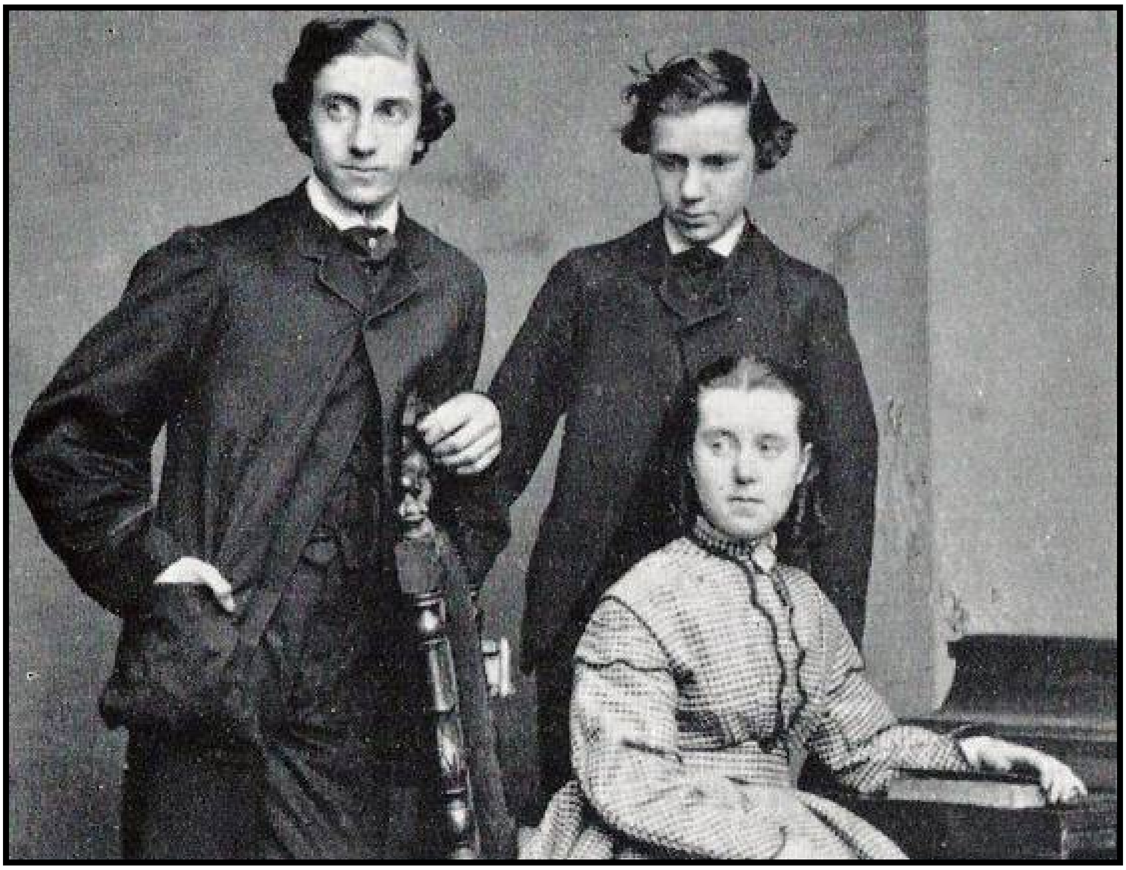
# JOHN HOPKINSON
# PIONEER ELECTRICAL ENGINEER

**by Brian Roberts, CIBSE Heritage Group**

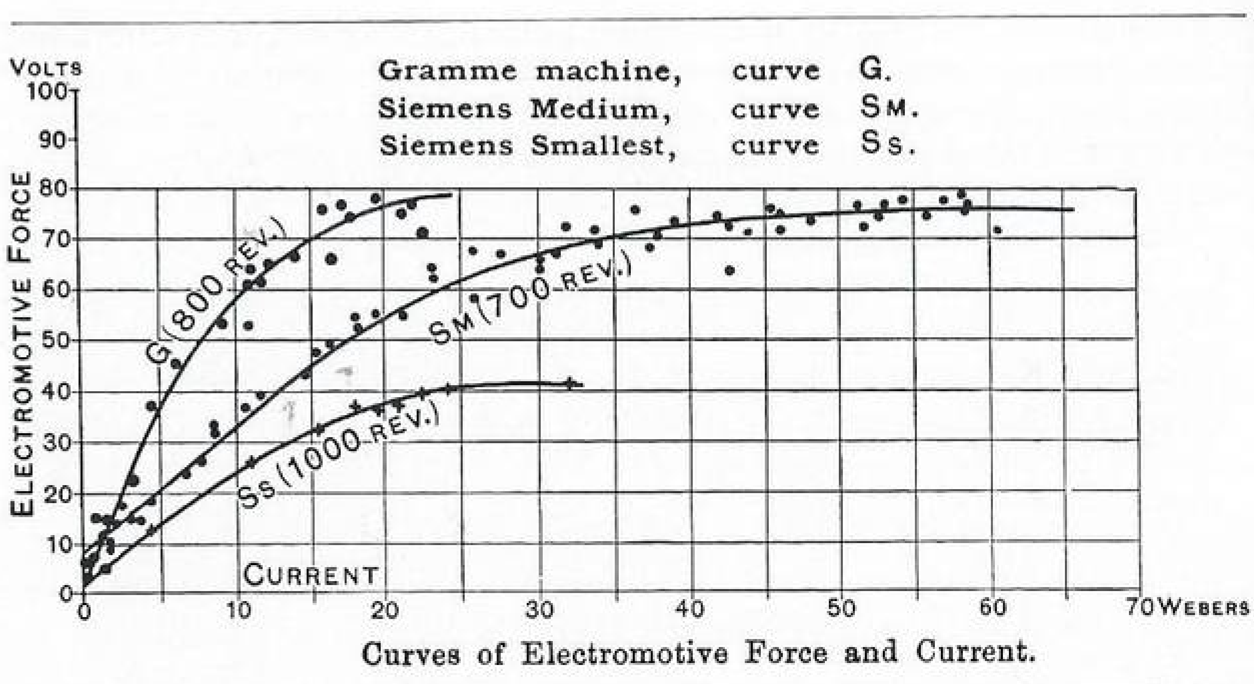
*Dr John Hopkinson 1849-1898*

John Hopkinson was born in Manchester on the 27th July 1849, the eldest son of Alderman John Hopkinson, a former Mayor of Manchester. He was educated at Lindow Grove School near Manchester and Queenwood College in Hampshire. In 1864 he went to Owens College in Manchester and distinguished himself in science and mathematics, going on in 1867 to Trinity College, Cambridge. He then graduated as Doctor of Science in pure