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Cyclopaedia of Telescope Makers

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The *Cyclopaedia* consists of short biographical notes on telescope-makers, telescope-opticians, and telescope-engineers, and includes contemporary astronomers, natural philosophers, and a few surveyors, and wholesalers and retailers of optical scientific instruments of particular influence in their time.

The names, places of work, family business connections, business associations with astronomers, and a few historical references, are listed alphabetically together with an outline of the type of constructional work carried out and brief details of some notable telescopes. The period covered is roughly from 1600 to 1970. Our list does not include the most recent developments, the so-called *New Technology Telescopes* of the 1980s and 1990s, but does include the 200in Hale telescope and the optical giants constructed by Grubb-Parsons in the United Kingdom, the Clarks and Warner and Swasey in the States, and the instruments of Merz, Repsold, Steinheil and Zeiss in Europe.

The *Cyclopaedia* is intended to provide some guidance to those seeking up-to-date information, a kind of abridged *Who's Who* in telescope making, retailing and designing over the last four centuries worldwide. It is impossible to avoid overlap with other scientific instruments, particularly those employing a telescope as an *accessory* to a measuring device, nautical and surveying instruments, such as the sextant and the theodolite, as well as instruments employing telescopes to simply read graduated circles. Frequently, peripheral optical trades are associated with telescope makers only on the basis of a single surviving instrument. Also, it is not our present intention to list all types of telescopes and accessories constructed by major firms. Neither can we do full justice to present-day optical companies although they are entering history during an on-going commercial explosion.

We see, therefore, that collated under groups such as *Optical Scientific Instrument Maker, Philosophical Instrument Maker, Mathematical Instrument Maker*, the telescope makes its appearance under the guises of several trades. It must be emphasized that we have specifically searched only for telescope-related manufacturers and retailers, and some omissions are bound, inadvertently, to have occurred. Trade labels, early advertisements, street directories, guilds and companies, obituaries, biographies and auctioneers' catalogues frequently provide useful historical and social information, although the present work has mostly drawn upon the efforts of other researchers, such as Clarke, Morrison-Low and Simpson in their brilliant book, *Brass and Glass*. Also, the classic book by H.C. King, *The History of the Telescope*, although dated 1955, has been an invaluable starting point in this work. The microscope maker frequently overlaps the telescope and optical instrument maker. Microscope makers listed by historians have, therefore, been a very important source of names since this instrument has received the most attention in the past. Recent sources are G.L'E. Turner's book, *Nineteenth Century Scientific Instruments*, and A.J. Turner's book, *Early Scientific Instruments, Europe 1400-1800*, and other important studies by the same authors, referred to in our *References and Sources*. Numerous early texts have been consulted from the *Archives of the Armagh Observatory*, although by no means exhaustively (See J. McFarland's *Rare and Antiquarian Book Collection of Armagh Observatory*).

In the compilation of the *Cyclopaedia*, a specific problem encountered has been to identify, or to avoid mis-identification of family-related instrument makers, with names as common as Adams and Harris. For this reason, we have included within the *Cyclopaedia* a few makers' names, strictly not connected with the telescope, which should help to avoid such confusion. At the same time, it was thought useful to include the names, and brief biographical details of a few astronomers, natural philosophers and mathematicians and dilittants, who have designed or owned early optical instruments. Invaluable for this search, the source from which we have drawn is E.G.R. Taylor's book, *The Mathematical Practitioners of Hanoverian England, 1714-1840*. Navigational "warehouses" and "academies" became more important than a simple ships' chandler. The ownership of some of the best

examples of the work of a particular telescope and instrument maker can be traced mostly to National Museums, and occasionally to fine private collections. Many of these institutions and individuals suppling invaluable information are noted in our *References and Sources* and *Acknowledgements.* We are particularly grateful for the use of illustrations from the following:

National Maritime Museum Greenwich,

Whipple Museum for the History of Science Cambridge,

Museum for the History of Science Oxford,

National Museums of Scotland Edinburgh,

National Museum of Science and Industry London,

Deutsches Museum Munich,

Boerhaave Museum Leyden,

Teyler's Museum Haarlem,

National Museum of American History.

Recent private collections, unfortunately, frequently remain anonymous for security reasons, although the appearance of telescopes at auctions reveals the hidden riches, for example, in Christie's and Sotheby's Sale Catalogues, and similar Catalogues in the States (Vernonscope New York) and elsewhere. These invaluable records contain the hidden history of an ever-circulating component of the totality of scientific innovations and inventions. A later generation may be more priviliged than us to study these exquisite privately-owned instruments.

The optical and mechanical development of the telescope is taken into consideration within some of the entries, when appropriate, and details are given when known. The complete tracing of the optical and scientific trade is outside the scope of the present *Cyclopaedia.* Those interested in further details should consult Project SIMON (contact: Dr Gloria Clifton), a thorough programme to research the British scientific instrument industry from 1550 to 1850 and to record on computer a national archive of data about instrument makers and retailers, under the direction of the historian, Prof. G. L'E Turner of Imperial College, London. Apart from Project SIMON which does not, in fact, list instruments themselves, and presumably other similar national enterprises, there is no handlist of telescope makers which incorporates the extensive, recent research on the subject. We must emphasize that SIMON has not yet been thoroughly searched by us as yet, although it is planned to do so in a forthcoming study.

Apart from the more notable telescope makers, including outstanding cases of monumental work by men such as the third Earl of Rosse and Sir William and Sir John Herschel and "lesser" known men such as Bate, Crickmore and Pyefinch, the *Cyclopaedia* contains the names of some astronomers possessing fine instruments such as Brühl, Dawes, Lee, Pearson and Shuckburgh, as well as innovators and glassworkers. This brings us into the fascinating area of the amateur astronomer and telescope builder. A *Directory* of amateur observatories has recently been commented upon in *Sky and Telescope.* Difficulties are encountered here because the field is extremely large and there has, therefore, been a leaning towards the so-called 19C and early 20C *gentleman* astronomer with almost unlimited means at his disposal, Aubert, Lassell, Lowell, R.S. Newall etc. and a few well-known amateurs capable of producing optical and mechanical work of the highest quality. Even so, we regret having to exclude a large number of amateurs capable of producing a telescope which is superior to many of the early instruments. This may, possibly, be remedied in the future.

We have tried to avoid confusion when describing a telescope of a certain focal length or a certain aperture. For example, W. Herschel's 7ft telescopes were only 6in to 8in aperture. Today, we talk of a 1 metre telescope, referring always to the aperture, the focal ratio and the type of optics. To the early astronomer the focal length largely determined the magnifying power since poor optics placed constraints on image quality and resolution, although in the better optics the latter is limited by the available light-gathering aperture.

The *Cyclopaedia* provides some information for those interested in dating and identifying a signed telescope, thereby relating it to the history of the development of scientific instruments, and assisting in the research into social-economic conditions when the instruments were constructed, and informing us regarding the changing needs of the scientific, nautical and surveying communities. We also provide identification of German World War II optical instruments, particularly binoculars by means of the codes listed by J.A. Gould. Naturally, the *Cyclopaedia* does not replace the standard texts by historians except in presenting in a condensed form much written in recent years. Each entry provides an entrance to a labyrinth of inves-

tigation. There is no doubt that this labyrinth is vastly more open than a decade ago with the advent of the desk-top computer and the biographical data base. Not only can historical inconsistencies be easily detected and possibly resolved but valuable work can be achieved in tracing the development of early instrumental design over the important period of our history when scientific advancement exceeded our means for its international communication. We trust that our compiled information may prove of assistance to those standing where the author stood a few years ago.

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Observation of Giovanni Battista Odierna (Odierna 1657, title page).

Abbreviations (Referencing within Footnotes)

Aed Hart = Smyth,

ApJ = Astrophysical Journal,

AZ = AZ London Street Atlas (20C),

Astr Nachr = Astronomische Nachrichten,

BG = Clarke et al.'s *Brass and Glass,*

Barl = Barlow,

Chamb = Chambers' *Descr. Astr.,*

Chamb H = Chambers' *Handbook II,*

CHr = Christie's sale catalogue,

D and C = Danjon and Couder,

Dict.Nat Biog = Dictionary National Biography,

J.Hersch = John Herschel's *The Telescope,*

Hersch. Coll. = Steavenson list,

Handlist = Anderson et al.,

JBAA = Journal Brit. Astr. Assoc.,

JHA = Journ. Hist. Astronomy,

Lock = Lockyer,

MACP = Wallis and Provin,

MNRAS = Monthly Not. Roy. Astr. Soc. (incl. early Astr. Soc.),

MHS = Museum Hist. Science,

MNASSA = Monthly Not. Astr. Soc. S. Africa,

NMS = National Museums of Scotland,

RP = Pearsall,

Sedg = Sedgewick,

Shad Tel = Buttmann,

ST = Sky and Telescope,

Tayl = E. Taylor's *Math. Pract. Hanov. England,*

Turner Mic = G. L'E Turner's *Essays,*

Turner 19C = G. L'E Turner's *19C Sci. Instr.,*

Turner Antiq = G. L'E Turner's *Antique Sci. Instr.,*

Turner ESI = A.J Turner's *Early Sci. Instr.,*

Vistas = Vistas of Astronomy.

The remaining footnote references within the text are simply by author, and refer unambiguously to the main References and Sources. Single numbers following our abbreviated footnote references are page numbers, e.g. Tayl 209.

Acknowledgements

Several classic books on historical instruments, astronomy and optics, and numerous learned societies have been drawn upon for their excellent illustrations, and many major National Museums and Institutions listed in our References and Sources have provided invaluable assistance. To all these, we gratefully acknowledge their interest and support. For many of the illustrations we are particularly indebted to Mr Jeremy Collins (Christie's). Those named below are not in any way responsible for the possible slips contained within the *Cyclopaedia* in its present form.

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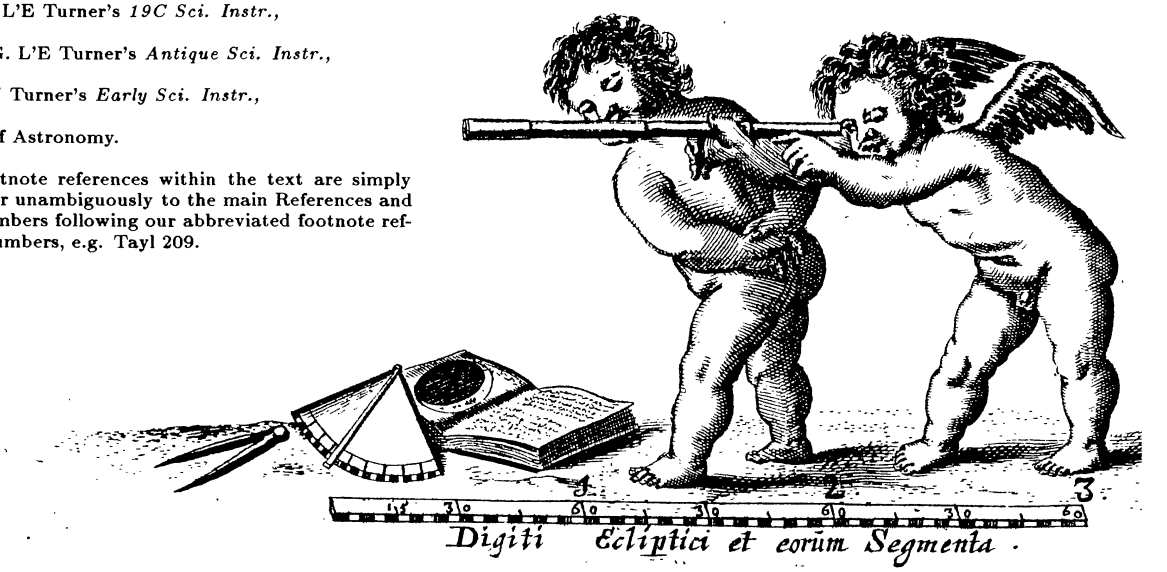


CYCLOPAEDIA OF TELESCOPE MAKERS

PART 1 [A-F]

A

ABBÉ Ernst - theoretical optician, 1840-1905. Employed by Carl ZEISS, he made major theoretical contributions to the early Jena optical works from 1866 onwards, and helped to lay the foundations of the modern ZEISS company. Earlier optical designs had relied heavily on empirical techniques similar to those used, for example, by CLAIRUT in the 18C and John DOLLOND in the 19C. [1] ABBÉ introduced the "sine condition" into the theory of geometrical optics, explored the theoretical principles of the apochromat microscope objective [2] and the high-power oil-immersion microscope (1877), [3] and gave an expression for the resolving power of a lens of given aperture. [4] He was contemporary with Otto SCHOTT, the expert glass-worker also at Jena, [5] for whom he also invented the refractometer to measure the refractive indices of glass used in lens design. [6]

ABRAHAM Jacob - English optical and mathematical instrument maker, at *7 Bartlett St, Bath.* fl.1805-41. [7]

ABRAHAM Abraham and Co - notable English 19C optical instrument maker and wholesalers, *9/10 Lord St, Liverpool*, also at *20 Lord St.*. [8]. fl.1817 onwards, also with business in *Glasgow.* [9] The firm was associated with WOOD, and became partners with J.B. DANCER of *Manchester* in 1840 (dealing very largely in microscopes, e.g. selling DUNN and LENNIE instruments). [10] The firm under Josiah ABRAHAM was later taken over completely by DANCER. [11] but a take-over of ABRAHAM and Co by P. COHENS of *Glasgow* is recorded.[12]

ADAMS - a frequently occurring name amongst makers and teachers from late 17C until early 19C. One notable English family of optical and mathematical instrument makers, George ADAMS and two sons, George and Dudley is well-known.

ADAMS George (Snr) - English optical and mathematical instrument maker, c.1704-73; The business flourished under the sign of *Tycho Brahe's Head, Corner of Racquet Court, 60 Fleet St, London; (later) 61 Fleet St* (1767), opposite which MARTIN set up shop. In 1761/62 ADAMS made instruments for the King's private observatory at Kew. [13] Unfortunately, the George III collection has since been dispersed. [14] It contained important instruments by other notable makers such as Jeremiah SISSON and GRAHAM. [15] In 1750 ADAMS took out a patent for a refracting telescope of new construction [16] in collaboration with R. JACK. It was the custom, more so than today, to protect every innovation. He was author of "Micrographia Illustrata" (1746), a work on microscopes, and wrote also on sea quadrants and octants. [17]

[1] Danjon and Couder 153 (hereafter D and C).

[2] The ABBÉ apochromat objective, with the mineral fluorite added to the glass, has colour corrections at three wavelengths (1886). See also concerning the sine condition and achromatic doublet design in Born and Wolf 419, Ditchburn 291, or simple account in Bell 88. Also, regarding roof-prisms for binoculars, Bell 162, and Astroph. Journ. vol.21, 379, 1905, hereafter Ap.J.

[3] ABBÉ's designs for the oil -immersion microscope were largely adopted by POWELL in 1879.

[4] Discussed in G.L'E Turner 19C, 165 (hereafter Turner 19C).

[5] There was also a certain Cleveland ABBE (fl.1869) working on solar spectra. See Clerke's "Astrophysical Problems", although no connection with Ernst is established.

[6] For a biography, see Hans Gause's "Ernst ABBE memoriam" in Jena Review vol.10, part 1, 71, 1965, and Nature, vol.145, 89, 1940.

[7] See Taylor's "Mathem. Practit. Hanov. England" 354 (hereafter Tayl). See ABRAHAM *Bath* late-19C [CHrDec88]. The square brackett on Christie's [CHr] Ref. indicates that an illustration is available in their catalogues.

[8] Anderson et al., hereafter Handlist

[9] See Tayl 380, Clarke et al.'s "Brass and Glass", 292/298. hereafter BG, c.f. NORTON's and GREGORY's business structures.

[10] c.f. the large firm of LIZARS.

[11] See also ABRAHAM [monoc CHrDec85], CHrJun89, CHrApr88 lot274 microscope. An ABRAHAM spectroscope appeared at Sotheby's auction in 1960.

[12] See BG.

[13] Regarding the George III collection (reign 1760-1820), see Tayl 61, 152 and Chaldecott in main refs.

[14] An almost equally important collection is that of the Earl of Bute. See A.Turner's Early Sci. Instr., hereafter Turner ESI,

[15] At Armagh Observatory there is a Gregorian reflector by ADAMS and also a theodolite (McFarland 194, hereafter JMcF). An innovative "apparatus" probably for an ADAMS transit instrument is also in the archives (JMcF 179). See also Handlist.

[16] Tayl 209.

[17] Early ADAMS instruments may be dated from differences in the signature, but later instruments, signed G.

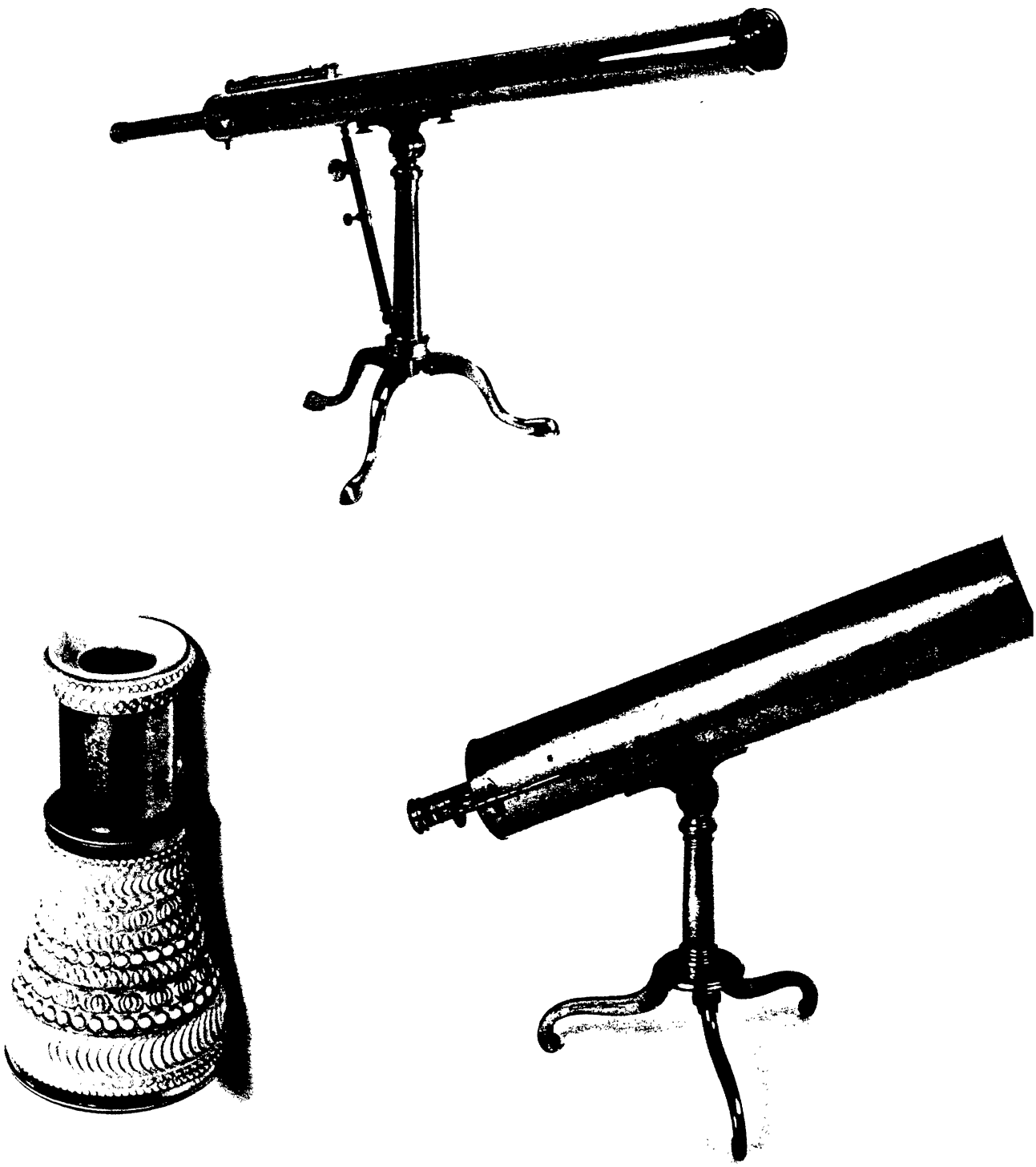


Figure 1: (a) A fine late-19C 2.75in refractor signed on the eye-piece backplate ABRAHAM.BATH, in lacquered brass, with rack and pinion focussing and steadying rod, is shown (top) on a tapering pillar support and tripod stand terminating in pad feet (sold at Christie's for £935 in December 1988). (b) A 19C gilt-Sheffield single-draw 1.75in monocular signed A. ABRAHAM Liverpool (inscribed in small script), is shown (bottom left) with its machine-turned and decorated bell-shaped body tube (sold at Christie's for about £100 in December 1985). (c) A late 18C 4.25in reflecting telescope (24in long) in brass signed ADAMS*LONDON on the eyepiece back-plate is shown (bottom right). This fine instrument has speculum (polished metal) mirrors, screw-rod focussing to the small secondary mirror, with folding tripod cabriole legs and inswept feet (sold at Christie's for £990 in December 1988).

ADAMS George (Jnr) - optical instrument maker, elder son of George (Snr), 1750-95. Taking over his father's business, he continued at *60 Fleet St, London*, 1782-96. George (Jnr) was the author of several scientific essays in 1787-94. [18]

ADAMS Dudley - optical and mathematical instrument maker, brother to George (Jnr), b.c.1760, *53 Charing Cross, London* (1796-97); *6 Jewry St, London*, near *Fleet St* (1800-22); *60 Fleet St, London* (1801-26). In 1800 he took out a patent for a portable telescope, and in 1815, another for improvements in vellum telescope tubes. [19] Dudley ADAMS was prosperous, making small telescopes in gold. [20]

ADAMS John - optical instrument maker, fl.1693-1738. Probably unrelated to the above ADAMS, John was a member of the Spectacle Makers' Co., possibly maker of ADAMS' *New Patent Portable Telescope* which is now at the National Maritime Museum, Greenwich. [21]

ADAMS John - mathematics teacher and mathematical instrument maker, fl.1758-96. He was working at *Farnhill Academy, Essex* (1773), and *Ratcliff Cross Mathematical Academy* (1780), near the London Docks in the area containing many nautical instrument makers and retailers, at *Wapping and St Katherine's, Tower bridge.* His name is associated with the *Ratcliff* mathematical instrument maker, Richard RUST [22] who apprenticed both the elder SPENCER and BROWNING.

ADAMS Nathaniel - optical instrument maker, 1708-43. He flourished at the sign of *The Golden Spectacles, Charing Cross, London.* He was apprenticed to Edward SCARLETT. The relationship to the other ADAMS family is unclear. The optical instrument maker, Francis WATKINS was apprenticed to Nathaniel ADAMS. [23]

ADIE - notable family of instrument makers in 18C-19C *Edinburgh and London.* The partnership, ADIE and Son consisted of Alexander and Richard, fl.1835-81 at *395 Strand, London.* A further partnership was set up c.1835, ADIE and WEDDERBURN, surviving into the late 19C in *Edinburgh.* [24]

ADIE Alexander - optical instrument maker, fl.1775-1858 *15 Nicholson St, Edinburgh* (1823); *50 Princes St, Edinburgh* (1828-43). Alexander was apprenticed to his uncle John MILLER, later forming MILLER and ADIE c.1803 at *86 South Bridge, Edinburgh.* [25] We find also ADIE and Son, fl. 1835-81. [26]

ADIE John - 1746-1815, (Alexander's son), [27] *50 Princes St*, and *37 Hanover St, Edinburgh* 1835-80). John had three brothers, the youngest being Patrick. [28]

ADIE Patrick - instrument maker, 1821-86, *1A and 14, Conduit St, Regent St, London* (1846-47), [29] *395 Strand* (1848-68), *15 Pall Mall and 29 Regent St* (1869-73), and also at *Broadway Works, Westminster St* (1874). The business continued after Patrick's death at *28 Medway St, Horseferry Rd* (1936) and *45 Beaumont Rd, London* (1942). We record ADIE and WEDDERBURN 1881, RICHARDSON ADIE and Co. 1913, and in 1943 the ADIE name was dropped. [30]

ADIE Richard - instrument maker, fl.1835-81. His workshop manager was WEDDERBURN.

AE OPTICS - English optical company, present day, *28 Drayton Industries, Scotland Rd, Dry Drayton, Cambridge CB3 8AT.* In the 1960s, the firm, ASTRONOMICAL EQUIPMENT (Luton) Ltd., *26 Guildford St, Luton*, operated under M.Goddard, E and R.Hysom, J.Mathers and C.Shuttlewood.

AIRY George Biddell (Sir) - 1801-92, Astronomer Royal (1835 - 92), Director at Greenwich (1835 -82). [31]

ALEXANDER - English nautical instrument maker, *Yarmouth*, fl.c.1790. There is an octant (in-

ADAMS London, are difficult.

[18] See Handlist and [CHrDec88] and [CHrMar89 transit colour].

[19] See Tayl 303. Vellum is a fine parchment of skin, originally of calf, and later of sheep or goat. Vellum paper from which early telescopes were frequently constructed was an imitation of this and would need to be strengthened by using many layers.

[20] ADAMS' gold telescopes may be seen Utrecht.

[21] Dudley ADAMS also patented a portable telescope. See also Tayl 109.

[22] Tayl 222.

[23] Tayl 152.

[24] The firm maintained the connection between London and Edinburgh.

[25] See other addresses in BG 30.

[26] It is unclear whether this was with Richard or John ADIE, BG 25-49.

[27] Perhaps there is another ADIE and son.

[28] See BG 25.

[29] We question 1A Conduit St as a misprint for 11.

[30] See BG 75, 84 (illustr).

[31] Vistas vol.20, 157.

scribed SBR on the scale) by him. [32]

ALLAN James - mathematical instrument maker, *12/13 Blewitt's Buildings, Fetter Lane, London,* fl.1790 -1825. Apprenticed to Charles FAIRBONE, he was later associated with RAMSDEN and WOLLASTON, the latter concluding at one time that his divided circles (c.1811) were superior to RAMSDEN's. [33]

AMICI Giovan(ni) Battista - instrument maker and optician, *Modena and Firenze,* 1786-1868. [34] Excellent examples of Amici's work are to be found in the Museo di Storia della Scienza, Firenze. Amongst the large telescopes he built are an 11in aperture, f=16ft, equatorial refractor c.1841, and another 23.8cm, f=3.18m, refractor c.1844. See also the small refractor 1827, [35] and the well-known Amici three-component prism (crown, flint, crown). [36] He designed a camera lucida, [37] as did others such as WOLLASTON in 1804, and produced a reflecting microscope. A water-immersion microscope objective by him was shown at the Paris Exhibition in 1855.

ANDERSEN J.A - US executive officer supervising construction and optical workshop for the 200in Hale telescope, in collaboration with F.G. Pease, S.Smith, J. Strong, C. McDowell, R. Porter, M. Serrurier, B. Rule, B. Hill and E. Poitras. The telescope was conceived by Hale 1928/29 and saw first light 1947/49.

ANTHEAULME - mid 18C, contemporary of CLAIRUT.

APPS Alfred - optical, mathematical and philosophical instrument maker, *West Strand, London WC.* [38]

ARNOLD - *London.* [39]

ASAHI PENTAX - A telescope by them was recently sold at auction. [40]

ASKANIA-WERKE - telescope and instrument maker, *Bambergwerk, Berlin -Friedenau, Kaiserallee 87/88,* 20C.

ASTRO EXPLORER OPTIKK - present day, *Box 12, N-8472, Ringstad, Norway,* providing telescopes and accessories.

ASTRO PROMOTIONS - retailer, present, *Luton, Bedfordshire, UK.* This firm provides a range of accessories and telescopes, 8.5in to 12in reflectors (mirrors by HINDS), and small refractors on the VIXEN Super Polaris equatorial mount. See ASTRONOMICAL EQUIPMENT (Luton) Ltd. under AE OPTICS.

ASTRO SYSTEMS Inc - US company, present, *1109 Kimbark St, Longmont, CO 80501.* An English firm, ASTRO SYSTEMS, provides telescopes such as a 6in f/6 Newtonian (optics by HINDS) on alt-azimuth stand called the FG1, recently upgraded and renamed the FG150 (same aperture, 150mm).

ASTRO-PHYSICS - US company, present, *7470 Forest Hills Rd, Loves Park, IL 61111; recently 11250 Forest Hills Rd.* They produce 4in -7in Starfire apochromatic refractors.

ATKINSON Robert d'E - Chief Assistant 1937-64. He developed the mirror transit circle at Royal Greenwich Observatory. [41]

AUBERT Alexander - astronomer, *Austin Friars; Highbury* and *Loampit Hill, Nr.Deptford,* 1730-1805. [42] With his friend, the engineer SMEATON, he constructed an observatory at *Highbury House, north of Islington* in 1788. [43] The observatory was comparable to that of BRÜHL. AUBERT had also had a private observatory at *Loampit Hill* with a large collection of instruments by makers such as SHORT. He possessed a 3.75in DOLLOND /RAMSDEN achromatic refractor, with a DOLLOND triplet objective, 46-in focus, on a simple RAMSDEN equatorial mount, [44] and also a 6in aperture Cassegrain reflector by SHORT, 24in fo-

[32] Tayl 328.
[33] Tayl 328.
[34] Turner 19C 166, and JHA vol.22.
[35] Howse 37, 38.
[36] Sedgewick 332, hereafter Sedg.
[37] Ganot 611
[38] Pearsall, hereafter RP.
[39] CHrSep86.
[40] CHrJul86.

[41] An instrument suggested by H.H. Turner. See King 394.
[42] Tayl 279.
[43] We have tried to trace the whereabouts of several early observatories, such as that of AUBERT. Highbury House was built by John Dawes in 1781, seven years before the building of the observatory, on high ground of a 74-acre estate about one mile north of Islington Church. Highbury New Park (a present-day street) over-built the Highbury House in 1859/60 with several new mansions. See AZ 46 3C-5C.
[44] KITCHENER purchased this instrument in 1806. The hydrographer, HUDDART, had a similar telescope at Highbury Terrace.

Figure 2: The notable firm of ASKANIA advertised widely (see 1930's advert.) and constructed telescopes and specialised instruments such as micro-photometers to measure stellar brightness on photographic plates.

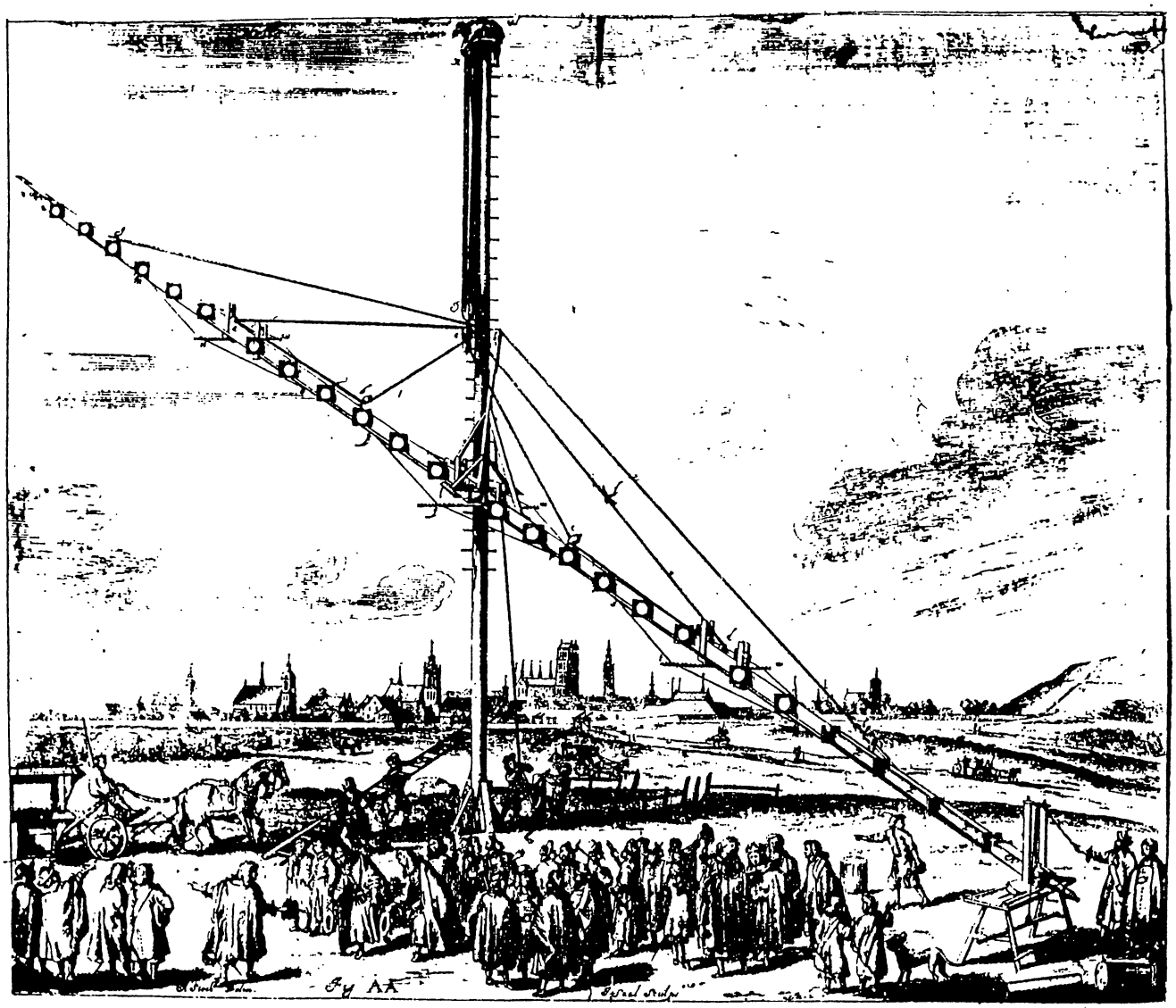


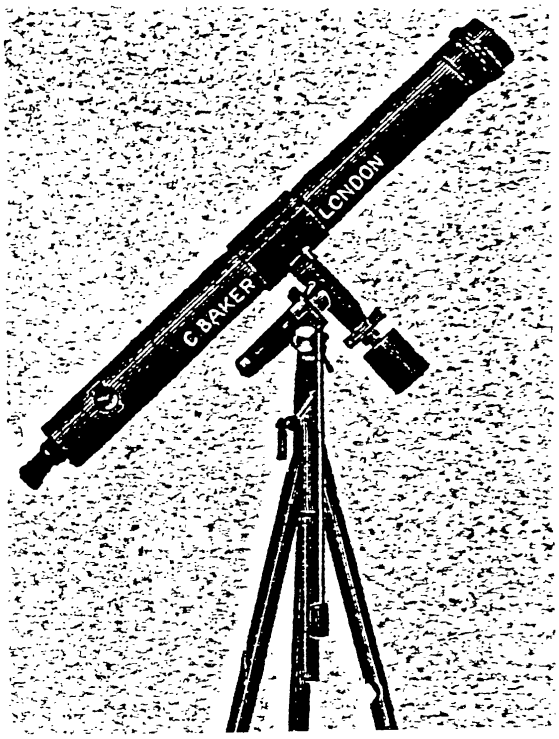
Figure 3: An aerial telescope, 150ft long, belonging to HEVELIUS is shown. The similar constructions by AUZOT (c.1630-91) were sometimes closed square tubes, but the larger instruments were necessarily lightened using open tubes.

cus, the famous Dumpy of SHORT. [45] He was contemporary with HERSCHEL, MASKELYNE, SISSON, BIRD, DOLLOND and RAMSDEN, sadly dying of apoplexy at St Asaph. [46]

AUDE and REIPE - optical industry, *Babelsberg* (World War II binocular code eaf). [47] AUDE = Mechanoptik Gesellschaft für Prazasions-technik.

AUZOUT Adrian - French natural philosopher, c.1630 -91. [48] He made several very long-focus aerial telescopes, some of them, unfortunately, proving to be almost unmanageable, the largest being a 600ft telescope. He also invented a 6-wire (+3 movable wires) micrometer [49] with which he measured the diameters of planets. He was associated with TILLOCH, the editor.

AYSCOUGH James - instrument retailer, *Ludgate St, London*, fl.1732-62. HALL's achromat was said to be in AYSCOUGH's shop window prior to DOLLOND's work on achromatism. His business was taken over by Joseph LINNEL. See also MANN.



