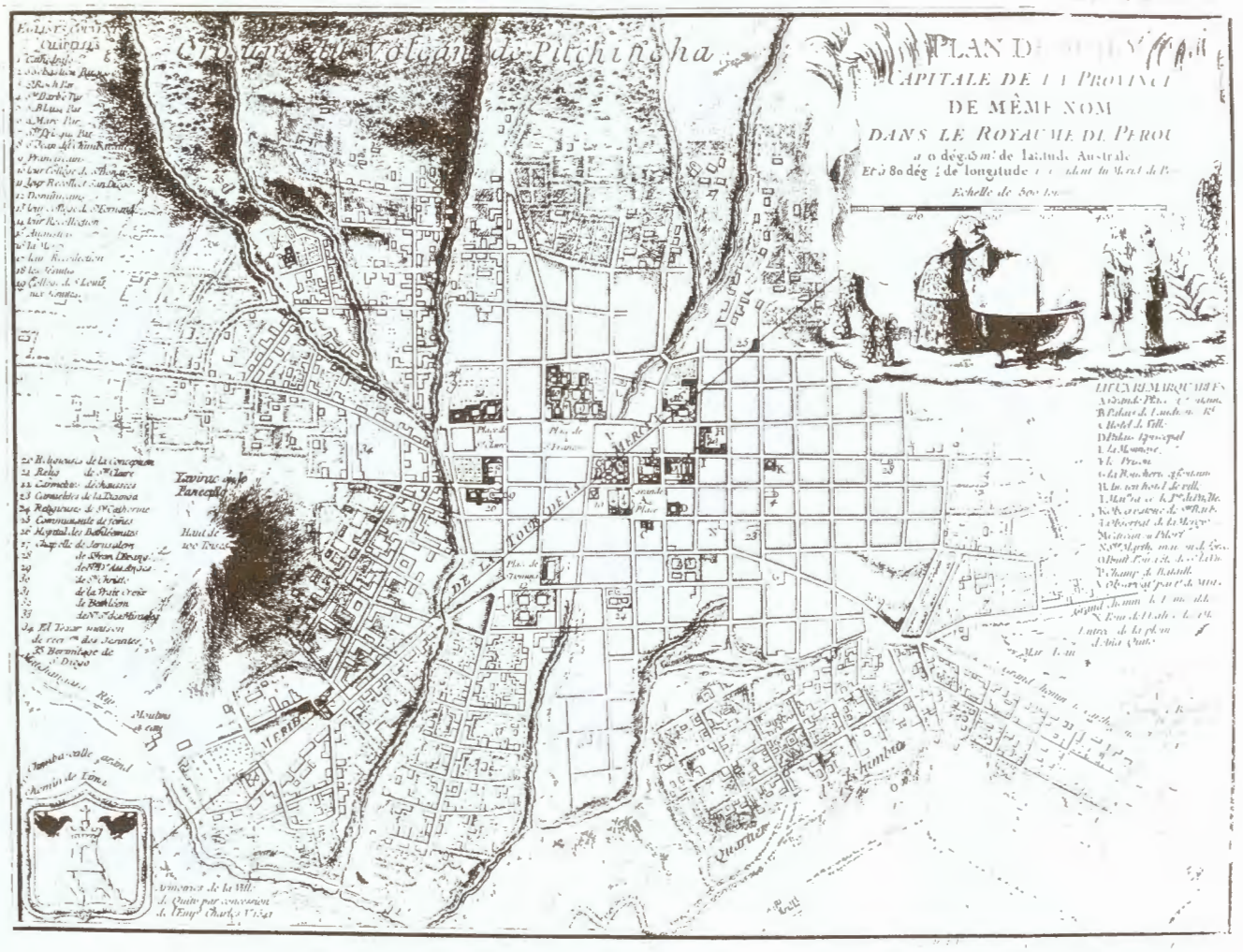
In the 1680s Newton was preparing the contents of his 'Principia'. Among the pronouncements he put forward in it was one where by using the results of Picard's work he was able to demonstrate that the figure of the earth ought not to be exactly spherical. He maintained that the equatorial radius should be longer than the polar radius in the ratio 230 to 229 i.e. that the length of a degree increased from the equator towards the poles to give an oblate spheroid.

Now soon after this the Cassinis were active in France measuring five arcs in different areas, with different instruments and with different methods. All the results were consistent in that they all inferred a prolate figure of the earth. With such evidence from many years work was it any wonder that they considered Newton to be wrong?

Before any advance could be made towards settling the controversy methods and instrumentation had to be improved. Telescopes, micrometers, thermometers and barometers were all in their infancy as were log tables and the methods of circle graduation. So small was the flattening that instrumental and observational errors could, when expanded over a degree of arc, give a completely false impression.

By the 1730s there were several rising mathematicians and scientists leading French scientific activity and among these was the young Charles-Marie de la Condamine. In 1733 he put forward the suggestion that an expedition should be mounted to measure an arc of the meridian as near the equator as possible. At about the time that that idea came to fruition another French scientist Pierre Louis Maupertuis suggested that a second expedition should be sent as near the pole as possible such that the separation of the two geographical locations was as large as practicable and hence any variation in degree length similarly large.

The controversy should be settled once and for all.



Plan of Quito compiled by those on the Peruvian expedition. Dated 1741. By M. de Morainville.

The Peru expedition

This expedition under the 3 French Academicians Pierre Bouguer, Charles-Marie de la Condamine and Louis Godin sailed from La Rochelle on 16 May 1735. At Carthagena in Colombia they were joined by two Spanish naval officers Jorge Juan and Antonio de Ulloa. This was a political necessity since the area of survey was then under Spanish control.

The survey work started from a baseline of 6,273 toise (12,226 m) on the Plain of Yarouqui near Quito which was measured with two sets of 3 wooden bars each 20 ft long.

A series of 33 triangles ran more or less due south to another base of 5,259 toise (10,250 m) at Tarqui near Cuenca. All triangulation stations were at elevations of more than 7,000 ft and some were at 14,000 ft.

The angles were by cast iron quadrants of 3 ft radius and all results were initially reduced to the level of the lowest base line terminal since at that stage there was no connection to sea level. Such a connection was later made in a very tenuous manner by Bouguer.

The observations were completed by 1743 and the results gave an arc of 3° 07′ 01″ or 1° = 56,750 toise (110,606 m).



Map of the location of the "Lapland" arc. It straddles the R. Tornea on the present Sweden-Finland border.

The Lapland expedition

This expedition left Paris on 20th April 1736 under the leadership of Pierre Maupertuis who was accompanied by such well known personalities as Alexis-Claude Clairaut and Anders Celsius. Theirs was a much smaller scheme of only 8 triangles and far lower hills, – the highest was 335 m. The site straddled the River Tornea at the north end of the Gulf of Bothnia.