and applied mathematics at the University of London. He was also one of the first Whitworth scholars.

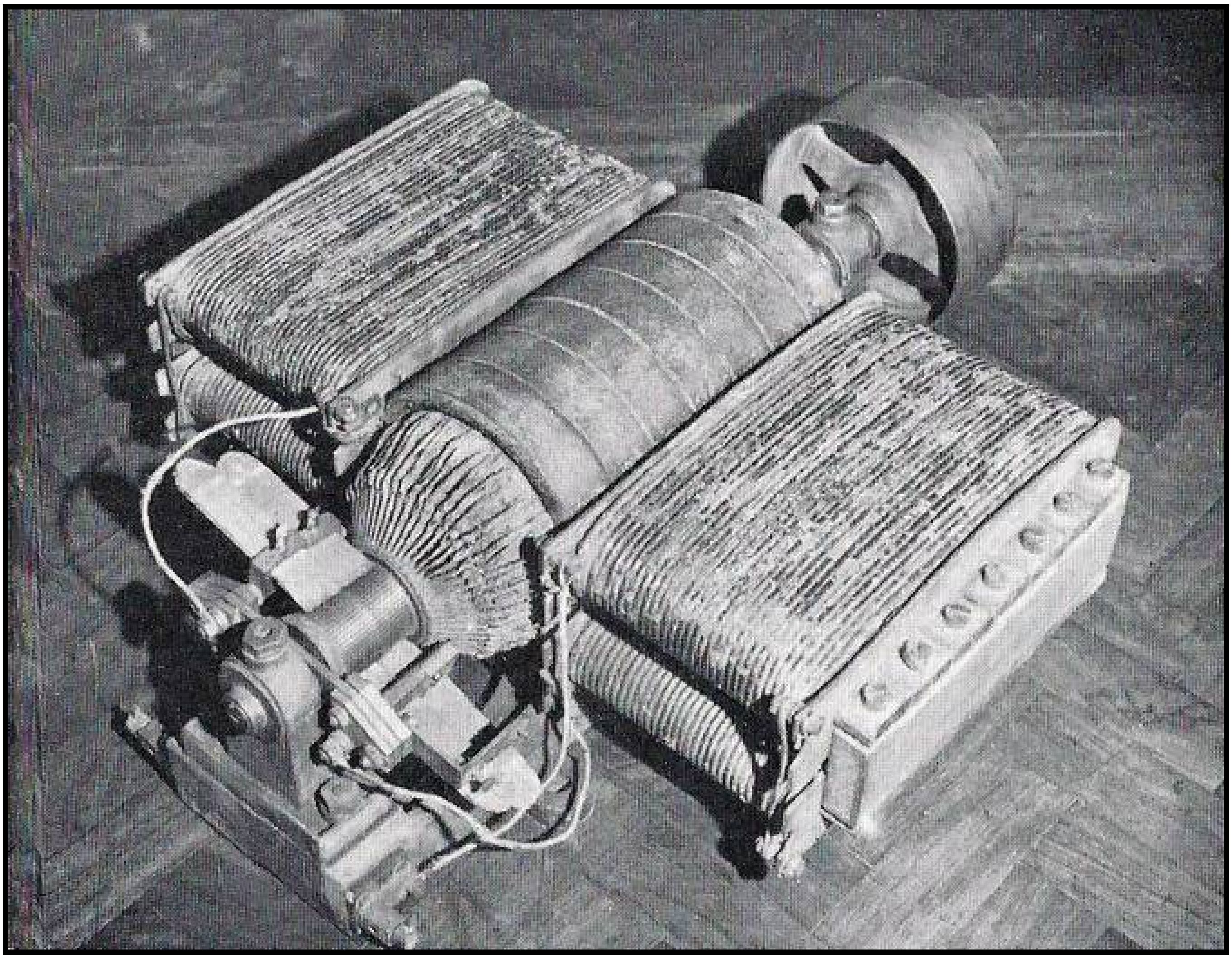


*John Hopkinson (left) with his brother Alfred and sister Ellen*

From 1872 to 1877 he worked for Chance Brothers as manager of their Lighthouse Department (see Appendix I). In March 1873 he married Evelyn Oldenbourg. In 1878 he moved to London and set up in practice as a Consulting Engineer. In 1879 he delivered his first paper *On Electric Lighting* to the Institution of Electrical Engineers. He also analysed the properties of dynamos by means of *characteristic* curves.