[45] See also Pearson 558, Plate XII Fig.2. The illustrated instrument observed the polar region only, and regrettably crumbled.

[46] Howse 69, King 126, 159.

[47] See J.Gould 1985 in main Refs. All binocular codes supplied in our text are from Gould.

[48] D and C 626. Chambers' Descript. Astron. 718 (hereafter Chamb). George ADAMS in his "Micrographia Illustrata" (1771) spells the name AZOUT, and recently we find AUZOT in Turner ESI 133.

[49] Lockyer 219/221, hereafter Lock, King 59

B

BABBAGE Charles - English mathematician, *1 Dorset St, Manchester Sq., London*, 1792-1871. He was particularly noted for his design of calculating machines, and was a founder member of the Astronomical Society in 1820. [50]

BABCOCK H.W - researcher at Eastman Kodak, 20C. [51]

BABCOCK and WILCOX - *U.S.* boiler makers company c.1935, called upon to make the 200in mirror cell for Mt Palomar. [52]

BACHARD J.B de Saron - French engineer, 1730 -94. He made copies of RAMSDEN's dividing machine, as did also TROUGHTON. [53]

BAILEY - retailer ? *Birmingham*, 19C. [54]

BAILY Francis - astronomer (during 19 years' retirement), *37 Tavistock Place, London*, 1774-1844, closely associated with the Astronomical Society in London and the DOLLOND family. He made important work on editing early star catalogues, and contributed to defining the boundaries of the constellations. Awarded the RAS Gold Medal for redetermining the density of the Earth (1843), he is also known for "Baily's beads" seen during an annular eclipse of the Sun from Inchbonny (1836) using a 42in focus DOLLOND refractor. [55]

BAKER Charles - retailer and optical instrument maker, *244 High Holborn, London*, c.1855-1926 (mostly microscopes). [56]

[50] MNRAS vol.32, 101.

[51] See Babcock, Astronomical Techniques 107, and Wallis and Provin's Manual of Advanced Celestial Photography 15 and 214, hereafter MACP.

[52] King 408.

[53] A.Turner's Early Scientific Instruments 229, hereafter Turner ESI.

[54] CHrApr88.

[55] BAILY's beads are simply the breaking up of the fine solar crescent seen through the Moon's mountainous edge at start and finish of totality. HALLEY noted these in 1715 (Phil. Trans. vol.29, 248).

[56] [CHr Dec89 lot 103, said to be a Maksutov-Cassegrain but undoubtedly a recently modified instrument], [CHr Apr88 theodolite].

See Handlist. Sometimes the initial 'C' is dropped on inscriptions. There is also Henry BAKER (1698-1774), microscopist and botanist, scientific writer and speech therapist, founder of the Bakerian Society. See Turner's History of the

Figure 4: Eric Mervyn Lindsay, Director of Armagh Observatory, 1937-74, whose inspiration brought about the installation of the ADH telescope in South Africa for Irish photographic research of the southern skies.

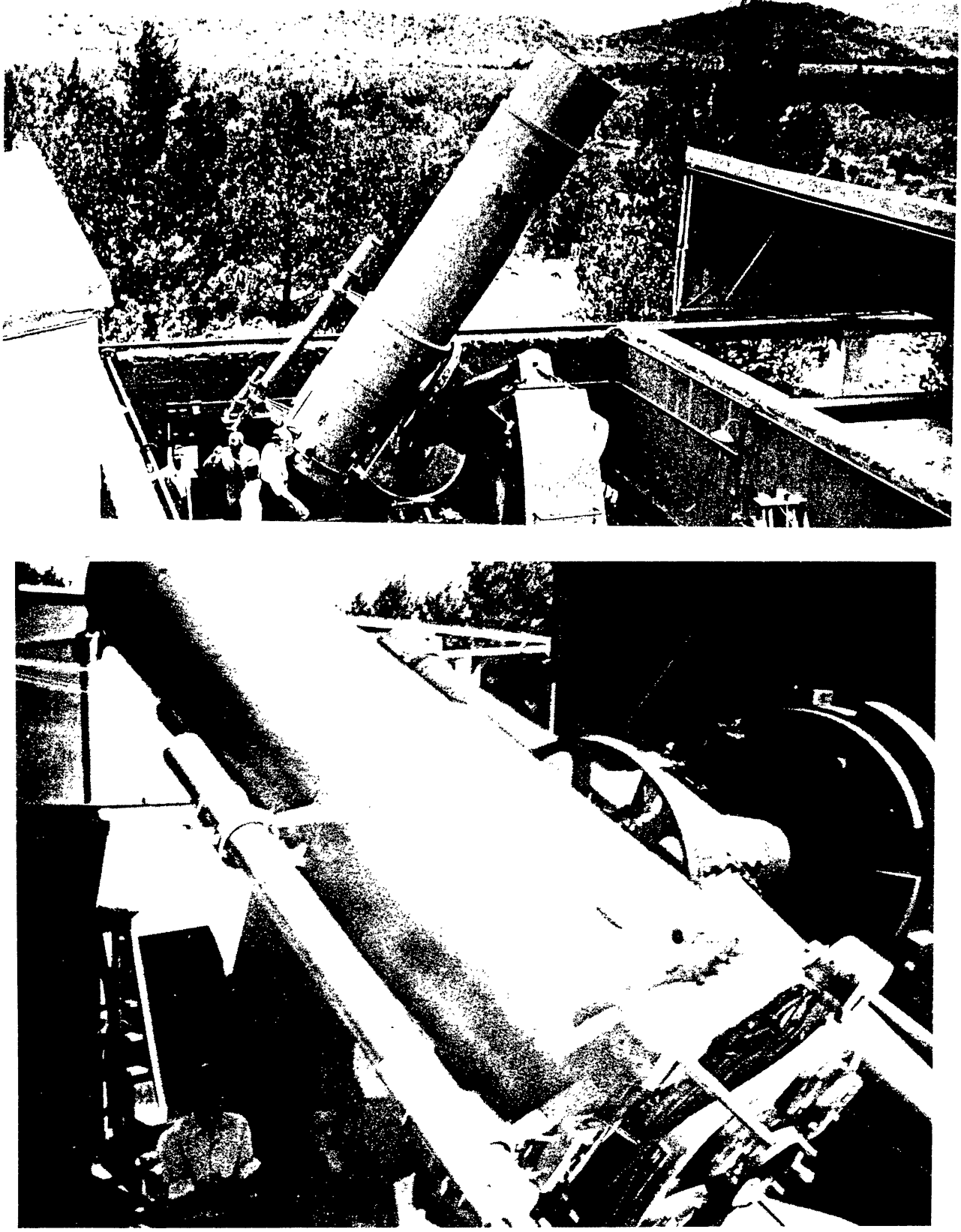


Figure 5: The Armagh-Dunsink-Harvard photographic telescope, a 32/36in CASSEGRAIN BAKER - SCHMIDT, at the Boyden Observatory is shown (PERKIN-ELMER). The largest photographic plates employed were circular with a 4.5-degree flat field. In the early 1950s, the ADH telescope possessed the largest objective prism in the world. The optical parts are now stored at Dunsink Observatory.

BAKER J.G - chief consultant to PERKIN-ELMER (US), 20C. He is author of "A Family of Flat field Cameras", [58] and designed the Baker-Schmidt system employed in the Armagh - Dunsink -Harvard 32/36in (ADH) telescope built by PERKIN-ELMER for the Boyden Observatory. [59] See also NUNN.

BALLE William - *Devon.* He owned a REEVE aerial telescope.

BAMBERG Carl Johann Wilhelm - optical instrument maker, *Berlin*, 1847-92. He designed a number of navigational instruments, theodolites and meridien instruments. The firm was a contender for the optics of the Carte du Ciél astrographs.[60]

BANKS Joseph - well-known optical and mathematical instrument maker, particularly microscopes, *441 Strand, London.* [61] There is a BANKS 3.25in equatorial refractor in Australia 1822 [62] We also find a BANK's dynamometer to measure the diameter of the exit pupil (Ramsden's disk) and hence, magnification. [63] Taylor mentions a J. BANKS of *Liverpool* 1795 [64] and we record William BANKS (see below), and the well-known, Sir Joseph BANKS, 1743-1820, president of the Royal Society who is known to have purchased an equatorially mounted telescope from RAMSDEN 1770-73. [65]

BANKS William - English retailer, optician? *32 Corporation St, Bolton*, late 19C. He advertised astronomical telescopes mounted equatorially, with collimator and driving clock. [66]

BANCKS Robert - surveying instrument maker, 1796-1827. [67] *441, Strand* [68]

BARCLAY Andrew - 1814-1900. [69]

BARDIN W and T,M - notable globe makers, *16 Salisbury Sq, Fleet St, London*, c.1780 -1800. [70]

BARDIN Thomas M - globe-maker, associated with CARY and JONES, 1806-27. He continued making exquisite 18in celestial globes, [71] computed by W. JONES under POND's direction, using Francis WOLLASTON's star catalogue of 1789.

BARDOU A - French maker of small telescopes and field glasses, *Paris.* [72] His work was, sadly, not recommended by BRASHEAR, [73] but we have no way of knowing on what this opinion was based.

BARLOW Peter - English mathematician, with an interest in optics, *Woolwich*, 1776-1862. Although well-known for the BARLOW lens used today, he had actually sought an alternative for achromatic lenses in the form of liquid-filled lenses (see EULER), partly because he could not acquire flint glass. In collaboration with G.DOLLOND, he made 3in and 6in achromats with separated lenses and a liquid lens about half the diameter of the objective. Today's well-known BARLOW lens for increasing the effective focal length and hence the power of eyepieces is a negative achromatic combination of flint and crown, as suggested by him and applied in 1833 by DOLLOND. The proto-types were tested by DAWES on close double stars. [74] BARLOW was also interested in the magnetic field of the Earth and made a globe to illustrate magnetic variation. [75]

BARNES William and Co - glass-blowers fl.1767-80. [76]

BARNET-ENSIGN-ROSS - notable 20C English firm, dealing mostly in photographic objectives, enlargers and accessories.

BARNETT Thomas - mathematical instrument maker, *21 East St, Lambeth, London (1789) and 61*

Microscope, 116, hereafter Turner Mic.

[58] Proc. Amer. Phil. Soc. vol.82, 339.

[59] The ADH Baker-Schmidt was a joint Irish and US project, utilized most effectively by Velghe (Belgium), Lindsay, Butler, Byrne and Andrews (Ireland) and others, in photographic studies of the Milky Way, the Magellanic Clouds and the Orion nebula, and a search for gravitational waves.

[60] See ASKANIA, Bennett 161, King 244, Ambronn. See also Glass' article in MNASSA vol.121, 1991.

[61] See sextant and microscope in CHrNov86.

[62] Howse 1. An interesting monocular telescope in brass and ivory is in D Andrews' collection.

[63] Presumably by BANKS. The exit pupil is the real image of the objective seen through the telescope optics. The "dynameter", invented by RAMSDEN is similar. Sedg 150.

[64] Tayl 343.

[65] See King 126, Prince 78.

[66] Advertisements appeared in Nature June 25, 1891.

[67] Also possibly a son in business.

[68] See Handlist, with same address as BANKS, which could be an error. Also see Tayl 330.

[69] Frank Coll NMScotl

[70] T.M. BARDIN appears later and was probably a son or nephew.

[71] BARDIN's globes were said to be as good as CARY's.

[72] See late 19C CHrApr88 illustr.

[73] See Brashear's autobiography.

[74] MNRAS vol.10, 176, and vol.23, 127.

[75] See King 197, Tayl, Astr.Nachr. No.127, King 190, J.Herschel's The Telescope 51, hereafter J.Hersch, and c.f. BLAIR ibid 29.

[76] BELL, BUTTON, BARNES and PARKER were contemporary 18C glass manufacturers.

Tower St, London, 1768-1816. He was apprenticed in 1782, and his output included some telescopes. [77]

BASS George - optical instrument maker, *Bridewell Precinct*, c.1692-1769. In 1733 he made early achromatic lenses for HALL. [78]

BASSETT-GOWIN - English 20C amateur astronomer, *Saltdean, Sussex.* [79] He owned several early telescopes.

BATE - a notable family of optical and instrument makers in late 18C - 19C in *London.*

BATE Robert Bretsell - nautical instrument maker, including telescopes and geographical charts, *17 (later 20/21 Poultry), London*, b.c.1794, apprenticed 1807, the business flourishing 1807 -c.1815. In 1840 the firm became BATE and Son. They were associated with CARY. Later, POTTER, the instrument maker, took them over as official chart makers, at *31 Poultry.* [80]

BAUSCH and LOMB - opticians, *Rochester, New York*, c.1877. [81] The firm mostly made microscopes and photographic objectives until c.1906, but advertised astronomical instruments c.1907 when the business was already rapidly expanding.

BAYLEY William - mathematics teacher, astronomer, *Stoke near Bristol; Goodwood; Portsmouth Naval Academy*, 1727-1810. He was assistant to MASKELYNE at Greenwich and sailed with Capt. COOK 1772-75 and 1776-80. [82]

BEACON HILL TELESCOPES - UK company, present, *112 Mill Rd, Cleethorpes, S.Humberside DN35 8JD.*

BEAUFOY Mark (Colonel) - English gentleman astronomer, son of a London brewer, c.1764-1827 at *George St, London* (1792); *Hackney Wick* and *Bushey Heath, near Stanmore, Herts* (1815). BEAUFOY had a private observatory with some international standing, containing telescopes by DOLLOND (5ft focus) and CARY (3in aperture 4ft transit and a 26/24.5in alt-azimuth circle). He was noted for his observations of eclipses of Jupiter's satellites (1818-26). His instruments were moved to SMYTH's observatory at Bedford, and today are in the MHS. [83]

BECK G - mathematical instrument maker, c.1800-40. [84]

BECK C and J - instrument makers, *London*, 1848-67. They were contemporary with ROSS and associated with SMITH (the American instrument maker). See SMITH BECK BECK *6 Coleman St, London.* [85] We record also R and J BECK, instrument makers, fl.1866-1910, *31 Cornhill, London* (1866), *68 Cornhill* (1880), factory at *Lister Works, Holloway* (1868) and *Kentish Town* (1894 onwards). Also, they are recorded at *1016 Chestnut St, Philadelphia US* (1874). [86]

BECKER C - instrument maker (theodolites), *Arnhem*, mid-19C. Later we find BECKER and Son, *New York.*

BELL Richard - glass grinder, *Bankside, Southwark, London*, fl.1767.

BELLETI Paolo - Italian instrument maker, late 17C, *Bologna.* [87]

BENNET(T) John - instrument maker, *28 Medway, and 395 Strand, London*, [88] fl.1745-68. We also record John BENNET(T) at *The Globe, Crown Court, St Ann's Soho, near Golden Square, St James', London*, an instrument maker known to have opposed Peter DOLLOND's patent in 1764. [89]

BERGE John - English optical and mathematical instrument maker, c.1742-1808. John was probably father or brother to Matthew BERGE (Snr), who worked with DOLLOND 1756-91. John BERGE worked at *59 St Paul's Churchyard, London; 119 Picadilly, London; Johnson Court, Fleet St, London* (1791). He divided circles for RAMSDEN instru-

[77] Daumas 323, Tayl 304.
[78] Tayl 109, King 144.
[79] See JBAA vol.77, 1966.
[80] Tayl 355. See 18C [CHrDec85], early-19C [CHrJun89] illustr(x2), early-19C [CHrMar91].
[81] See Handlist.
[82] There was a later BAILEY.
[83] See Howse 66, Tayl 304, MNRAS vol.23, 127.
[84] BECK undertook optical work for J.J.LISTER.
[85] CHrJul86 microscope.
[86] See Handlist and Lock Pl.37, Fig.205.
[87] See G. L'E Turner, "Three late 17C Italian Telescopes, two signed by Paolo Belleti of Bologna", in Annali dell'Istituto e Museo di Storia della Scienza di Firenze IX/1, 41, 1984, and G L'E Turner, "Scientific and Experimental Philosophy 1550-1850", Variorum 1991.
[88] Patrick ADIE was established at 395 Strand, 1848 -68.
[89] Taylor 197. See also BENNET working with RAMSDEN, given as fl.1785-1814 (Tayl 304). William SIMMS was apprenticed to a BENNET in 1807.

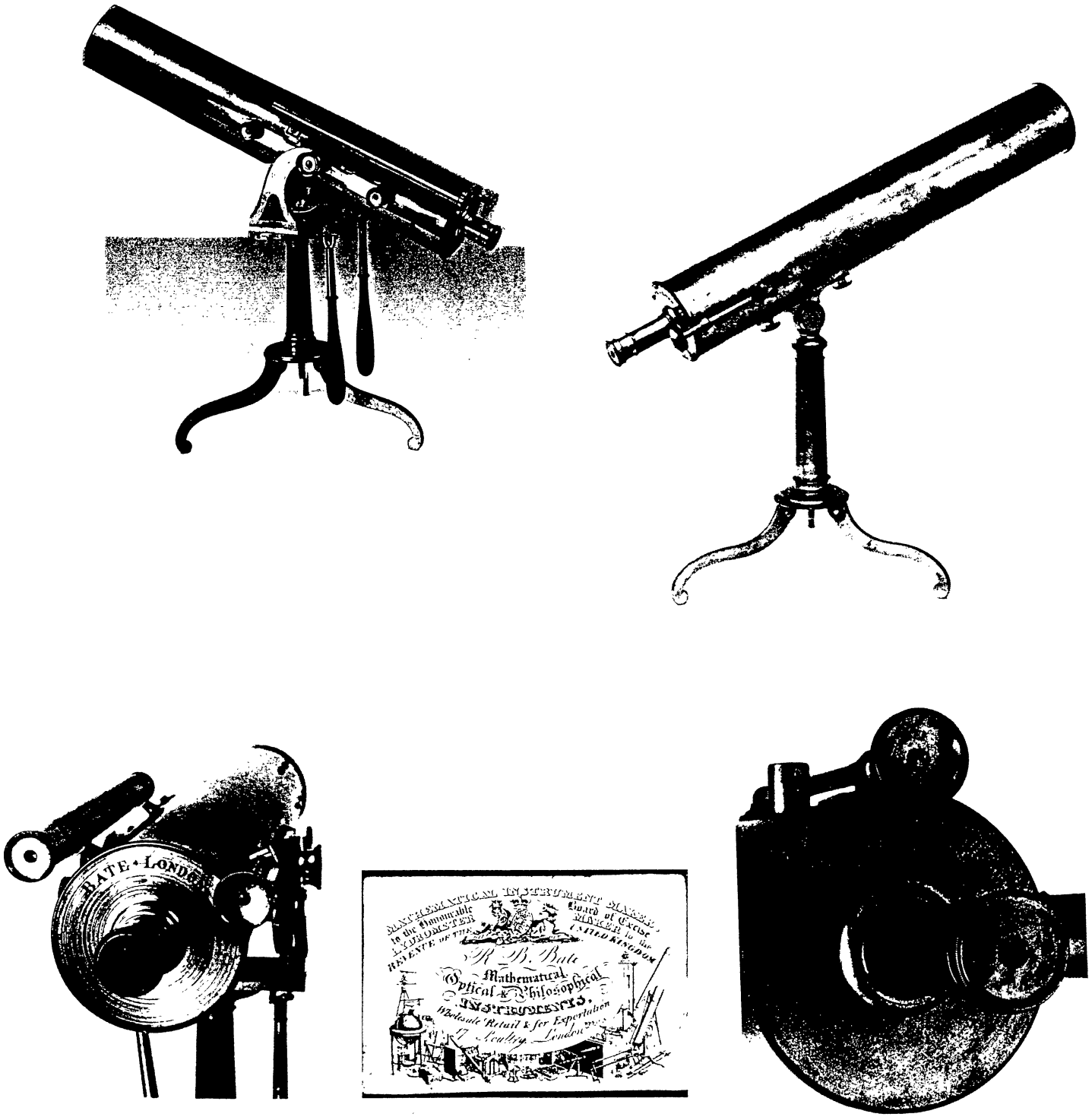


Figure 6: (a) A 4in reflecting telescope, signed on the eye-piece backplate BATE*LONDON, is shown. The body (24.5in long) is mounted on scroll-shaped trunnions incorporating a tangent-screw drive with mahogany and brass universal joints and rods. The tripod cabriole legs terminate in under-scrolling feet (sold at Christie's for £2640 in March 1991; appeared also June 1989 with trade label). (b) Another BATE instrument, a 4in reflecting telescope, 25.5in long, on a simpler pillar tripod mounting is shown (valued by Christie's at about £700 in December 1985). A detail of the backplate, similar to the above, is also shown.

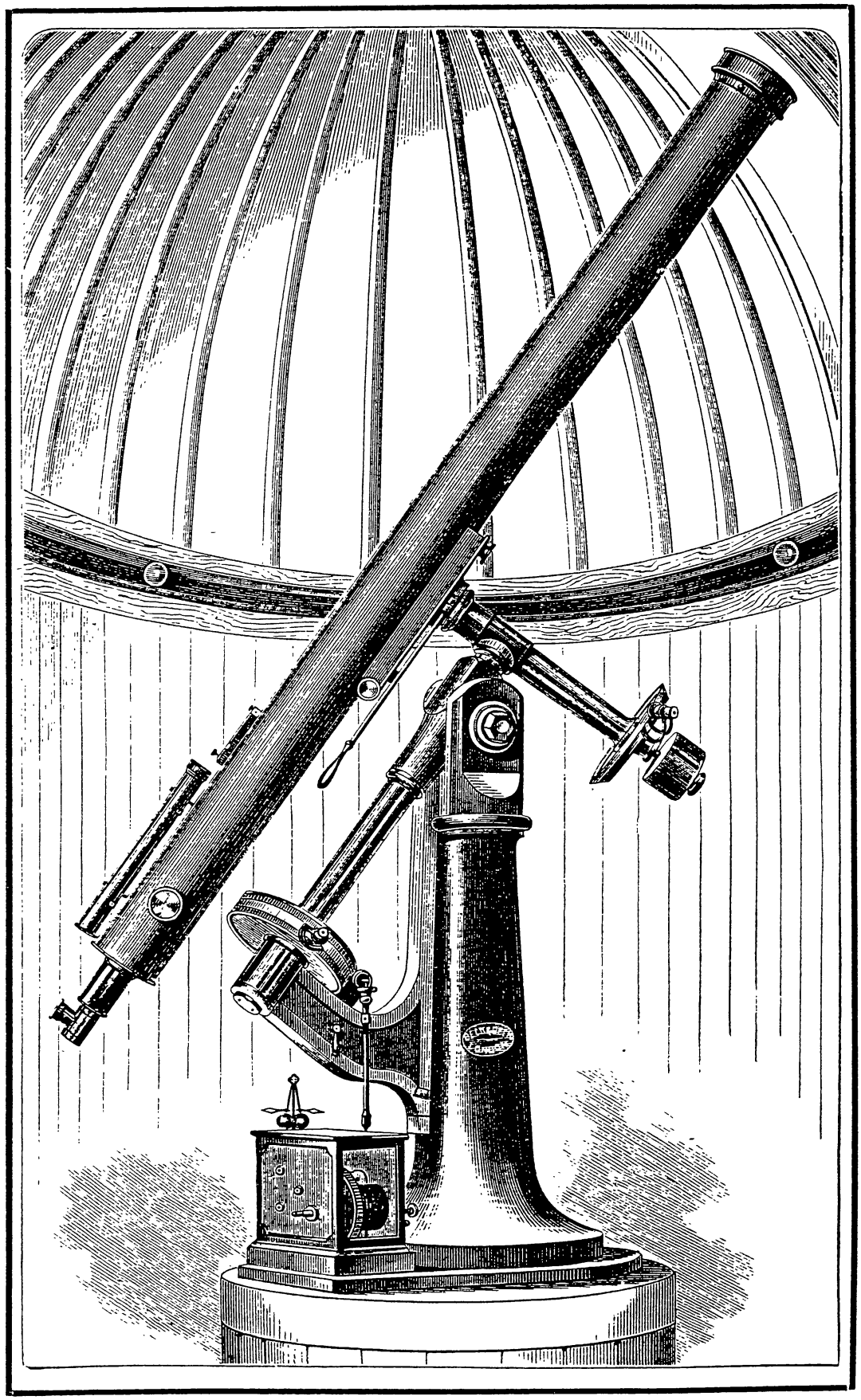


Figure 7: An equatorially mounted 4.5in refractor by BECK.

ments, notably the SHUCKBURGH and MUDGE instruments. Several instruments are engraved BERGE, late RAMSDEN. [90]

BERGE Matthew (Jnr) - fl. 1805-51. He was son or nephew of John BERGE. The BERGE business passed to WORTHINGTON and ALLEN.

BERGER - *Boston, US.* See BUFF.

BERNE - see SCHENK.

BERNIER - mathematical instrument maker, *Au Niveau à Paris,* 18C. [91] He constructed an excellent mounted, as opposed to customary hand-held, telescopic quadrant.

BERNOULLI Jean (Jnr or III) - Swiss mathematician /scientist, and commentator, 1744-1807, born at *Basle.* [92] His grandfather was the famous mathematician, Jean BERNOULLI 1667-1748. He visited instrument makers in Europe in October 1768 and July 1769, and described workshops of George ADAMS, Peter DOLLOND and Benjamin MARTIN. [93]

BERTELE - optician. He designed a wide-angle eyepiece. [94]

BERTHON E.L (Rev) - vicar of *Romsey.* He built a very early "Romsey-type" telescope housing. [95]

BESSEL Friedrich Wilhelm - eminent German astronomer and mathematician, 1784-1846, who was associated with REICHENBACH.

BEVIS John - astronomer, 1693-1771. [96] He is said to have coined the word *achromatic* for John DOLLOND's telescope objective. [97]

BILDT Jan van der - instrument maker, *Franeker, Netherlands,* mid-19C. He is known to have made Gregorian reflectors. [98]

BIRD John - prominent English instrument maker, *At the Sea Quadrant, Court Gardens, Strand, London,* 1709 -76. He had an international reputation for making divided circles and owned his own business by 1745. BIRD made his own lenses unlike many other instrument makers of his day. The standard yards of 1758 and 1760 were constructed by him, but they were destroyed by fire in 1834 within the Houses of Parliament. He made the Oxford zenith sector, and a BORDA-type reflecting circle for Admiral CAMPBELL. [99] BIRD observed the 1761 Venus transit and the 1765 annular solar eclipse using his own instruments. [100]

BIRD Thomas - optical instrument maker, *Sheffield.* fl.1822.

BIRDSTRUP J - optical instrument maker, *London,* c.1750. His name is inscribed on a 3in Gregorian telescope. [101]

BIRMINGHAM - gentleman astronomer, *Tuam, Galway, Ireland,* 19C. His telescope, a 5in refractor exists today in Galway but not in use, and his catalogue of red stars is well-known. [102]

BISHOP George - gentleman astronomer, retired from a wine-making business, *South Villa, Regent's Park, London,* 1785-1861. He owned a 7in aperture, f/18, G.DOLLOND refractor. Several well-known amateurs worked at *South Villa*; DAWES on double stars 1839-44; HIND discovered ten asteroids there, and MARTH discovered one. The search for planets was popular especially after the orbit determination of asteroid Astraea by HENCKE in 1845. The observatory moved to *Twickenham* at his death, and put to use by his son. [103]

BLAIR Robert - Scots naval surgeon, professor of astronomy at *Edinburgh,* living at *Merchiston,* fl.1783-1828. He was interested in liquid-filled lens, and wrote on methods of constructing achromatic and aplanatic telescopes in 1797 employing the younger George ADAMS to construct his optical

[90] See sale of instruments, late RAMSDEN, 19C ChrSep86, BERGE [ChrJun89]. See AZ 62 6A, Tayl 255 and King 172.

[91] Daumas 346.

[92] King 117.

[93] See "Lettres astronomiques...." in main Refs. Also note Daniel BERNOULLI 1700-82, and see Buttmann's Shadow of a Telescope 28, hereafter Shad Tel.

[94] Barlow 62, hereafter Barl.

[95] Bell 250/251. A very early (c.1791) copper spherical housing, i.e. a dome, is preserved at Armagh Observatory.

[96] Tayl 111.

[97] There was apparently also a certain G. BEVIS (King 85).

[98] G. L'E Turner's Antique Sci. Instr. 120, hereafter Turner Antiq.

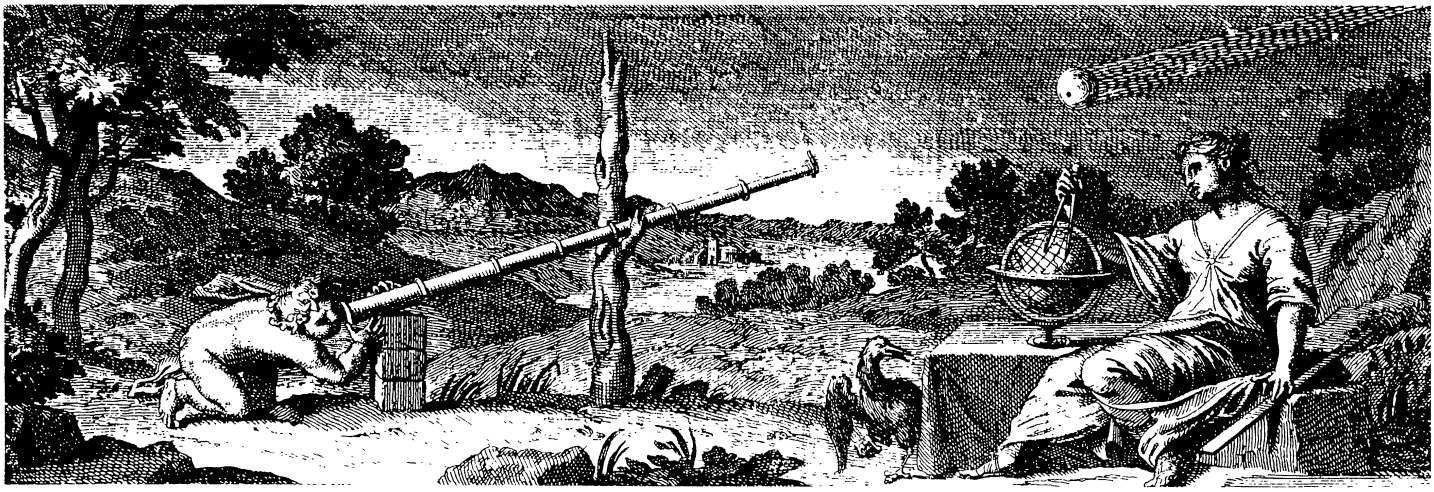
[99] Pearson 433, 577.

[100] See Chapman, Vistas vol. 20, 148 (quadrant micrometer), Dewhirst, Tayl. 169, and 18C [CHrDec89 lot 111], and King 115, 117. See Isis vol.17, pt.1, 127, 1932. Also on early telescopes, Isis vol.40, pt.3, 213, 1949, and MNRAS vol.85, 659, 1925.

[101] Tayl 224.

[102] Trans. Roy. Irish Acad.26 (1877).

[103] Hersch 42, and Smyth's Aedes Hartwelliana 244, hereafter Aed Hartw, MNRAS vol.22, 104.



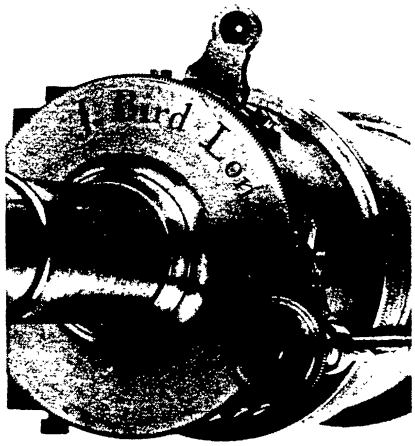


Figure 8: (a) A 2.3in refracting telescope, 36.6in long, signed BERGE, London, late RAMSDEN (inscribed small script), with steadying bar and ivory turn-key and azimuth slow motion on a universal joint, with cabriole legs terminating in pad feet, is shown (valued at £800-1200 at Christie's in June 1989). (b) A rare miniature 2.25in reflecting telescope by BIRD, 10in long, is shown. Vernier scales were originally incorporated in focussing, the alt-azimuth mount being fitted with engraved scales, level and cross-bubble, and finder sights were provided. (valued at £3000-5000 at Christie's in December 1989. See colour illustration in catalogue).

Figure 9: John BIRD, a notable instrument maker (1709-76).

instruments. [104] His son Archibald BLAIR was an optician in *Edinburgh* 1827, and later in *London.*

BLACHFORD Robert and William - chart makers in *Minoris.* [105]

BLEULER John - optical instrument maker, *27 Ludgate St, London*, 1757 -1829. He was apprenticed to SHUTTLEWORTH 1771, and later worked with him until 1791. [106]

BLISS Nathaniel - Astronomer Royal during 1762-64. He continued BRADLEY's meridian work on positional astronomy.

BLUNT Thomas - English mathematical and optical instrument maker, *22 Cornhill, London*, fl.1760 -1822. [107] He was apprenticed to NAIRNE and later became his partner. We also record T and T BLUNT, opticians, at the same *Cornhill* address.

BOFFAT - *Toulouse*, 17C. He proposed a polar heliostat in 1682.

BOND George Phillips - US, 19C. He successfully used wet collodion plates in celestial photography c.1865. See footnote under FOUCAULT.

BOLTON Thomas - mathematical instrument maker, late 18C. [108]

BONTEMPS - French optical glass manufacturer. He was a pupil of Henry GUINAND from PARRA and MANTOIS in Paris, and contributed his skills to help set up the firm of CHANCE in *Birmingham* c.1848.

BORDA Jean-Charles de - designer of the reflecting circle. He is sometimes referred to as Chevalier BORDA, a sign of distinction in France. BORDA's "improved" reflecting circle in its simplest form had been devised in 1752 by Tobias MAYER (1723-62), and later constructed by BIRD and by LENOIR. [109]

BOREL - French optician. [110]

BORELLI Giovanni Alfonso - Italian optician, telescope maker, "disciple of GALILEO". [111]

BOSCOVICH Ruggieri J - Jesuit priest, astronomer and mathematician, from *Pavia*, working at the *Roman College (Vatican) Observatory*, fl.1777 -82. He invented a ring micrometer, and is known to have visited William HERSCHEL. [112]

BOURIOT - contemporary wth CLAIRUT.