They measured a single baseline of 7,407 toise (14,436 m) and this was on the frozen surface of the River Tornea during the Christmas period of 1736. Wooden rods were used as in Peru and the quadrants and sector carefully calibrated. There is some doubt as to whether or not allowance was made for the slope of the ice surface and whether the bars were supported on trestles or laid directly on the ice. Temperatures during base measurement fell to as low as −37°R (= −46°C) on the last day.

The mean arc length was 0° 57′ 29″ or 1° = 57,438 toise (111,947 m).

What of the outcome of these expeditions?

At the Equator	1° = 56,750 toise	(= 110,606 m)
At the Polar Circle	1° = 57,438 toise	(= 111, 947 m)

The earth was flattened and Newton vindicated. Within 50 years the work led to the acceptance of a standard unit of measure for international use – the metre; and modern geodesy was born.

Reference

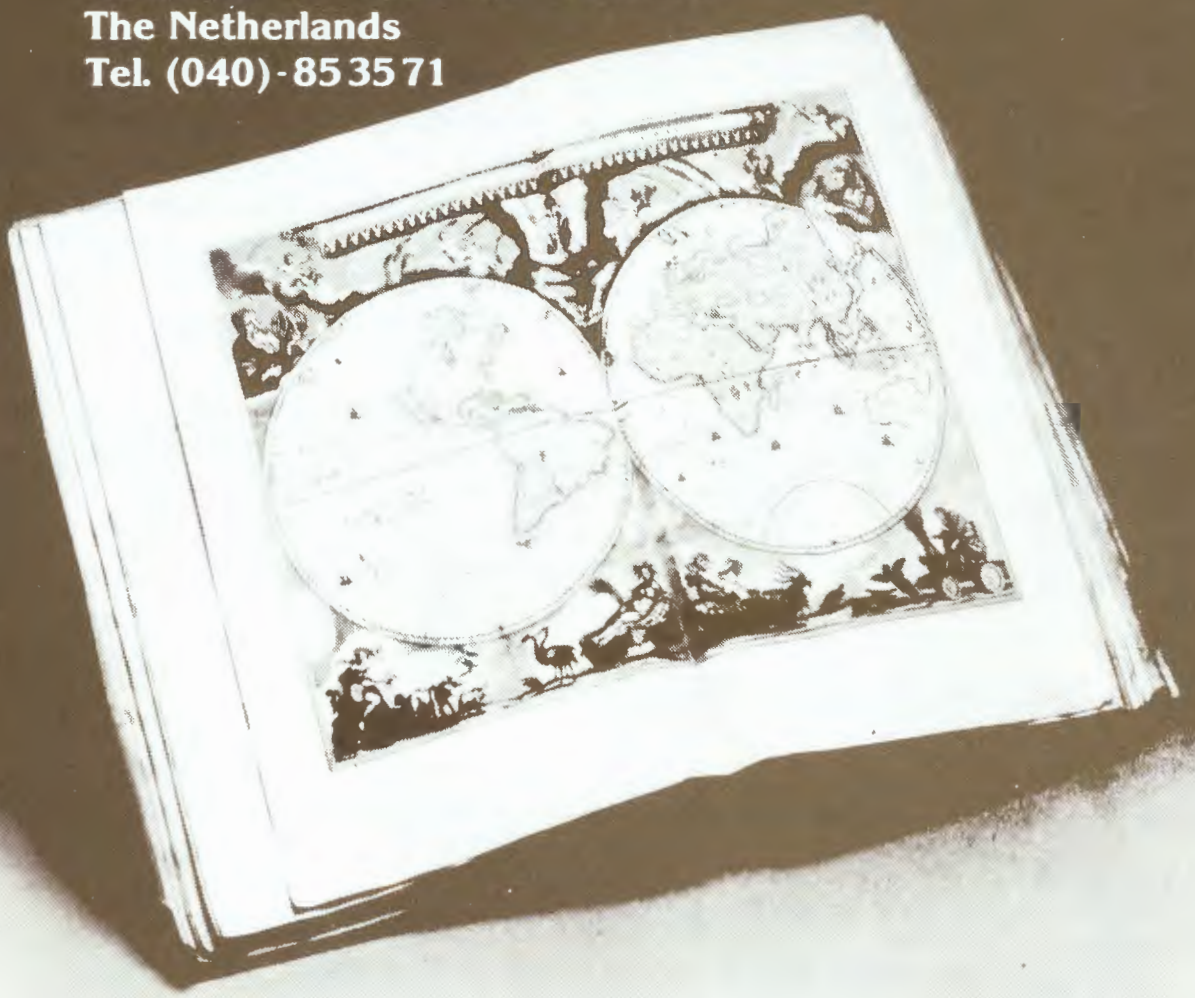
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EDWARDS'S TRIGONOMETRICAL LAND CHART

By Alan Bartlett

The illustrations will be on display at the Map Fair

1817. Published by J. Edwards, Brompton, Middlesex. Engraved by Edwards. Scale approx. 1 inch to 3 miles. 560 × 275 mm. Oriented halfway between North and the then Magnetic North.

The triangulation of South East England started by Roy at Hounslow Heath was completed and the link to the French triangulation made in 1787. Thus ended the last scientific survey he undertook before his death in 1790, the forerunner of triangulation of the whole of Great Britain and Ireland and the mapping of the Ordnance Survey.

It must be borne in mind that the county maps of the 18th century incorporated errors of as much as 15 per cent. To produce accurate maps on the scale of 1 inch to 1 mile selected by the Ordnance Survey, it was essential "to cover the country with a network of accurately observed triangles; the rays joining hilltop with hilltop, or where there are no hills, church-spire with church-spire or tower.

Many are the churches and cathedrals that have been, in this way, pressed into the service of geography. Remarkable scaffolding was erected, for instance, over the dome of Saint Paul's, . . ."

Edwards's Chart is entirely practical, rather than decorative, with its basis and function well described: "In which the Situation of CHURCHES and other remarkable Objects are deduc'd . . . THE Distances of the Objects are calculated to a Single Foot from the Grand Stations and by a very correct Scale pricked down upon the Copper Plate itself with the assistance of a Magnifying Glass by which means this CHART though on a small Scale will be found much more correct than any MAP executed in the usual way, though on the largest Scale ever yet Published."

The Chart marks "Gen. ROY's Base Line" and "Hornsey Hill Base" to the north of London. It features Greenwich Royal Observatory and the Observatory near Kew: close by is depicted a "remarkable object", namely the Pagoda in Kew Gardens, while in London, between crude representations of St Paul's and the Tower, is another unmistakeable landmark: the Monument to the Great Fire of London.