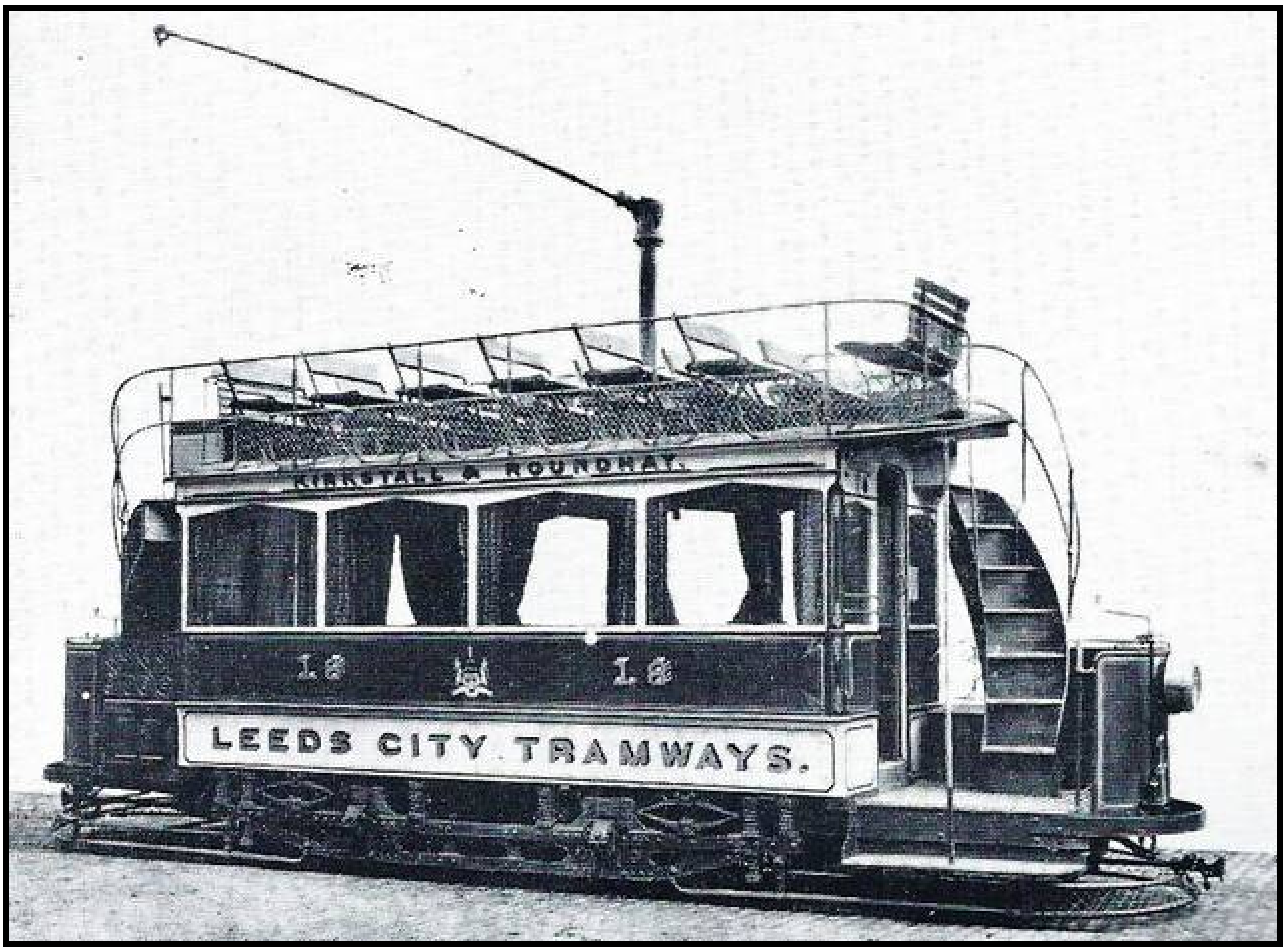


Curves of Electromotive Force and Current.