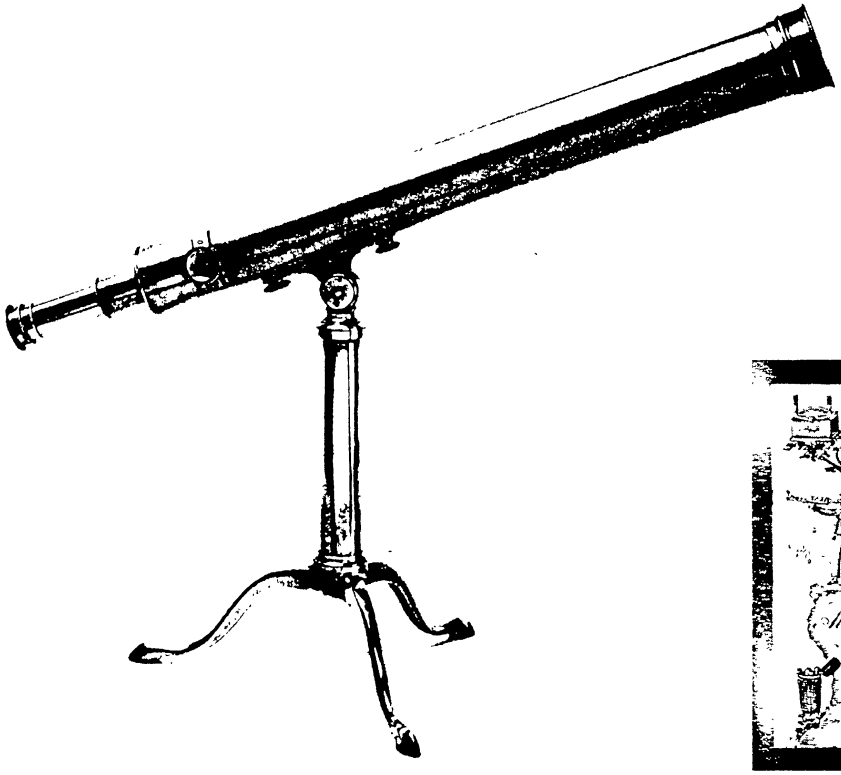
BOUWERS A - optical designer, *Delft, Netherlands*, 20C. Amongst his extensive work, he designed a modified meniscus corrector for the MAKSUTOV system. [113]

BRADFORD Isaac - mathematical instrument maker, *87 Bell Dock, Wapping, London* (1795 - 1822), *69 Bell Dock* (1805 -15), *136 Minoris, London* (1817 -22). [114]

BRADLEY James (Rev) - astronomer, 1692/93?-1762. He was Professor of Astronomy at Oxford, and later, Astronomer Royal 1742-62. With interests in latitude determination [115] and the position of the equinox, nutation, refraction, and accurate transit observations, BRADLEY discovered the *aberration of light.* [116] Working with S. Molyneux c.1725, he took lessons in speculum polishing from John HADLEY, and had a private observatory at *Wanstead, Essex*, and worked with Lord MACCLESFIELD (1st Earl, mid 18C) at *Shirburn Castle.* Initially he had a *repaired* 1721 transit circle by SISSON and a *modified* GRAHAM transit 1725; he eventually acquired a 12ft GRAHAM zenith sector 1727, which is now at Greenwich, and an 8ft BIRD transit 1750. Both BRADLEY and MOLYNEUX instructed SCARLETT and HEARNE on optical instrument making, who can then claim descendency from the HADLEY line. [117]

BRAHE Tycho - distinguished astronomer, working

[104] King 189.
[105] Tayl 240, 357, 461, 473, describing life in the Minoris.
[106] Tayl 280.
[107] See CHrDec88, CHrApr88, [CHrJun89], CHrSep89 (many monoculars). Possible connection with BRADFORD at 136 Minoris 1817 -22 (Tayl 332). Note McFarland 201, hereafter JMcF, object glass micrometer.
[108] Daumas 323.
[109] D and C, King 82, Howse. See also A.Turner, "From Pleasure to Profit" 51.
[110] King 59.
[111] King 60.
[112] See Maffeo, "In the Service of 9 Popes". Also see Tayl 63, and ROCHON JHA vol.22, 162.
[113] King 360.
[114] BRADFORD possibly took over from BLUNT. Tayl. 332. We find reference to John BRADFORD fl.c.1868 - 1910, a continuation of Isaac's business. See Handlist and CHrDec85.
[115] See, e.g. Bennett's The Divided Circle, and Tayl.
[116] See King 78, 112, for BRADLEY's original ideas on aberration.
[117] King 78.



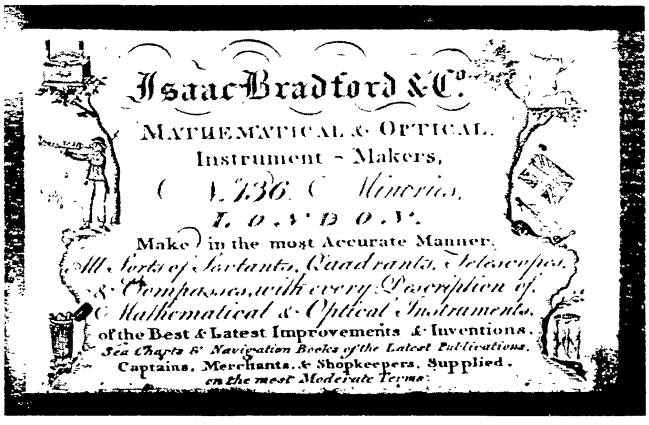
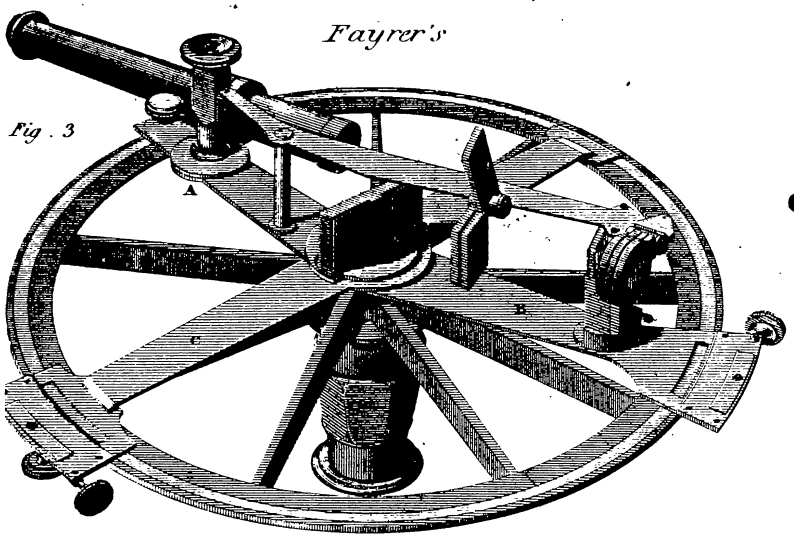


Figure 10: (a) A 1.6in brass refractor, 18.5in long, signed on the backplate *BLUNT*LONDON (inscribed capitals), is shown. It has pad feet very similar to BERGE's earlier instrument (sold at Christie's for £528 in June 1989). (b) A trade label from the mathematical and optical instrument maker, Isaac BRADFORD is shown. It accompanied a three-draw 1.75in brass telescope with mohogany outer tube, named the *Improv'd NIGHT O DAY*, one of several manufactured by BRADFORD (sold at Christie's for £180 in July 1986). (c) The BORDA reflecting circle, the rich mariner's nautical "sextant", used more by the German and French navy than the English, may be compared with those made by FAYRER and MENDOZA and TROUGHTON (fully described in PEARSON's "Practical Astronomy"). Constructed by reputed makers like BERGE and DOLLOND (London), DOLBERG (Rostock), PISTOR and MARTIN (Berlin), the reflecting circle consists of a graduated (360°) circle with two radial arms, one carrying a plane mirror and vernier scale at opposite ends, the other a telescope and a small mirror with another vernier at the limb (overleaf).

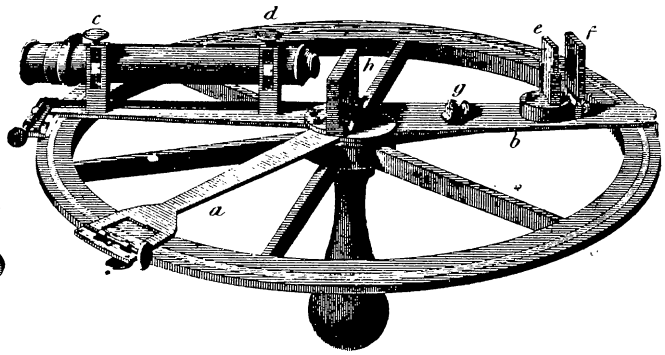
Fayrer's

Fig. 3



Borda's

Fig. 1.



Mendoza's

Fig. 2.

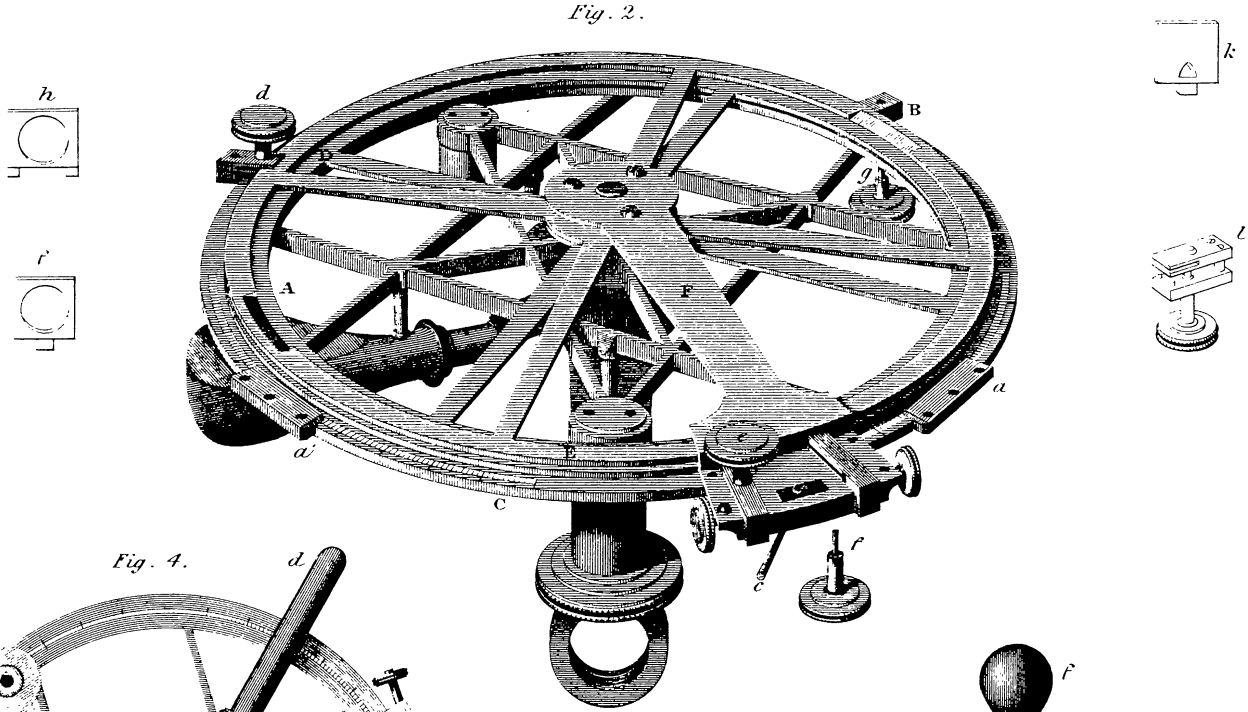
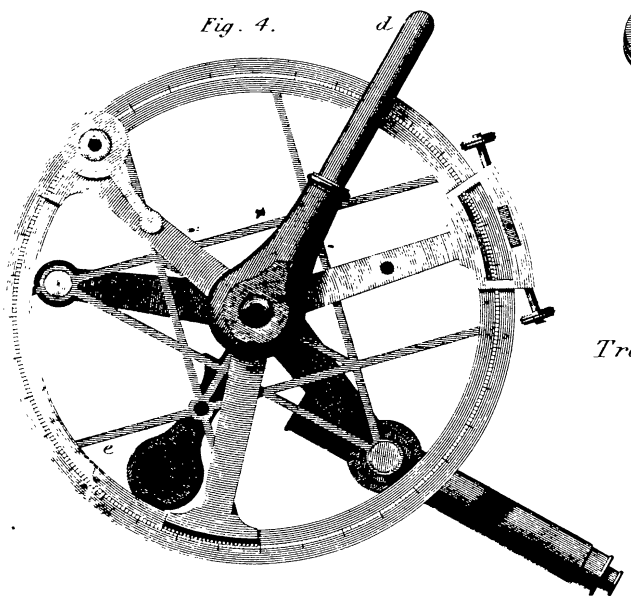
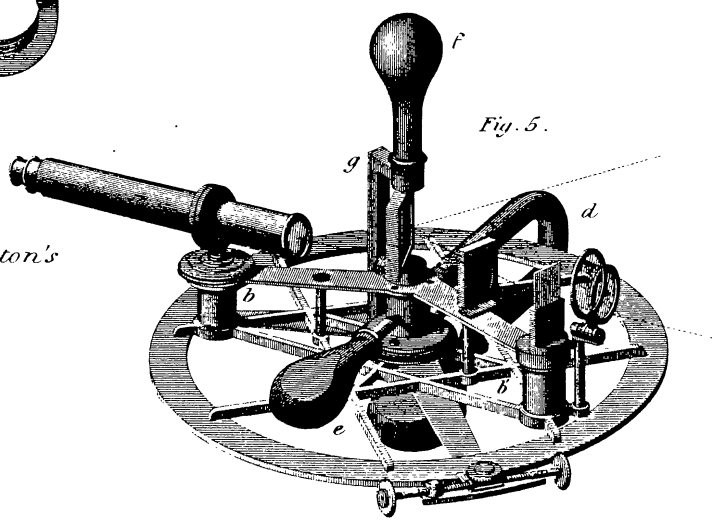


Fig. 4.



Troughton's

Fig. 5.



at Uraniborg 1576-80 on the island of *Hven* in Denmark. Although not using telescopes, he is known to have dispensed with the alidade on his quadrants and used a short cylindrical tube 'set' in an aperture (acting as tubeless and lens-less sights) and two parallel slits (to avoid parallax). Also, he used an armilliary instrument to make celestial measurements and a torquetum to make his calculations easier. [118] BRAHE also made clocks for use in measuring astronomical positions.

BRANDER Georg Friedrick - eminent Bavarian instrument maker. He was born in *Regensburg*, and studied and worked from 1713 until 1783 under DOPPELMAYR (1671-1750) at *Nurenburg*. He was partner to HÖSCHEL, his son-in-law, in a large retail business c.1775 in *Ausburg*, living c.1713-83. [119] He was associated with the making of an 8ft mural quadrant and a 12ft equatorial sector. and made the first German reflecting telescope in 1737 and a circle dividing engine. [120]

BRASHEAR John Alfred - eminent optical instrument and telescope maker, *3 Holt St, South Side, Pittsburgh*, fl.c.1882-1910. [121] He earlier worked for LANGLEY, Professor at the old Allegheny Observatory. As part of a substantial optical output, BRASHEAR made the 72in aperture mirror for the Dominion Astrophysical Observatory, Victoria, Canada in 1915, the mechanical parts of which were made by WARNER and SWASEY Co. of Cleveland. Other instruments made by him include a concave grating spectrograph. BRASHEAR's silvering process was used up until 1933 when vacuum aluminizing was developed. His later telescope objectives had the flint component foremost. This was a method used by STEINHEIL. BRASHEAR was associated with HASTINGS who determined the refractive indices of BRASHEAR's glass. We note that J.B. McDOWELL, his son-in-law, took over the business. [122] BRASHEAR later became Director of the new Allegheny Observatory.

BRAUER - optical instrument maker. A 19C portable transit instrument with 'broken axis' is known. [123]

BRAUN Carl - A.G. Optische Industrie, *Nunberg* (World War II binocular code hkm). We find also Antonius BRAUN in 1716 at *Löwenfeld*. [124]

BREITHAUPT Johann Christian - founder of *Kassel* workshop, where he made a 6ft mural quadrant for Kassel Observatory. He lived 1736-99. Two sons, Frederich Wilhelm and Carl Wilhelm worked with him. [125]

BREWSTER David (Sir) - natural philosopher /scientific commentator, *Scotland*, 1781-1868. [126] He was associated with ADIE and CARY, and was author of "A Treatise on Optics", 1853. [127] In 1815 he postulated the law of polarisation by reflection.

BRINKLEY John - astronomer, *Dublin*, 1763-1835. Royal Astronomer of Ireland, he had an 8ft alt-azimuth circle by RAMSDEN /BERGE. [128]

BROADHURST CLARKSON - *63 Farringdon Rd, London EC.* c.1900-26, although the original firm dates back to c.1785. [129] The company was taken over by FULLER of FULLERSCOPES.

BROCA - optician, known to have designed a constant deviation prism, as frequently used in early spectroscopes. [130]

BRODIE Frederick - English private astronomer *Eastbourne*, mid-19C. He owned a 7.5in aperture "modified" equatorial telescope. [131]

BROWN E - American instrument maker, mid-19C. [132]

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[118] The armilliary sphere is a skeletal celestial globe with interlocking rings from Hellenistic times, and the torquetum resembles an early equatorial telescope-mounting but uses an alidade, or a straight rule with sights (for transformations of coordinates, e.g. equatorial to ecliptic). See Bennett.

[119] JHA vol.22.

[120] A Turner 223. Examples of his work are in the Deutsches Museum (Howse).

[121] Handlist, autobiog. in Pop. Astr. 28, 373 (1926), Bell 46, King, Sinnott's article in Sky and Telescope, April 1991, 432, hereafter ST.

[122] King 370, Sinnott ST. A BRASHEAR collection is presently being attempted in Pittsburgh (private comm. F Zabrosky, Univ. Pittsburgh, Archives of Industrial Society).

[123] Shown by Bennett 172.

[124] Daumas 333.

[125] Bennett 84. See Astr. Nachr. No.3255, 227, c.1894, which shows a vertical telescope incorporating a prism, built in association with A BECK in Riga.

[126] The Edinburgh Encyclopaedia c.1830 was conducted by BREWSTER.

[127] See PEARSON's description and illustration (Plate II) of a patented telescope with an erecting eyepiece, a lens being placed in the middle of the main tube.

[128] Tayl 305.

[129] See CHrApr88, CHrSep89 illustr.

[130] Barl 126.

[131] See Chambers' Handb. Astron. II, 343 (hereafter Chamb H), and Chamb 639, Fig.204. Frederick BRODIE was the uncle of G.F. CHAMBERS, amateur astronomer and prolific author, and a friend of DAWES.

[132] See Turner's 19C Sci. Instr., 252.

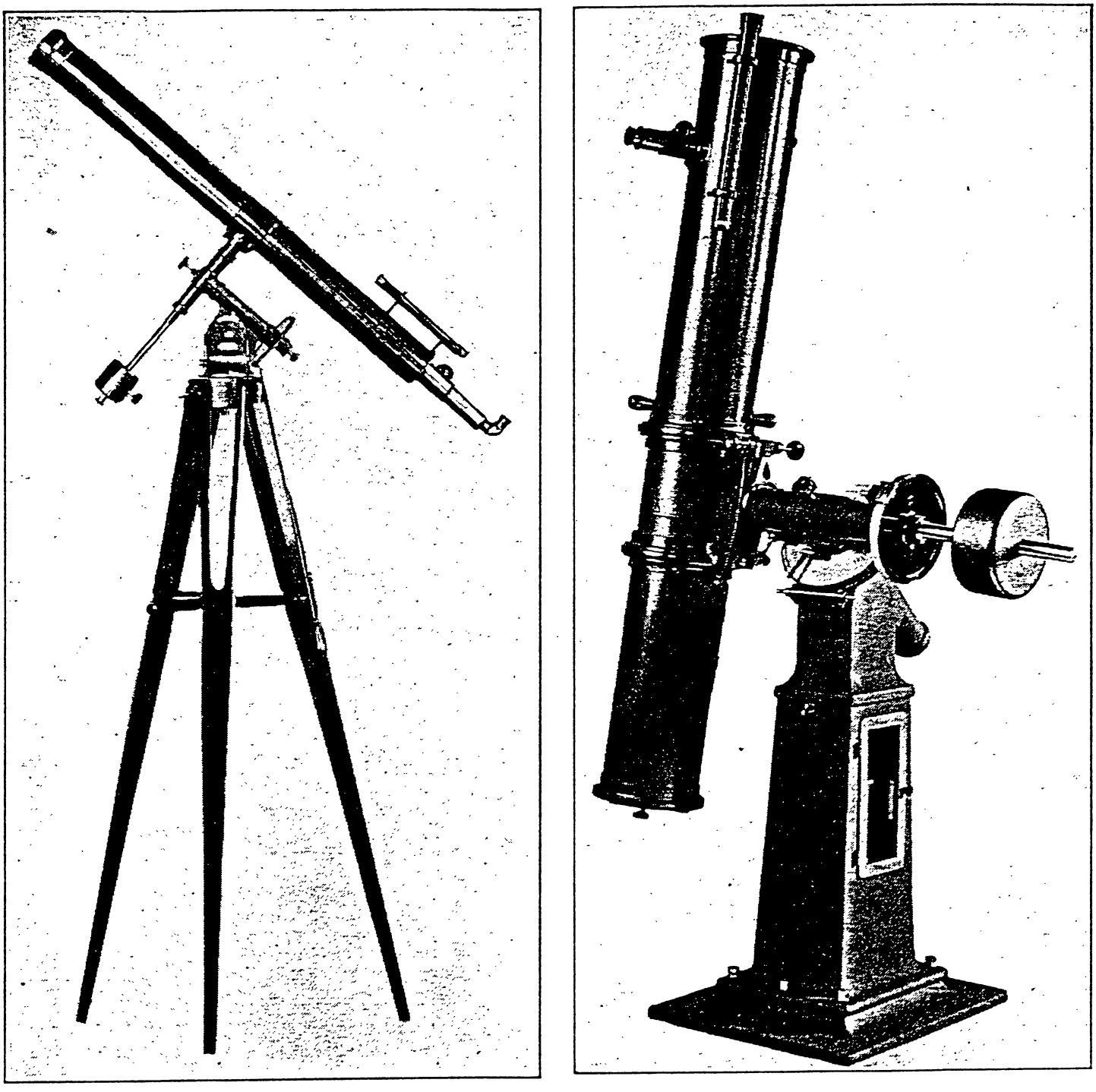


Figure 11: BRASHEAR refractor and reflector c.1890.

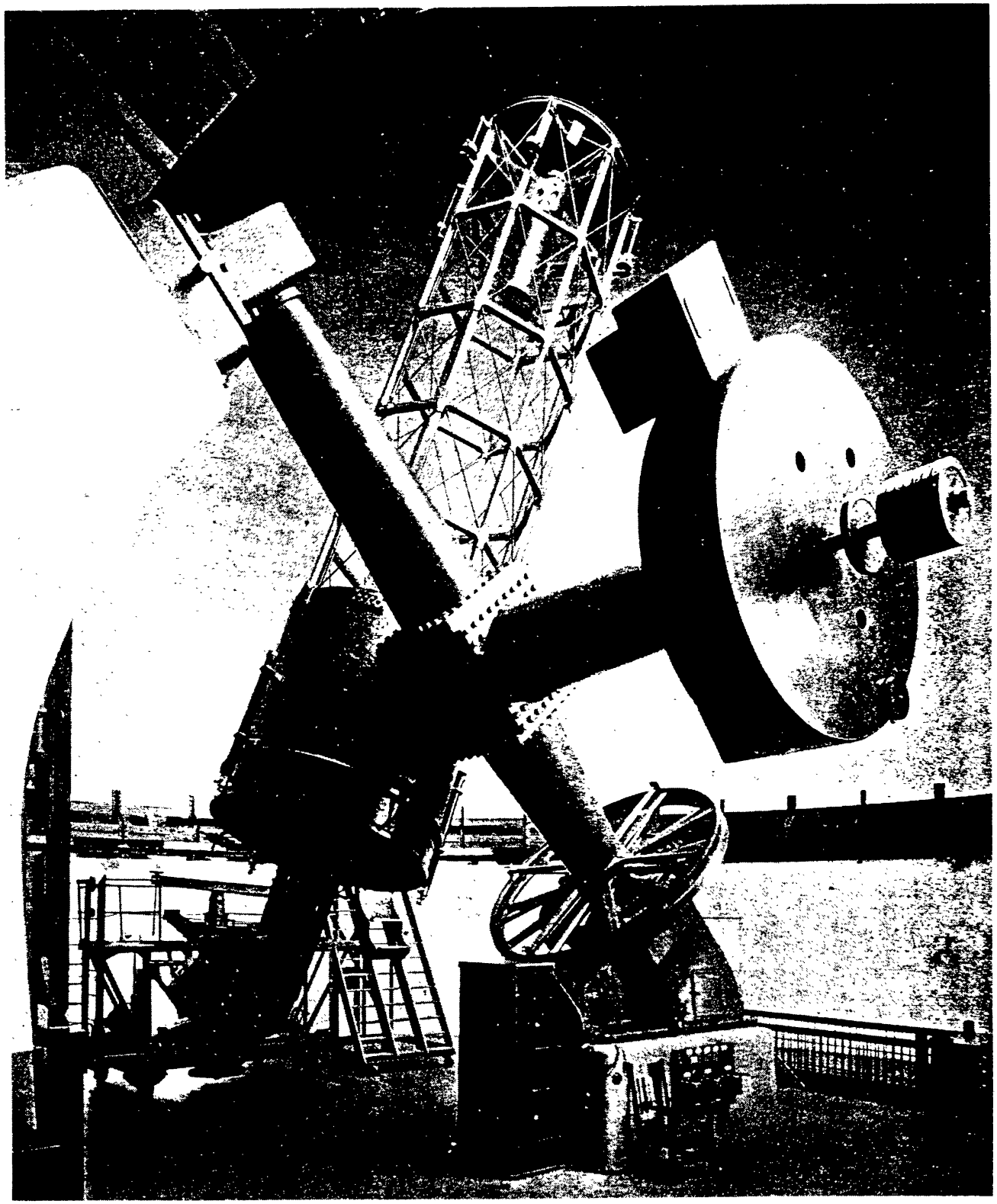


Figure 12: The 72in Reflecting Telescope of the Dominion Astrophysical Observatory, with mirror figured by BRASHEAR.

BROWN John and Thomas - mathematical instrument makers, 17C. [133]

BROWN J and son - *Newcastle upon Tyne*, late-19C. [134]

BROWNE Henry - scientist, *Portland Place, London*, fl.1797-1818. [135] He possessed a transit instrument (maker unknown) and was associated with KATER.

BROWNING Samuel (I) - the earliest known member of an important family of English instrument makers, bc.1752, dc.1819, apprenticed to Richard RUST 1768. Samuel (I)'s output is dated c.1782-1811. His brother John (I) was also the head of a line of instrument makers (see below). Samuel BROWNING (I) was in partnership with William SPENCER (I) from c.1781 and Ebenezer RUST from c.1784, inscribing their navigational instruments with SBR indicating the highest quality of graduated scale made on a RAMSDEN-type dividing machine. [136] Samuel had three sons, Samuel (II) bc.1777, John (II) bc.1780, fl.1803 onwards, and Richard fl.1818 onwards. The firm flourished in *London, St Neots and 66 High St, Wapping* (1816-39). [137] The name SPENCER and BROWNING, optical and mathematical instrument makers may be found at *327 Wapping* (1788-96).

BROWNING John (I) - instrument maker, bc.1753, dc.1811, brother of Samuel (I). He had a son, William. His great grandson was the famous John BROWNING (III) of *Minoris and Strand, London.*

BROWNING William Spencer - nautical instrument maker, *23 South Castle St, Liverpool*, bc.1825, flourished until c.1860. He was John (I)'s grandson, and his son was the famous John BROWNING (III). [138] There were possible business connections in *Newcastle.*

BROWNING John (III) - optical and mathematical instrument maker, 1835-1925, well-known for his spectroscopes and telescopes (especially reflectors). His business flourished to c.1905. Possibly starting at *1 Norfolk St, Strand* c.1866, the firm had their factory in *Vine St, EC. London* (1872-76) and *Southampton St. north off the Strand* (1877-82) and *William St* [139] (1887). John BROWNING entered his father's business, after giving up medical studies, the shop being at *111 Minories, London* and working under the name, SPENCER, BROWNING and Co. [140] In the early 1870's BROWNING's shop moved to *63 Strand.* [141] John BROWNING's home was in *Sevenoaks, Kent*, but he retired to *Chiselhurst.*

The eminent instrument maker, Adam HILGER, and W. WOODWARD who both worked for BROWNING, left in the mid 1870s. [142] John BROWNING was the author of "A Plea for Reflectors", 1867, [143] and is known to have mounted many of WITH's fine mirrors. SORBY collaborated with BROWNING on the production of the micro -spectroscope, [144] and BROWNING's fame spread through Europe. KONKOLY , for example, possessed instruments by BROWNING-WITH, SPENCER BROWNING AND RUST etc. in Hungary. [145]

BROWNING Louis P - instrument maker, *147 Holborn Bars EC.* [146]

BRUCE William - optical and brass turner, *16 King's Head Court, Shoe Lane, London*, flourished

[133] Daumas 92, 96.

[134] See CHrDec88, and also James BROWN, *Glasgow*, (retail?) BG183.

[135] Tayl 332.

[136] SBR was probably also used by Samuel (I)'s son, Richard, and nephew, William. An ebony, brass and ivory octant inscribed SBR is in the Newcastle Museum of Science and Engineering, according to project SIMON.

[137] Richard BROWNING inherited the BROWNING share of the SBR wealth. See Project SIMON.

[138] William Spencer BROWNING's shop possibly inspired "Dombey and Son" 1848 (Dickens).

[139] We find today a William IV St, near the Strand.

[140] Many instrument makers worked in the vicinity, e.g. BRADFORD was at nearby 136 Minoris. In early 19C, the Minoris had been a hive of activity for navigational instrument makers, chart makers etc. with lectures being given at nearby venues, e.g. by a certain Janet TAYLOR. See Tayl 102.

[141] We record that on the north side of Tower Hill, near Minoris, a great improvement was carried out with the removal of blocks of houses between Postern Row and what was called George St. In the 1870s, buildings were destroyed to allow the extension to the Fenchurch St railway station. See Clunn 48. This probably devastated the navigational instrument trade in the Minoris temporarily.

[142] See BROWNING's obituary in MNRAS Feb 1930, 359. There is a touching story that LOCKYER approached John BROWNING to construct a HERSCHEL-type spectroscope in 1864 but BROWNING declined to part with the spectroscope until it performed totally to his satisfaction. This meant that LOCKYER missed being the first to observe solar prominences outside a total eclipse.

[143] HARGREAVES in 20C wrote another, "New Plea for Reflectors", see JBAA vol.46, 193.

[144] Turner Mic 126.

[145] Private commun. M.Vargha and K. Olah. See also CHrDec88 illustr and BROWNING spectroscope CHrSep86 illustr.

[146] See RP. We have not identified the family connection.

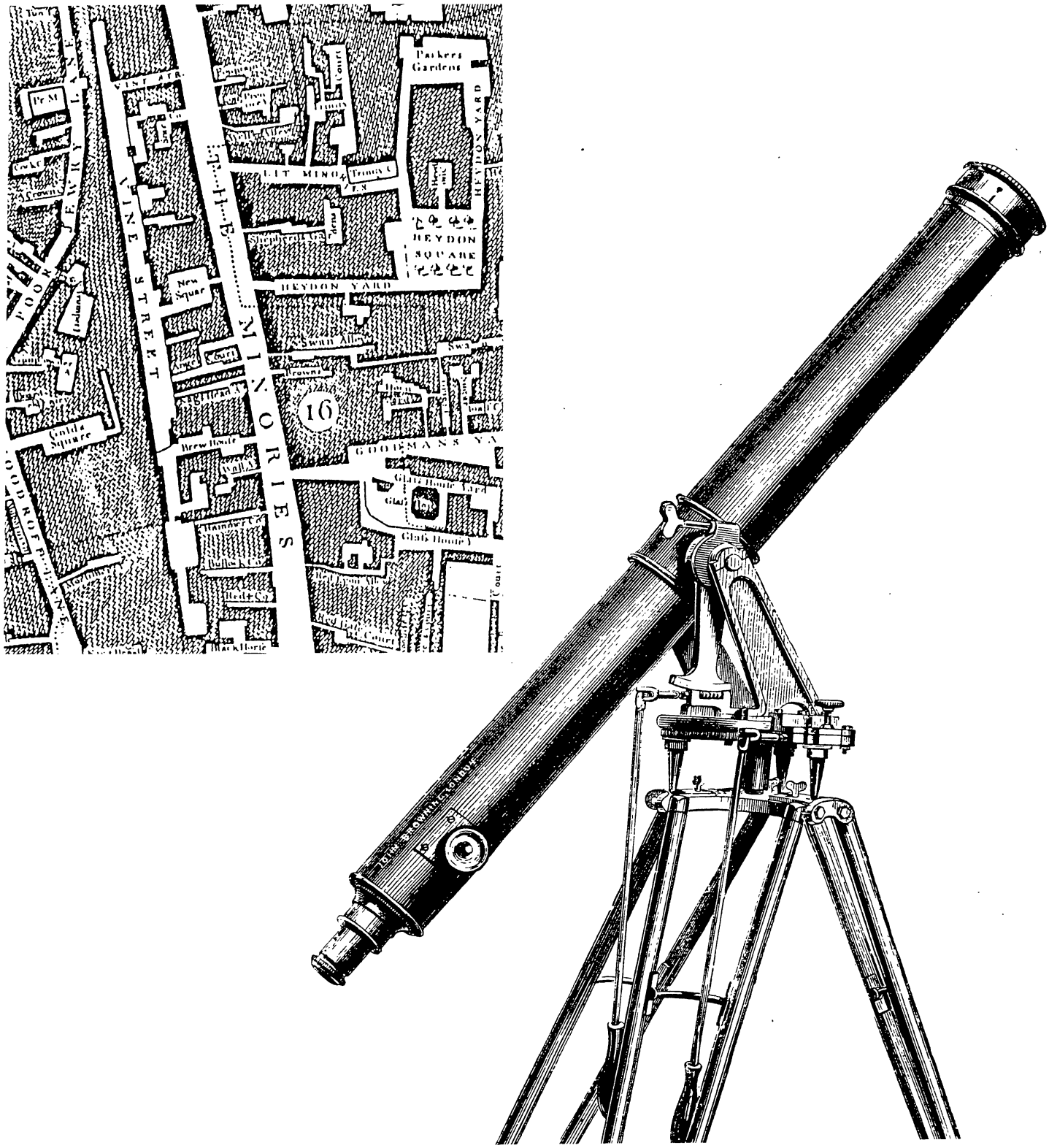
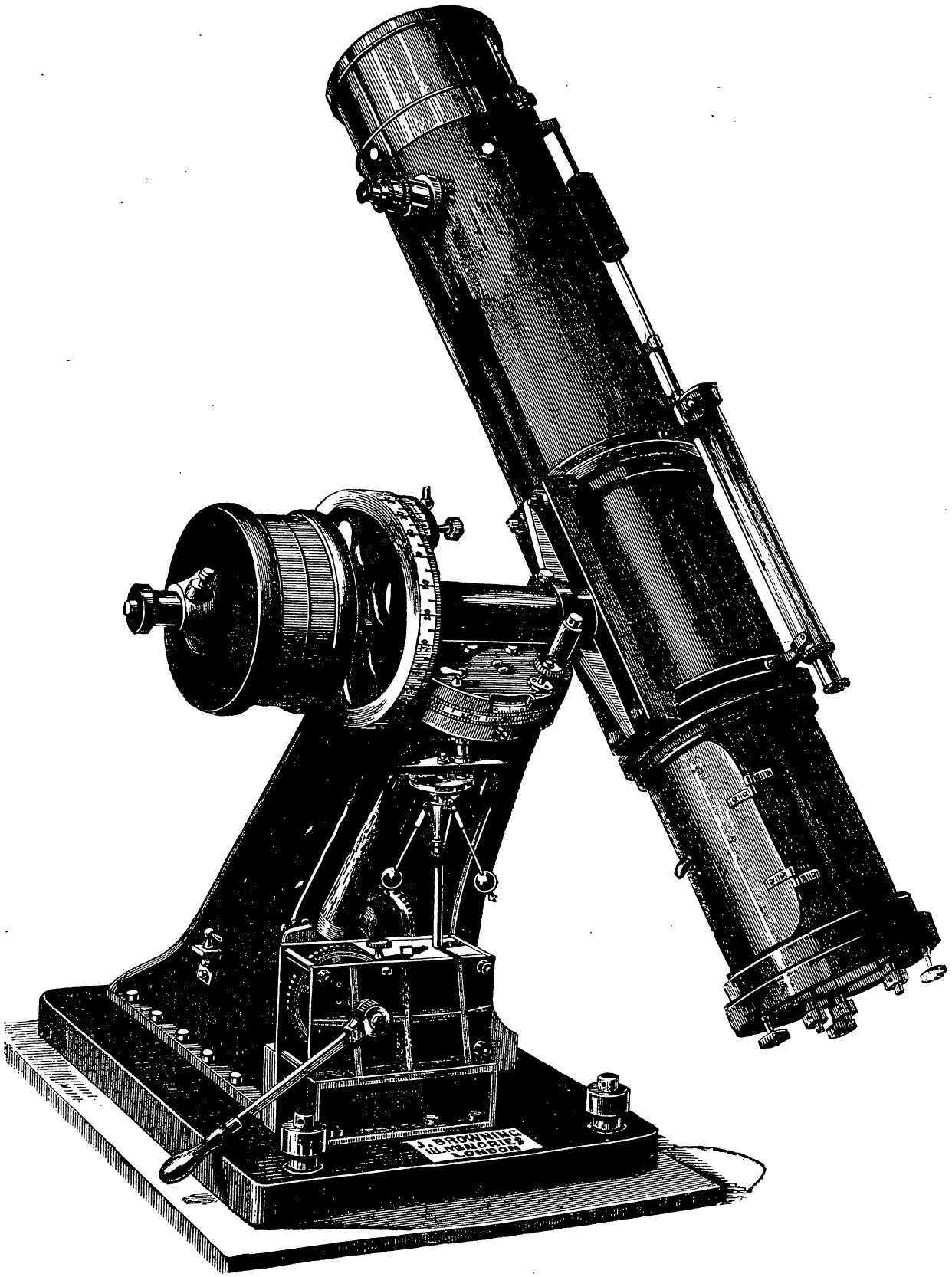


Figure 13: (a) A very fine John BROWNING astronomical refractor c.1890. The trunnions were mounted on three levelling screws, and slow motion in altitude ingeniously applied through a short sector as in much larger equatorially mounted instruments. (b) Typical solid reflecting telescope by John BROWNING, mirror aperture about 10in to 12in (overleaf).