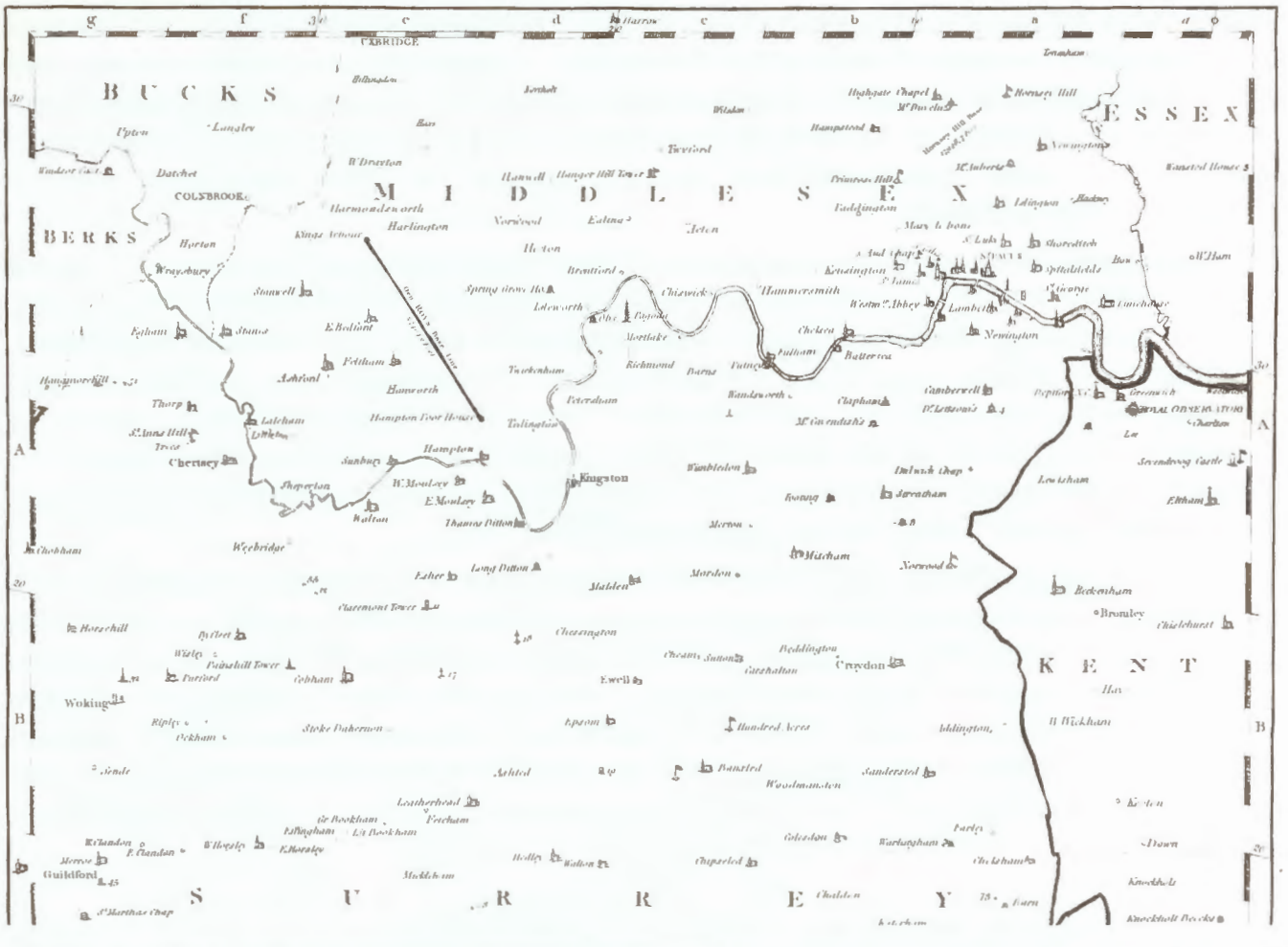
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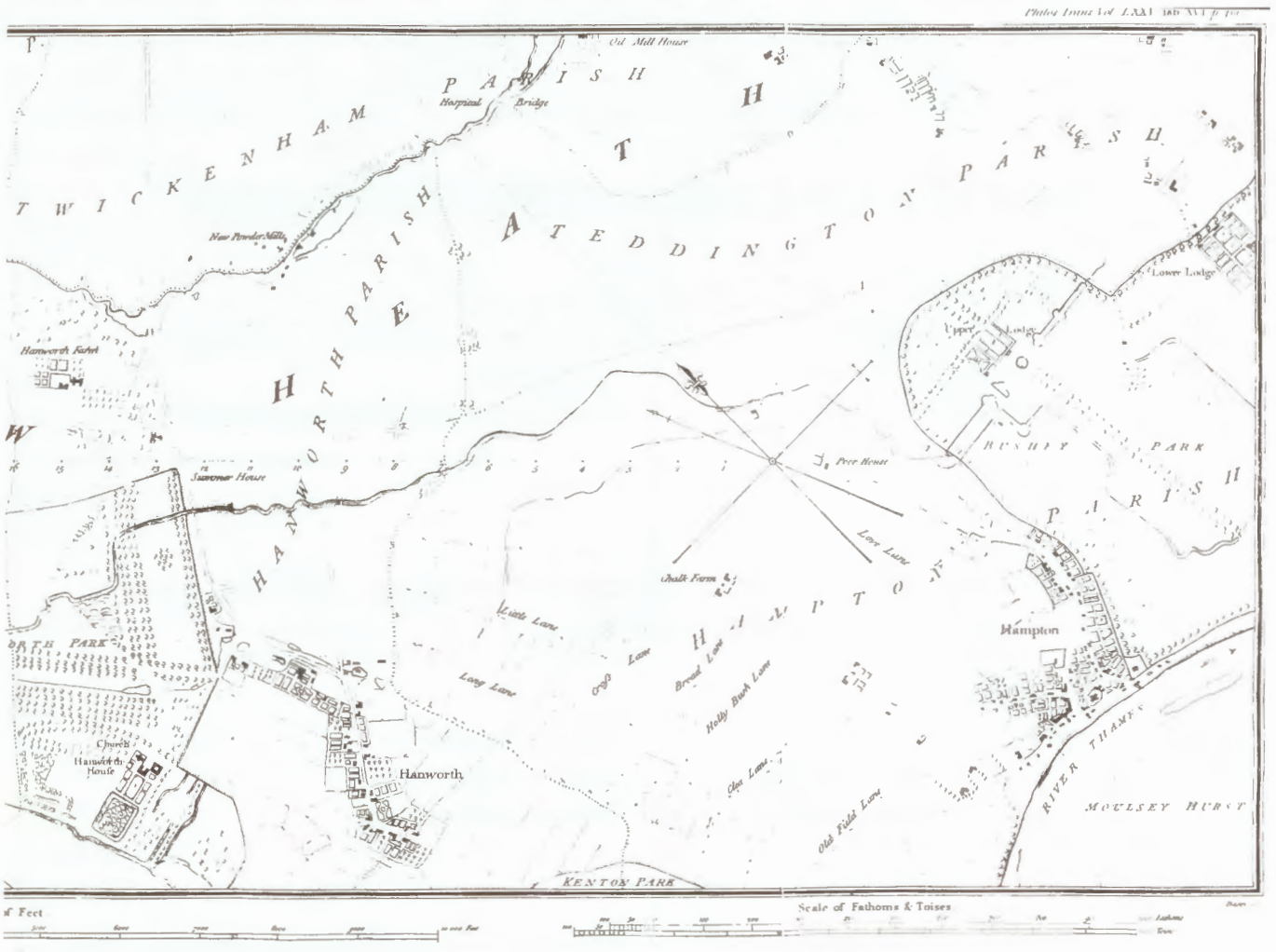
Charles Close, *The Map of England* (London, Peter Davies, 1932)

PLAN OF THE BASE MEASURED ON HOUNSLOW HEATH

1785 From the Philosophical Transactions of the Royal Society, Volume LXXV. Engraved by Basire. Scale approx. 4 inches to 1 mile. 200 × 640 mm.