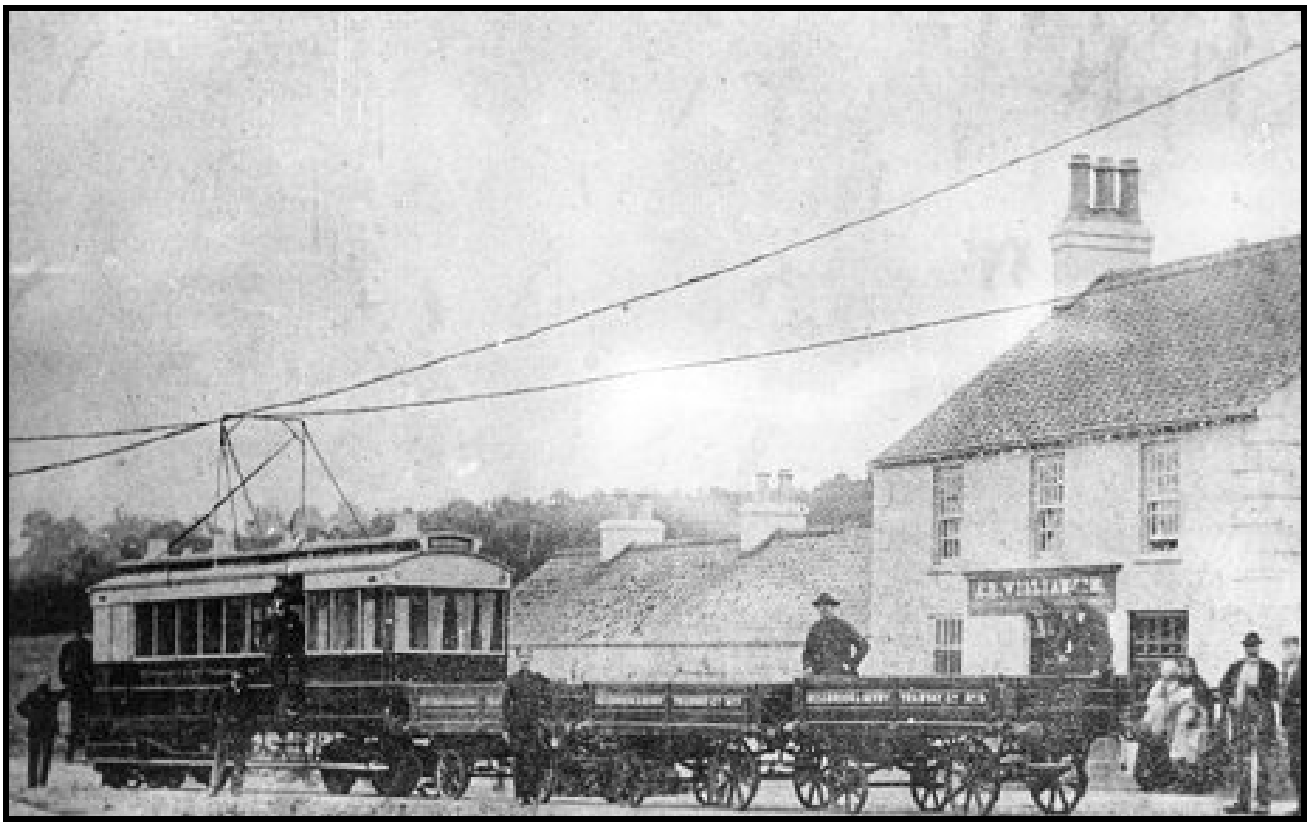


*Siemens Dynamo, possibly the machine used by Hopkinson in his paper "On Electric Lighting"*

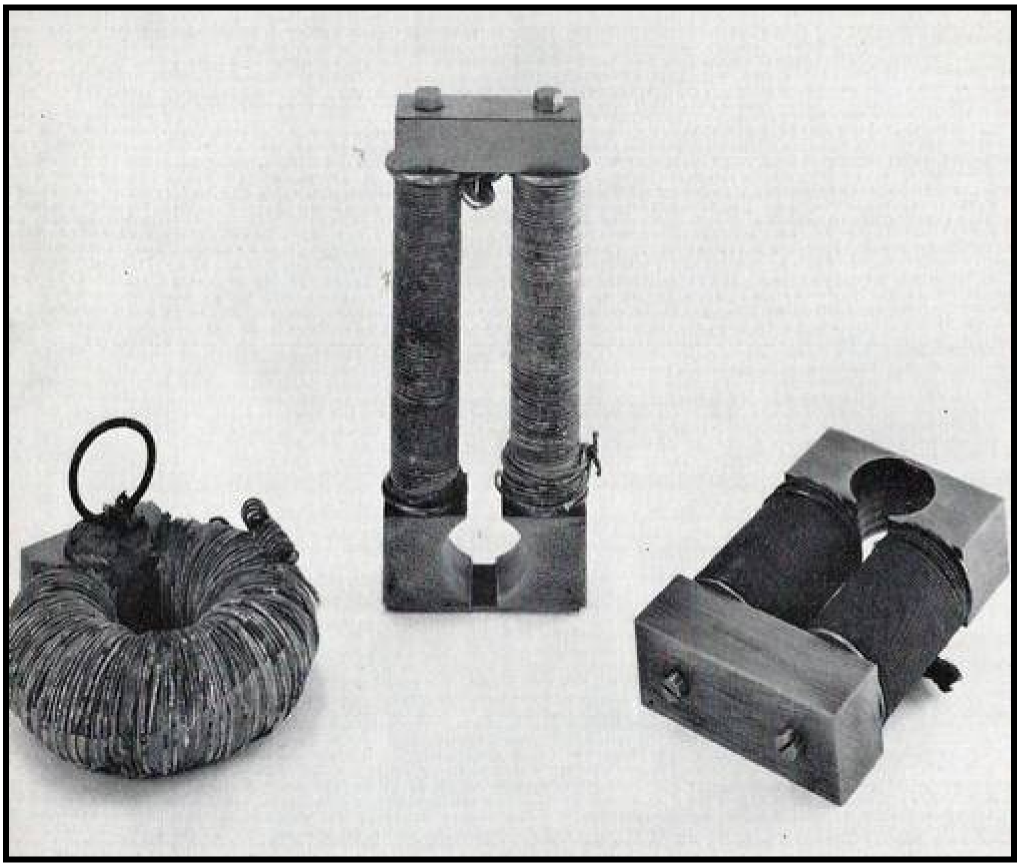
His father, John Hopkinson Senior (1824-1902), entered into business with his third son Charles Hopkinson (1854-1920). This was about 1880. The business was styled John Hopkinson & Son. After the father gave up work, Charles entered into partnership with his older brother, Dr John Hopkinson. Together they became responsible for many large electric tramways and lighting schemes, including the tramways serving Leeds and Newcastle and parts of Ireland.