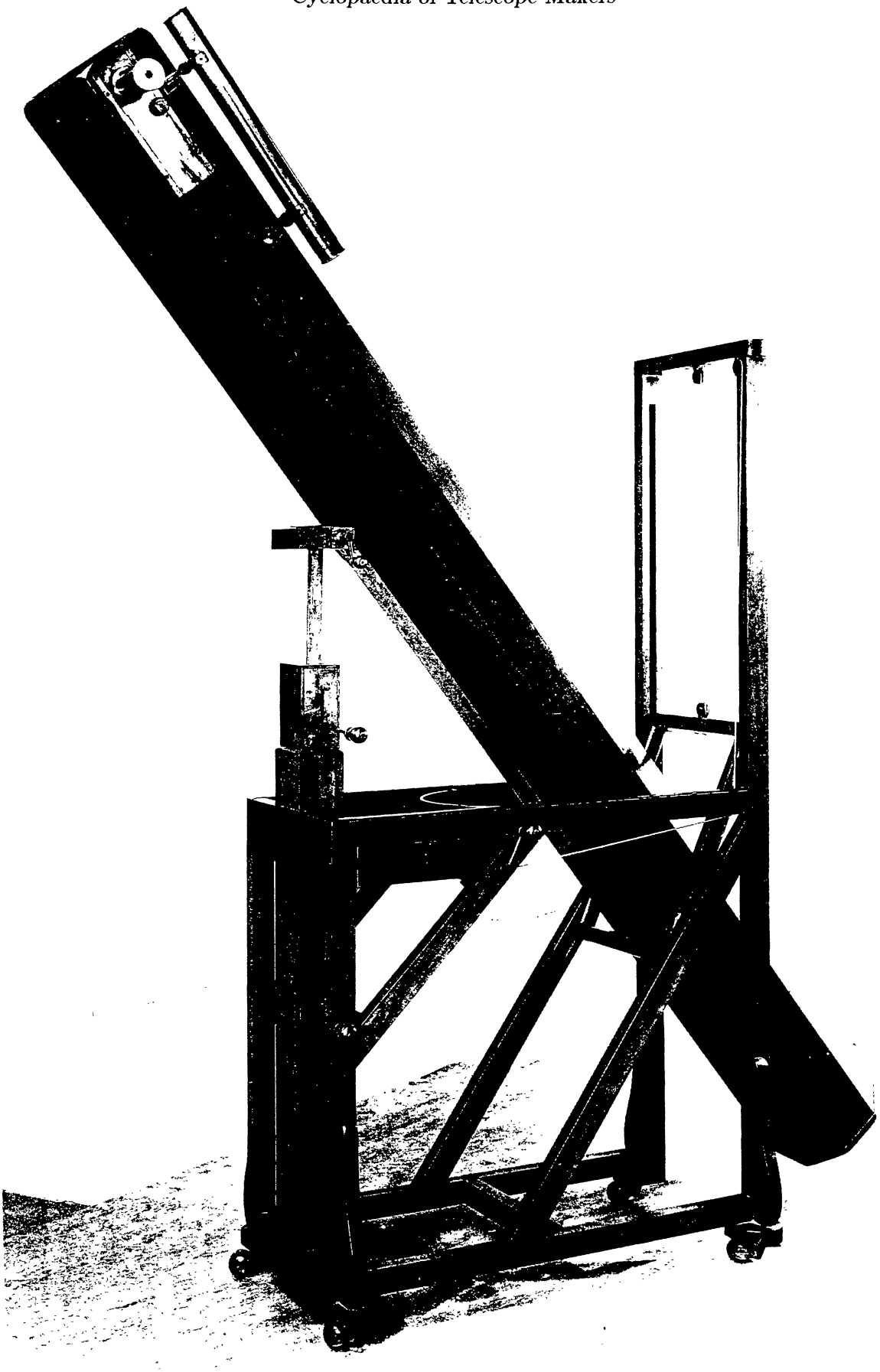


Figure 14: This is the type of HERSCHEL reflector that King George III gave to Count von BRÜHL.

from 1806 until 1827. He cooperated with Charles WEST, instrument maker, in designing a portable telescope in 1806. [147]

BRÜHL John Maurice (Count Moritz von BRÜHL) - amateur scientist 1736-1809. Count BRÜHL was the German ambassador of Saxony, and was much interested in science. He set up a small observatory at *Harefield* c.1787 with a 2ft RAMSDEN circle. Also, TROUGHTON made him a 2ft altitude and azimuth circle in 1792. [148]

BRYSON James Mackay - instrument maker, 1825-94. From a family of clockmakers, founded by Robert BRYSON in 1810 and continued by Robert's sons, Alexander (1816-66) and Robert (1819-86), J.M. BRYSON studied with REPSOLD in *Hamburg* and MERZ in *Munich*. He was at several addresses in *Edinburgh*, starting at *65 Princes St* c.1850, making scientific and mathematical instruments, including spectroscopes and microscopes. [149]

BUCKINGHAM J - amateur astronomer, *Walworth Common, Nr London*. He owned a 21in (28.5ft focal length) equatorial refractor, temporarily installed on *Carlton Hill, Edinburgh*. [150]

BUFF - engineering and surveying instrument maker, c.1878-1914 *Boston, US*. He was associated with BERGER (*Boston*) and COOKE (*York, UK*). [151]

BULLIALDUS
Ismael - associated with HEVELIUS (See Prince in main Refs.).

BURATTINI Tito Livio - *Poland*, c.1660 -80. He constructed an aerial telescope for HEVELIUS at *Varsovic*. He attempted making liquid-filled lenses. [152]

BURON - French telescope maker, mid 19C. [153]

BURRELL E.P. - telescope designer and engineer with WARNER and SWASEY. [154]

BURTON Mark - mathematical instrument maker, *Euclid's Head, near New Church, Strand*, fl.1730 - c.1751. Known to have worked with SHORT and BIRD, he made barometers, thermometers and divided scales, and it is suggested that RAMSDEN may have been influenced by him early on (c.1751). [155]

BURTON John - *England*, fl.1758-75. [156]

BURTON George (I) - optical instrument maker, *136 Borough, Southwark, London*, fl.1772 -1815. [157] His instruments appear on several ship's lists. [158]

BUSCH Emil - Prussian telescope maker, mid 19C. [159] See also BUSCH AG Optische Industrie, *Rathenow* (binocular codes cxn, czn, krg)

BUTTERFIELD Michael - instrument maker, *Paris*, 1635 -1724, specialist in microscopes.

BUTTON John - glass-grinder, fl.1767.

BUTTI Donati - Italian instrument maker, probably not telescopes, *Milano*. [160]

BUTTI Louis Joseph - (see ZENONI) probably retailer. [161] He set up independently in 1825 but not making scientific instruments.

BUTTON John - glass grinder, *33 Crooked Lane, London*, fl.1767. [162]

BYERS Edward - present U.S. company, *29001 West Highway 58, Barstow, CA 92311*, established in the 1980s. [163]

[147] Tayl 358, 378.
[148] See Pearson 429, and JBAA vol.82, 225 (1972). A 7ft HERSCHEL 6.25in reflector, given to BRÜHL by George III is now at the Staatlicher Mathematisch Physikalischer Salon, Dresden - Zwinger.
[149] See BG 114. In c.1865 J.M. BRYSON made a copy of PIAZZI-SMYTH's wet plate camera used by the latter to photograph the interior of the Great Pyramids.
[150] The BUCKINGHAM objective was probably by WRAY, and was shown at the 1862 Exhibition alongside with NEWALL's. See also CRAIG. King 254.
[151] See Handlist.
[152] Daumas 90, Vistas vol.28, 357.
[153] Turner Antiq 120.
[154] King 352.
[155] Tayl 225.
[156] Tayl.
[157] Southwark was a centre for the glass industry.
[158] BURTON is noted for supplying a reflecting telescope and nautical instruments which went on a Pacific voyage of discovery (Vancouver and NW America). He also supplied Capt COOK with an instrument. See Tayl 282.
[159] Turner Antiq 120.
[160] Daumas 332.
[161] BG 102.
[162] See also BARNES at the Falcon Glass Works, and BELL at Southwark.
[163] A notable side of the firm is the supply of 359-tooth gears for CELESTRON telescope drives. See MACP 38.

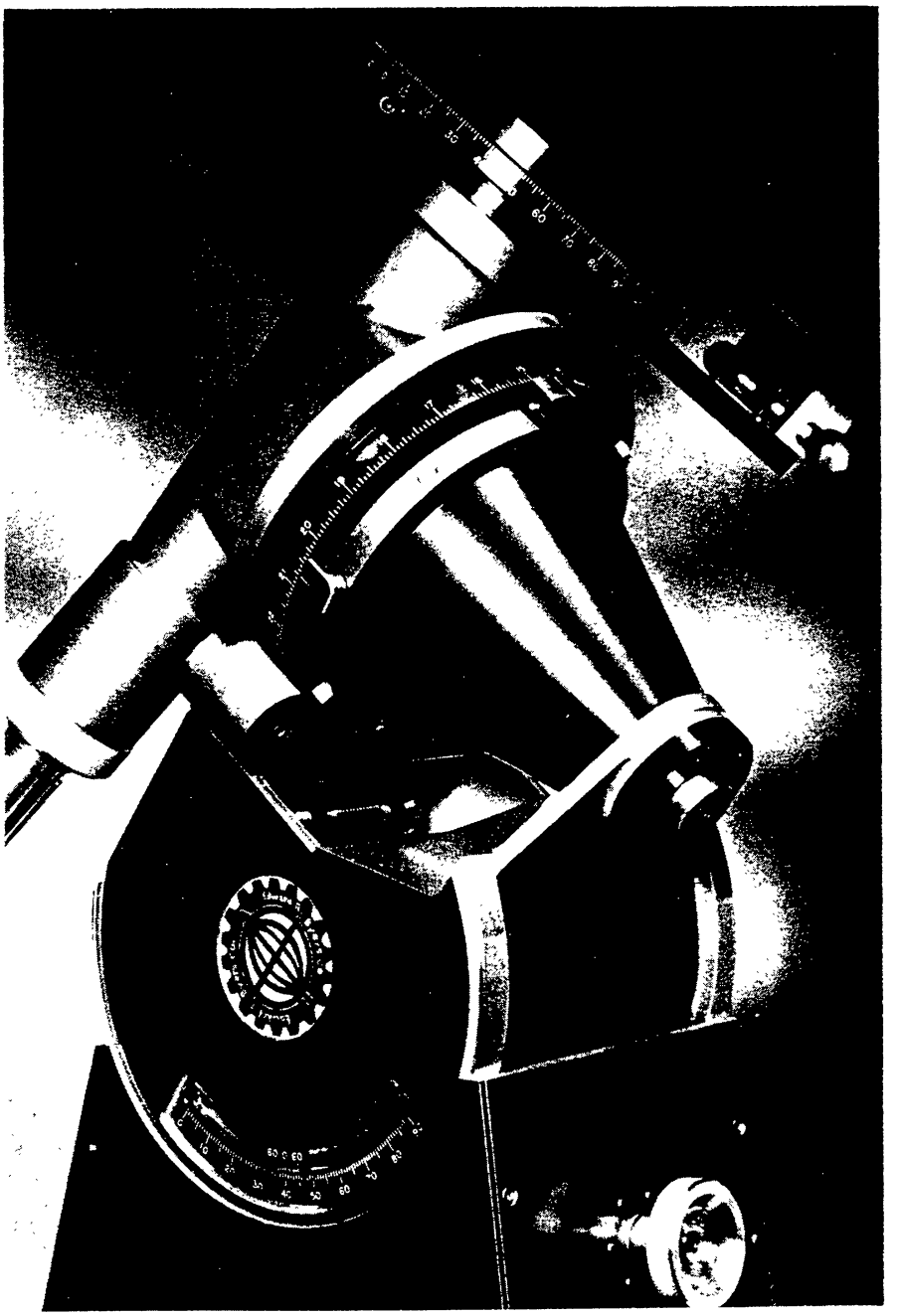


Figure 15: The modern BYERS' equatorial mounting for telescopes up to 12in reflectors and about 8in refractors.

C

CALVER George - notable mirror maker, *Yarmouth; Widford, near Chelmsford* (1870). Many of his telescopes were mounted by his collaborator, OTTWAY (*Ealing*). It is estimated that he made or re-figured 2000-4000 mirrors. [164] An 18in telescope with a CALVER mirror at Armagh 1883 [165] was converted to a 12/18in Schmidt telescope by HARGREAVES, a design utilizing a corrector and field-flattening lens.

CAMPANI Giuseppe - renowned Italian aerial telescope maker, *Rome and Bologna*, c.1620 -95. [166] He benefited from the Venetian glassworks nearby. He constructed the 10.8m aerial telescope at the old Paris Observatory. We find a CAMPANI lens-grinding machine and lenses in Bologna. [167]

CAMPBELL John (vice-Admiral) - 1720-90. His name is linked with many nautical instruments. [168]

CAMPBELL Colin - astronomer, fl.1730-38.

CANBY J - *South Castle St, Liverpool*, 19C. [169]

CANIVET - optical and mathematical instrument maker, d.1774. He was successor to LANGLOIS, and he himself was succeeded by LENNEL. Amongst his major commissions were a 6ft sextant and 6ft mural quadrant for the Jesuit Observatory in Milan in the 1760's, and many geodetic instruments. [170]

CAPLATZI Anthony - mathematical and philosophical instrument maker, *3 Chenies St, Bedford Sq, London WC, and 22 Charlotte St*, c.1894. [171]

CAREY George - mathematics teacher, *London*, fl.1818-25. He wrote on astronomical and nautical instruments. [172]

CAROCHÉ Noël Simon - optician at *Passy* working with ROCHON. His name can be found spelt CARROCHÉ [173] and CAROCHEZ. He constructed the small achromatic refractor at the private Viviers Observatory c.1797. [174] He also made a 6ft focus Gregorian with platinum alloy 8in mirror, [175] which was claimed to be a larger optical advance than DOLLOND's success with achromatism. The mirror, however, was so expensive that a second mirror was thought appropriate (for King of Spain) to defray the costs. CAROCHÉ may be compared with William HERSCHEL as the French artisan who could have brought French telescopes to the fore. A contemporary of DESLANDRES and LAVOISIER, he worked during difficult times. The French declared war on Spain 1793, hostilities ceasing 1795. We find LAPLACE and LEGENDRE on the scene and actively interested after the war, and the platinum project was briefly resumed c.1799. ROCHON wanted to build a French 60ft telescope. However, GUINAND was already successfully producing excellent flint glass for refractors using fire-clay stirrers, [176] and this finally led to a return to refracting telescopes in early 19C, i.e. of much shorter focal length and achromatic.

CARPENTER and WESTLEY - *24 Regent St, London*, 19C. [177]

CARRINGTON - English gentleman astronomer and assistant lecturer at *Durham University*, living at *Redhill, Surrey*. He owned a SIMMS 5in aperture transit circle, modelled on AIRY's at Greenwich. With this instrument he compiled a catalogue of 3735 stars within 9° of the north celestial pole. [178]

CARY John (Snr) - cartographer and globemaker, *Corner of Arundel St, Strand, London* (1783), *181 Strand* (1792), *85/86 St James' St* (1821), *181/182 Strand*, living during the period 1754-1835. [179]

CARY William - notable English instrument maker (younger brother of John Snr), 1759-c.1825. He was at *272 Strand* (1786), *182 Strand* (1794-1822), and also the firm's name appears possibly *near Norfolk*

[164] See Marriott, Astronomy Now Feb.1991.
[165] JMcF 172.
[166] Daumas 87, Bell 17, Chamb 718 (See also AUZOT)
[167] CAMPANI optical instruments may be found in the Kassel Museum. See Aed Hart 225, vellum 8-drawer spy-glass of 10ft focus, having single 2in objective lens.
[168] Tayl 199.
[169] See CHrNov86.
[170] Bennett 87.
[171] RP.
[172] See Tayl. CAREY is not, in this case, an alternative spelling for CARY (See Nat Biog. but in which no Carey, instrument maker appears. Nor does Carey appear in Project SIMON).
[173] King 91.
[174] Howse 22.
[175] See Chapin, JHA vol.3, 87, 1972.
[176] King 178.
[177] Tayl. See CHrApr88.
[178] Vistas vol.28, 147.
[179] John CARY's premises were re-built after a fire and taken over by William CARY. His sons, George and John, continued W. CARY's business in 1831, as well as continuing in their father's business.

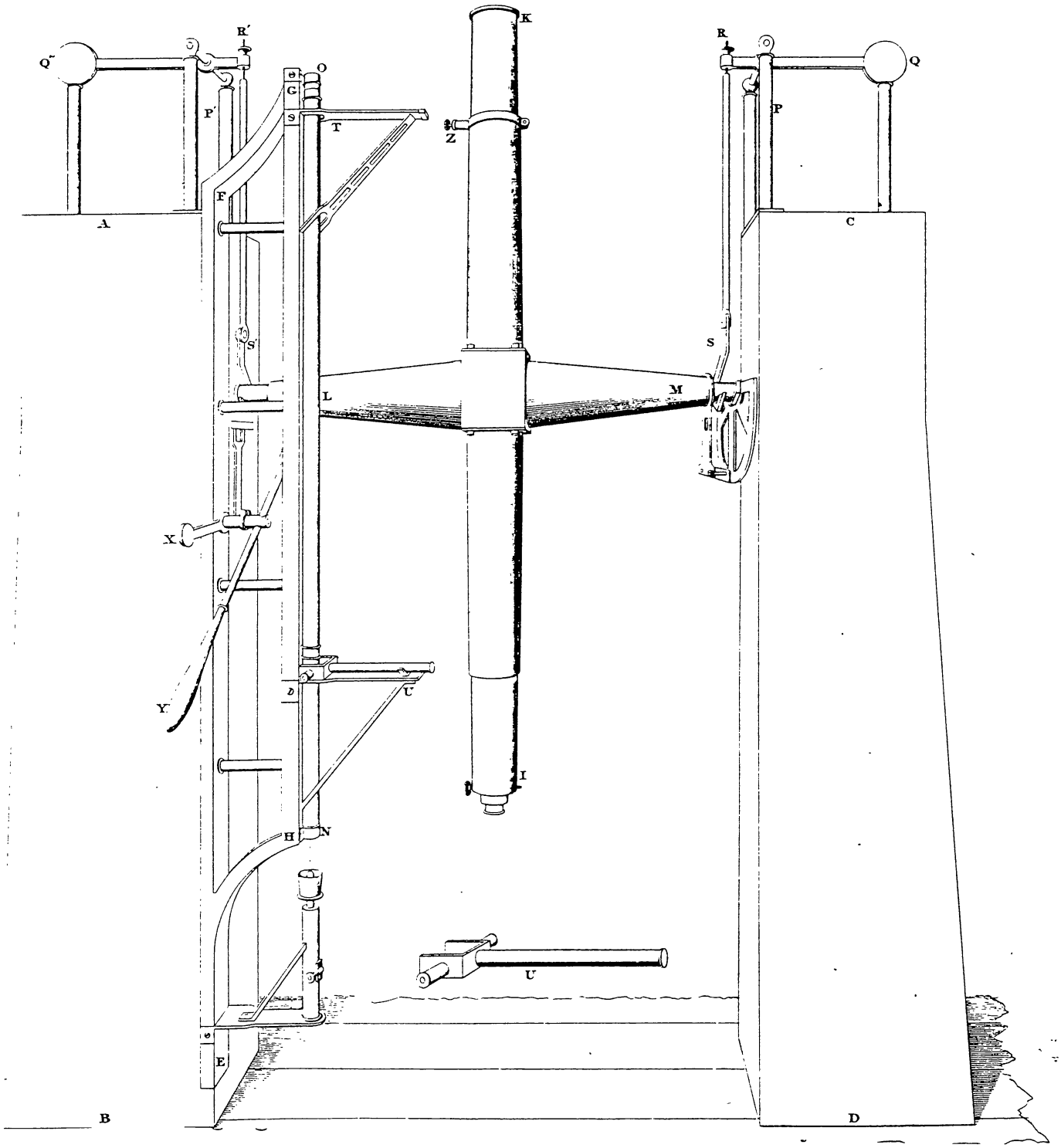


Figure 16: CARY transit circle made for Moscow Observatory.

St. London (c.1827-32) and we record that a fire necessitated a temporary move in 1820. [180] c.1827-32. William was a pupil of RAMSDEN, and owned his own business prior to c.1790. He is famous as the maker of WOLLASTON's true transit circle (1793) which replaced earlier mural circles. He constructed similar 2.5ft alt-azimuth instruments for BESSEL at *Königsberg Observatory* and Mark BEAUFOY. [181] Henry PORTER is recorded as William CARY's apprentice and successor c.1825 to after c.1859.

CARY George and John - globe-makers, sons of John (Snr), *86 St James', London*, fl.1821-59. [182]

CASARTELLI Joseph - surveying instrument retailer, *Manchester*. [183]

CASSEGRAIN Guillaume - Frenchman (possibly a sculptor) with interest in astronomy, although rather a misty figure, late 17C. [184] The CASSEGRAIN two-mirror system (c.1672) with perforated primary (and focal image *inverted*) proposed by him was probably not constructed by him. [185] Today's Cassegrain telescope has a parabolic primary mirror and a hyperbolic convex secondary mirror placed inside the focus of the primary. [186]

CASSINI Jean Dominique (IV) - eminent Italian astronomer. As Director, he tried to re-organize the Paris Observatory c.1785, This famous family included Jacques Dominique CASSINI (I) c.1625-1712, known for his discovery of the CASSINI division in Saturn's rings in 1675, which he discovered with a 5in aerial telescope of length 34ft, his son, CASSINI II c.1677-1756, and his grandson, C.-F CASSINI de Thury (III), c.1714-84. [187]

CAUCHOIX Robert-Aglaé - notable French optician, 1776 -1845. [188]

CAVALIERI Bonaventura - Italian instrument maker, c.1598-1647. He attempted to use mirros in telescopes c.1660. The *burning mirrors* were well-known at that period, and he may have preceded NEWTON's success in 1668. [189]

CAVENDISH Charles Sir - distinguished English scientist. In our context, we note that he commissioned an hyperbolic telescope lens from REEVE. [190] There was also Henry CAVENDISH, c.1741. [191]

CECIL - English engineer known for his grinding machine, fl.1820-22. [192]

CELESTRON INTERNATIONAL - present U.S. telescope manufacturer, a firm founded by Thomas Johnson, *2835 Columbia St, Torrance, CA 90503*. Their instruments include astronomical telescopes of various sizes (4.5in, 6in and 8in reflectors, the C4.5, SP-C6 and SP-C8), and the Schmidt-Cassegrains well-known as Powerstar 4, Ultima and Classic, usually incorporating BYERS' drive gears. The Classic 8 is an 8in Schmidt Cassegrain on fork mount, and there is a large, equatorially mounted Ultima 14. Their moderate-sized refractors (80mm SP-C80, 102mm SP-C102 and fluorite SP-C102F) are usually mounted using VIXEN equatorial mountings, the Super Polaris, and they make a range of spotter-scopes.

CETTI and Co - instrument retailer ? *London*, 19C. [193]

CHADBURN Bros - mid-19C optical, mathematical and philosophical instrument maker and retailer, *Albion Works and Nursery St, Sheffield*, with branch at *71 Lord St, Liverpool* and optical glass grinding room at *Nursery Steam Wheel*. [194]

CHAMBERS George F - notable 19C English writer

[180] Project SIMON does not record Norfolk St, a street which is now actually over-built, between Surrey St and Arundel St, and William CARY's business may have been taken over there by his apprentice, Henry PORTER.

[181] Tayl. See CHrJul86 and Aed Hart 224 in which Smyth possibly confuses William CARY and George CAREY. Smyth refers to a portable transit instrument 24in long with cast-iron stand and a 7in theodolite with tripod. See Vistas vol.28, 154, and 155 (illustration of the Wollaston circle, also in PEARSON, his Plate XV), and an interesting catalogue of sales in Naturforschende Gesellschaft, Zürich, and Mem RAS vol.2, 532.

[182] Tayl. See [CHrMar89 transit colour] and GOULD.

[183] See Dumpy level in Turner 19C 254.

[184] See MACP 24. His identity is uncertain, King 75, Bell 22.

[185] Chamb 719.

[186] J Hersch 72, and Born and Wolf.

[187] Bennett 87 and King 58. Also see Ph.D thesis, describing the activities of the CASSINIs, by A. Mallon, "Science and Government in France 1661 -1699: Changing Patterns of Scientific Research and Development". Queen's Univ. Belfast 1983.

[188] See J.Hersch 40, King, Howse. For COOPER's Markree objective, see JHA vol.13, 146, 1982.

[189] Turner ESI 140. He was author of " Lo specchio ustorio onero frattato delle settione conische" (The burning glass or a Treatise on Conic sections), Bologna 1632.

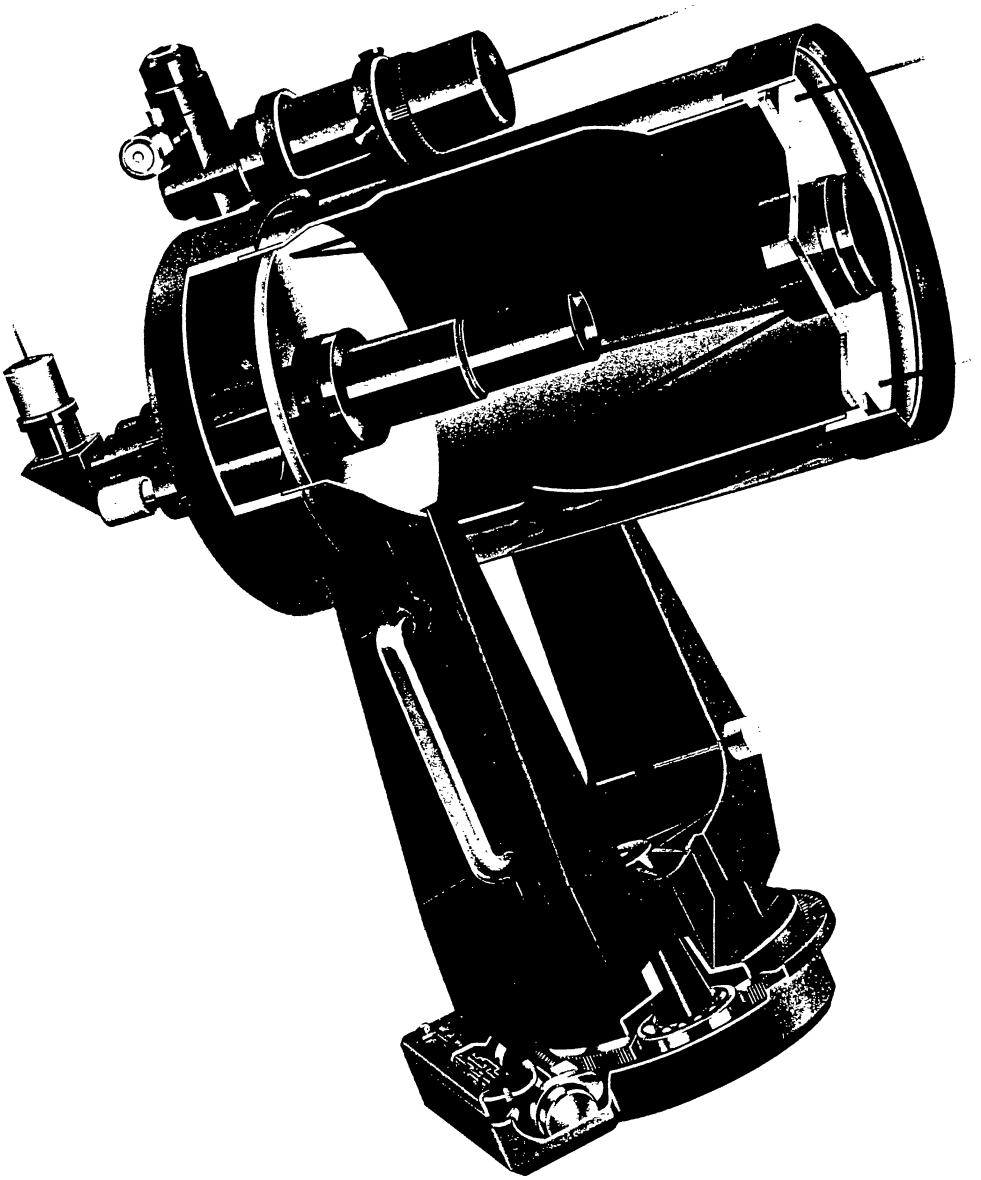
[190] Simpson, Vistas vol.28.

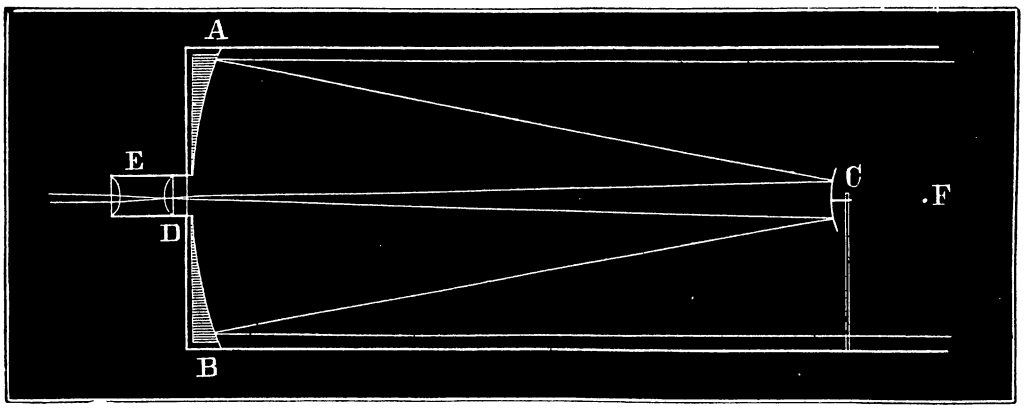
[191] Daumas 260.

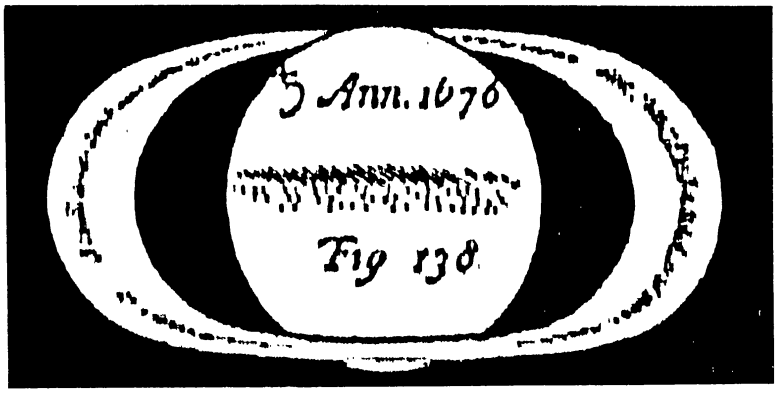
[192] Tayl.

[193] See CHrDec88.

[194] See 1851 Catalogue in Turner ESI and CHrSep86.







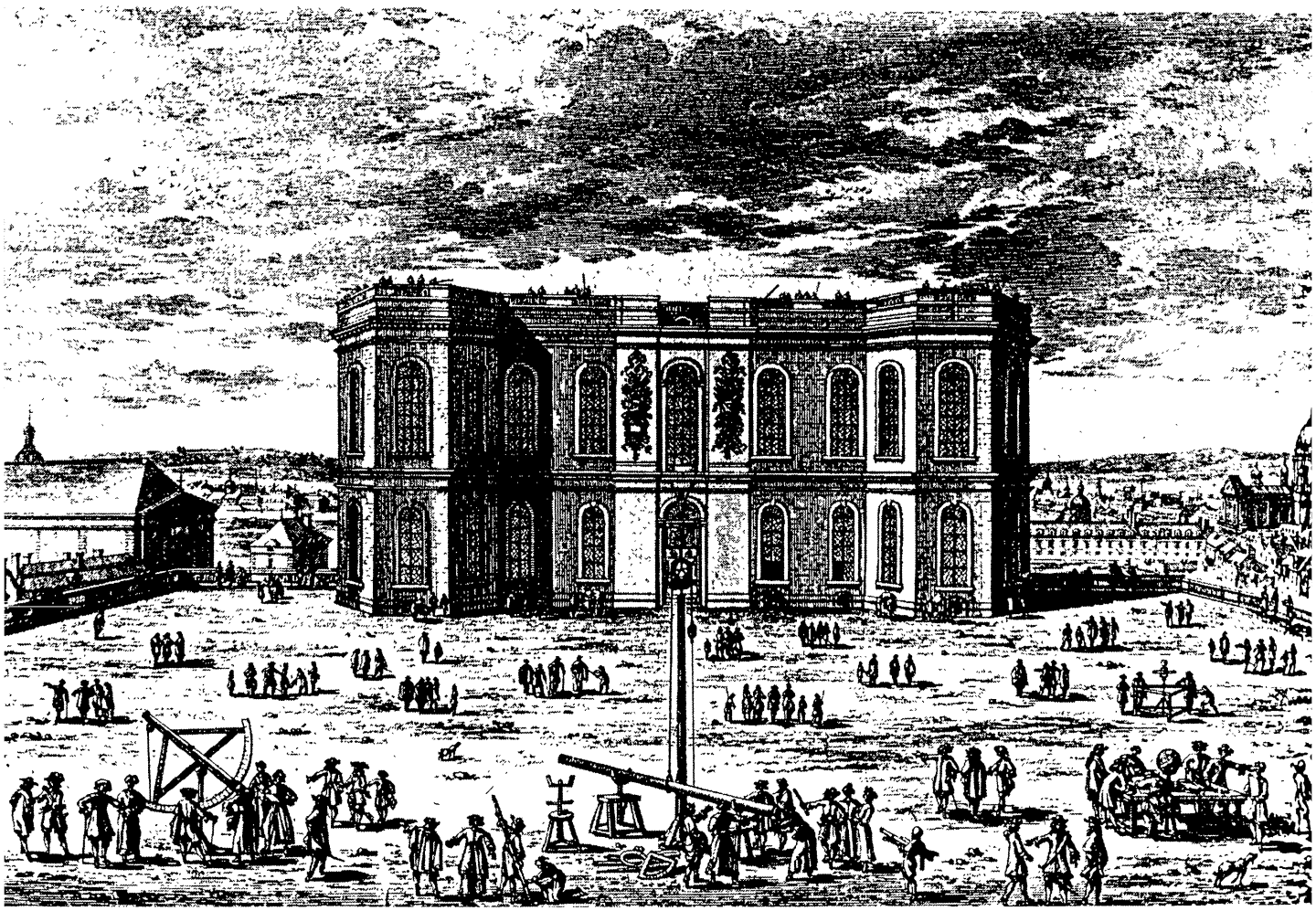


Figure 17: (a) CELESTRON Ultima 8, the 8in Schmidt-Cassegrain, shown without its equatorial wedge and tripod (previous page). (b) Principle of the simple CASSEGRAIN reflecting telescope (previous page) (c) CASSINI's division in Saturn's ring system (See dark ring in the outer part of the ring system). (d) Paris Observatory at the time of CASSINI (I), c.1667-72.