In 1783 Cassini, Director of the Paris Observatory, proposed a triangulation of South East England, which linked to the French triangulation, would accurately position the Greenwich and Paris Observatories relative to one another. The


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Holly Bush Lane
Old Field Lane
RIVER THAMES
MOULSEY HURST
KENTON PARK
Scale of Fathoms & Toises
Feet

project was entrusted to General William Roy, who began with the measurement of a base on Hounslow Heath, west of London. It was measured three times, first with a hundred foot chain, then with twenty foot deal rods, and finally with glass rods, to give a length of 27,404.72 feet. Roy justifiably claimed that "There never has been so great a proportion of the surface of the Earth measured with so much care and accuracy."

Roy read this paper "An Account of the Measurement of a Base . . ." to the Royal Society in 1785, and it was published in Philosophical Transactions in the form of a detailed description of the instruments amd methods he had used, together with a plan showing the exact course of his base line. He had chosen the site believing it to be suitable also "for extending different serieses of triangles from there in all directions to the remotest parts of the Island" to provide for an "accurate survey of the British Dominions", thus initiating his right to the description: "father of the Ordnance Survey."

The Heath he used, while long a notorious haunt of highwaymen and a site of military manoeuvres because of its barren nature and flat aspect, was for the same reasons ideal for his needs. Others before and after found it so. Typically reflecting his interest in Roman military history, Roy clearly marks across his plan the "Roman Way from Staines to London." Although most of the district covered by his plan is now heavily built up, one area remains unusually flat and barren. The starting point for his base was close to Heath Row village and Field, now totally obliterated by the giant international airport.

Reference

Yolande O'Donoghue, *William Roy 1726-1790 Pioneer of the Ordnance Survey* (London, B.M. Publications, 1977)

NOTICE OF COMMITTEE MEETINGS

Oak Room
The Farmers Club
3 Whitehall Court
London SW1A 2EL

5.30 pm

(Embankment Underground)

Committee Meetings are held monthly and overseas representatives visiting London are welcome to attend.

1987:

Tue. 14 July
August: no meeting
Wed. 9 September
Tue. 13 October
Wed. 11 November
Tue. 8 December


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adapted to Mons.r BUACHE's Memoire
wherein are represented all the known LANDS
which traverse the GLOBE, from the NORTH POLE.
Read at the R. Academy of Sciences.
The Superior Hemisphere of the Globe
of Projection; but it was not thought proper
it would have given the several Countries
bounded by the Equator, as done according to the rules
to follow them for the inferior Hemisphere, because
a very different figure from what they really have
ANTARCTIC LANDS OF THE GREAT SEA
ANTARCTIC LANDS OF THE INDIAN SEAS
ANTARCTIC LANDS IN THE OCEAN
SOUTH CONTINENT
New Holland
Holy Ghost Land
St Croix I.
Lord Solomon
Equator or Equinoctial Line
Tropic of Cancer
NORTH SEA
PACIFIC SEA
GREAT SOUTH SEA
INDIAN SEAS
Maldivian I.
Plain of Africa
Plain of South America
Equinoctial Line or Equator
Tropick of Capricorn
SOUTHERN OCEAN
First Meridian
Cape of Good Hope
Cape of Circumcision
Terra del Fuego
Magellan's Streights
Cape Horn
Madeiras
Cape Verd Is.
C. Tagri
Maldivia
Abyssinia
Arabia
Persia
India
Japan
Formosa
Philippines
Moluccas
Sumatra
Java
Borneo
Celebes
New Guinea
Solomon's Is.
Marquis Is.
Archipelago of Amsterdam
Terra Australis
Terra del Fuego
Cape Horn
Cape of Good Hope
Cape of Circumcision

A PHYSICAL PLANISPHERE wherein are represented all the known LANDS and SEAS w^th^ the Great Chains of Mountains w^ch^ traverse the GLOBE from the NORTH POLE adapted to Mons^r^. BUACHE's Memoire Read at the R. Academy of Sciences.

By Alan Bartlett

Published by the Gentleman's Magazine for March, Engraved by B. Cole. 320 × 290 mm.

Philippe Buache, 1700-1773, was successor to De l'Isle as Premier Géographe du Roi. A creditable cartographer, he turned to speculative theories in the field of physical geography which, having no basis in rigorous scientific methods, were both controversial and in fact, erroneous. His speculative approach was scarcely surprising for that period, since the Académie des Sciences had still not accepted Newtonian principles by 1757, and, on the other hand, public interest in scientific matters was more in terms of amusement than learning.

The article in the Gentleman's Magazine, which this map accompanied, was for popular consumption. Avoiding a scientific challenge to accepted religious belief, it suggested "Upon the retiring of the waters of the general deluge, the points of the highest mountains . . . were probably the first that appeared . . . if it had pleased the divine will to have drained away all the water . . . the continents . . . would be united . . . by the summits of those hills which in their present state are always hid under the waters."

Buache held "That the globe of the earth is held together by divers chains of mountains, which traverse the sea, as they do the land, and probably conduce to confirm the solidity of the globe." While he accepts that "To survey the universe in such a state, the waters must be completely annihilated, which is a thing impossible; yet however such a spectacle be denied to corporeal eyes, it is not so to the eyes of the understanding." Buache confidently placed himself in the latter category and created his maps accordingly.

This English version map, apart from illustrating his speculation about the location of marine mountain chains and valleys, has some interesting features reflecting the contemporary state of geographical knowledge and concepts. Notable are the massive gulfs of the sea reaching far inland from the coastline of N.W. America; also the existence of a vast southern continent suggested, but not indicated on this projection, by the inscriptions: ANTARCTIC LANDS IN THE OCEAN, OF THE GREAT SEA and INDIAN SEA, respectively.

An explanatory sub-title indulges the idea that on a flat surface can be shown the "real" shapes of countries by means of a particular projection, but not by others: "The Superior Hemisphere of the Globe bounded by the Equator, is done according to the rules of Projections; but it was not thought proper to follow them for the inferior Hemisphere, because it would have given the several Countries a very different figure from what they really have."