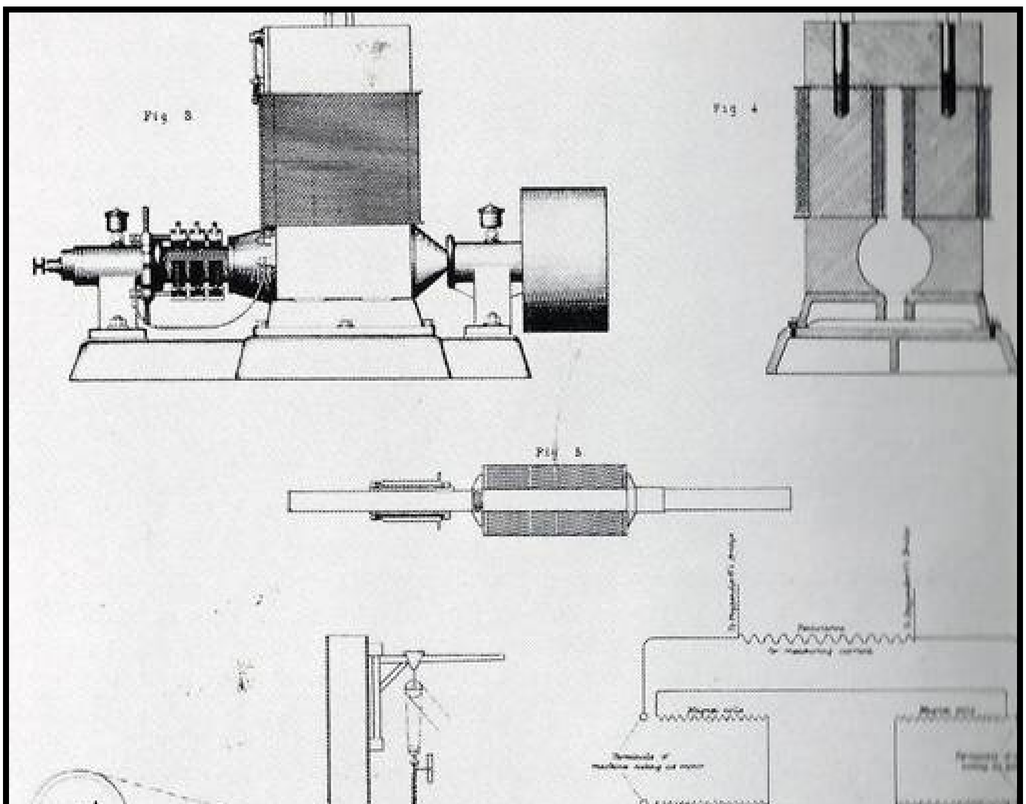

*Leeds Tramcar*



*Bessbrook & Newry Tramway in Ireland*

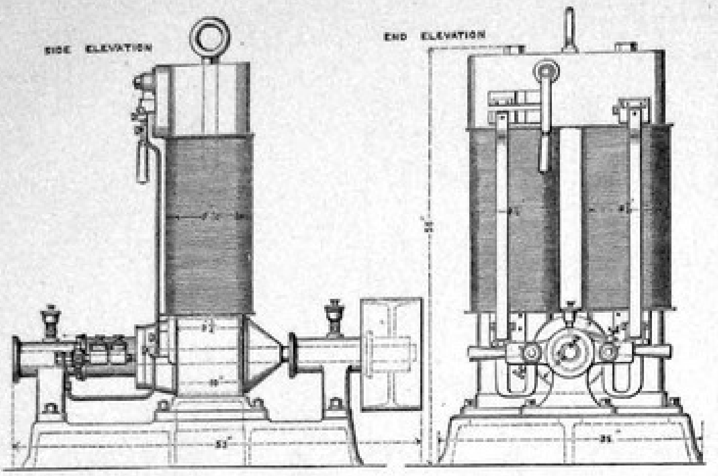


*Experimental dynamo field models used by Hopkinson in his redesign of Edison's machine*



*The Edison-Hopkinson machine of 1886 (Phil. Trans. Royal Society)*

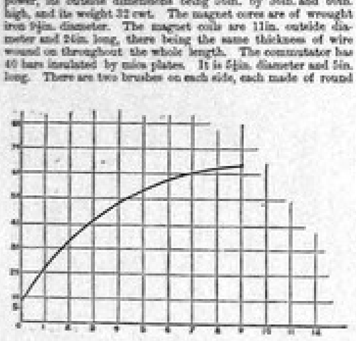
# THE EDISON-HOPKINSON DYNAMO.