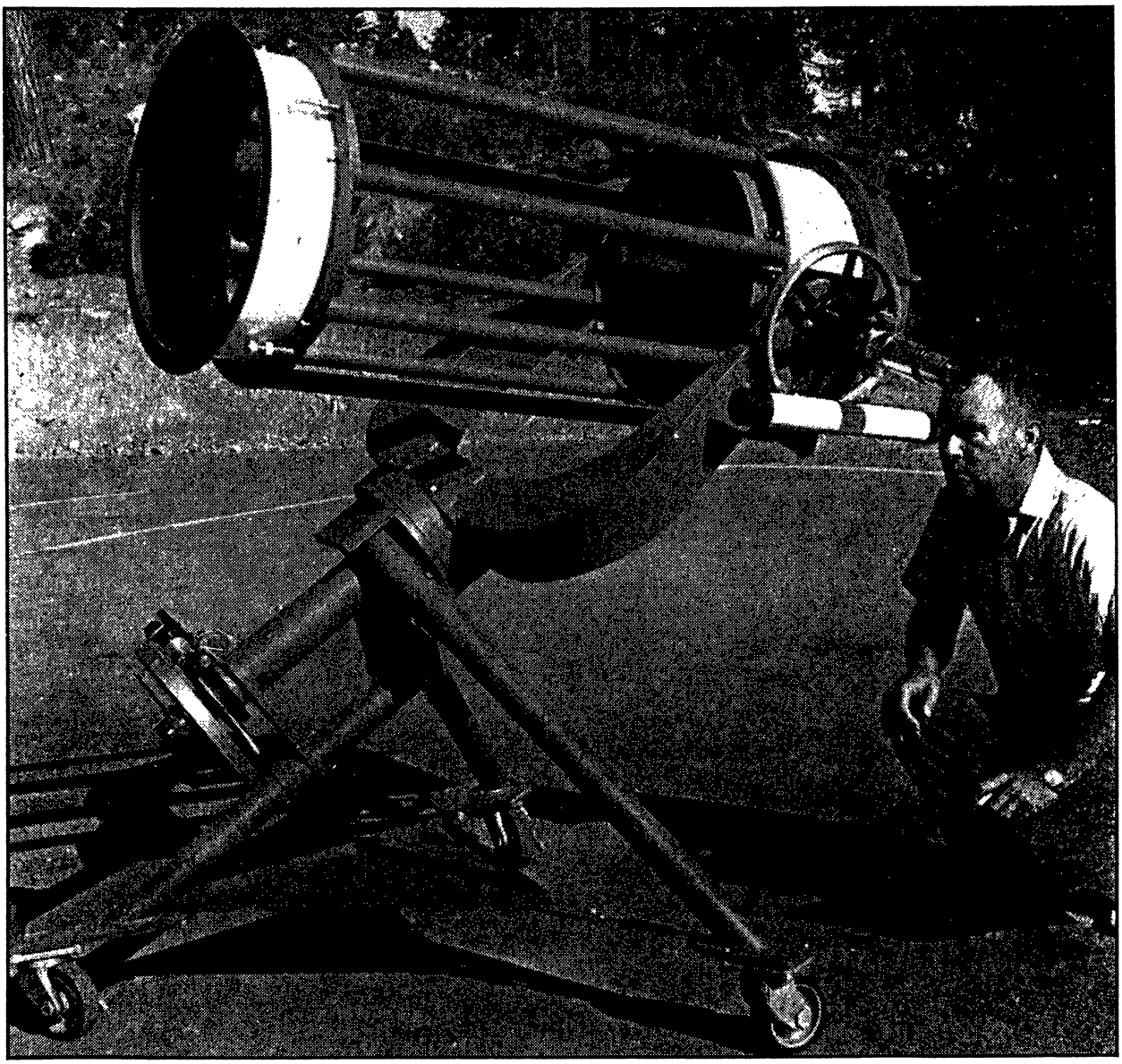
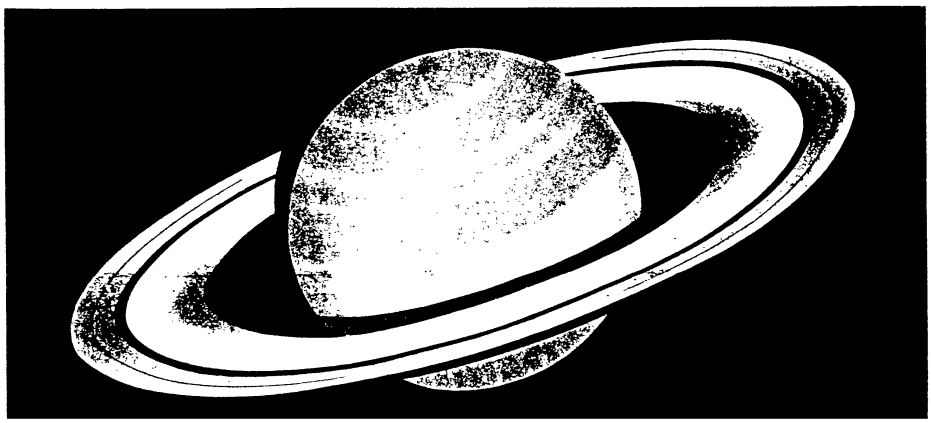


Figure 18: Thomas Johnson's 18.75in Cassegrain reflector, the proto-type of the CELESTRON series which he now produces commercially *(Courtesy of Sky and Telescope).*



on astronomy and telescopes. [195]

CHAMPNEYS James - English mathematical instrument maker, *Cornhill, London*, fl.1764-85. He was associated with John CUTHBERTSON (fl.1768 -1800) of *Amsterdam*, possibly his partner, [196] dealing with electrical apparatus and pumps. [197]

CHANCE W.H.S and J - *Oldbury, near Birmingham*, partners in CHANCE Bros., a 19C glass manufacturing firm in which BONTEMPS contributed his knowledge and skills of French glass making. [198] In c.1877, HEROY and MARRENNER New York were their agents in the U.S. The CLARKs obtained many of their earlier mirror blanks from CHANCE. Today we find CHANCE-PILKINGTON, Pilkington Optical Division, St. Asaph.

CHAPLAIN - See footnotes. [199]

CHAPMAN James (I) - nautical instrument retailer, *at Hadley's Quadrant, opposite King's Store House in St Catherine's, London*, fl.c.1760.

CHAPMAN James (II) - optical and mathematical instrument maker, *5 (later 41) St Catherine's St, London*, late 18C. Amongst several instruments known by him, there is a one-draw tube telescope and sextant 1788. [200] fl.1788-1802. He was possibly James (I)'s son.

CHARITÉ - *Paris*, 1782-99. He was partly responsible for constructing the achromatic transit instrument at the Paris Observatory. [201]

CHÉRUBIN - Capucin monk, *Orleans*, fl.1665-79. [202] He is known for his attempt at making a binocular telescope, as were also GALILEO and CHOREZ c.1620 before him.

CHEVALIER Charles - early-19C French optician, *165 Palais Royal, Paris.* He was succeeded c.1840 by his son, also Charles (1804-59). [203]

CHEVALIER Victor - French instrument maker, *Paris*, 1770-1841. [204]

CHRÉTIEN Henri - eminent 20C French optician. [205] He was associated with RITCHEY at Mt.Wilson, where the 60in and 100in telescopes were constructed.

CHRISTIE W.H.M - astronomer, 1845-1922. As Astronomer Royal, he was actively involved in decisions on several instruments, notably the Carte du Ciél astrograph design.

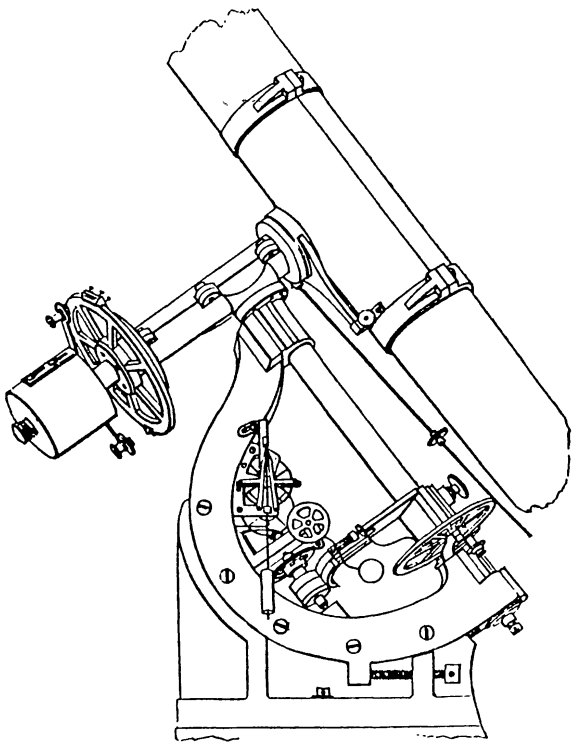
CLAIRUT - astronomer and optical designer, famous for his early CLAIRUT-type objective. [206] His lenses were made by ANTHÉAULME, DE L'ÉTANG, BOURIOT. He wrote a treatise on the motion of the moon which occupied John DOLLOND's interest in mathematics.

CLARK Alvan - America's most notable telescope maker, together with his two sons, 1804-87. His optical work began in 1844 or 1846 when he made speculum mirrors. He was also an engraver and painter. [207]

CLARK Alvan Graham - notable telescope maker, son of Alvan, 1832-97. The firm of CLARK and Sons manufactured the greatest objective lenses in the world, the Lick 36-in, the Yerkes 40in (1895), and the 24in Bruce doublet astrograph (1893) for Harvard College Observatory. [208] The firm of MANTOIS in Paris supplied the giant 40in glass blank, and WARNER and SWASEY in the US supplied the telescope mounting and the rising observatory floor. We note that GRUBB's improved drive for astrographic telescopes (c.1888) was used by CLARK until 1925. [209] Considered by double-star experts like DAWES to possess the best objectives, the CLARK telescopes of moderate size are perhaps the most highly sought after, early instruments, and many excellent examples may be found in US observatories and elsewhere. [210] The CLARK business was taken over by LUNDINS bros. [211]

CLARK George Bassett - notable telescope maker,

[195] See CHAMBERS' books given in our Refs.
[196] There was another earlier Jonathon CUTHBERTSON c.1743 -1806 in Rotterdam (navigational instruments).
[197] Tayl 257. He was a plaintiff against DOLLOND, and went bankrupt after being sued for infringing DOLLOND's patent for achromatic telescope objectives.
[198] See King xi.
[199] Tayl. and King 84.
[200] Tayl 307.
[201] Howse 14.
[202] Daumas 47, King 57.
[203] Turner 19C 167, King 196 (microscopes).
[204] Turner Antiq 26.
[205] King 353.
[206] Mem. de l'Acad. Sci. 1757. See also Sedg, King 158.
[207] See D.J. Warner's "Alvan Clark and Sons, Artists in Optics", hereafter D Warner. See also Marriott, JBAA vol.101, 6, 1991, and King.
[208] See Warner's biography. Also, King, Bell 82, 92, 109, 110, 163.
[209] Private commun. Ian Glass.
[210] See Warner, and also Marriott.
[211] Bell 65,76.



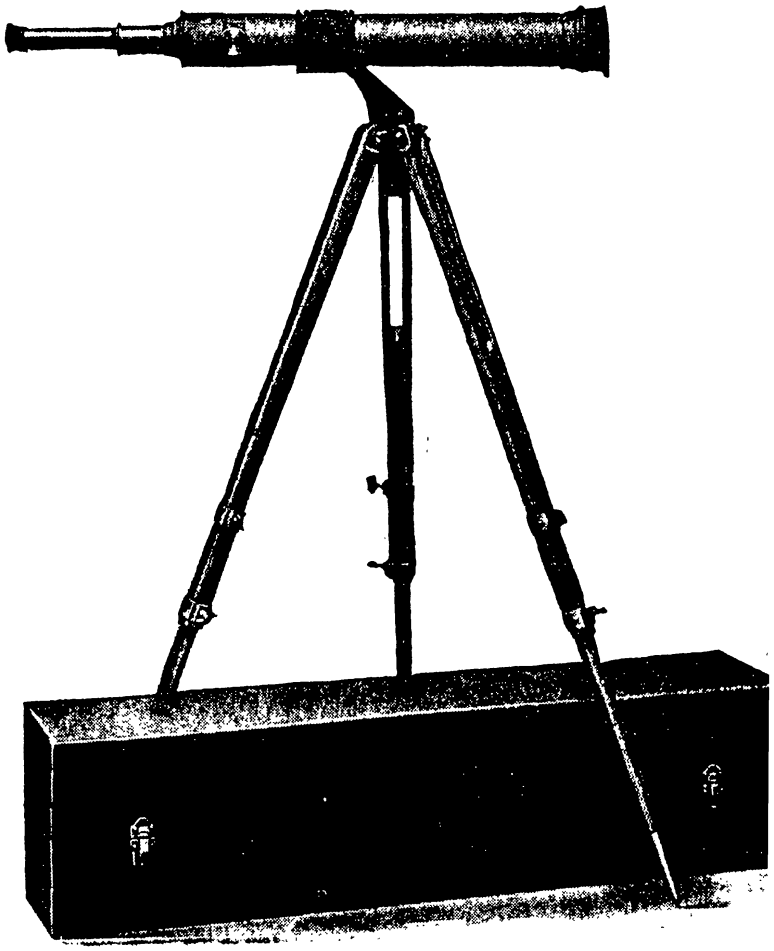


Figure 19: (a) left, Alvan CLARK (1804-87), (b) right, George Bassett CLARK (1827-91), (c) Alvan CLARK and Son's equatorial mounting for a small refracting telescope (taken from Dawes' article in MNRAS vol.20, 62, 1859/60), (d) An early CLARK refractor on tripod.

Figure 20: Alvan Graham CLARK 1832-97.

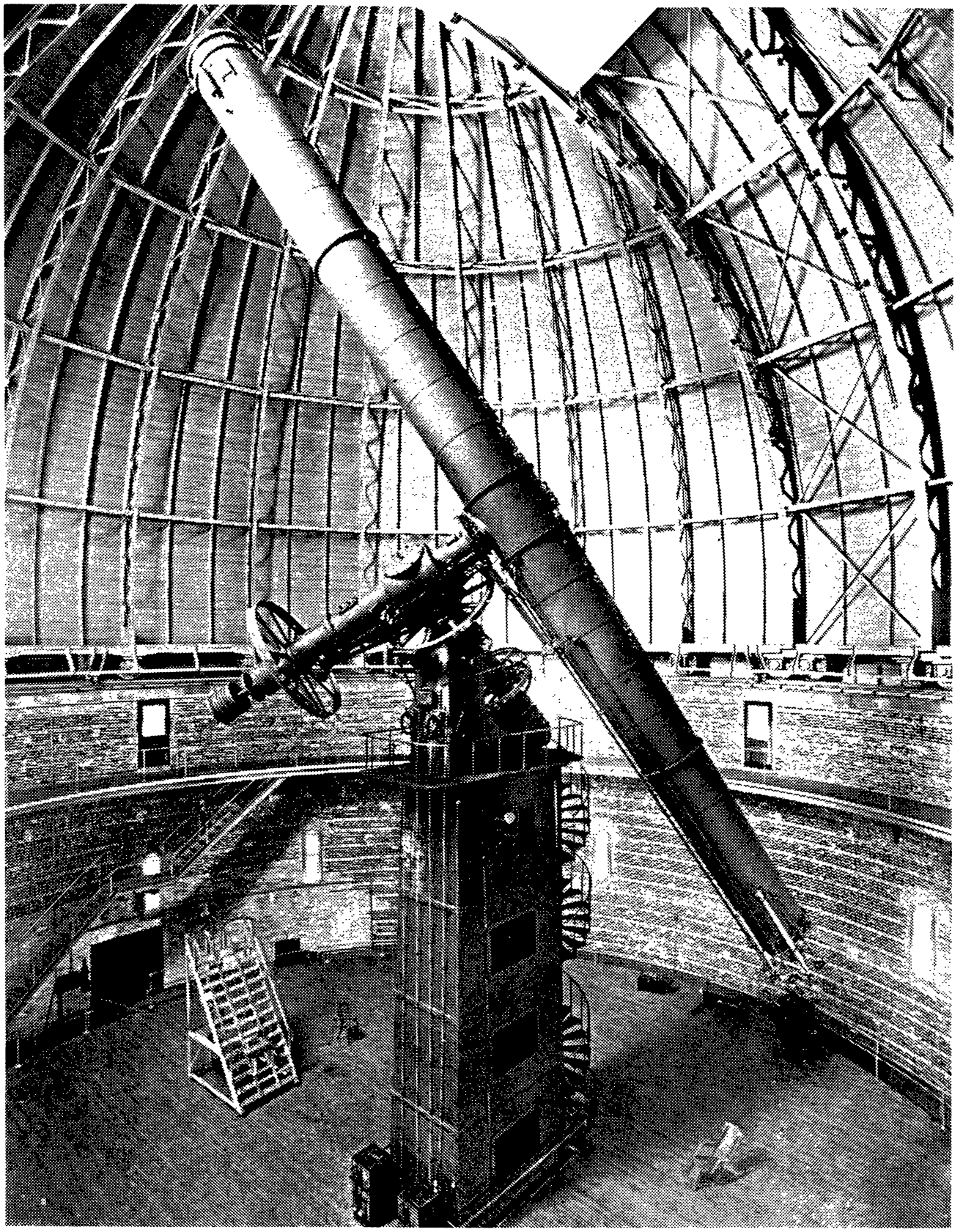
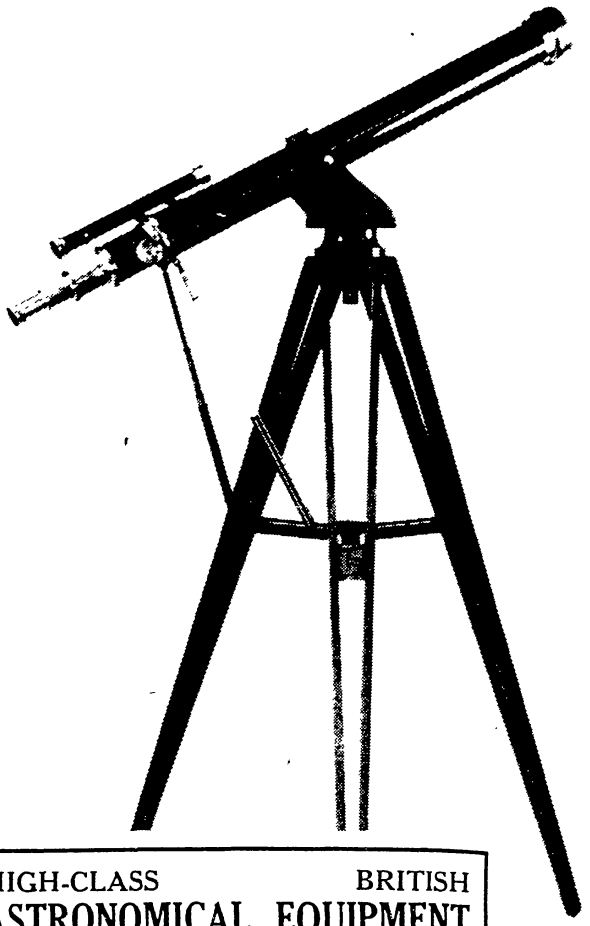


Figure 21: The Yerkes Observatory 40in refractor mounted by WARNER and SWASEY and with the large objective made by CLARK and Sons (1893/95), the largest astronomical objective in the world today.



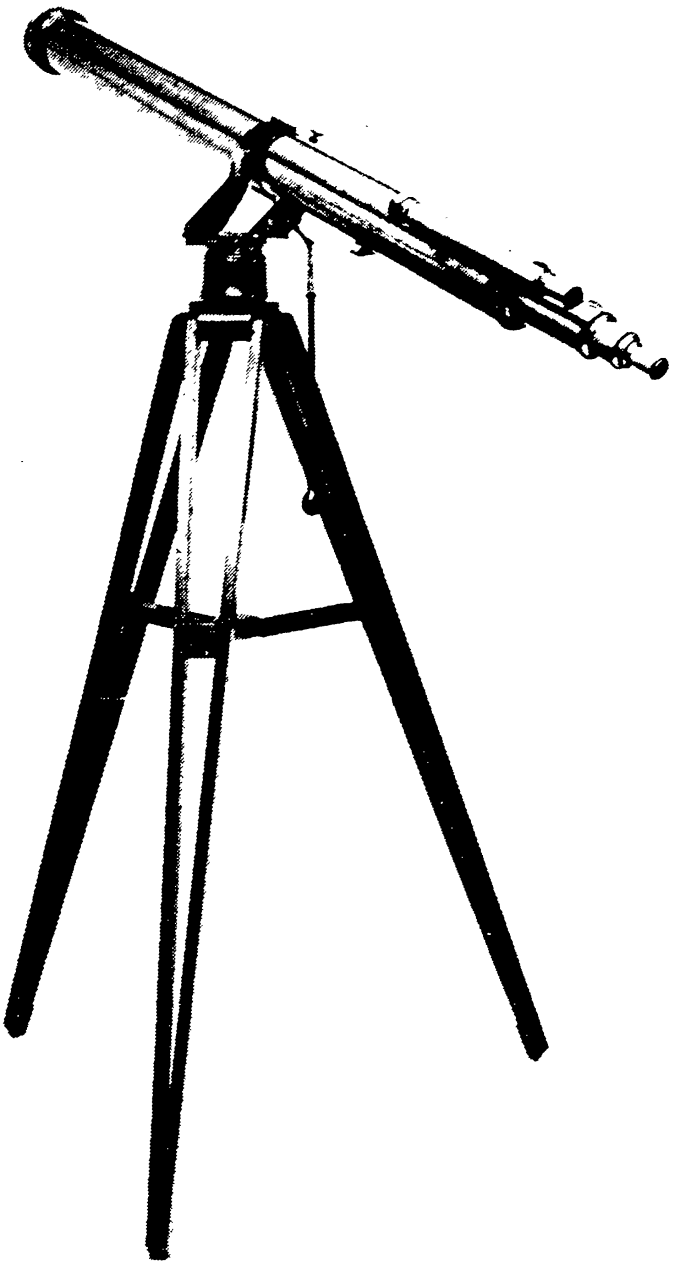


Figure 22: (a) A 5in refractor by T COOKE and Sons on a mahogany and brass tripod (right, valued at Christie's at £1500-2000 in April 1988). (b) A 3in refractor by T COOKE and Sons, in black enamelled and lacquered brass, with two steadying rods (left), valued by Christie's at £800-1200 in November 1986).

another son of Alvan, 1827-c.1897. He was an expert on rock salt optics, as applied, for example by BRASHEAR, and was chiefly involved in the engineering side of telescope manufacture.

CLARKE E.M - *London.* [212]

CLARKSON Alex - wholesale manufacturer of surveying instruments and retailer, *28 Bartlett's Bldgs, Holborn Circus, London EC*, c.1894. [213] and *338 High Holborn, London. (opp. Gray's Inn Road)*, at least until c.1926.

CLAUSEN Thomas - 19C natural philosopher. [214]

CLODE - French instrument maker, *Paris*, 1703-1767. [215]

COCK Christopher - English optician, *Long Acre, London*, fl.c.1660 -97. He trained REEVE (Snr) and it is known that NEWTON purchased a 14ft COCK telescope in Cambridge 1668. There is another C. COCK 14ft example in the Whipple Museum. He made a 60ft lens for Hevelius' aerial telescope.

COCK Thomas - English mathematics teacher, fl.1750. [216]

CODDINGTON - optical designer, c.1900. He is known for his solid eyepiece, cut from a sphere, designed to cut down light loss but little used. Probably he is from mid-19C since TOLLES developed CODDINGTON's ideas. [217]

COGGS John (Snr) - mathematical instrument maker, fl.1690-1740, [218] *The Globe and Sun, Fleet St. London.* Had worked with John ROWLEY (globe-makers) and Thomas WRIGHT, and was in partnership with William WYETH.

COHENS P - *Glasgow*, 19C. He took over the ABRAHAM business. [219]

COLBERT J.B - French glass worker, minister to Louis XIV, astronomer at the French Academy, owning a glass works at *Tourlaville, near Cherbourg* in 1665. [220] He was a contemporary of CAMPANI and CASSINI.

COLE Humphrey - instrument maker, 16C.

COLE Benjamin (Snr) - mathematical instrument maker, 1695-1755. *Poppins Court, Fleet St, London;* [221] *Bull Alley, Lombard St; The Orrery, next the Globe Tavern, Fleet St; 136 Fleet St*, formerly the shop of Thomas WRIGHT. [222]

COLE Benjamin (Jnr) - mathematical instrument maker, *The Orrery, next the Globe Tavern, 136 Fleet St, London*, 1727-1813. He made quadrants and orreries, [223] and also sold books. Associated earlier with John TROUGHTON, the firm was taken over by John and Edward TROUGHTON 1782.

COMMON Andrew Ainslee - English telescope maker, 1841-1903. [224] He built the 36in CROSSLEY reflector used at Lick Observatory to obtain very early photographs. GRUBB was involved with some refiguring of the famous mirror. See COMMON's fork-type mount etc. in the references noted. [225] COMMON made LOCKYER's 30in mirror, and several early domes. [226]

COOK James (Capt) - famous mariner, 1728-79. [227] On his voyages he carried many important nautical instruments. [228]

COOKE Thomas - eminent English telescope maker, 1807-1868, with business at *50 Stonegate, York*, 1837, and later at *Coney St, York.* He built many famous early telescopes, e.g. the 7in refractor used by PIAZZI-SMYTH in Tenerife in 1851, and the largest telescope of his later years, unfinished at his death, the 25in NEWALL refractor. [229] Many first-class small telescopes were also manufactured by COOKE and Sons. The company became Thomas COOKE and Sons af-

[212] See Handlist.
[213] See RP. He was not associated with BROADHURST CLARKSON.
[214] JHA vol.22. See also PORRO.
[215] See Czenakal's article in Vistas vol.9, 53.
[216] Tayl.
[217] Barl, and Sedg 140.
[218] Tayl 114.
[219] See BG.
[220] King 59, 60.
[221] AZ 62 6B.
[222] Tayl 114.
[223] See Tayl 199. A COLE reflecting telescope, presumed to be by Benjamin was sold at auction in 1804.
[224] MNRAS vol.46, 173 and vol.48, 386, and also MACP 4.
[225] MACP 5, also van Helden in Vistas.
[226] See Bell 244, 246, 248, 250, 251.
[227] See e.g. Tayl.
[228] On Capt COOK's second voyage in Adventure (at the time of a solar eclipse, 1772), there was a WATKINS 18in focus reflector, used by COOK, a BIRD 2ft focus reflector, used by CLERK, and a DOLLOND 3.5ft achromatic refractor, used by WALES.
[229] King 251, 252.

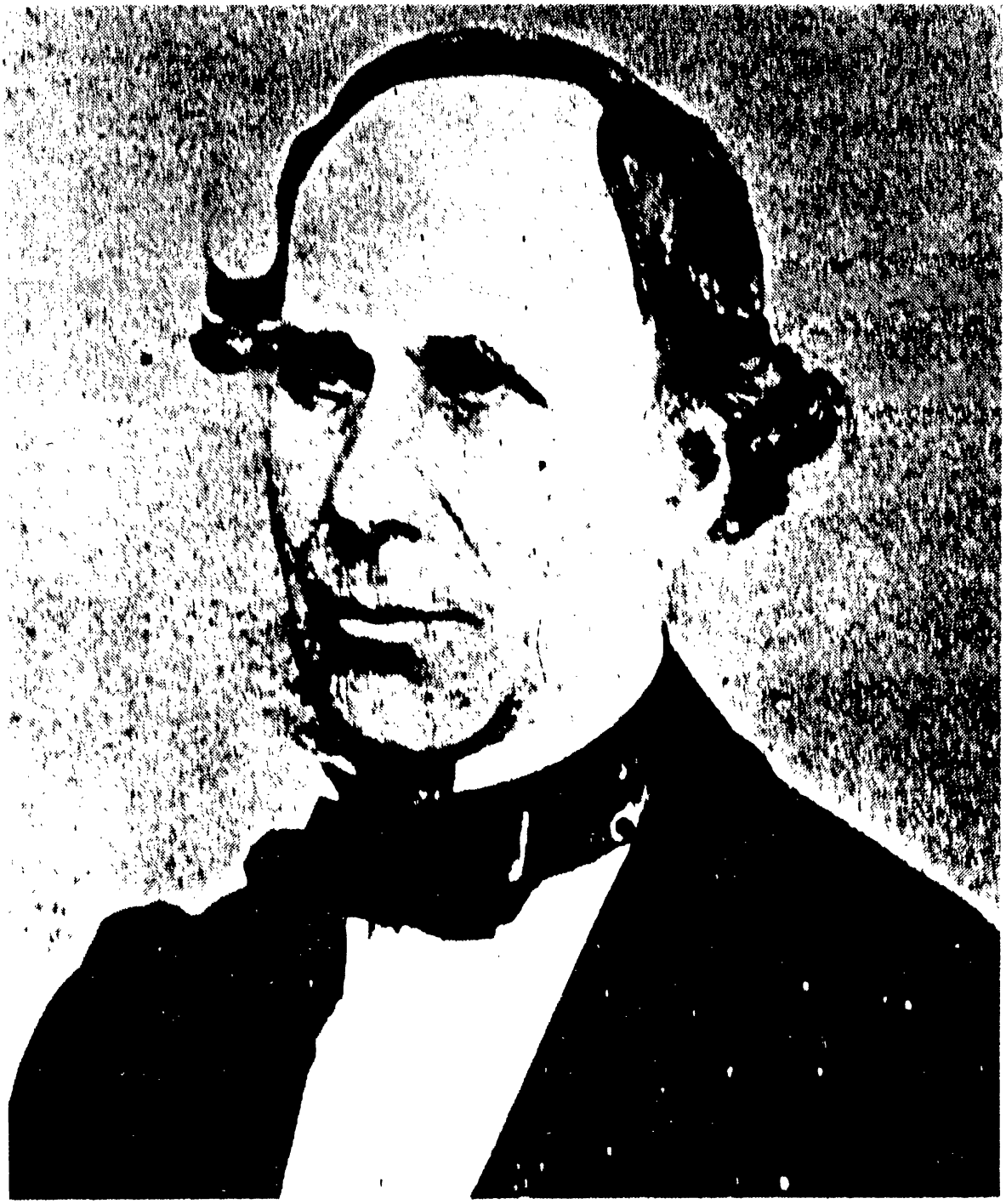


Figure 23: Thomas COOKE 1807-68.

ter 1868, still in *Buckingham Works, Bishophill, York*, and continued until 1913. The firm later became COOKE, TROUGHTON AND SIMMS in 1922, with works also in *Broadway Court, London SW1 (c.1930)*. Dennis TAYLOR was the optician who designed for COOKE, and noted especially for his fine photo-visual refractors. The optical business was bought by GRUBB PARSONS in 1938. [230] COOKE, TROUGHTON and SIMMS were at *31 Southampton St, Strand, London*, with branches in South Africa and agencies worldwide. We know of 21 equatorial refractors with apertures from 5 to 10ins built by Thomas COOKE. [231] Insight into his methods is provided in COOKE's article, "On the adjustment and testing of telescope objectives", T. COOKE and SONS, York 1891 (new edition 1922). Thomas (Jnr) and Frederick COOKE suggested papier-mâché coverings for observatory domes, c.f. the customary, expensive, heavy copper sheeting. [232]

COOKSON Bryan - telescope designer, nephew of H.F. NEWALL. He designed the floating zenith telescope at Cambridge University Observatory c.1900. [233]

COOPER Charles Thomas - maker of drawing instruments, *Russell Place, 9 Old Kent Rd, London SE*, c.1894. [234]

COOPER Edward Joshua - Irish gentleman astronomer, established private observatory 1831 at *Markree*, Callooney, Co Sligo fl.1831-63. He owned a 13in CAUCHOIX achromat mounted by Thomas GRUBB 1834, and instruments by TROUGHTON, ERTEL and DOLLOND. [235] His assistant was Andrew GRAHAM, and together they worked on an ecliptic star catalogue 1851-56.

CORNING GLASSWORKS - notable and long established US company. [236] They made, for example, the 200in pyrex blank disk.

COTES R - English mathematician, *Cambridge*, mid-18C, known for Cotes' formula relating to the total divergence of an optical system consisting of many components. He was a contemporary of HOOKE and HALLEY, and proposed a polar telescope, as did also BOFFAT. [237]

COUDER André - French optician, *Paris Observatory*, associated with DANJON. [238] He worked on an astigmatic photographic telescope of Newtonian design in 1926, on a basis suggested by K. SCHWARTZSCHILD in 1905. [239]

COULTER OPTICAL Inc - present U.S. optical company, ***PO Box K, Idyllwild CA 92349 -1107.*** Noted for the Odyssey Dobsonian telescopes (see DOBSON).

COX R.E - eminent American optician /engineer, noted for his designs for mirror cells etc. [240].

COX H. W - member of COX, HARGREAVES and THOMPSON in *England*, 20C. [241] COX and HARGREAVES, both with a knowledge of optics and amateur astronomy, designed and constructed the optics for the Edinburgh Schmidt telescope and the Vatican 25/38in Schmidt. Another L.A. COX, within the family, was involved in the construction of a Schmidt camera in 1936. [242]

COX and FARQUAHSON - glass-workers (associated with SCARLETT and DOLLOND), fl.1775-91. [243]

CRABB OPTICAL UK - present company, *1 Penybanc, Tan-y-Fron, near Denbigh, Clwyd LL16 5NP.*

CRAIG (Rev) - English amateur astronomer, vicar of *Leamington*, c.1862. He owned a 24-in aperture refractor, 75ft long, of dubious quality erected on a tower wall near *Wandsworth Prison.* See firms of RENNIE and Thomas SLATER who built CRAIG's telescope. [244]

CRAWLEY William - English optical instrument maker, possibly partner or successor of Thomas

[230] See advertisement in e.g. BAA Handbook 1929.
[231] See Handlist. For COOKE and Sons telescope objective designs, see H. Dennis TAYLOR, or Bell 44 or Born and Wolf. Also CHrNov86 (illustr), [CHrApr88], [CHrMar91], CHrSep86.
[232] King 254.
[233] King 394.
[234] See RP.
[235] See McKenna-Lawlor and Hoskin, JHA vol.13, 146, 1982, JHA vol.15, 64, 1984. Also Vistas vol.9, 283, 1968.
[236] King 387.
[237] King 60. See Cotes formula in e.g. Herman's "A Treatise on Geometrical Optics" (1900), 77, and Smith's "Compleat System of Opticks" (1738).
[238] King.
[239] See D and C, and also Sedg 173. The secondary mirror is a concave ellipsoid. The system suffers from field curvature and an inaccessible focus.
[240] See many articles in ST. See also MACP 48.
[241] King 392.
[242] King 358.
[243] Tayl.
[244] See illustration of CRAIG's telescope in King 254, 255.