See also: Helen Wallis, *A Banquet of Maps* (The Map Collector, September 1984, No. 28). P.8: illustration of and comment on another map by Buache dealing with his theory of "Chaînes de Montagnes Marines."

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THE TRIANGULATION OF A HARBOUR SURVEY

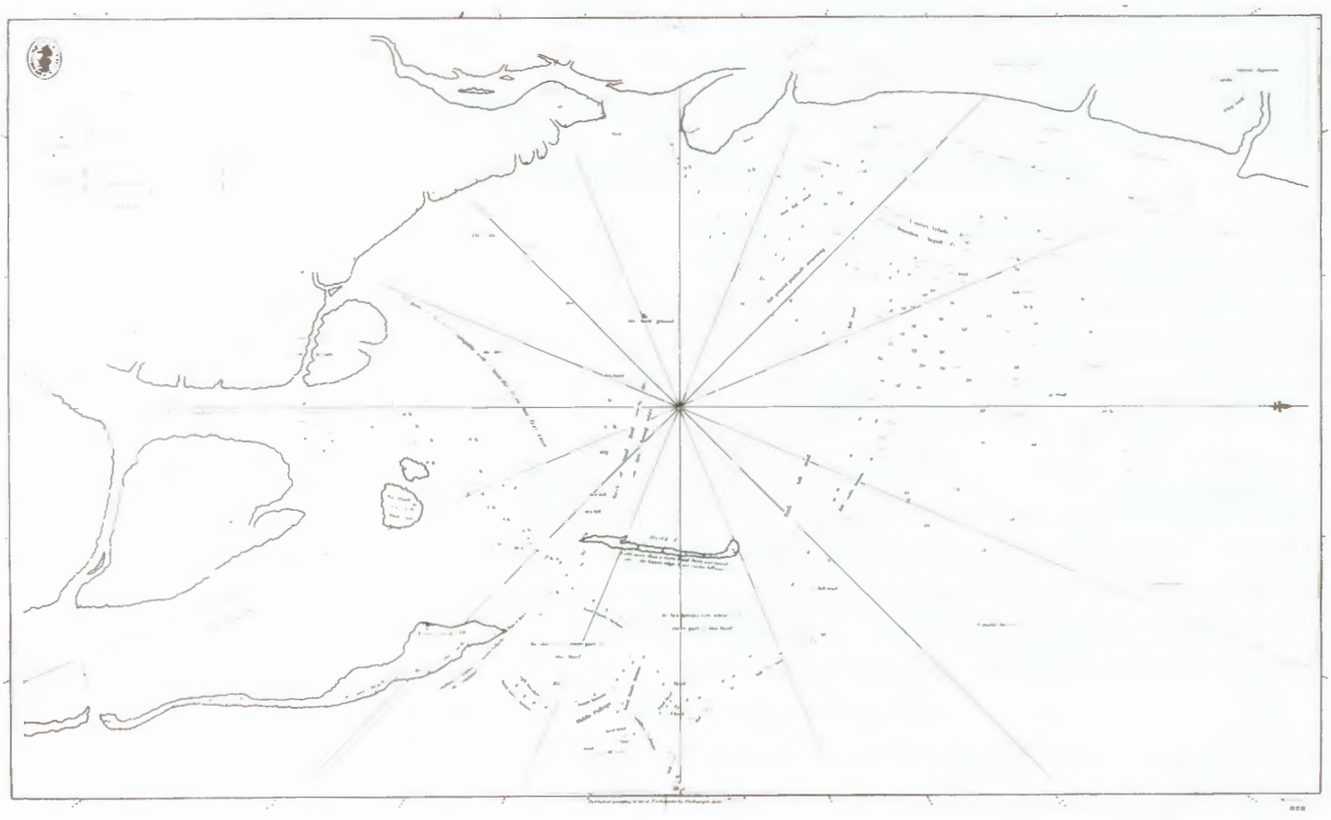
By Susanna Fisher

It is rare to find a published map or chart showing evidence of the surveyor's working methods as in general such information is superfluous for the end user of the map and would only detract from its clarity.

Michael Topping's chart, "A TRIGONOMETRICAL SURVEY of the BAY of CORINGA" published by Alexander Dalrymple in 1791, is an exception. Topping's base line of 1543 fathoms and the fourteen stations set up from it which he used for his triangulation are all shown on the finished chart. On land the lines between the stations are shown complete, though over the sea where they might be broken. There are also numbers along some parts of the coast, probably secondary stations that Topping used to put in his coast line.

The chart is fixed for latitude, with latitudes of four of the survey stations given. The longitude of one of them, Point Gardewar (Godavari), is also given. Ironically this longitude, the more difficult observation in the 18th century, is more accurate than the latitudes which are a surprising 10 miles south of their actual positions.

Coringa (Cocanada) Bay was the best anchorage on the east coast of India. Unlike Madras Coringa was relatively free from surf and had a navigable river mouth with the only wet dock on the coast. Topping was the East India Company's surveyor, and it was becuse of the importance of Coringa for refitting Company ships that the survey was ordered. This example of the chart is a late printing after it was taken over by the Admiralty. It was still being offered by the Admiralty, without correction, in the 1840's.



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BOOK REVIEWS

International Directory of Map Dealers. (s.1): The Map Collector Publications (1982) Inc. and International Map Collectors' Society, (1986).

Published jointly by the Map Collector Publications (1982) Ltd. and the International Map Collectors' Society (IMCoS), the *International Directory of Map Dealers* is indeed "a handy pocket-sized reference for people travelling in either their own country or abroad", just as its compilers had hoped it to be. Measuring roughly 8¼ inches by 3¾ inches, this 64 page directory lists 304 names of map dealers and can be placed easily in a handbag or suit-pocket for safe-keeping. Arranged alphabetically by country and business name, the entries include the address, telephone number, proprietors' name, hours of work and catalogue availability. The entries are broken down further by country and major city for Great Britain and by state for the United States. The type-set is clear and the layout attractive, with illustrated advertisements sprinkled throughout the volume. However, while the directory is international in scope, there are 109 map dealers listed for Eire and the United Kingdom, 95 for the United States, and 14 for Canada which leaves 87 entries for remaining countries. Perhaps this fact merely indicates that map dealers in the United Kingdom have a large piece of the market. In any case, the compilers hope that other map dealers will submit their names for subsequent editions.

As a first attempt, the *Directory* is a useful source and can be purchased from Map Collector Publications (1982) Ltd., 48 High Street, Tring, Herts HP23 5BH, England; however at £3.50 (roughly $6.00 Cdn.), it is not inexpensive. It is to be hoped that the binding for the second edition is more than the two staples which barely hold this plump volume together.

Nadia Kazymyra-Dzioba,
National Map Collection,
Public Archives of Canada.

This review first appeared in Association of Canadian Libraries Bulletin.