In our issue of 23rd January we shortly described a test of an Edison-Hopkinson dynamo made at the works of Messrs. Mather and Platt, of Manchester. We now give full details of this specially interesting and severe test, along with drawings of the machine.

The dynamo subjected to test is designed for a load of 250 ampères, with 55 volts between the terminals, running at a speed of 900 revolutions per minute. This is equivalent to feeding 250 Swan lamps of 20-candle power. As seen below, during the test the speed varied from 920 to 927 revolutions, the current from 273 to 278, and the electro-motive force from 54·6 to 55·5, so that the test load was considerably in excess of the designed working load.

Fig. 1 shows a side and an end view of the machine with a section of the armature, and also the characteristic curve. The leading dimensions are marked on the drawing. The machine is compact; at least it occupies very little floor space for its power, its outside dimensions being 56in. by 36in. and 66in. high, and its weight 32 cwt. The magnet cores are of wrought iron 9½in. diameter. The magnet coils are 11in. outside diameter and 24in. long, there being the same thickness of wire wound on throughout the whole length. The commutator has 40 bars insulated by mica plates. It is 5½in. diameter and 5in. long. There are two brushes on each side, each made of round



wire laid in a pile about ⅜in. thick. The two pairs of brushes can be adjusted rotationally to minimise sparking independently of each other. After a three weeks' severe work they had worn less than ⅛in., and were showing no sparks at all, the commutator surface being perfectly smooth and ungrooved. This is effected by giving the shaft and all that it carries an oscillatory end motion. The collars are placed so as to give the desired amount of end play which is set up and maintained by the slightly irregular pull of the belt. The oscillation is regulated and steadied by a plate spring—not shown in the drawing—that presses on the end of the shaft with a force that can be regulated by a set screw. The commutator bearing is 8½in. long by 1½in. diameter, and that at the pulley end 9in. long, the shaft being 2in. These are oiled by drip lubricators, and keep remarkably cool during the long continuous run. As seen from the day-to-day record given below, the temperature of the pulley bearing varied from 26 deg. to 37 deg. Cent., and that of the commutator bearing was usually about 2 deg. Cent. higher. These temperatures went up and down with the temperature of the air in the room, a conclusive proof that the bearings worked well, their temperature being generally 10 deg. Cent. higher than that of the air. Curiously enough, the lowest bearing temperature was taken on the last day of the run.

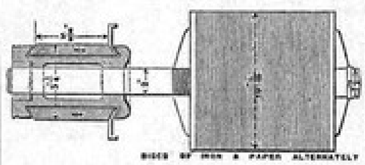
It is worth noticing that the pulley bearing was cooler than the other, in spite of its having a very much heavier pressure on it. This is due to the heating of the other bearing by conduction from the commutator, which of course rises to a much higher temperature in consequence of the rubbing of the brushes. The commutator temperature was from 70 deg. to 75 deg. Cent., while that of the brushes lay between 60 deg. and 70 deg. Cent. While we were present the lubrication was at the rate of forty drops of oil per minute to each journal.

The armature is what is called 10in. by 10in., its actual outside diameter being 10⅜in., and the pole pieces being bored to 10⅝in., thus leaving $\frac{1}{16}$in. side clearance. The armature core is built up of 28 b.w.g. iron plates insulated from each other by sheets of unprepared paper. There are 500 of these plates in the 10in. length, the 28 b.w.g. corresponding to ·014in. thickness. These plates, instead of being held by bolts piercing the plates from end to end, which method destroys good insulation, are clamped in place by two large stiff washers or loose collars on the shaft, one being screwed up on a screwed part of the shaft against the other. The shaft itself is well insulated from the plates. These plates are wound over with cotton-covered wire of about 16 b.w.g. to a depth of about ⅝in.

In a larger size of dynamo of the same type designed for 110 volts, to feed 500 Swan 20-candle power lamps, the magnets are of nearly rectangular sections, with large rounded corners, 11in. by 19½in., and 24in. long in the coiled part; the armature is 10in. diameter by 20in., and the commutator 5½in. diameter by 8in. long, with three brushes on each side and forty bars with mica insulation. The journals are 10½in. and 12in. long. Both of these have the magnets shunt wound, no advantage being found to accrue from compound winding owing to the low armature resistance. In the smaller machine used in the test, the magnet resistance is 7·54 ohms, and that of the armature is 0·009 ohm. The characteristic curve is given in Fig. 1, the horizontal scale giving the current through the magnets, and the vertical the electro-motive force between the terminals. It has been calculated by reducing to a speed of 900 revolutions per minute from the following measurements:—

| Speed. Revs. per min. | E.M.F. Volts at terminals. | Current. Ampères through magnets. | E.M.F. reduced to 900 revs. |
|---|---|---|---|
| 906 | 64·2 | 9·04 | 63·7 |
| 786 | 54·1 | 7·62 | 61·9 |
| 740 | 43·3 | 6·8 | 58·7 |
| 556 | 31·2 | 4·99 | 50·5 |

In the test, lamps were not employed as external resistance. For these were substituted boxes of strip iron with large surface,




giving free access to the atmosphere, so that the temperature and resistance kept nearly constant, this resistance being almost exactly 2 ohms.