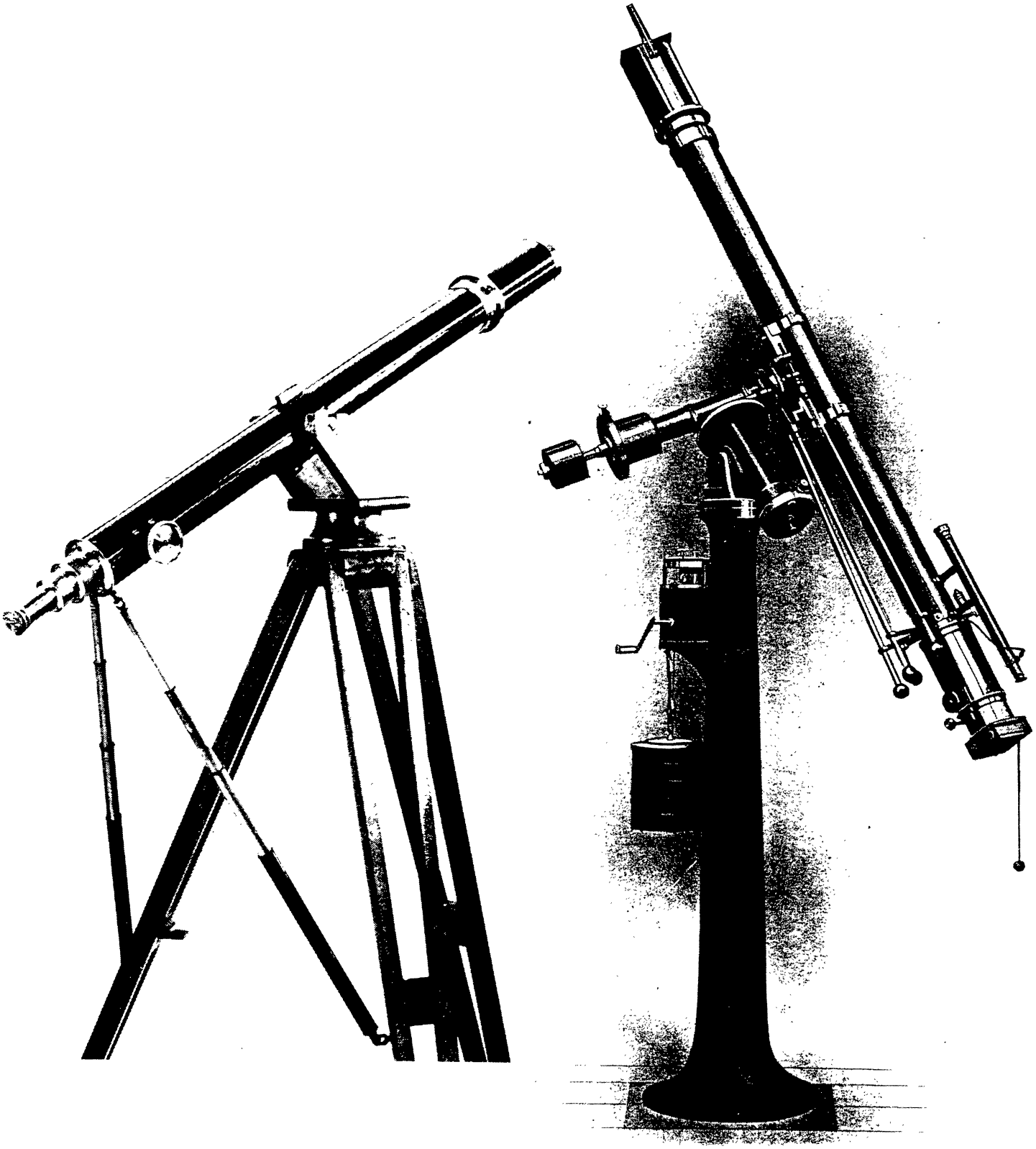


Figure 24: (a) 3in refractor by COOKE and Sons, black enamelled and lacquered brass, on trunnion and tripod alt-azimuth mounting, with two steadying "telescopic" rods (left, sold at Christie's for £800 in September 1986. (b) 5in COOKE and Sons equatorial refractor c.1920 mounted on pillar with clockdrive (right).

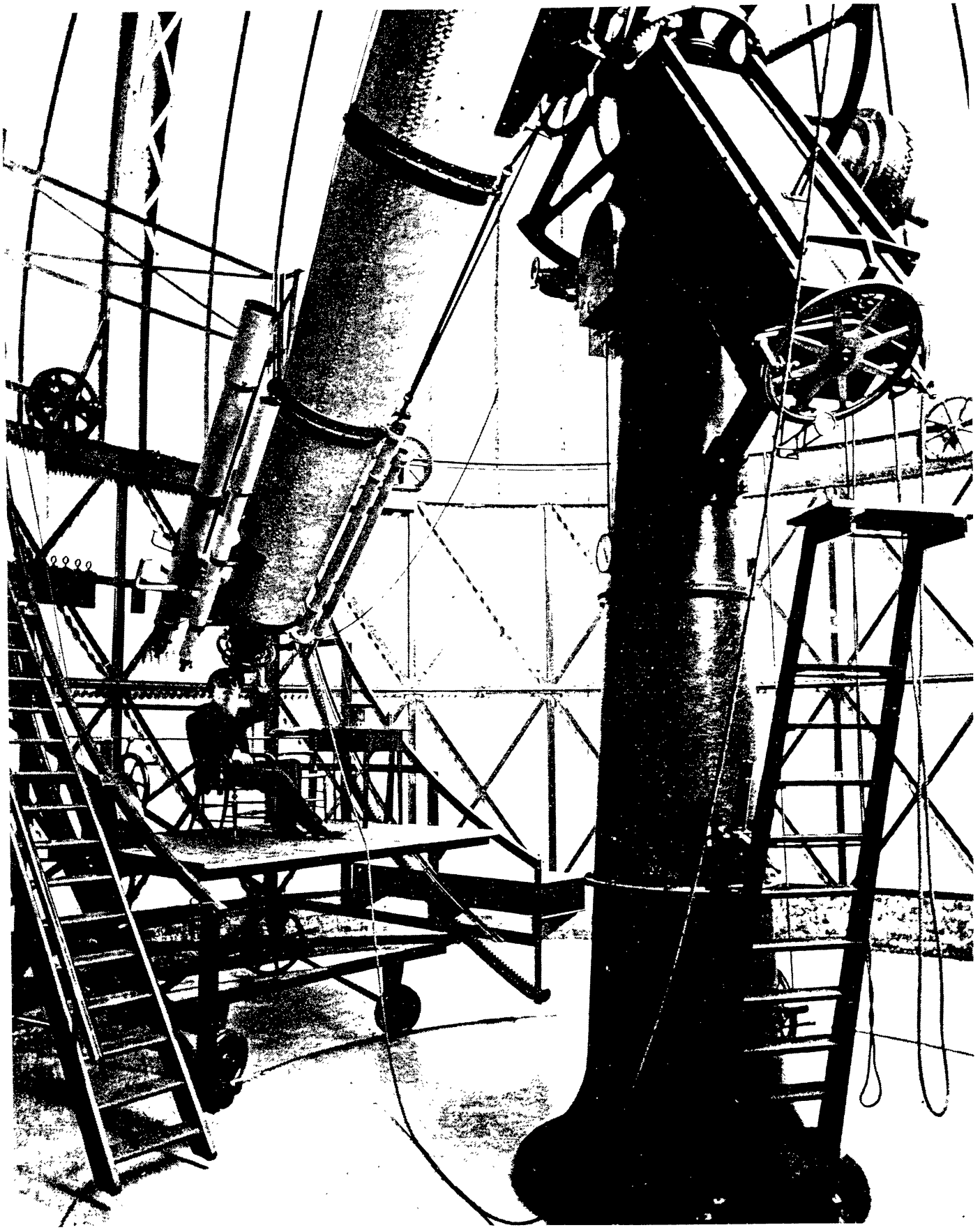


Figure 25: Thomas COOKE's 25in refractor made for R.S. NEWALL (c.1869). The enclosed box over the polar axis was typical of COOKE's large refractors.

JONES, at *21 Oxenden St, London*, fl.1838-46. [245]

CRICKMORE - English optical instrument maker, who worked for KATER making Gregorian telescopes, c.1800. [246]

CROSSLEY Edward - English gentleman astronomer, owning a private observatory, *Bermerside, Halifax.* [247] The noted mirror maker, COMMON sold his 36in aperture reflector to CROSSLEY in 1885. This telescope was purchased by Lick Observatory in California and was fully operational there in 1896. It was used by James E. Keeler to photograph nebulae, but required to be substantially modified. The name of CROSSLEY was given to this COMMON 36in telescope at Lick. [248]

CROUCH H and W - *London*, fl.c.1865 -1905. The business of CROUCH became HENRY CROUCH BARBICAN OPTICAL WORKS. [249]

CUFF John - eminent optical instrument maker, *London*, c.1708 -72. [250] The business was at *The Sign of the Reflecting Microscopes and Spectacles, opposite Sergeant's Gate, Fleet St, London* from 1742. A *Sergeant's Inn EC4 lies near Fleet St.* CUFF moved to other premises nearby in 1755/56, and then finally moved to *near Salisbury Court.* [251] CUFF was apprenticed to James MANN in 1722, and employed Henry SHUTTLEWORTH as an apprentice. Although more famous for his microscopes, he made some small telescopes of excellent quality, and many other instruments. Henry BAKER, the eminent microscopist, designed a microscope and chose CUFF to construct it. This was a time when brass was becoming much used in instruments. CUFF went bankrupt in 1750. See also MARTIN.

CULPEPER Edward - engraver, instrument maker and retailer, manufacturing microscopes. [252]

CUNIGHAM Jacob - 17C instrument maker. The earliest *dated* telescope is made by him (1661).

CURTIS Ralph Hamilton - US astronomer, b.1880, Director of Ann Arbor Observatory from 1927. He designed prism spectrographs for pioneering work in the early 20C using the 37.5in reflector. [253]

CUSHEE Richard - notable English globe-maker, fl.1708-32, *Globe and Sun, between St. Dunstan's Church and Chancery Lane, London.* [254]

CUSHEE E - English globe-maker, fl.1729-68. He took over from R. CUSHEE. [255]

CUTTS J.P - *London*, 19C. See note. [256]

[245] Tayl.
[246] Tayl 360.
[247] See ST vol.58, 307, vol.58, 396.
[248] See King 278.
[249] Handlist.
[250] [CHrDec85], Tayl 154.
[251] See Turner Mic 198, and A. Turner ESI 131.
[252] Turner, Vistas vol.20, 173.
[253] See CURTIS' obituary in MNRAS for 1930.
[254] This area of London where the CUSHEEs worked, north of Fleet St, between Chancery Lane and Fetter St, has been re-built. St Dunstan's in the West (adjoining the new Gresham Assurance Co.) was built on the old site of the old church 1831/33. The CUSHEEs were within ear-shot of the famous old church, opposite the now demolished Cock Inn, with a clock on which two giants struck the hour. See Clunn, Tayl 79 and 115, and AZ 62 6A.
[255] Tayl.
[256] CHrJul86.

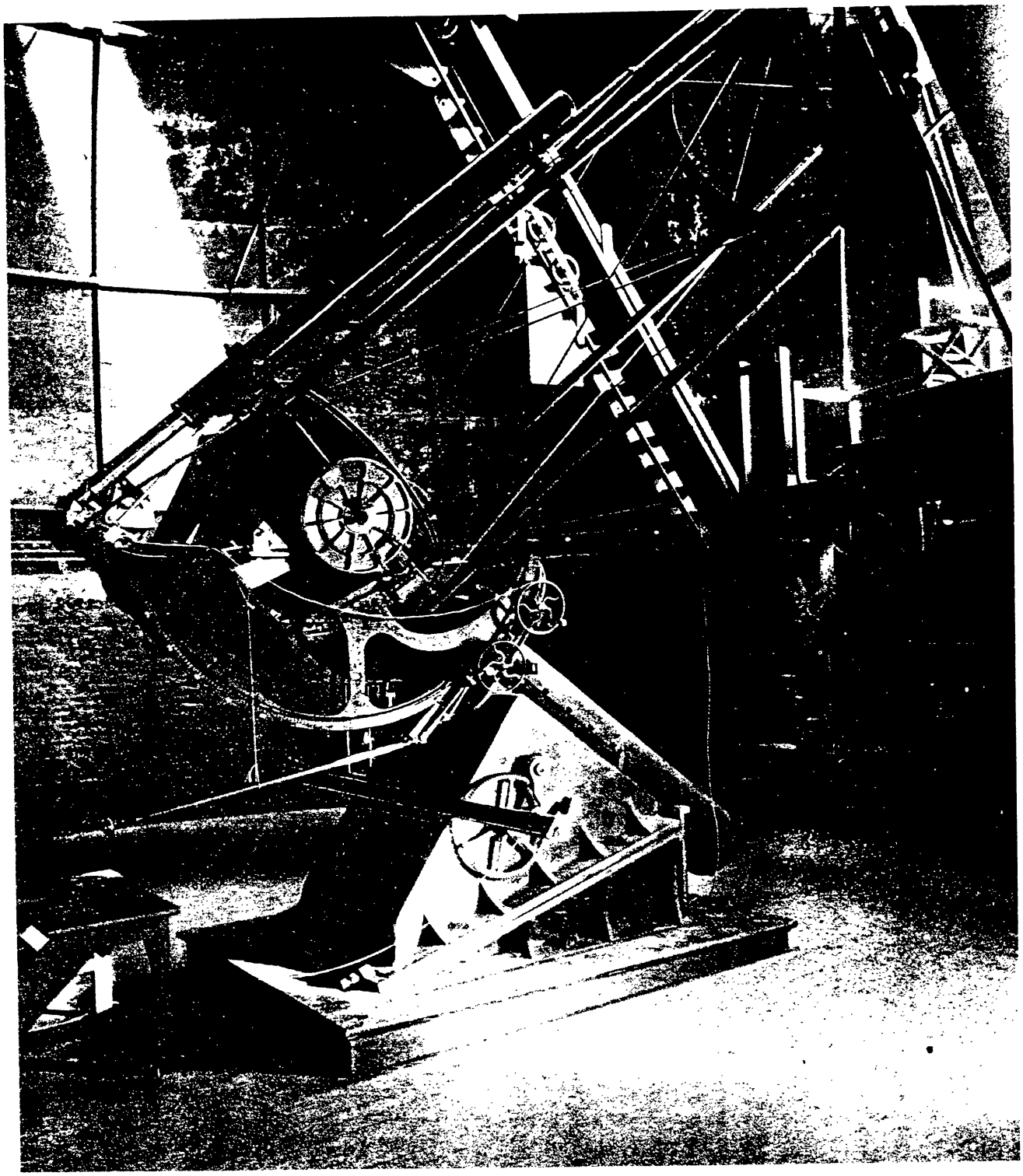


Figure 26: Opposite (a) A.COMMON (top), (b) E.CROSSLEY (bottom). Above, the CROSSLEY 36in reflector with mirror by COMMON c.1885. The Lick Observatory bought and modified the instrument in 1896. NB. The mirror is strangely positioned above the polar axis, necessitating heavy counter-weights at telescope's lower end.

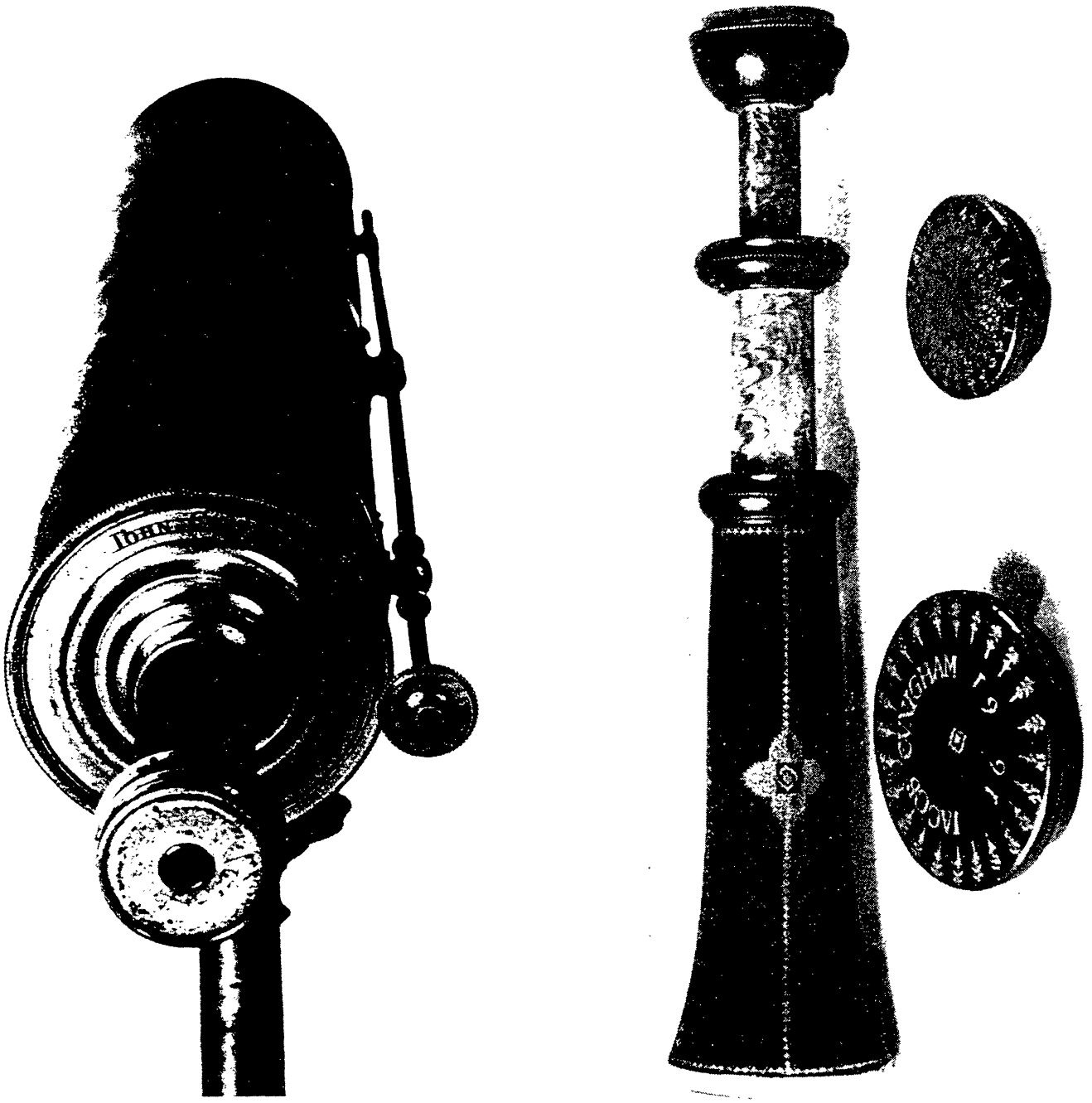


Figure 27: (a) A fine and rare 2in reflecting telescope, 13.5in long, by John CUFF (c.1708-72). The tube is covered with simulated fishskin and it is mounted on a baluster column and folding tripod, with chamfered cabriole legs terminating in plain feet (Christie's valued it at £1800-2200 in December 1985). (b) A two-draw telescope by Jacob CUNIGHAM 1661. This is the earliest "dated" telescope.

D

D'ALEMBERT - mathematician, natural philosopher and encyclopaedist, 1717-83. He worked on geometry and the theory of lenses, introducing theories of longitudinal and latitudinal lens aberrations. [257]

DALL Horace E - optician. He is well-known for the DALL-KIRKHAM optical system. [258] DALL and KIRKHAM designed a Cassegrain system with elliptical primary and spherical secondary. By modern standards, its severe comatic distortion means it is only good for on-axis work, e.g. planetary photography.

DALLMEYER J.H - optician, son-in-law to A. ROSS, working mostly on photographic lenses, *Church End Works, High Rd, Willesden, London NW 10*, fl.c.1865-88. The "Rapid Rectilinear" portrait lens used by GILL (1843-1914) in his photographic catalogue of the southern sky, the Cape Photographic Durchmusterung, was by DALLMEYER, as was also the optics of GILL's photo-heliograph. [259] There is no mention of a merger with ROSS.

DALLMEYER T.R. - optician. [260]

DANCER Josiah - instrument retailer /maker(?), *Manchester*, fl.1812-35. [261] He was possibly succeeded by John Benjamin DANCER.

DANCER John Benjamin - instrument maker, *Manchester*, 1812-87. He is noted as the originator of micro -photography. An autobiographical sketch, with some letters and a foreward by W. BROWNING is preserved. [262]

DANCER Abraham - microscope retailer /maker(?), fl.1838-42. DANCER was partner with Abraham ABRAHAM in the early 1840s. [263]

DANCER Michael - 1791-1817. We record DANCER and Sons fl.1800-10.

DANJON A - notable French astronomer and optician, 20C, Director of Paris Observatory, associated with the optician, COUDER. He was co-author of the authoritative text, "Lunettes et Télescopes" 1935, and designed the impersonal astrolabe. [264]

DARBOUX - French mathematician known for his "Théorie des Surfaces 1894" describing the properties of a pencil of rays after reflection. [265]

DAVIDSON F and Co - possibly designed or built the "Davon" micro-monocular. [266]

DAVIS - *Cheltenham*, 19C. Several DAVIS' are known in three locations. [267]

DAVIS John - maker of mining instruments, *Derby*, c.1880. We record John DAVIS and Son. [268]

DAVIS John - instrument retailer(?), *Edinburgh*. [269]

DAVIS and SARGENT - glass-grinders, fl.1767-82.

DAWES William Rutter (Rev) - eminent gentleman astronomer, 1799-1868. He is known especially for his double star work c.1858. [270] Working initially as assistant to BISHOP until 1844, he then moved to *Camden Lodge, near Cranbrook* (1844-49), to *Torquay* 1849, and *Wateringbury* 1850. [271] DAWES owned an 8.25in Alvan CLARK f=110in refractor, and a 7.5in f/15 CLARK refractor, now at Temple Observatory, Rugby. [272] He was very largely responsible for Alvan CLARK's emergence as a telescope maker in the US.

DAY A.L - American optician, noted for testing 100in Mt Wilson mirror, using an optical flat made from a blank disk from the famous St Gobain glass works in Paris. [273]

DAY I (or J) - an early 5-draw telescope in vellum

[257] Dict. Nat. Biog. and King 157.
[258] See e.g. MACP 25.
[259] See Handlist, Tayl.
[260] King 273.
[261] [CHrDec85] illustr.
[262] See Memoirs and Proceedings of Manchester Philosoph. Soc, vol.107, 115, 1964 See also A.McLeod's article in Brit. Journ. Photog. vol.120, 138, 1973.
[263] BG 298.
[264] See Stars and Stellar Systems, Vol.1, eds. Kuiper and Middlehurst, Univ. Chicago Press 1960, 115.
[265] See e.g. Herman.
[266] Bell 148.
[267] CHrSep89 monocular illustr.
[268] Turner 19C 256. See also Handlist (Derby 1877), CHrJul86 illustr.
[269] BG 99.
[270] See Warner's "Artists in Optics", and LASSELL, Vistas vol.32, 341 and JHA vol.22.
[271] Marriott.
[272] King puts DAWES at Hopefield Lodge, Haddenham, Berks. See also Chamb H 347, and c.f. similar 7.25in telescope at Amherst College. See ERCK.
[273] King 333.

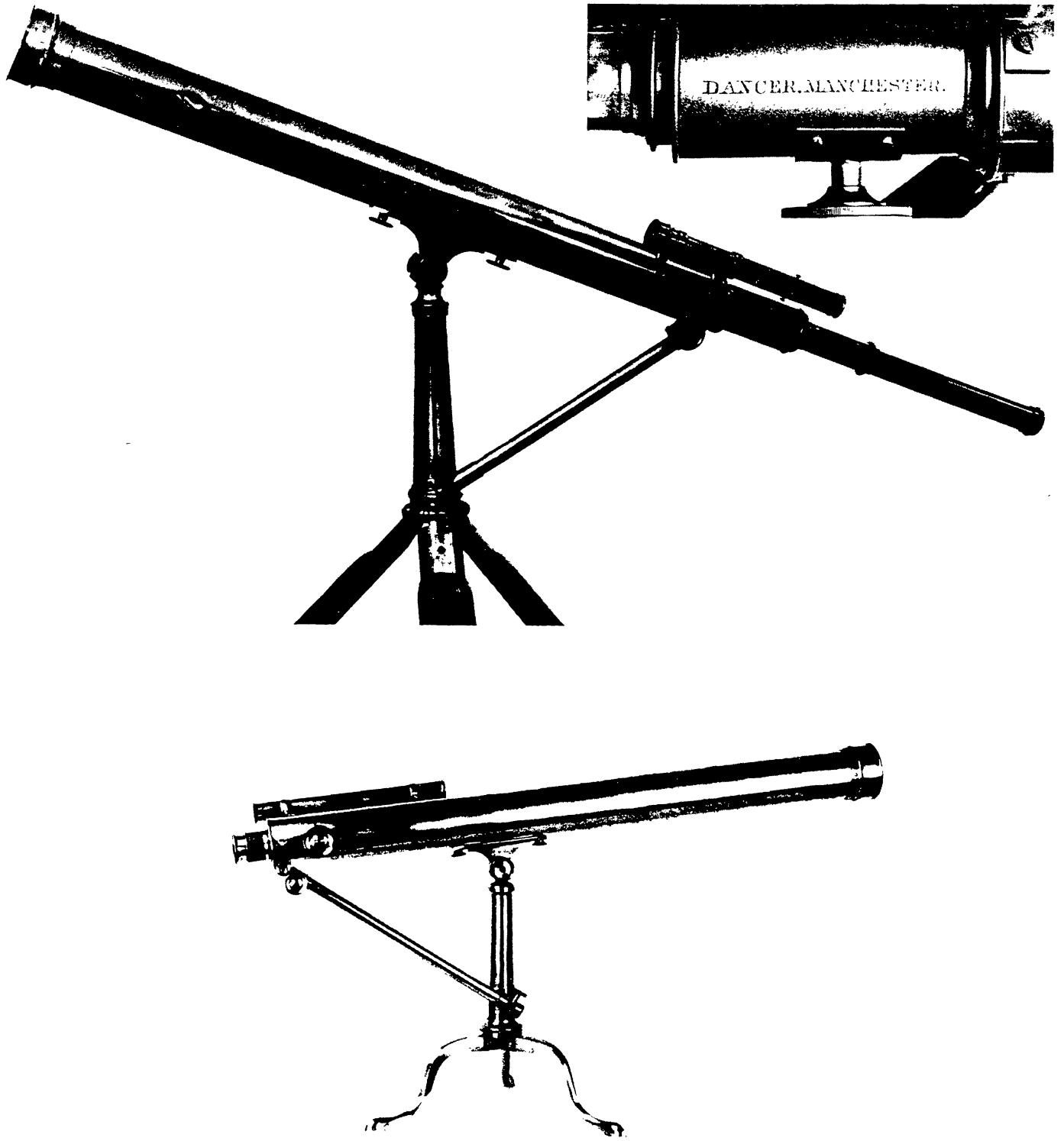


Figure 28: (a) 2.75in astronomical telescope by DANCER, 34.5in long, on a tapering pillar and mahogany and brass tripod, with a single steadying rod (valued by Christie's at £800-1200 in December 1985), and (b) 2.75in refracting telescope by DE SILVA, 37.8in long. This instrument is similar to those of BERGE and BLUNT with pillar support and cabriole legs terminating in pad feet (sold at Christie's for £800 in December 1989).

by him is recorded. [274]

DEANE David - fl.1724-77. [275]

DEIJL Harmanns van - instrument maker, *Netherlands.* [276]

DE LA RUE Warren - manufacturer of stationery, self-taught engineer and well-known English astronomer, *Bunhill Row, London*, 1815-89. NASMYTH cut him a 13in mirror blank with which DE LA RUE made his celebrated telescope at *Canonbury.* He drew many pictures of the planets [277] and was a pioneer in celestial photography [278] using the *Kew* photo-heliograph and a wet collodion photographic process for lunar and solar studies c.1852 and the 1860 total solar eclipse. [279]

DEMAINBRAY Stephen Charles Triboudet - astronomer at King George III's private observatory at *Kew*, 1710-82. [280]

DENTON Cuthbert - instrument maker and assistant to FLAMSTEED, fl.c.1681. He was contemporary with John STAFFORD, neither of whom appeared to be good engineers. [281]

DEPARCIEUX - inventor, c.1736. He is known for a machine for polishing lenses. [282]

DESLANDRES - director of the Saint-Gobin glassworks. [283]

DESLANDRES Henri - French astronomer at *Meudon Observatory, Paris.* He is known for his design of a spectroheliograph in 1890. [284]

DESCARTES René. - philosopher /mathematician, 1596-1650. He published the laws of refraction and reflection, [285] and invented cartesian coordinate geometry . He demonstrated that the ideal shape of a lens was non-spherical 1637. [286] DESCARTES' optical design was impractical in his day and the optical problem was partly overcome using very long focus, small-curvature (and spherical) objectives (employed in aerial telescopes. See AUZOT).

DE SILVA William - instrument retailer(?), 19C, *126 Duke St* and *25 Chapel St, Liverpool.* [287]

DIGGES Leonard - c.1520-59, *Kent.*

DIGGES Thomas - c.1546-95. He is a contender for the maker of the first reflecting telescope. [288]

DIVINI Eustachio (Eustacio?) - *Rome*, 1620 -95. His name appears in latinized form as DE DIVINIS. There are instruments by him in the Firenze Museum. [289]

DIXEY C.W - retailer (?) possibly of telescopes, *New Bond St, London.* [290]

DOBBIE Alexander - Glasgow 1815-1887 (DOBBIE McINNES retail? BG).

DOBSON John L - 20C US telescope maker. He constructed the proto-type Dobsonian reflecting telescope, usually a large aperture instrument with an alt-azimuth mounting of unique simplicity. [291]

DOLBERG - notable nautical instrument maker, *Rostock.* He is especially known for his reflecting circles. [292]

DOLLOND John (Snr) - eminent English optical instrument maker, 1706-1761, [293] *Denmark Court, Strand, London* (1753). From a family of French protestant emigrants, John was well-known in 1750 as an accomplished optician and experimenter. [294] He was joined c.1758 by his eldest son, Peter, who already had his own optical business since

[274] Turner Mic 91.
[275] Tayl.
[276] Turner Antiq 120.
[277] See Dreyer and Turner's History of RAS, 154.
[278] See MACP 3
[279] See King 217, 224, 273, 388 and illustr. 225.
[280] Tayl 174.
[281] See L.Murdin's book, Under Newton's Shadow, p.122, Adam Hilger 1985.
[282] Daumas.
[283] We find also Henri DESLANDRES, astronomer in Paris c.1890.
[284] c.f. HALE. See King 321.
[285] The sine law of refraction was, however, discovered by SNEL(L) c.1621, and that of reflection was known by the Greeks.
[286] See his text, "Dioptrica", Bell 11/12.
[287] [CHrDec89].
[288] Ronan. JBAA vol.101, 335, 1991. See also Turner Mic 48, and D and C 620, in connection with VERNIER.
[289] See Howse, Bell 17 and Daumas.
[290] Turner Antiq 120, and CHrDec85.
[291] See ODYSSEY. Many amateur astronomers prefer to construct this type of instrument on account of its relatively low cost and high light-gathering power. See Astronomy Now 1991 p.94 and "How and Why to make a User-Friendly Sidewalk Telescope" (Everything in the Universe 1991) by J.L.Dobson.
[292] Turner Antiq 35.
[293] Tayl 155.
[294] The DOLLONDs used PARKER's glassworks.

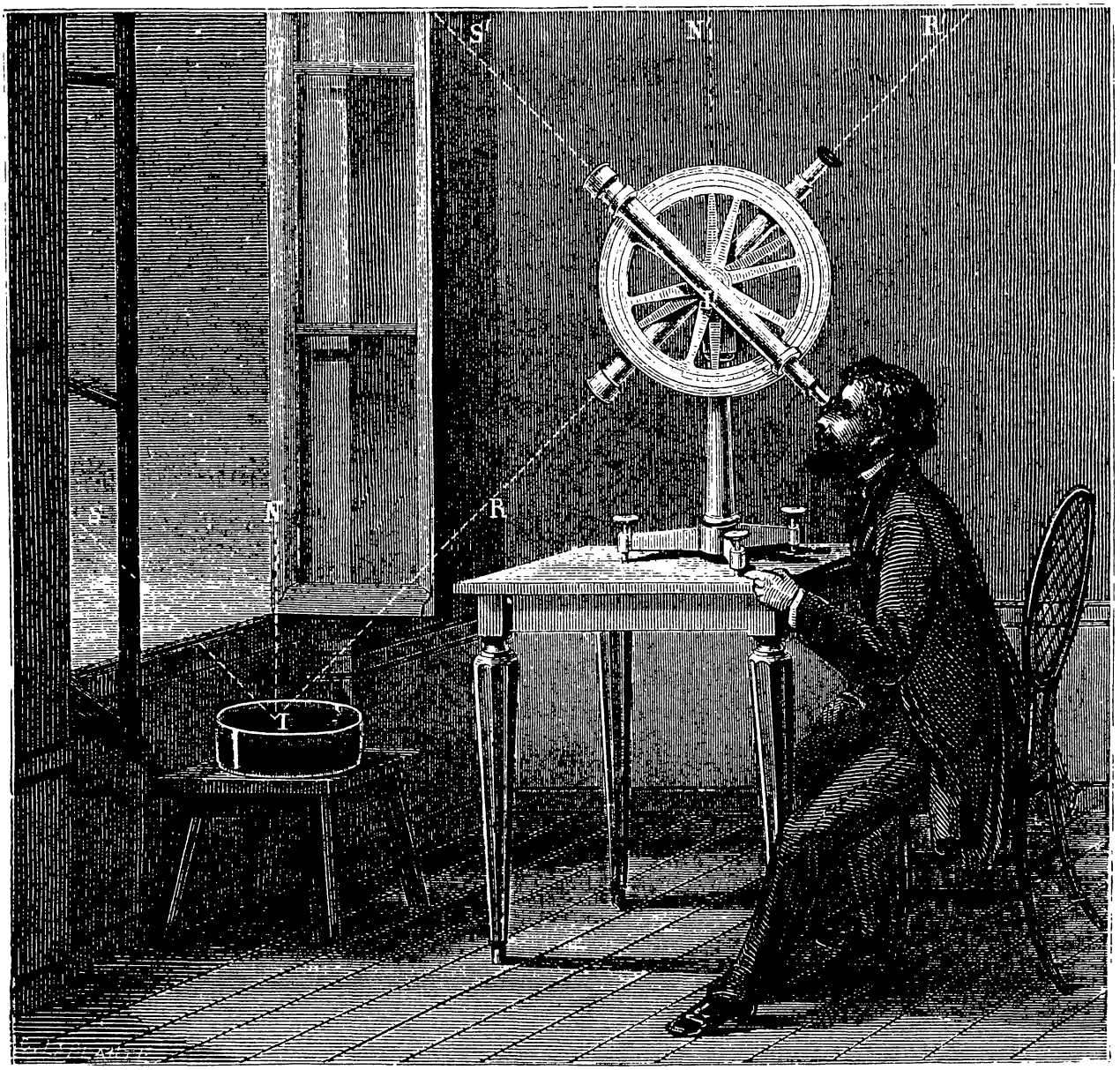


Figure 29: DESCARTES wrote on the laws of reflection and refraction 1637, although SNEL(L) discovered the sine law of refraction c.1621 and the Greeks had known the laws of reflection. The demonstration "apparatus" such as that shown above was very popular in Victorian times, incorporating telescopes.

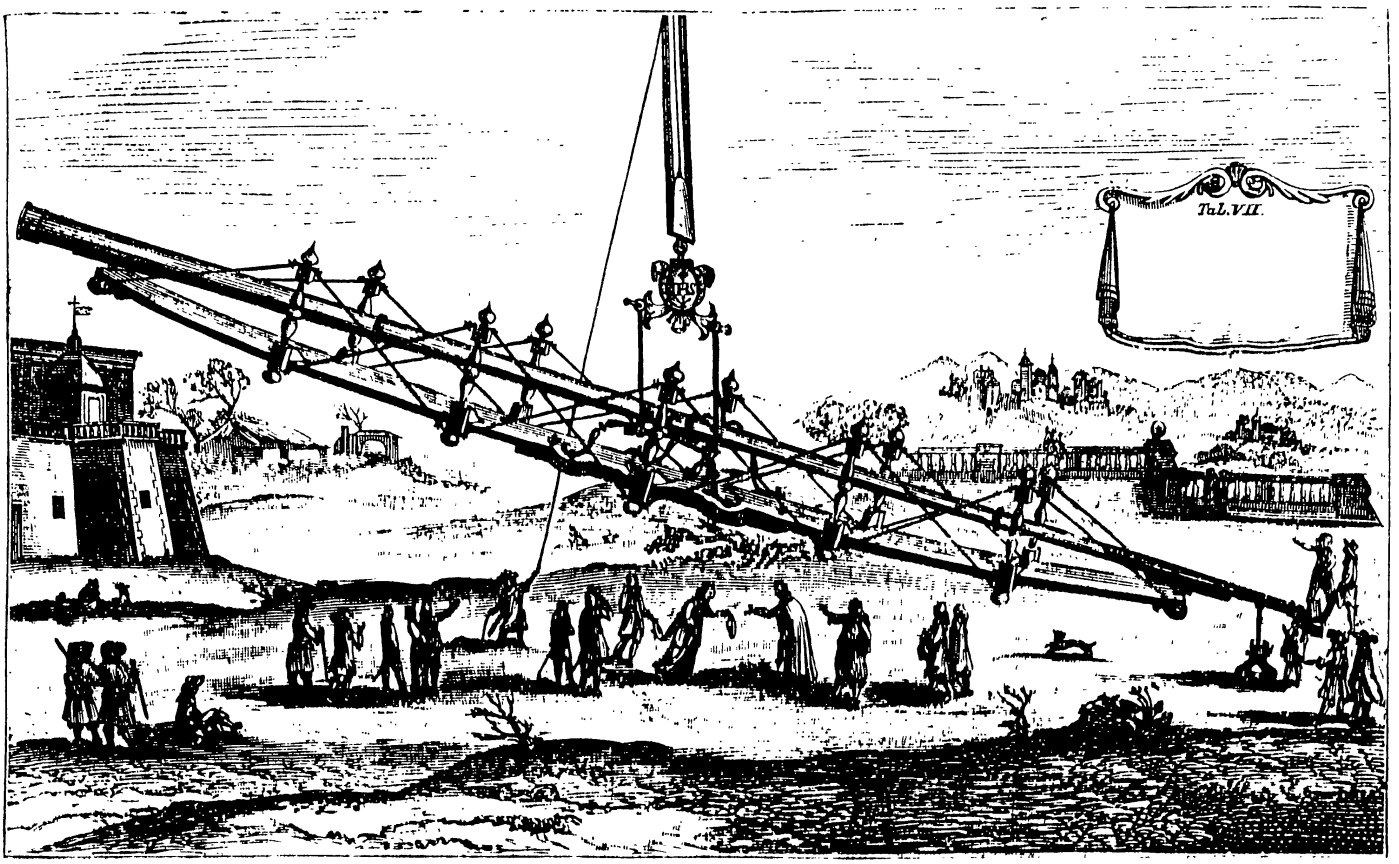


Figure 30: (a) The aerial telescopes of DIVINI, HEVELIUS, BLANCHINUS, AUZOT and CAMPANI (17C), similar to that illustrated above, were extremely long and cumbersome, suspended from towers and poles. These instruments, however, provided Man's first glimpse of the Moon and the planets under moderately high magnification. (b) Overleaf, DOLLOND's early altazimuth and equatorially mounted refractors (c.1800).