Exploration and Mapping of the American West[1]. Published by Speculum Orbis Press. 1986. Size 155mm x 235mm. 182pp with 28 black & white illustrations, cloth bound. ISBN 0-932757-01-4.

Comprising eight selected essays this book describes in a cartographic sense 'How The West Was Won', in essence it deals mainly with the important historical period commencing with the Louisiana Purchase of 1804 through to the war with Mexico to fix the South Western border in 1848. The essays describe in some detail the more important explorations, surveys and routes for Waggons and Railways. It commences with an overview of the early maps of the 15/1600s, followed by the early Spanish explorers, and finally into the real detailed surveys of the 1800s. The authors give us an insight into the people, the terrain and the various government's viewpoints behind these explorations/surveys, why they were necessary and what they hoped to achieve. As they unfold so they convey the vastness of the area involved, the problems of communication, the urgent need for safe practical routes not only for quick communication, but for the waggon trains of settlers seeking to develop these new territories. They give a whole new meaning to our understanding of Waggon Trains, Stage Coaches, Pony Express, Telegraph and most of all the first Trans Continental Railway. I shall watch my next 'Western' in a completely new light!

To the Student/Collector of maps covered by this area, the information this book contains will be invaluable. To the merely interested bystander it will fascinate and educate, and to them I would add, please keep your U.S. atlas to hand it will prove useful in following the text.

R.A.B.

NEW PUBLICATIONS

The Public Archives of Canada wishes to announce that the complete list of its 1985-1986 accessions is now available on microfiche. Copies in English and French can be obtained by writing to:

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344 Wellington Street
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March 27, 1987

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Additions to the list published in the last Journal, these publications are currently out on loan but can be made available if required.

Pastoureau. 'Les Atlas Francais'
Exhibition Catalogue, 'Raleigh and Roanoke'
Papers of the Nordenskiold Seminar.
Smith D. 'Antique Maps of the British Isles'
'Centralny Katalog Zbiorow . . . Polsce'

Missing Item:

Sarah Tyacke's 'English Map-Making', this book is now required for loan and I would be obliged for it's early return please.

In view of the above for which I have no record, it is possible that Members have other books out on loan. I would appreciate either notification of what volumes they have or better still their early return, storage is not a problem at this end. If you find it more convenient to return them by hand, I shall of course be present at the Map Fair, this will also save you postage.

Tony Burgess

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Enquiries should be addressed in the first instance to Dr N.A.F. Smith, Reader in History of Technology, Department of Humanities, Sherfield Building, Imperial College of Science and Technology, London SW7 2AZ, U.K.

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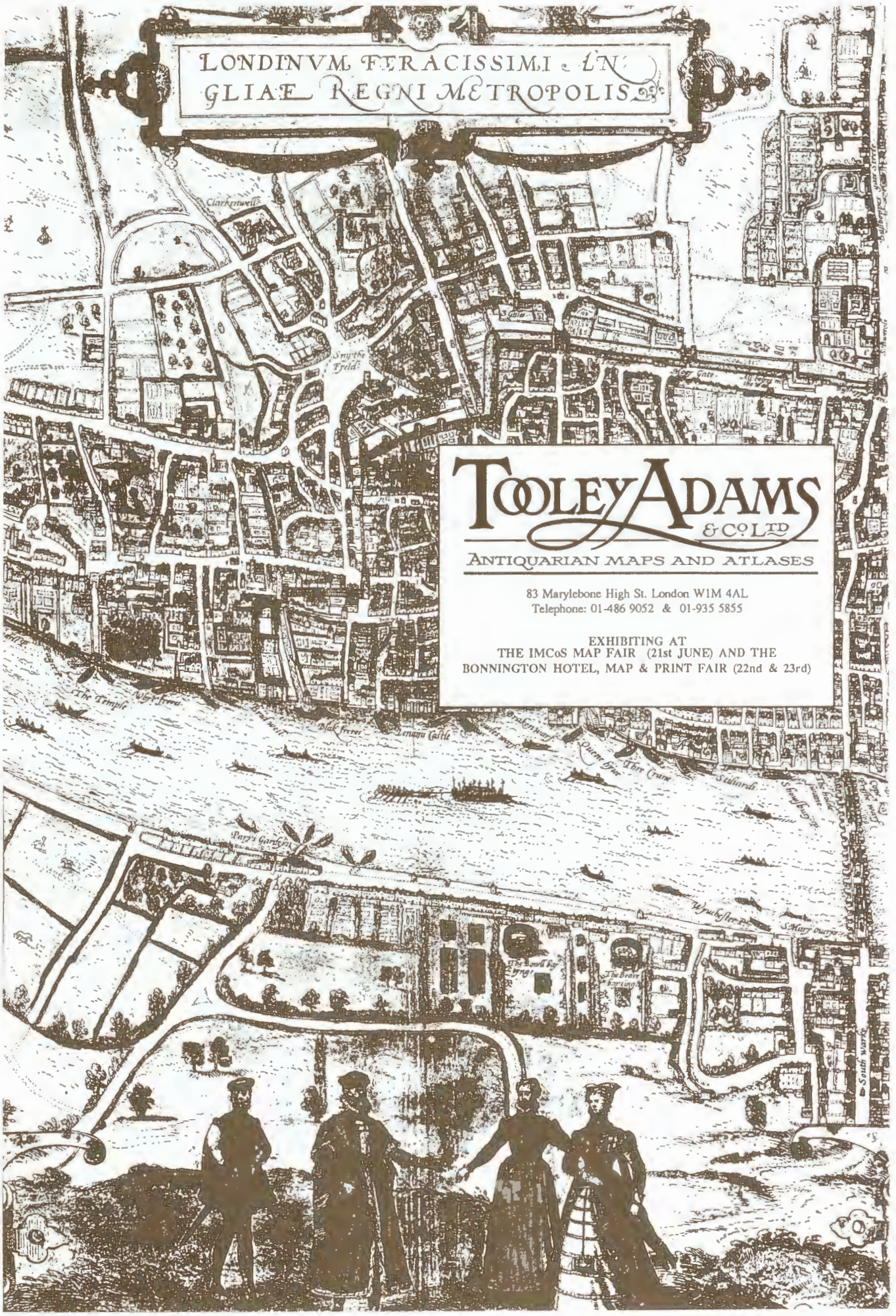


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ANNUAL GENERAL MEETING 1987

The 6th Annual General Meeting of the Society was held in London at the Farmers Club on Tuesday 12th May 1987. The Chairman welcomed all those present and presented his report to the meeting. He said the past year had been a most successful one for the Society but regretfully the Society had lost two of its Honorary Members. Ronald V. Tooley and Arno Piltz died within a few weeks of one another.