From the measurements the following have been calculated:—

| | Watts. | H.P. | Percentage. |
|---|---|---|---|
| Total electrical horse-power developed | 16,250 | 21·78 | 100 |
| " loss in magnets | 400 | 0·54 | 2·4 |
| " " armature | 720 | 0·96 | 4·5 |
| Useful power in external circuit | 15,130 | 20·28 | 93·1 |

The mechanical horse-power delivered by the belt was also measured by a Siemens belt dynamometer. As between the belt horse-power and the total electrical horse-power, the efficiency was found to be about 93 per cent. As between the belt power and the useful electrical power, the efficiency would, therefore, be about 86 or 87 per cent.

Throughout the test a continuous indication of the electro-motive force between terminals was given by a Thomson graded potential galvanometer, and the current was also read at intervals of one hour day and night by means of a Thomson graded current galvanometer. The bearing temperatures were taken by thermometers placed in mercury cups. The speed of the engine was continuously indicated by a tachometer, whose readings were checked from time to time by taking the dynamo speed by a revolution counter direct.

The first test was on December 30th, readings being taken at five, twelve, and twenty-four hours from the beginning of the run. The readings were:—

| Temperature Cent. | Room. | Pulley bearing. | Commutator bearing. | Magnets. | Armature. | Commutator. |
|---|---|---|---|---|---|---|
| After 5 hours' run | 17 | 35 | 36 | 33 | 76 | 70 |
| After 12 hours' run | 20 | 35 | 34 | 33 | 84 | 75 |
| After 24 hours' run | 15 | 30 | 29 | 33 | 78 | 74 |

The machine was then run continuously until January 6th, stopping only ten minutes each day to read the temperatures of the armature and commutator, and during Sunday. On January 6th the armature was taken out, examined by Mr. Blackburn, and found uninjured in any respect. The armature being replaced, a fourteen days' continuous run absolutely without break was commenced. At the end of this run the armature was still found uninjured in any way, either by swelling, charring, or breaking in the insulation of the plates. The conditions of this test were specified by Messrs. Albright and Blackburn for the Edison and Swan Company, and it was supervised and constantly watched by them and their representative, Mr. Creagh. Most of the readings were taken hourly. The following is a résumé of the record, consisting of the readings taken at the end of each day, and of the temperatures of armature and commutator at the end of the fourteen days' run. These latter were taken immediately on stopping, and again half an hour after stopping. They could not be taken, of course, during the run; and, of course, these temperatures could not be read for perhaps a couple of minutes after the instant of stopping. During this short lapse a certain amount of cooling, of course, took place, but seeing that the rate of cooling was only 9 deg. in the case of the armature and 6 deg. in that of the commutator in the course of half an hour, it is evident that the temperatures while running could not be more than a fraction of a degree above those recorded. During the last day of the test, however, the room was specially cool, and the bearings 10 deg. lower than their previous maximum. Therefore it is fair to infer that the armature temperature on, say, the 10th of January must have been nearly 100 deg. Cent.

| Date. | Speed. | Ampères in external circuit. | Volts at terminals. | Temperature of room. | Temperature between magnets. | Temperature of bearings: Pulley. | Temperature of bearings: Commutator. |
|---|---|---|---|---|---|---|---|
| | | | | deg. C. | deg. C. | deg. C. | deg. C. |
| January 6 | 920 | 273 | 55·5 | 20 | 55 | 31 | 33 |
| " 7 | 920 | 276 | 54·9 | 21 | 55 | 34 | 34 |
| " 8 | 925 | 278 | 54·9 | 22 | 55 | 32 | 32 |
| " 9 | 927 | 275 | 54·7 | 22 | 54 | 32 | 33 |
| " 10 | 926 | 278 | 54·9 | 22 | 56 | 37 | 35 |
| " 11 | 926 | 275 | 54·6 | 19 | 55 | 32 | 34 |
| " 12 | 921 | 276 | 54·6 | 20 | 53 | 30 | 32 |
| " 13 | 926 | 275 | 54·9 | 19 | 51 | 29 | 31 |
| " 14 | 921 | 275 | 54·6 | 18 | 52 | 28 | 32 |
| " 15 | 924 | 275 | 54·6 | 17 | 50 | 30 | 32 |
| " 16 | 125 | 276 | 54·6 | 22 | 53 | 32 | 32 |
| " 17 | 922 | 275 | 54·6 | 21 | 51 | 31 | 32 |
| " 18 | 922 | 275 | 54·6 | 21 | 50 | 29 | 31 |
| " 19 | 921 | 275 | 54·6 | 20 | 49 | 30 | 32 |
| " 20 | 923 | 275 | 54·9 | 18 | 50 | 26 | 32 |