Dollond's Plain Stand.

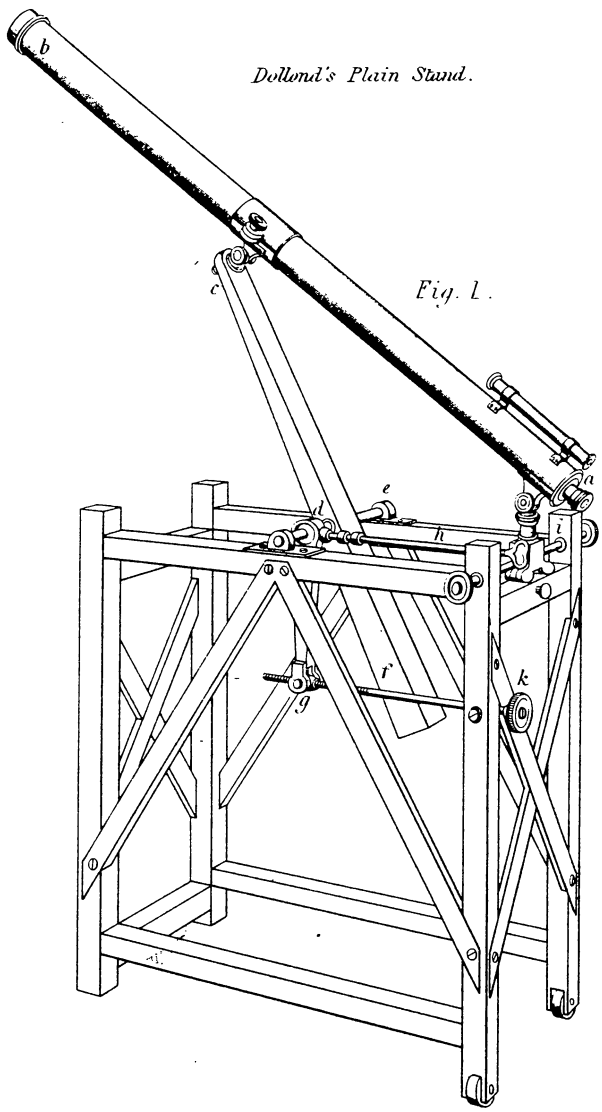


Fig. 1.

Dollond's Equatorial Stand.

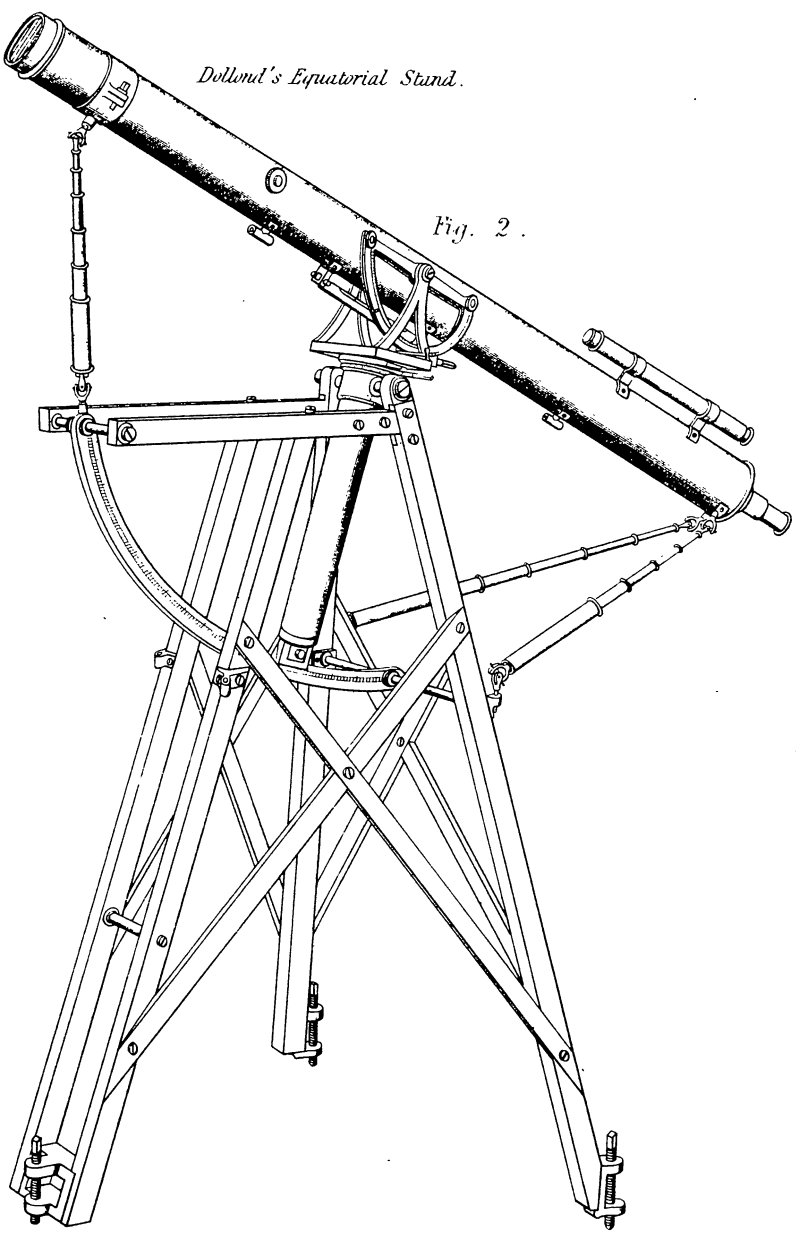


Fig. 2.

Figure 31: John DOLLOND 1706-61.

1750 or 1752. [295] His younger son was also John DOLLOND. Independently of others interested in the problem, John (Snr) invented the achromatic objective lens 1757/8 (although contested by HALL). This first step towards colour-free images was achieved some years after HALL's similar discovery (1729) and construction (1733) [296] HALL asked SCARLETT and MANN (Snr) to each grind one component of the doublet lense. They, however, sub-contracted to BASS who told others (possibly REW), whence occurred an unpleasant series of arguments over the patent. In some views wrongly, Peter DOLLOND won the day (1764) on behalf of his father since it was the DOLLONDs who published the result and successfully mastered the commercial manufacture.

DOLLOND Peter - eminent optical instrument maker, 1730-1820/21, working in 1750 at *Vine St, Spitalfields, London*, [297] Peter retired in 1818 after more than half a century's work. He was at *The Sign of the Golden Spectacles and Sea Quadrant*, near *Exeter Change, Strand* in 1752, before starting in business with his father, John (Snr). Peter improved the achromat by constructing a crown/flint achromatic triplet combination with curvatures also designed to greatly reduce spherical aberration (1765). The earliest DOLLOND triplet (with tube and stand) was sold from 1764 onwards. [298]

DOLLOND John (Jnr) - d.1804. He joined Peter c.1766. The DOLLOND family business was then at *St Paul's Cemetery, London.* This is where BERNOULLI visited them. [299] At this time RAMSDEN, the eminent instrument maker (John Snr's son-in-law), noted as a high-precision but slow worker, may have asked the DOLLONDs to take on some of his work. [300] In 1795 Peter and John (Jnr) moved to new premises in the *Haymarket.*

DOLLOND George - eminent optical instrument maker, (nephew, born HUGGINS, with famous uncle Peter DOLLOND), 1774-1852. [301] George was apprenticed to the optician, Charles FAIRBONE, with whom there was a family connection, at *Great New St. London.* George Huggins had a son, William, with ill-health and therefore not contributing to the business. The business continued trading under the name, DOLLOND and Co. when George died, and was eventually sold to CHANT who was either an employee or an employer elsewhere. Certainly, CHANT's father had worked within the DOLLOND firm. The business was then sold to PARSONS the chemist (not the GRUBB PARSONS), and finally to AITCHISON in 1927. The name of DOLLOND was retained by them, and the firm became almost exclusively an opthalmic business, DOLLOND AITCHISON which thrives today. Many excellent examples of DOLLOND's instruments abound. [302] [303]

DOWLING Daniel - English mathematics teacher, fl.1818. He owned a telescope.[304]

DRAPER John William - American scientist, 1811-82. John DRAPER was particularly interested in photography. [305]

DRAPER Henry - American astronomer, son of J.W. DRAPER. [306] In 1880 he obtained the first photograph of a nebula with his 11in CLARK telescope. It is recorded that he ground 100 telescope mirrors. [307] Well-known for the Henry DRAPER catalogue of stars, he used the excellent 8in f/5.6 VOIGTLÄNDER doublet (the BACHE telescope) made by Alvan CLARK for Harvard College Observatory and purchased by PICKERING using the Alexander Dallas BACHE fund of the National Academy.

DRAPER Edmund - American instrument maker /retailer, 19C. [308] He was associated with the American transit instrument, incorporating a vertical cir-

[295] Daumas 315.

[296] See e.g. King 144.

[297] There is a Vine St off Minories (near W.S. and J. BROWNING's later shop) and a Vine Court at east end of Whitechapel Rd, near Spitalfields.

[298] King 158, JMcF 184.

[299] See Bernoulli's "Lettres astronomiques" 1771.

[300] It may be assumed that DOLLOND inscribed the name RAMSDEN in these cases.

[301] See DOLLOND AITCHISON, and Handlist. Much of the information was kindly given to the author by S. Eadon-Allen of the above firm.

[302] Christie's of South Kensington have sold numerous fine examples. e.g. DOLLOND "Lookout" CHrDec85, CHrNov86, CHrSep89?, early-19C [CHrSep86 monocular], late-18C CHrSep89, DOLLOND-pattern late 18C CHrMar91, [CHrMar89 "The Student"], where the references are to their sale catalogues, the parentheses indicating illustrations available.

[303] The inscriptions, DOLAND, DOLLAND and DOULLON *London*, appear quite frequently, on instruments not made by DOLLOND. There is a DOLLAND telescope in the D.Andrews Collection. See also Astr. Nachr. vol.8, 42, and Notes Astr. Soc. vol.13, 110.

[304] Tayl.

[305] Shad Tel 145.

[306] King 267.

[307] Bell 170.

[308] Bennett 205.

cle and compass.

DUBOSCQ Jules - French instrument maker, mid-19C, *Paris.* He specialized in demonstration apparatus. [309]

DUNN Samuel - English mathematics teacher, 1723-94. [310]

DUNN John - c.1791-1841, *Edinburgh.* [311]

DUNN Thomas - c.1803-1893, *Edinburgh.* [312]

DUNNETT John - English turner and instrument maker, (sometimes spelt DUNNING), fl.1673 -c.1692/93. [313] He was MARSHALL's master, and specialized in telescope bodies and microscopes. DUNNETT is, therefore, in the MARSHALL (his apprentice), John SMITH, HAWKSBEE line.

[309] Turner 19C 150. We also record J and A DUBOSCQ, ibid 154.
[310] Tayl.
[311] BG.
[312] See BG, for a DUNN instrument sold by ABRAHAM.
[313] Turner Mic 104, and Vistas vol.28, 357.

E

EASTLAND William - 1704-68. There was also a son. [314]

EBSWORTH Richard - English optical instrument maker, fl.1819-20. [315] 4mm

ECCLESTON - English instrument maker, *At the Globe, London.* He made Newtonian telescopes. [316]

ECKHARDT A.G - amateur astronomer, fl.1770. He owned a DOLLOND telescope. [317]

EDMUND SCIENTIFIC - present U.S. telescope making firm, *Dept.11 B1, N937 Edscorp Bldg, Barrington, NJ 08007.* They are especially noted for the small reflector mounted within a split ball, reminiscent of NEWTON's first telescope.

EDWARDS John (Rev) - English amateur astronomer and speculum maker, *Ludlow, Shropshire*, 18C. He was interested in the chemical composition of specula. [318] His micrometer was favoured by the Astronomer Royal, MASKELYNE.

EICHENS William - head of Secretan engineering workshop, 1818 -84. He made FOUCAULT's famous silver-on-glass telescope in *Paris.* Originally from Berlin, he was naturalized French, and his position was later filled by the famous GAUTIER in 1884 and PRIN in 1910. [319]

ELLIOTT Bros - optical and mathematical instrument maker, *101/102 St Martin's Lane, London WC*, c.1881. [320]

ELLISON W.F.A (Rev) - instrument maker and astronomer. He was Director of Armagh Observatory 1918-36. He made a large number of small telescopes, and it is recorded that he made about 140 mirrors of apertures 6 to 12in and objectives of 4 to 5.25in [321] He was an ardent writer on telescope making and a contributor to the book, Amateur Telescope Making. His astronomical mirrors and correspondence (to INGALLS etc.) are widely scattered although there is a small collection of his

[314] Tayl 156.
[315] Tayl 390.
[316] Daumas 302.
[317] Tayl.
[318] Nautical Almanac 1787, King 89.
[319] Vistas vol.30, 161, and Lock 314.
[320] RP.
[321] King 417.

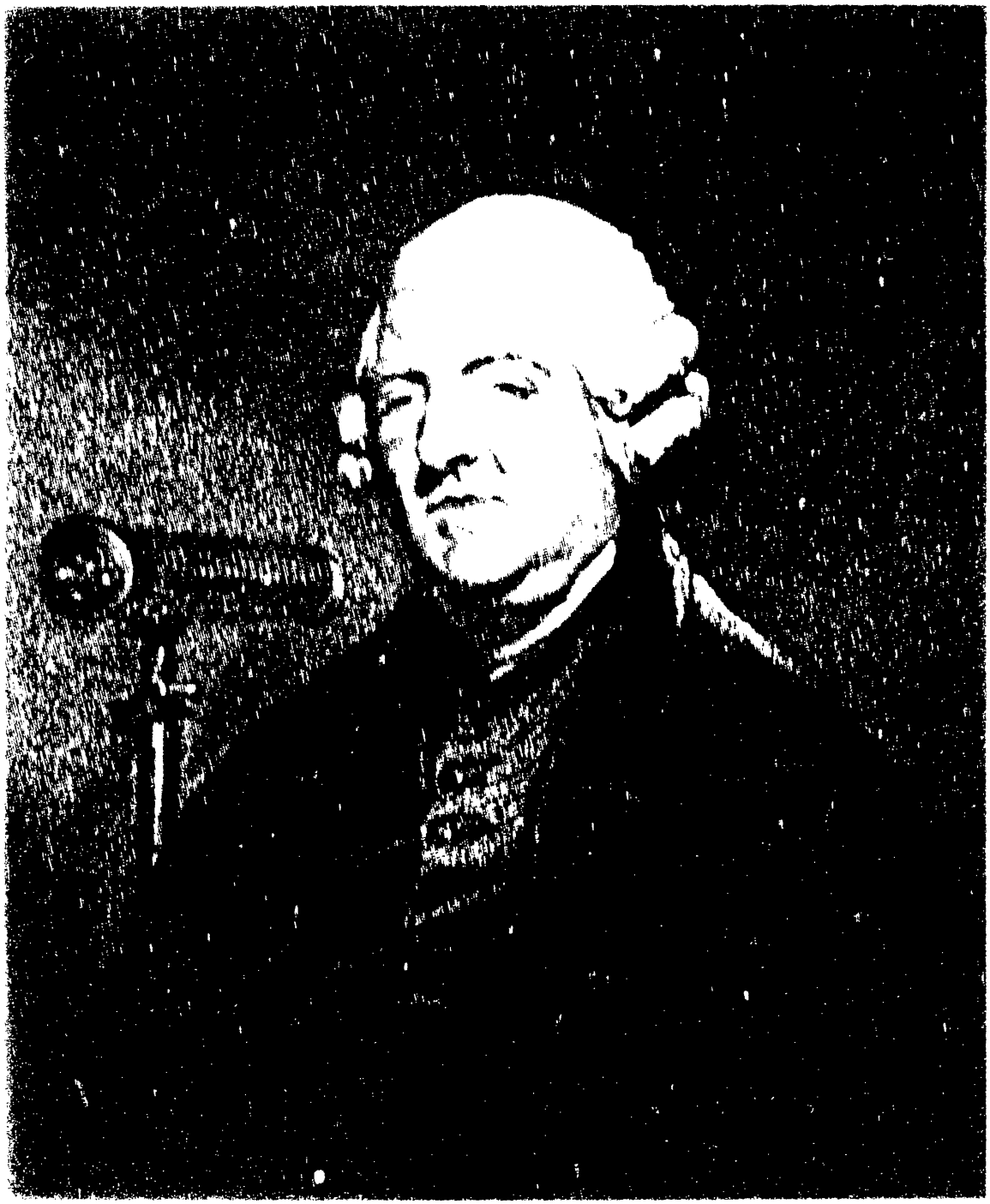
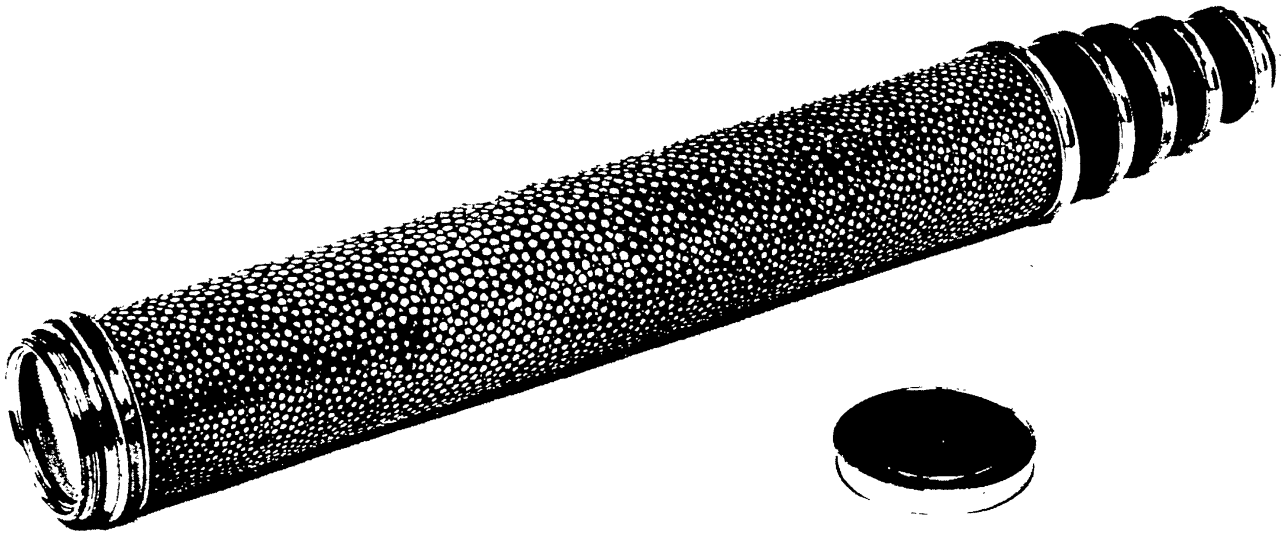


Figure 32: Peter DOLLOND 1730-1820/21. His triplet achromatic objective was standard for many years.

Figure 33: (a) Two 2in DOLLOND monoculars, made in decoratively turned ivory and gilt brass (top left), and two similar French monoculars by LEMIERE, in gilt brass and mother-of-pearl, and in brass, mohogany and ivory (top right). The DOLLONDs sold at £220 and the LEMIEREs for £154 at Christie's in September 1989. (b) An unsigned late 18C brass miniature 1.25in refracting telescope, 3.9in long, with a single graduated drawtube and rotating four-eyepiece wheel, mounted on cabriole legs with inswept feet (bottom left). The mount dismantles to store within the telescope tube. This is a DOLLOND pattern, and was valued at £300-400 at Christie's in March 1991. (c) A DOLLOND miniature 1.25in telescope (bottom middle), together with a fishskin covered card case (valued at £1500-1800 at Christie's in September 1989). (d) A DOLLOND single-draw monocular with silver and horn mounted shagreen body tube (bottom right). The drawtube of leather-covered compressed card is decorated with flowers and foliage, and the case is fishskin covered (sold at Christie's for £330 in December 1988).



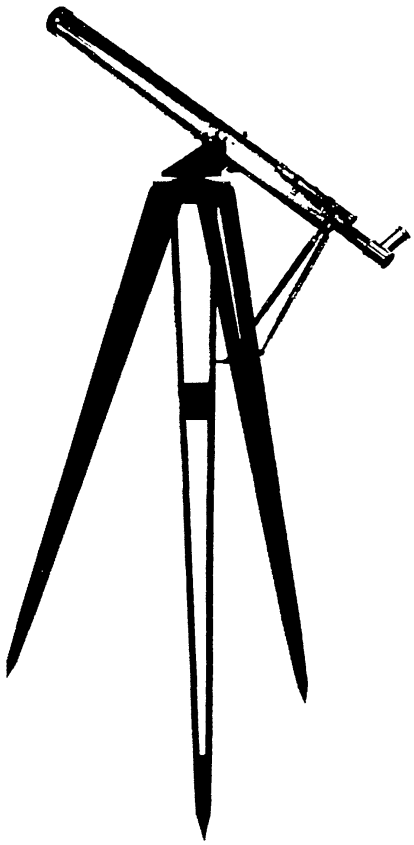


Figure 34: (a) DOLLOND 1.3in telescope in shagreen covered tube, with four drawtubes in green stained vellum and card, with lacquered brass fittings, stored in a chamois leather pouch 43in long (sold at Christie's for £1600 in September 1986). (b) "The Student" telescope by DOLLOND, constructed for astronomical and terrestrial observations (sold at Christie's for £935 in March 1989).

Figure 35: George DOLLOND 1774-1852.

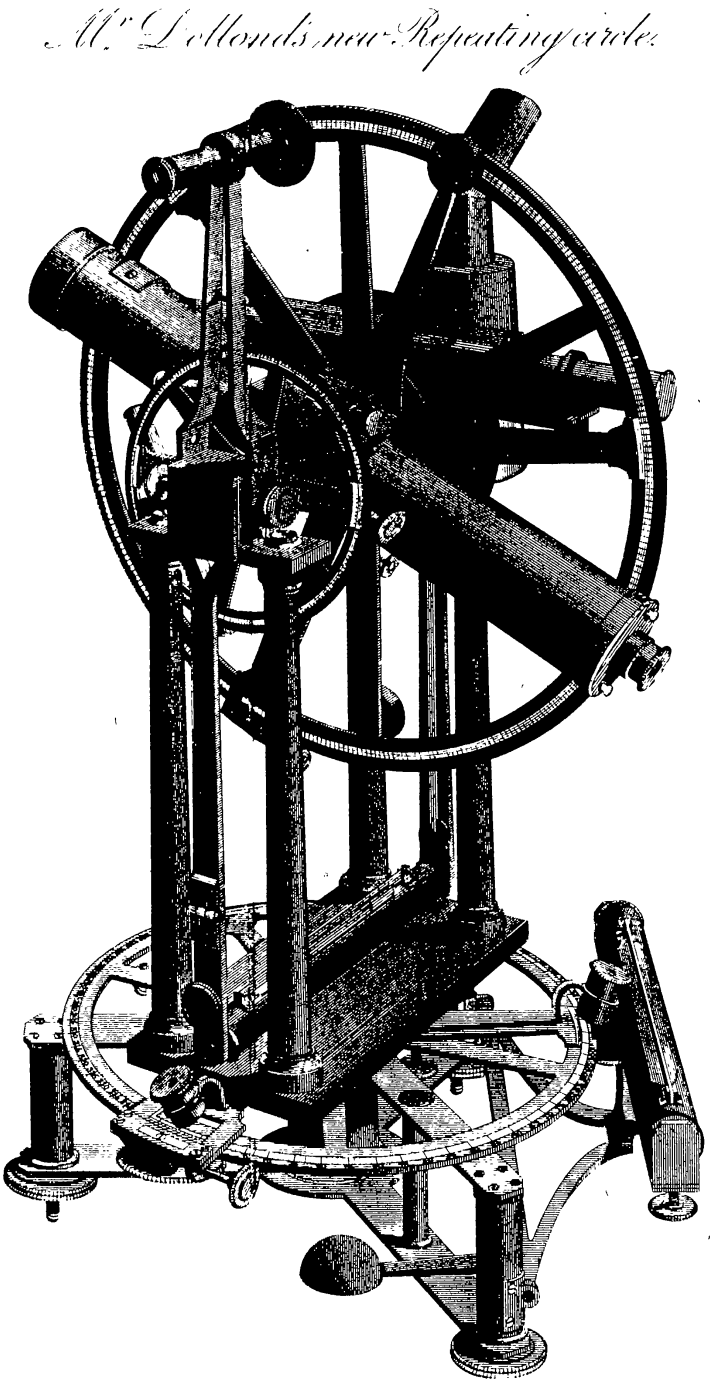
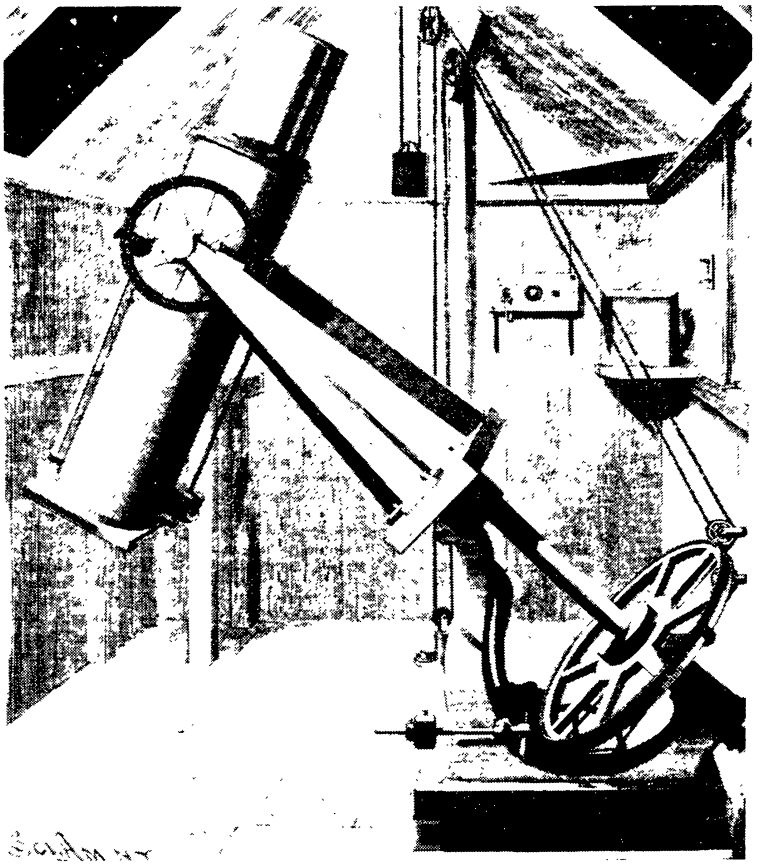
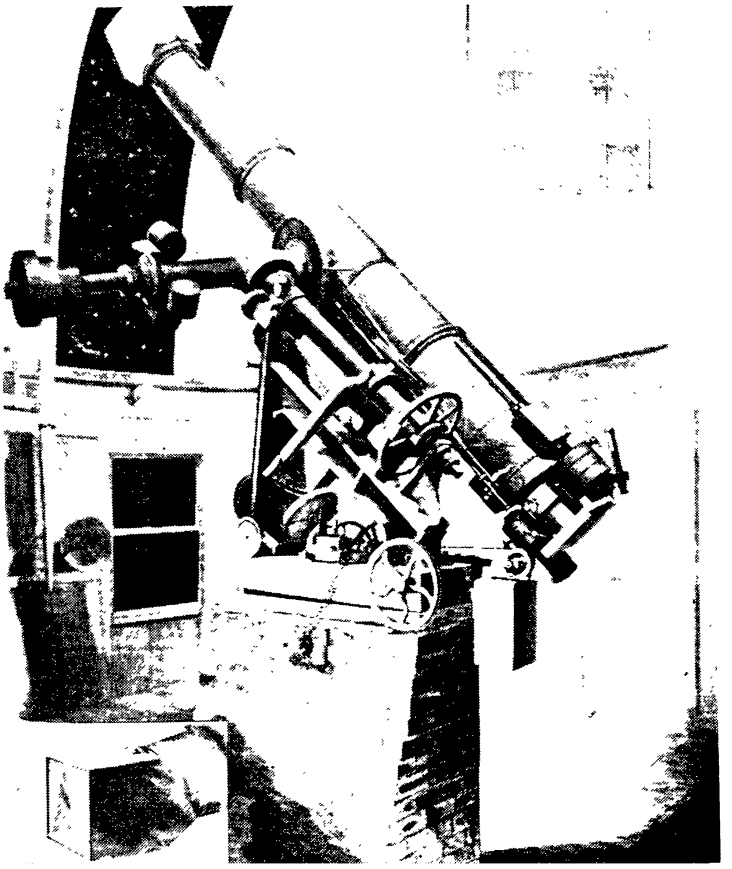


Figure 36: (a) DOLLOND repeating circle. (b) Bache 8in photographic telescope at Harvard College Observatory. See opposite top. (c) DRAPER 11in photographic refractor with objective prism also at Harvard. See opposite bottom.





notes and observations with the family in Romsey, Hampshire. When ELLISON came to Armagh, he brought with him an 18in diameter CALVER mirror which was put to use, and then replaced by a Schmidt system. [322]

ELLISON Mervyn A (Rev) - well-known astronomer at School of Cosmic Physics, Dublin, and Director of Dunsink Observatory. He was the son of W.F.A. ELLISON and was an authority on solar phenomena and spectrohelioscopes.

ELMSDEN Edmund - English, fl.1764. [323]

ENSIGN - English firm, retailing photographic apparatus, 20C. [324]

ERFLE - optician, known today by his wide-field eyepiece.

ERTEL Traugott Leberecht - optical instrument maker, 1778-1858. [325] The company became ERTEL and Son which was the successor to REICHENBACH's firm. He designed a vertical circle [326] and constructed an alt-azimuth instrument for COOPER.

ERCK Wentworth - Irish gentleman astronomer, *Bray*, where he set up *Sherrington Observatory* in 1877. ERCK owned the 7.5in f/15 CLARK objective which passed through so many famous hands (DAWES, BRODIE, PRINCE, ERCK, GRUBB, MONCK) and then was lost in Belfast. ERCK died in 1890.

ESCANGON - Frenchman interested in improving the accuracy of meridian instruments, c.1931. He was involved with refurbishment of the REPSOLD 1875 meridian circle at *Strasbourg Observatory.*

ESPIN T.E - English, fl.late 19C. [327] He designed a direct-vision spectroscope, and corresponded with the 4th Earl of Rosse. [328]

EUG - Polish optical instrument maker, *Warsaw*, early 20C. We record an example of the firm's binoculars. [329]

EULER Leonhard - Swiss mathematician, 1707-1783. His "Theoria Motuum" was the first analytical work on planetary motion, and "Dioptrica" contains his work on optics printed in Petersburg 1769. EULER was interested in the water lens (1747) inspired by the achromatism of the human eye. EULER's thoughts on achromatism were strongly opposed by NEWTON. He also designed a doublet objective (1769) with "minimal" spherical aberration.[330]

EVANS Thomas Simpson - English mathematics teacher, working at the private observatory of LARKINS 1777-1818. [331]

EVEREST George (Sir) - famous English engineer and surveyor, 1790-1866. He designed his own theodolite. [332]

EYRE and SPOTTISWOODE - mathematical instrument maker, *Gt New St, Fetter Lane, London EC*, c.1894. [333]

F

FAIRBONE Charles - English mathemaical and optical instrument maker, *20 Gt New St, Shoe Lane and Fetter Lane, London*, fl.1786-1810. Charles' father was possibly a partner of RAMSDEN in 1756. Charles was associated with George DOLLOND (1786) and James ALLAN. His son, John, was apprenticed to John DOLLOND (Jnr). Also, George HUGGINS (who changed his name to George DOLLOND) was apprenticed to a FAIRBONE of *Gt New St, London* c.1780.

FAIREY Richard and Joseph - English instrument makers, c.1790-1846. They are known for at least one quadrant. [334]

FALLOWFIELD - *London.* [335]

FALLOWS Fearon (Rev) - astronomer at the Cape Observatory, c.1829.

FAUTH and Co - notable U.S. optical instrument maker, *Washington DC*, working c.1877-85. We find very little documentation on FAUTH, the man, although the firm made some of CLARK's mount-

[322] See GROSSIE.
[323] A telescope by ELMSDEN may be seen in Oxford. See Tayl 259.
[324] See BARNET.
[325] Bennett 174.
[326] Lock 290.
[327] JHA vol.12, 224, 1981.
[328] See Birr archives, available on microfilm, and Sedg 335.
[329] See Gould 1975.
[330] D and C 227, and Chamb 719, King 145.
[331] Tayl.
[332] Chamb 678, Bennett 195.
[333] See RP.
[334] Tayl.
[335] See Herschel Collection in Bath.

Figure 37: (a) W.F.A. ELLISON, notable telescope maker, Director of Armagh Observatory 1918-36, and (b) Armagh Observatory, established 1791, as it is today.

ings and advertized widely in the U.S., competing with major firms like WARNER and SWASEY in the construction of telescope mountings. [336] The firm was taken-over by G.N. SAEGMÜLLER.

FAYRER James - English instrument maker, *35 White Lion St, Pentonville. London*, c.1768-1848, and later at *40 and 66 White Lion St.* He was employed by TROUGHTON, [337] and made TROUGHTON's dividing machine c.1838, a copy of RAMSDEN's.

FECKER Gottlieb L - a leading engineer at the firm of WARNER and SWASEY in the U.S. He was father of J.W. FECKER. [338]

FECKER J.W - a notable U.S. telescope maker, early 20C, d.1945, who formed a very successful corporation. He was responsible for the 20in photographic objective at Lick Observatory which was mounted by WARNER and SWASEY. He took over the BRASHEAR business in 1926. [339]

FEHRENBACH C - present eminent French astronomer and spectroscopist. As Director of the Haute Provence Observatory, he is noted for the design of a reversible objective prism to be used for the measurement of absolute radial velocities of stars. This is achieved (presently at the European Southern Observatory Chile) by alternatively allowing a spectrum and its reverse (in dispersion) to be recorded on one and the same photographic plate. This obviates the need for a comparison standard spectrum. The star is trailed along the direction parallel to the refracting edge of the prism.

FEIL Charles - French glass manufacturer in *Paris*, mid-19C, continuing the GUINAND line. [340] There were two FEIL brothers, associated with MANTOIS. They made in 1885 the crown blank disk for the 40in Yerkes refractor which was then figured by CLARK, following the success of the 36in Lick refractor.