The Chairman listed the meetings which had taken place during the past year starting with Leeds in April 1986 followed by a special viewing of "The City in Maps" at the British Library in June 1986. This event was organised by our President Dr. Helen Wallis OBE. The London Symposium, Dinner and Map Fair was held in June with the Barcelona Symposium following in October. This was very successful with about 115 attending. Our thanks go to our Spanish Representative Jaime Armero of Madrid and Montserrat Galero and her Committee. In November '86 a visit was made to the India Library and Records Office. In March 1987 membes attended an exhibition "The Art of MapMaking" at the Royal Geographical Society organised by the Netherlands Foreign Office. The Society published and distributed in 1986 a 'Dealers Directory' jointly with *The Map Collector.* A second edition is due in '88.

Both the Chairman (Malcolm Young) and the Past President (Rodney Shirley) gave talks in Cyprus in 1986.

The London Symposium, Dinner and Map Fair will be held on 20/21 June this year. The Jerusalem Symposium organised by Eva Wajntraub is scheduled for 25th-28th October this year.

Future venues for Symposiums are Zagreb and Dubrovnik in 1988, Athens '89 and the USA '90. Our overseas representation has increased by four during the past year.

The Chairman thanked Ted Freeman our Librarian who had handed over to Tony Burgess, it will have been noticed from the March Journal that Tony Burgess has already been active and the Library is now housed at Eltham. He also thanked Faith Ashwood who had been our Advertising Manager for the past five years and Warwick Leadlay who has taken over our advertising at such short notice. The Chairman expressed the Society's appreciation of our official Photographer, David Webb, who will be putting on a special display of photographs of past events at the Map Fair.

Finally he thanked our new President, Helen Wallis, for her enthusiasm and advice regarding the Society. He said she is well known throughout the world and we are very fortunate to have her experience and immense knowledge at our disposal.

The Secretary and Treasurer then gave a brief report and circulated the Accounts for 1986 (see below). As will be seen, the Society's finances are quite sound and there will be no increase in subscriptions this year. The accounts were passed and adopted by the meeting and thanks expressed to Geoffrey Ramsden our Treasurer. The Membership Secretary (Caroline Batchelor) advised the meeting 51 new members had joined from 10 different countries.

Officers due for election this year and elected

Directors: Kjartan Gunnarsson of Iceland, Themis Strongilos of Greece

International Secretary: Alan Bartlett

International Map Collectors' Society — YEAR 1986

Income and Expenditure Account, and Balance Sheet at 31/12/86

Income & Expenditure A/c		12 Months to: 31/12/86 £		31/12/85 £	
Income:	Subs credited for 1986	4,023		3,293	
	Annual Fair/Symposium/Dinner	1,175		341	
	Interest (Net)	23		204	
	Sundry	3		76	
	Total Income		5,224		3,914
Expenditure:					
	Journal and Dealer Directory ('86)	4,422		4870	
	Less Ad. Income	(1,867)	2,555	(1718)	3.152
	UK Meetings	225		251	
	Overseas Activities (Net)	4		492	
	Membership Costs	681		270	
	Tax (Corporation)	75		75	
	Sundry	436	1,421	36	1,124
	Total Expenditure		3,976		4,276
Surplus (Deficit) for Year			1,248		(362)

Balance Sheet

Assets:	Current A/c	265		1,049	
	Deposit A/cs.	4,649		4,707	
	Building Society	1,764		1,625	
	DEBTORS (all cleared)	1,523	8,201	185	7,566
Less Liabilities:	Creditors (all cleared)		(1397)		(1781)
Balance of Assets over Liabilities			6,804		5,785
Represented by:	3 Year Members' Fund	2,058		2,287	
	Life Members Fund	1,384	3,442	1,384	3671
Accumulated	Surplus: Brought forward	2,114		2,476	
Add	do. for 1986	1,248	3362	(362)	2,114
			6804		5,785

Geoffrey Ramsden
Hon Treasurer 5/5/87

LETTERS TO THE EDITOR

Dear Sir,

Copied from the *Daily Telegraph*: Page 21, 20th March 1987. Friday Col. 5 Bottom (Peterborough's Column)

ASKING THE EARTH
FROM LAST WEEK'S WESTERN GAZETTE:

"Wanted, Full Size Globe of World on Stand or Similar. Good Price Paid . . ."

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Dear Sir,

John Ogilby

For a number of years I have held a theory that the Ogilby strip maps were first hand drawn on long rolls of linen strips (previously sized) for use in the royal coach by being held by an upper and a lower spool, each with a handle for use in winding the strip either up or down.

The overall length of each copper plate printed map is approximately 6 feet 10 inches with a few inches of excess scroll at bottom left and upper right the width being 2⅛ inches. The total length being rather over 7 feet would approximate to that of standard linen bed sheets which might have been cut up into suitable strips.

This thought was confirmed by one of my seven examples, (that from Chelmsford to St. Edmondsbury and Saffron Walden), and some others examined in the British Library Map room. These exceptions to the normal all show a series of equidistant broken lines approximately ⅛ inches from each strip edge which may well be the artist's reproduction of the stitches for the hems that would be essential to prevent the strips from fraying.

On mentioning my theory to the curator of the Map Room he expressed great interest in the possibility. As a number of years have elapsed since this comment I wonder if anyone has persued this theory further.

Yours truly,

A.W. Rowntree

Dear Sir,

John Speed

In my collection of maps of North Yorkshire, (which includes a few that extend to two or all three Ridings), there are two copies of Speed which puzzle me:- One is the well known North and East Ridings with town plans of Hull and Richmond: the caption at the foot reads '. . . sold by Tho Bassett in Fleet-street, and Richard Chiswell in St. Pauls Church yard. And now sold by Henry Overton at the White Horse without Northgate London'. The attributed date is 1713.

The other is of all Yorkshire and said to be of 1676. Its caption at lower left reads '. . . sold by Thomas Bassett in Fleetstreet and by Richard Chiswell in St. Pauls Churchyard'.

What puzzles me is that only the later map agrees in outline with Saxton Hole (1610), Blaeu (1662) and Jansson (1700), the two former of which must have been available to Speed and yet his outline of the county in his 1676 map is, in proportion to the others, greatly foreshortened from E. to W. and elongated from N. to S. Why?

Yours truly,

A.W. Rowntree

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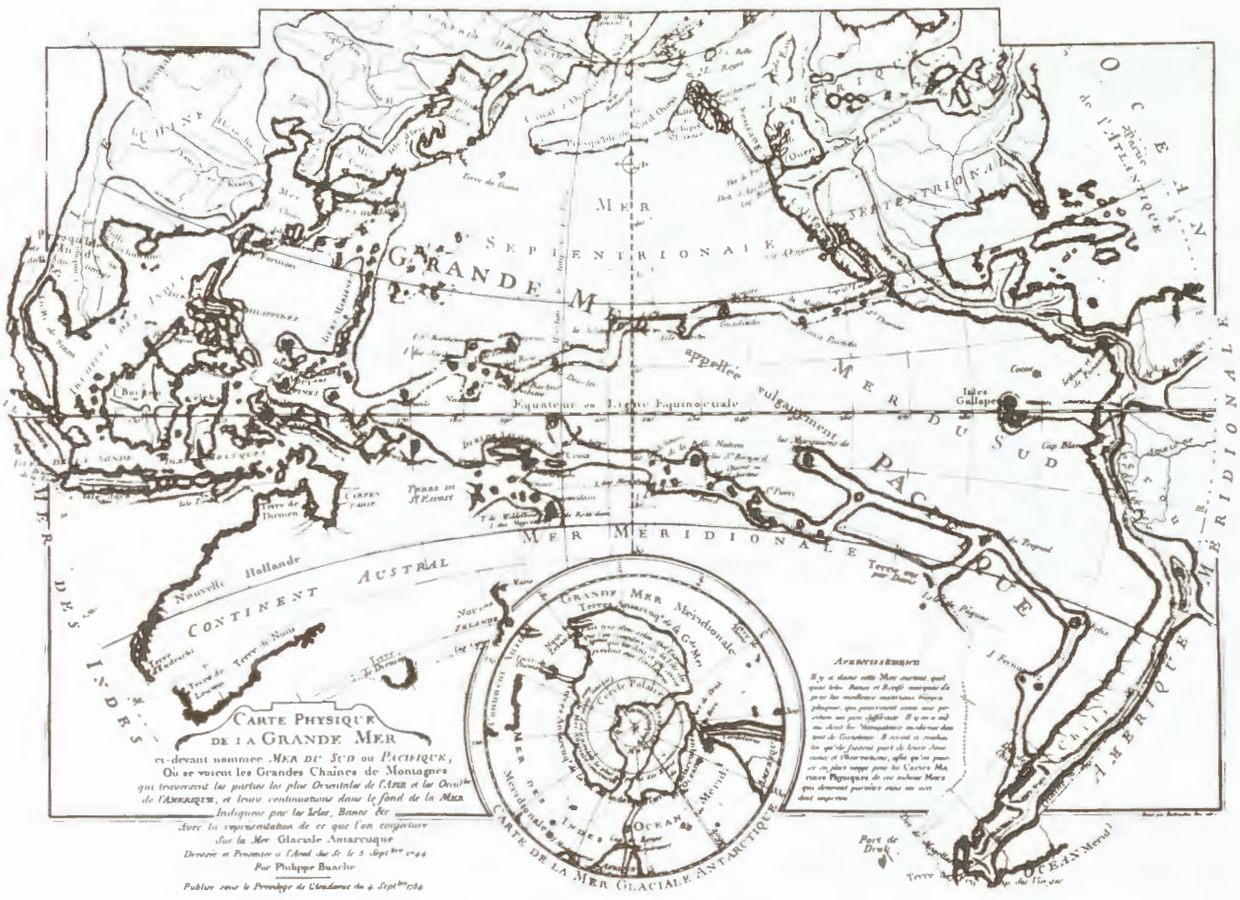
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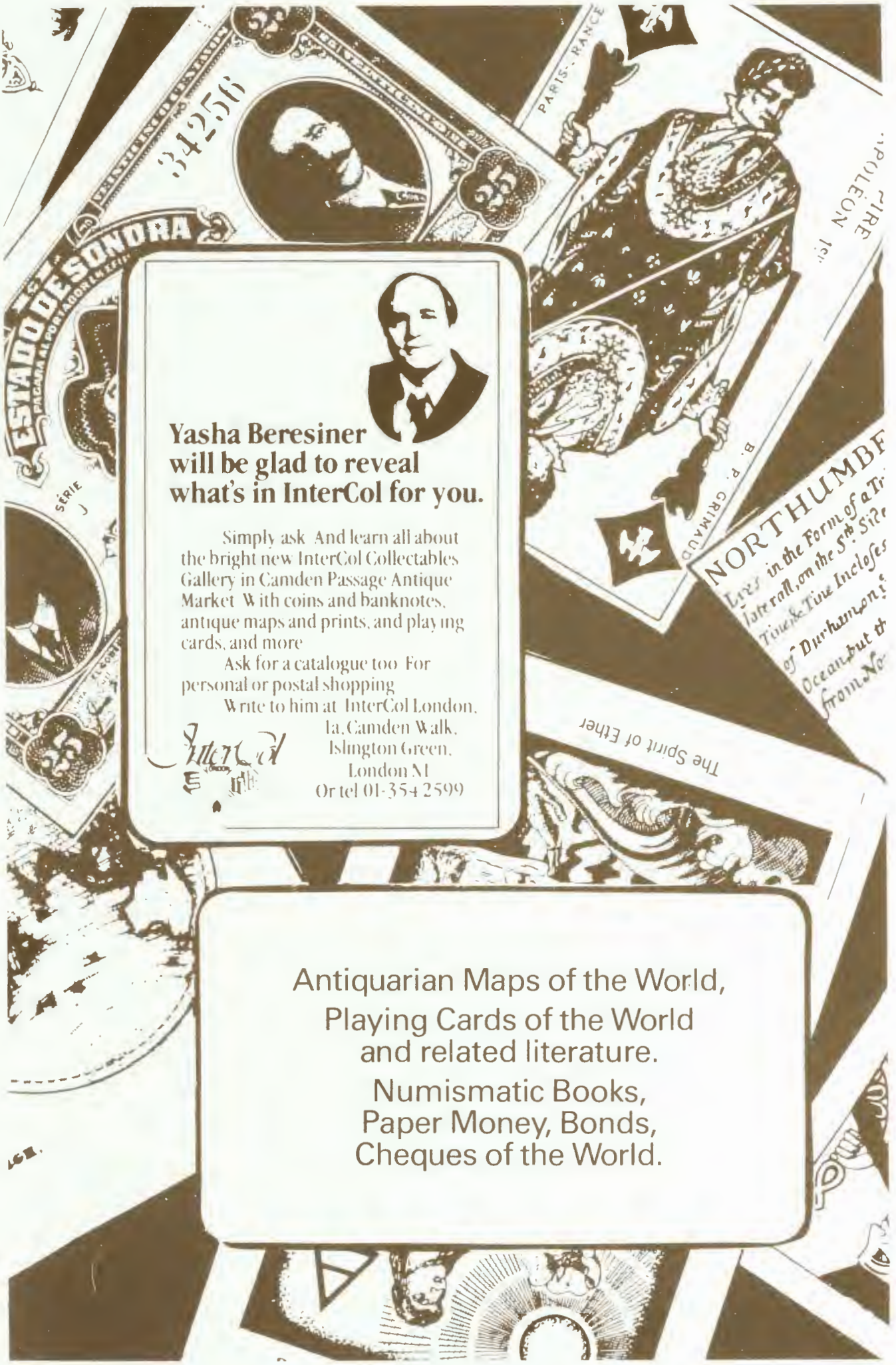
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