FERMAT - notable French scientist. The principles on which geometrical optics are based are the laws of reflection and refraction. These are contained within FERMAT's "Principle of Least Time" from which can be deduced the properties of pencils of rays caused by reflection and refraction.

FERRIER - French optician, first half of 17C. *Paris.* He was commissioned by DESCARTES to make aspheric lenses. [341]

FERTEL and sons - Austrian instrument makers, *Munich.*

FIELD - see MAUDSEY.

FIRMINGER Thomas - English astronomer, fl.1804 -23. He was associated with KATER and assistant to MASKELYNE. [342]

FISHER George - English amateur astronomer, 1794-1873.

FITZ Henry - U.S. optician, *New York*, 1808-63. He made several telescopes, often using wooden tubes, up to 18in aperture, especially photographic refractors, for L.M. RUTHERFORD of New York who was a pioneer in celestial photography. [343] A large FITZ objective (26in Washington refractor) was re-worked by CLARKE, and also re-mounted by WARNER and SWASEY due to its instability. A FITZ-CLARK telescope may be seen at *Westpoint, U.S.* [344]

FLAMSTEED John - famous English astronomer, 1646-1719, the first Astronomer Royal (1676-1719). Engravings of his instruments, e.g. the 6ft mural sextant at Greenwich, may be seen in the "Prolegomena" in the book "Historiae Coelestis". He worked with a 50in mural quadrant (1683) and a 79in mural arc by Abraham SHARP (1689), on the obliquity of the ecliptic and fundamental right ascensions.

FONTANA Francesco (or Giovanni) - early 17C Italian telescope maker. [345] He noted in 1638 the gibbous phase of Mars.

FORSTER - German theoretical optician, *Vienna.* He was interested in oblique cassegrain telescopes. [346]

FORTIN Nicolas - French natural philosopher and

[336] Handlist, King 244.
[337] FAYRER was Edward TROUGHTON's niece's husband. See TROUGHTON'S biography and PEARSON's Plate 28 illustrating his reflecting circle.
[338] King 370.
[339] King 395.
[340] Lock.
[341] King 48.
[342] Tayl.
[343] King 290.
[344] See Bell.
[345] Clagett 1976. Examples in Firenze museum.
[346] D and C 249. See also FRITSCH.

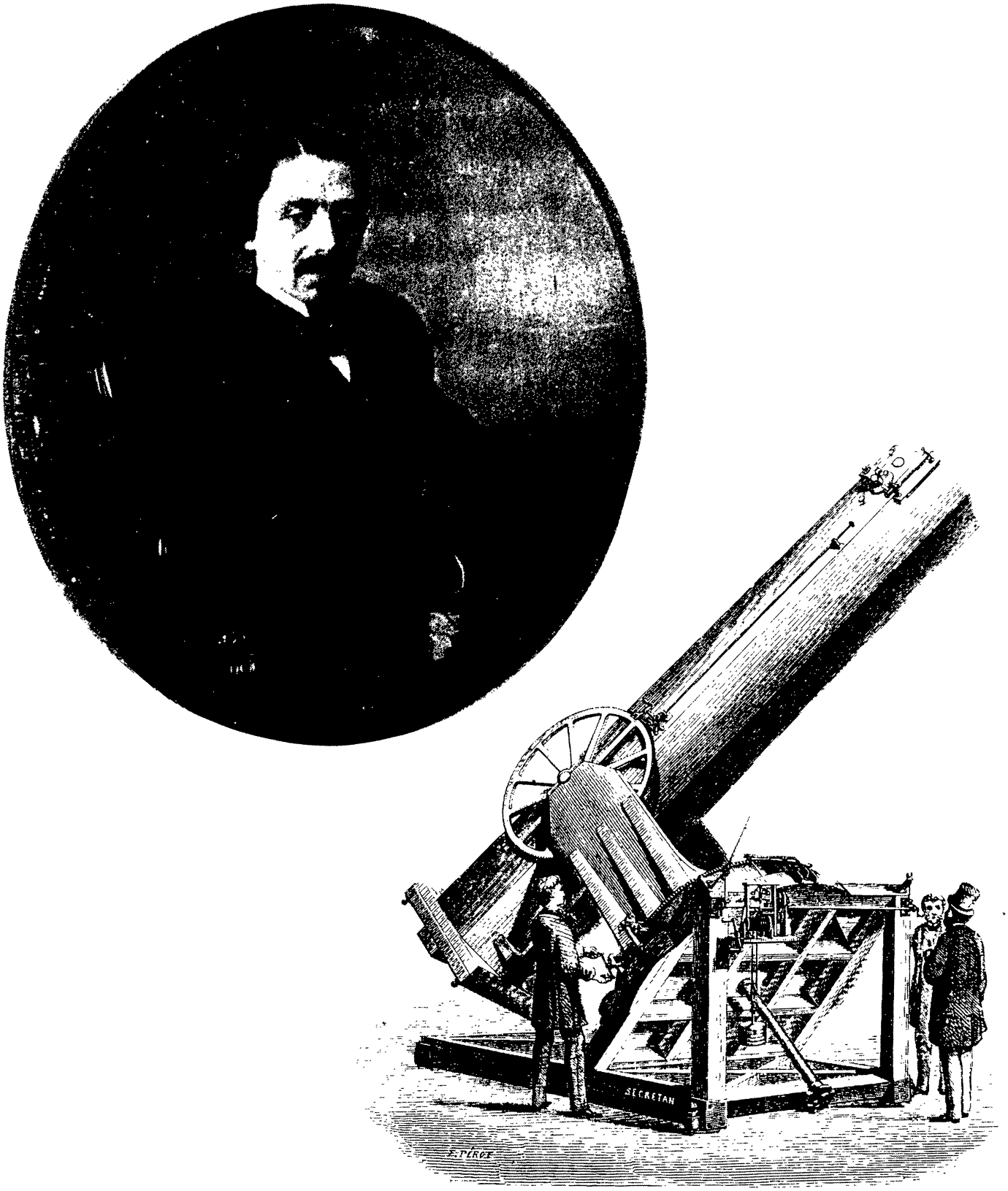


Figure 38: (a) Léon FOUCAULT 1819-68. (b) The 80cm silver-on-glass FOUCAULT reflector.

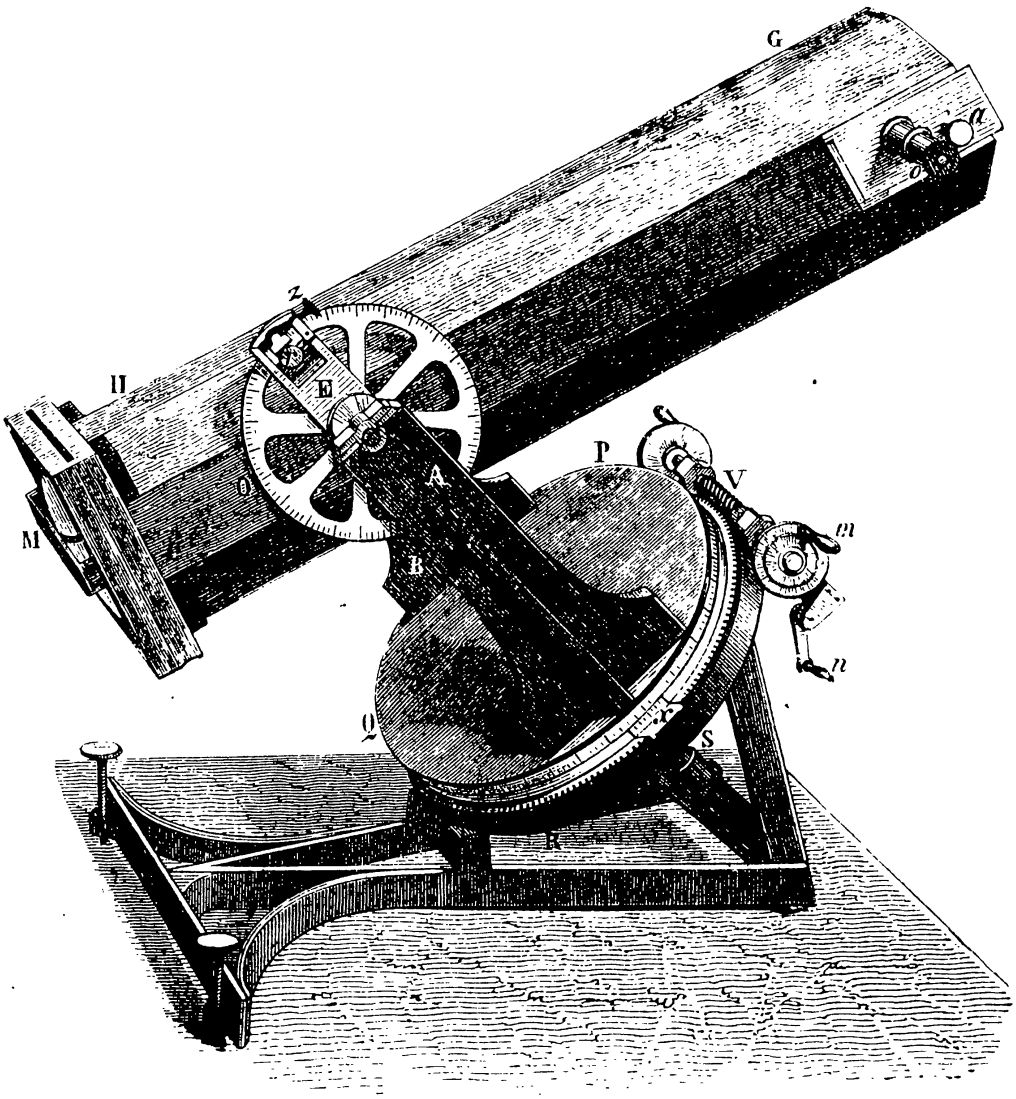


Figure 39: Early FOUCAULT reflector, with the first fork mount, constructed by SECRETAN c.1860.

instrument maker, 1750-1831. [347] He is today particularly famous for his FORTIN-type barometer but he interacted in many areas of science. [348]

FOUCAULT Jean B. Leon - eminent French scientist and inventor, 1819-1868. This remarkable man was responsible for the carbon-arc projection microscope (1844), the discovery that light travelled faster in air than water (1850), the first daguerreotype [349] of the Sun (with FIZEAU), the demonstration of the Earth's rotation (using a pendulum 1851), the construction of a silver-on-glass 10cm diameter f/5 mirror (1857, although STEINHEIL had succeeded in 1856), and important advances in the testing of mirrors. He also experimented with telescope driving clocks and governors, [350] and designed a siderostat (1862) [351] which was made by EICHENS in SECRETAN's workshop. He revolutionized the optical testing of telescope mirrors by three new methods, a pin-hole at the centre of curvature and a microscope, a steel wire at the centre of curvature to allow scanning cones of light for zonal examination, and the knife-edge test well-known today. This allowed FOUCAULT and his assistant, Adolf MARTIN to proceed by "local figuring" (c.1859). Their 80cm telescope was the largest silver-on-glass reflector in their day. [352] A less-known application of the knife-edge FOUCAULT test was the focussing of the BAKER - SCHMIDT Cassegrain telescope. The Armagh - Dunsink -Harvard (ADH) instrument at Boyden Observatory, S.Africa, was fine focussed during a night's observations by this method. [353]

FRANK Charles - one of the foremost English makers of small telescopes in the middle 20C, *145 Queen St, Glasgow, Scotland.* Established in 1907, the firm produced mostly small reflecting telescopes of about 6in aperture. The business was continued by his son, Arthur FRANK. [354]

FRANK Arthur - son of Charles, he took over the business during 1945-71. He donated the FRANK collection of early astronomical and scientific instruments to the National Museum of Scotland. [355]

FRANKLIN Benjamin - eminent U.S. scientist, 1706-90. In our context, he is known to have purchased several English scientific instruments. [356]

FRASER and son - English instrument maker, *3, New Bond St, London*, 1785-99, the son being made partner in 1799. They were associated with HAWK GRICE, the instrument maker. [357]

FRAUNHOFER Joseph - eminent Bavarian optician and physicist, 1787-1826, working at *Benediktbeuern* where he founded his glassworks. He is known for his identification and measurement of absorption lines in the solar spectrum and the formation of a centre of German optical design and construction. [358] His partners were UTZSCHNEIDER and REICHENBACH, in the *Munich* Institute. [359] The famous FRAUNHOFER "Dorpat" refractor is discussed at length in Pearson's "Practical Astronomy" 1829, the mounting of the telescope being the proto-type of the German equatorial.

FREIDRICKS Hanseatische Werkstatten für Feinmechanik und Optik - (World War II binocular code ctn).

FRITH Peter and Co - telescope maker, *Sheffield*, fl.1820-40. [360]

FRITSCH K - German theoretical optician, *Vienna.* He was a collaborator with FORSTER on optical designs. [361]

FRODSHAM - see PARKINSON. [362]

FROST A. J - instrument maker, *London* c.1884. He constructed an interesting transit instrument [363]

[347] Daumas 326, Lock.

[348] See A.J. Turner's From Pleasure to Profit.

[349] The following approximate dates in the development of photography are of interest : daguerreotype (1839-51), wet collodion (1851-79), early silver bromide emulsions (1879-87).

[350] Electric drives came later, e.g. by GRUBB. See Lockyer 323 (illustr.) and c.f. BOND's spring governor made by Alvan CLARK discussed in Lock 320.

[351] Lock 344.

[352] See Vistas vol.30, 153 and 159. Also Bell Fig.26, MACP 2 and 77.

[353] See description of FOUCAULT knife-edge focussing in MACP 77.

[354] See BG, and the ADIE, MILLER, George ADAMS lineage.

[355] BG is devoted largely to this collection.

[356] See e.g. Tayl.

[357] See 19C monocular CHrDec85.

[358] JHA vol.22, 158, and Howard-Duff's article in JBAA vol.97, 339, 1987.

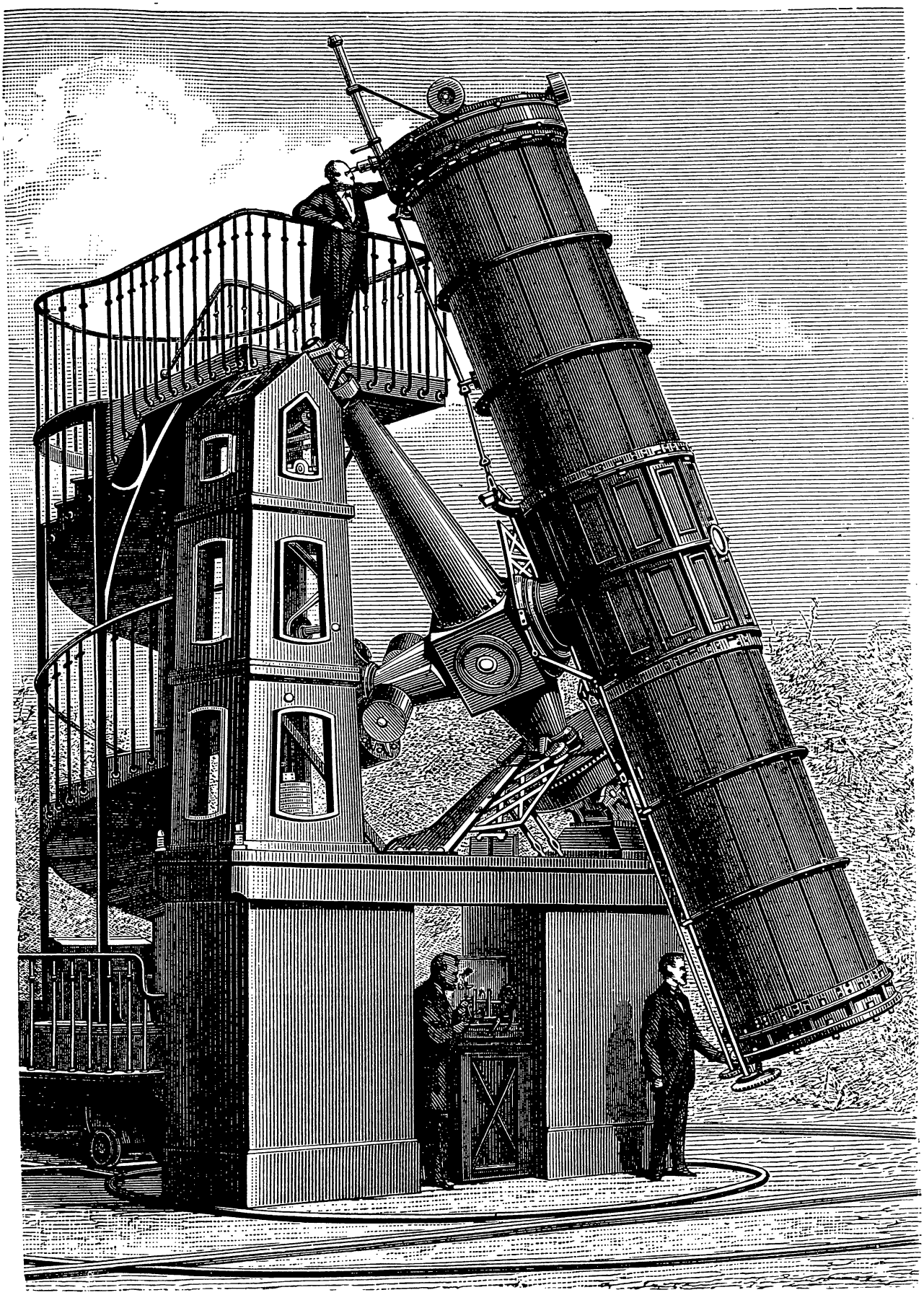
[359] King 178-188. Handlist suggests that the firm survived into the mid-1800s. A description of the FRAUNHOFER objective and examples of his work are to be found in King's classic book.

[360] Tayl.

[361] We assume FRITSCH is that quoted by King 244.

[362] Tayl.

[363] Bennett 171.



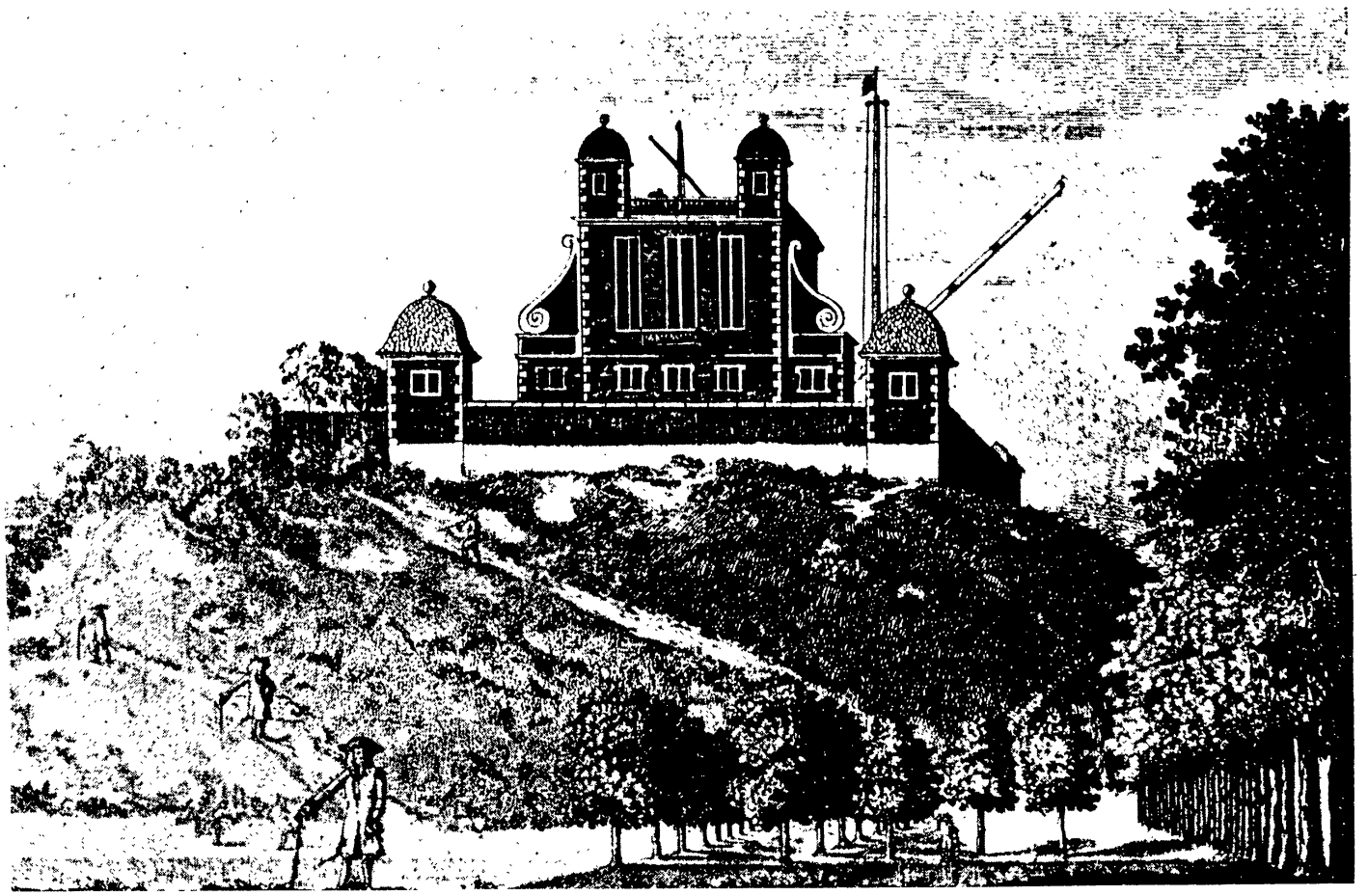


Figure 40: (a) Greenwich Observatory c.1676 from an engraving by Francis Place *(Courtesy of Royal Greenwich Observatory).* (b) The great FOUCAULT reflector at the Paris Observatory (see opposite).

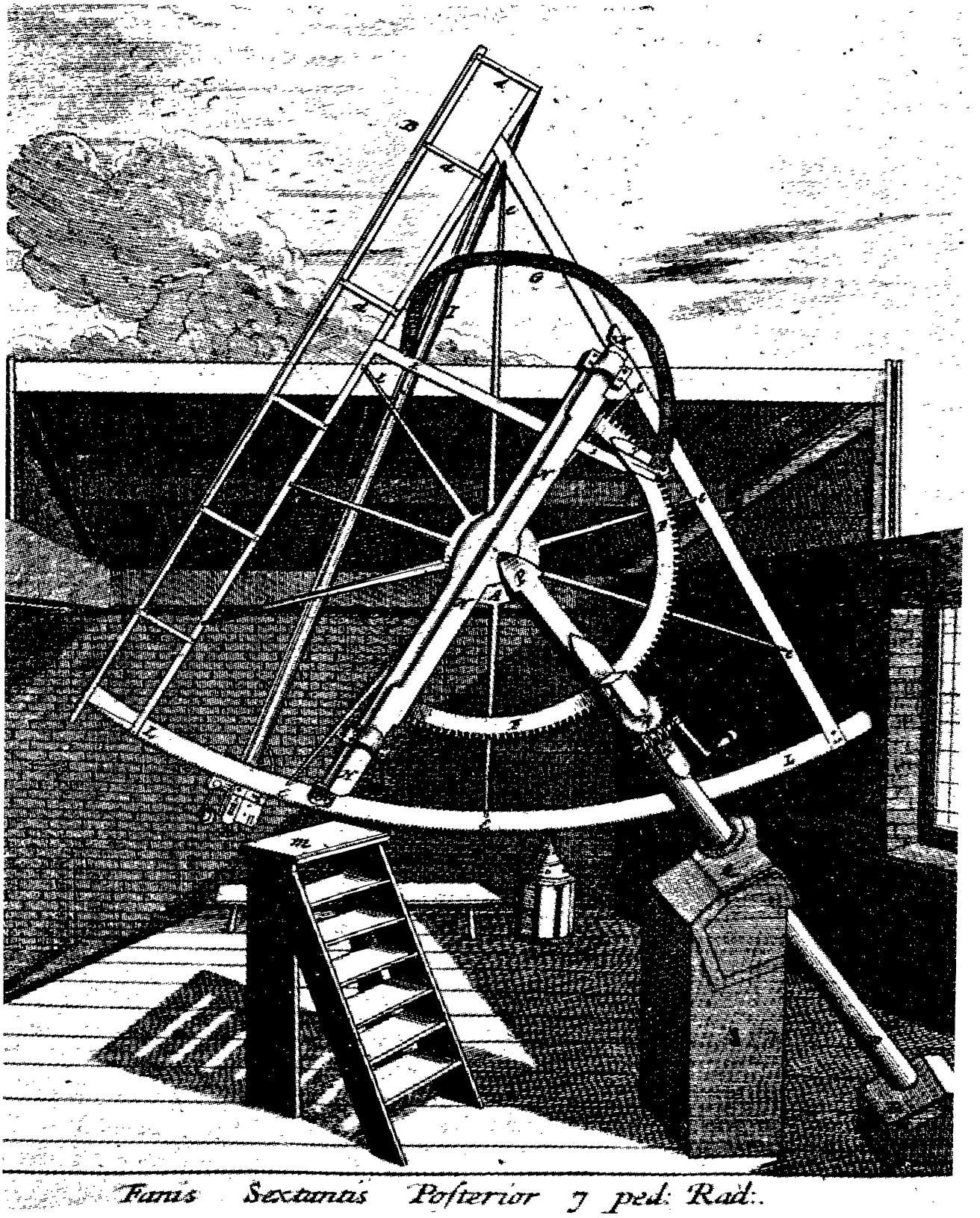


Figure 41: FLAMSTEED's 7ft sextant c.1676 (See interesting note on the instrument's bad performance in L.Murdin's book, *Under Newton's Shadow*, Adam Hilger Ltd. 1985).

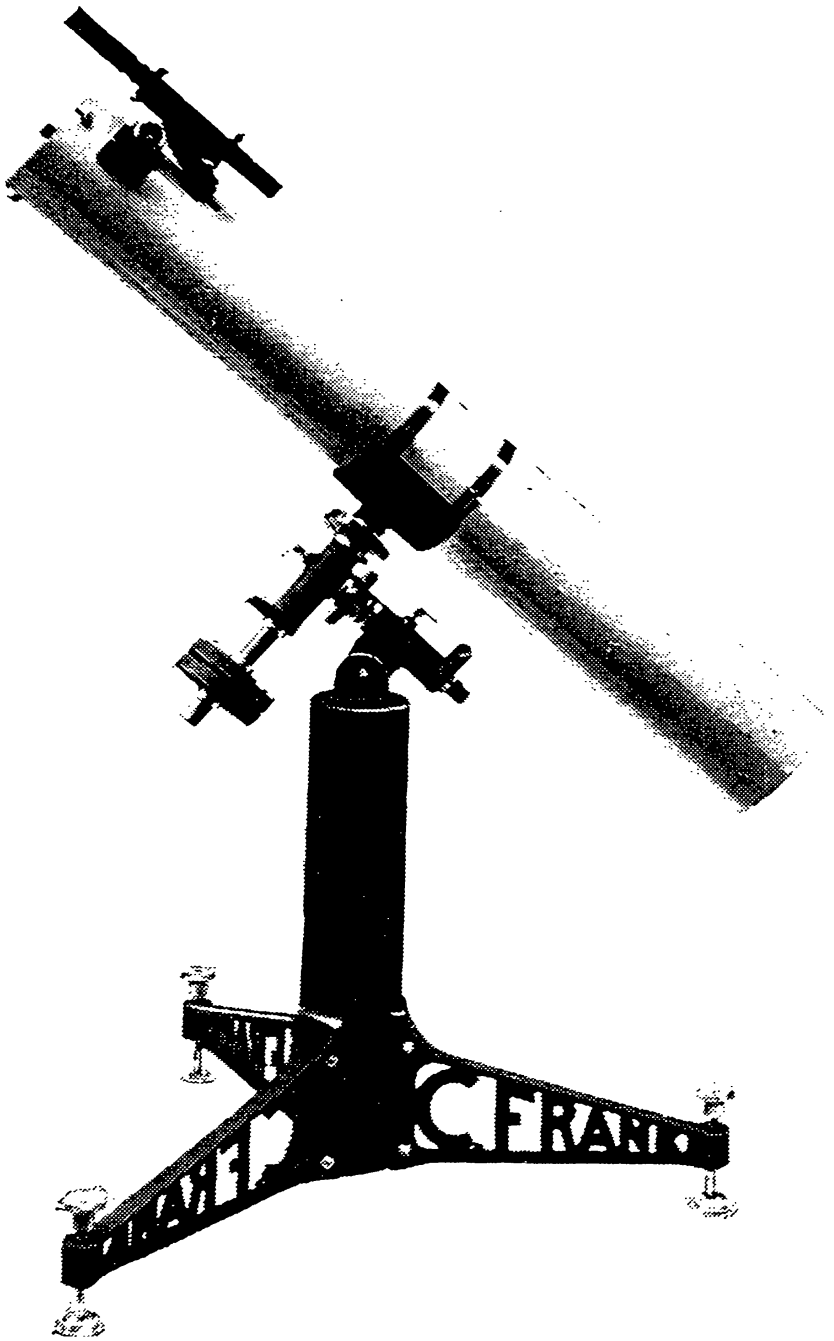
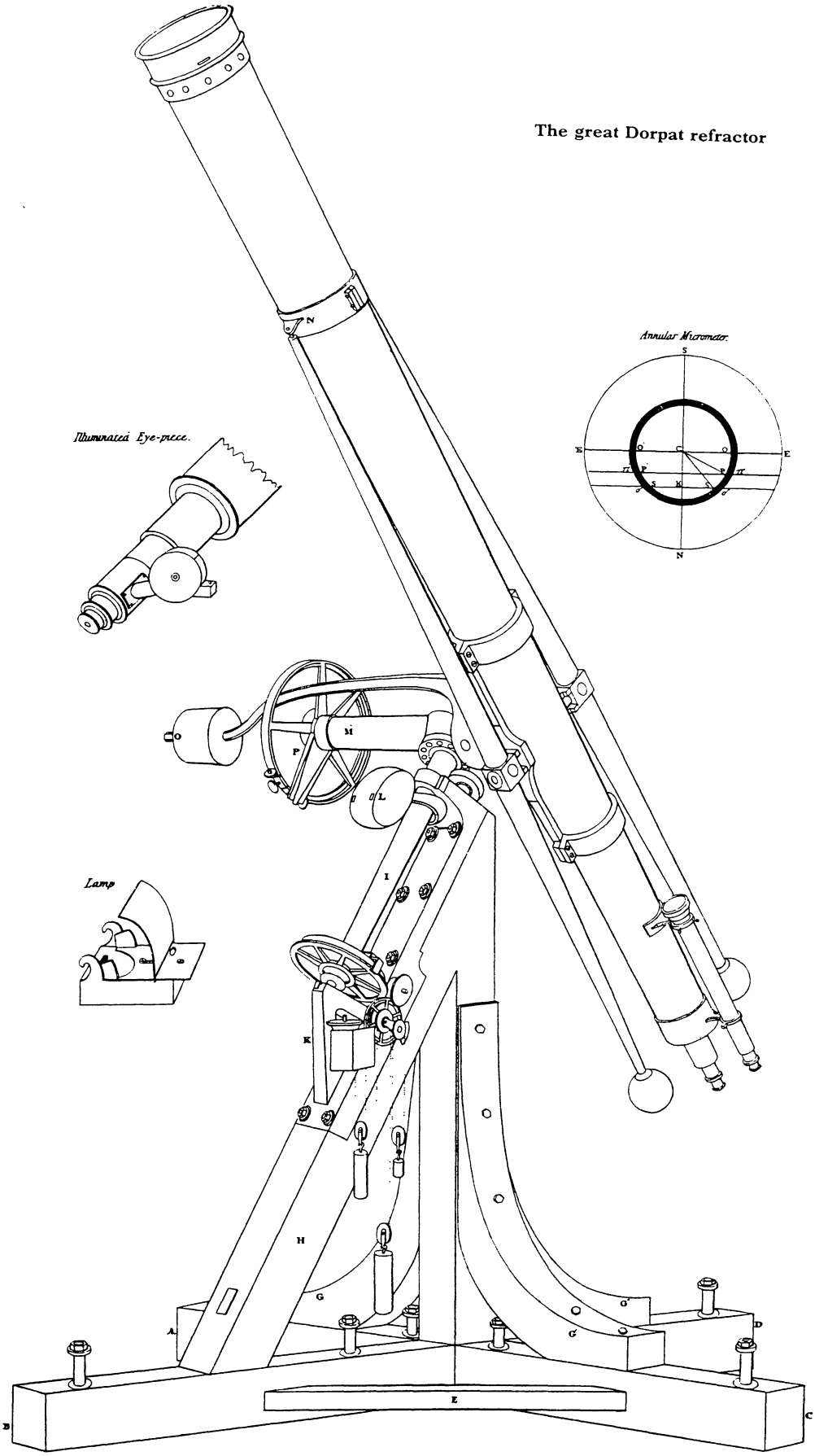


Figure 43: (a) FRANK's 6in Newtonian Telescope. (b) Overleaf, FULLERSCOPES shop in Finchley Road, c.1960. (c) FULLERSCOPE dual-purpose 10in Cassegrain. (d) FULLERSCOPE 6in Newtonian Telescope.

The great Dorpat refractor

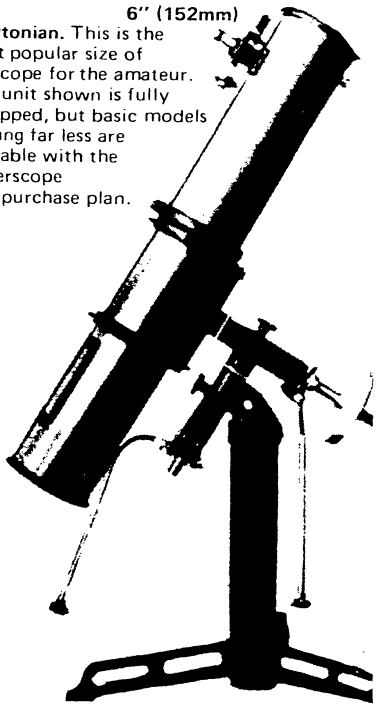


FUESS R - German optical industry, *Steglitz, Berlin* (World War II binocular code cro) fl.c.1880 onwards. See Handlist.

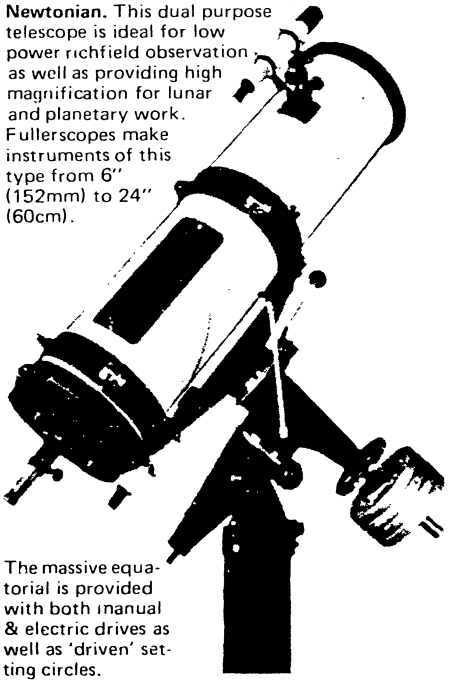
FULLERSCOPES - D.Fuller, one of the foremost English makers of small telescopes of the 20C, also retailers, originally at *760 Finchley Rd, London NW 11*, took over BROADHURST CLARKSON in the late 1960s to set up the firm of BROADHURST CLARKSON AND FULLER at *Telescope House, 63 Farringdon Rd, EC1M 3JB London, manufacturing Cassegrain reflectors up to 24in aperture.*

The Cyclopaedia of Telescope Makers *will be continued in the next issues of the Journal.*

6" (152mm)
Newtonian. This is the most popular size of telescope for the amateur. The unit shown is fully equipped, but basic models costing far less are available with the Fullerscope unit purchase plan.



10" (250mm) Cassegrain
Newtonian. This dual purpose telescope is ideal for low power richfield observation as well as providing high magnification for lunar and planetary work. Fullerscopes make instruments of this type from 6" (152mm) to 24" (60cm).



The massive equatorial is provided with both manual & electric drives as well as 'driven' setting circles.