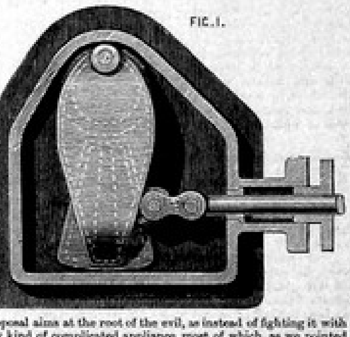
The final readings were:
Armature, at the end of the run, 90 deg.; commutator, 79 deg.
" half an hour after stopping, 81 deg.; " 73 deg.

NOTE.—The temperature under the heading magnets is that of the thermometer hanging over the armature between the two magnet limbs, about 1in. from the coil.

## PECK'S RELIEVED SLIDE VALVE.

In illustration of our remarks in our leading article of February 6th on this subject, we publish to-day three views of a new relieved slide valve designed by Mr. Ed. C. Peck, of Old Charlton, having for its main object the reduction of friction, but possessing besides this other peculiarities. Mr. Peck's

FIG. 1.



proposal aims at the root of the evil, as instead of fighting it with any kind of complicated appliance, most of which, as we pointed out, are open to break down as well as increasing the moving weight; he avoids it by removing the exhaust opening out of the line of motion and allowing the valve to partly rotate on a pivot pin placed in a position nearly or quite coinciding with the centre of the exhaust orifice. This pin is placed preferably

FIG. 2.

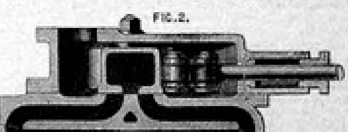
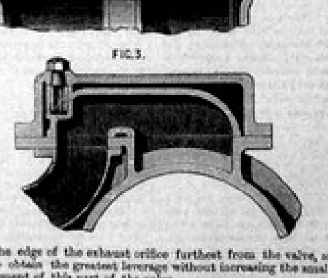


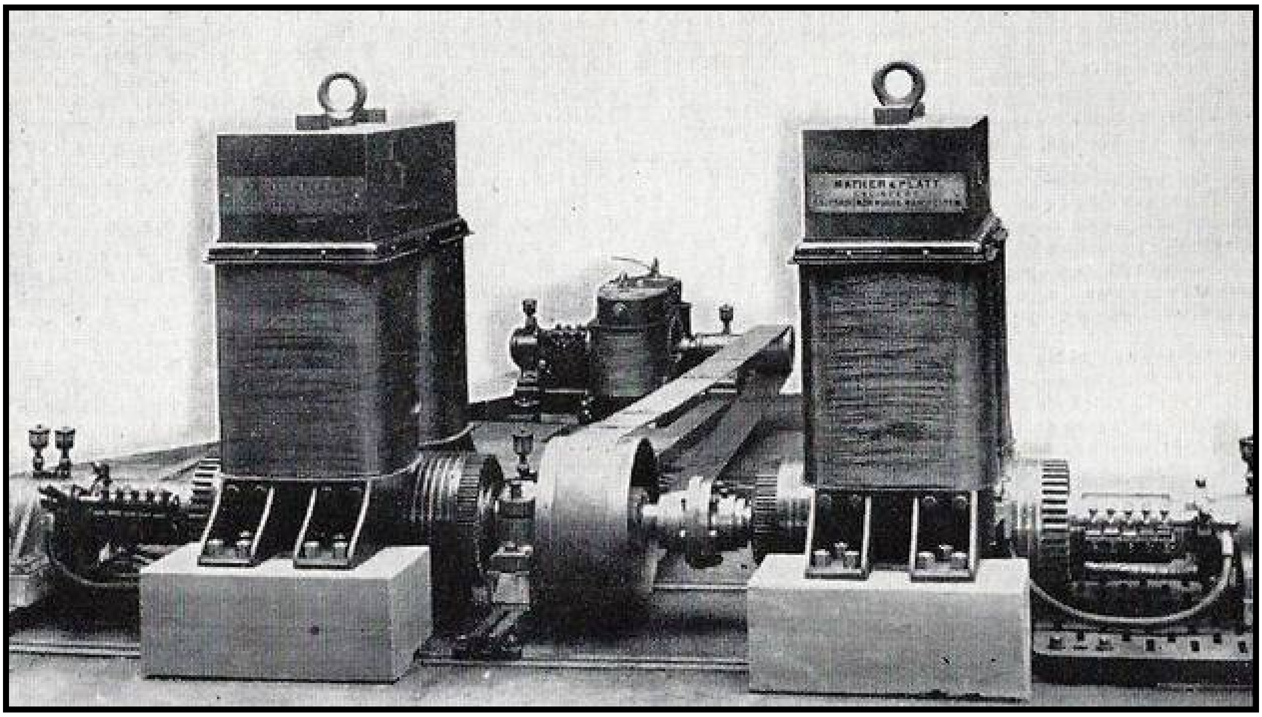
FIG. 3.



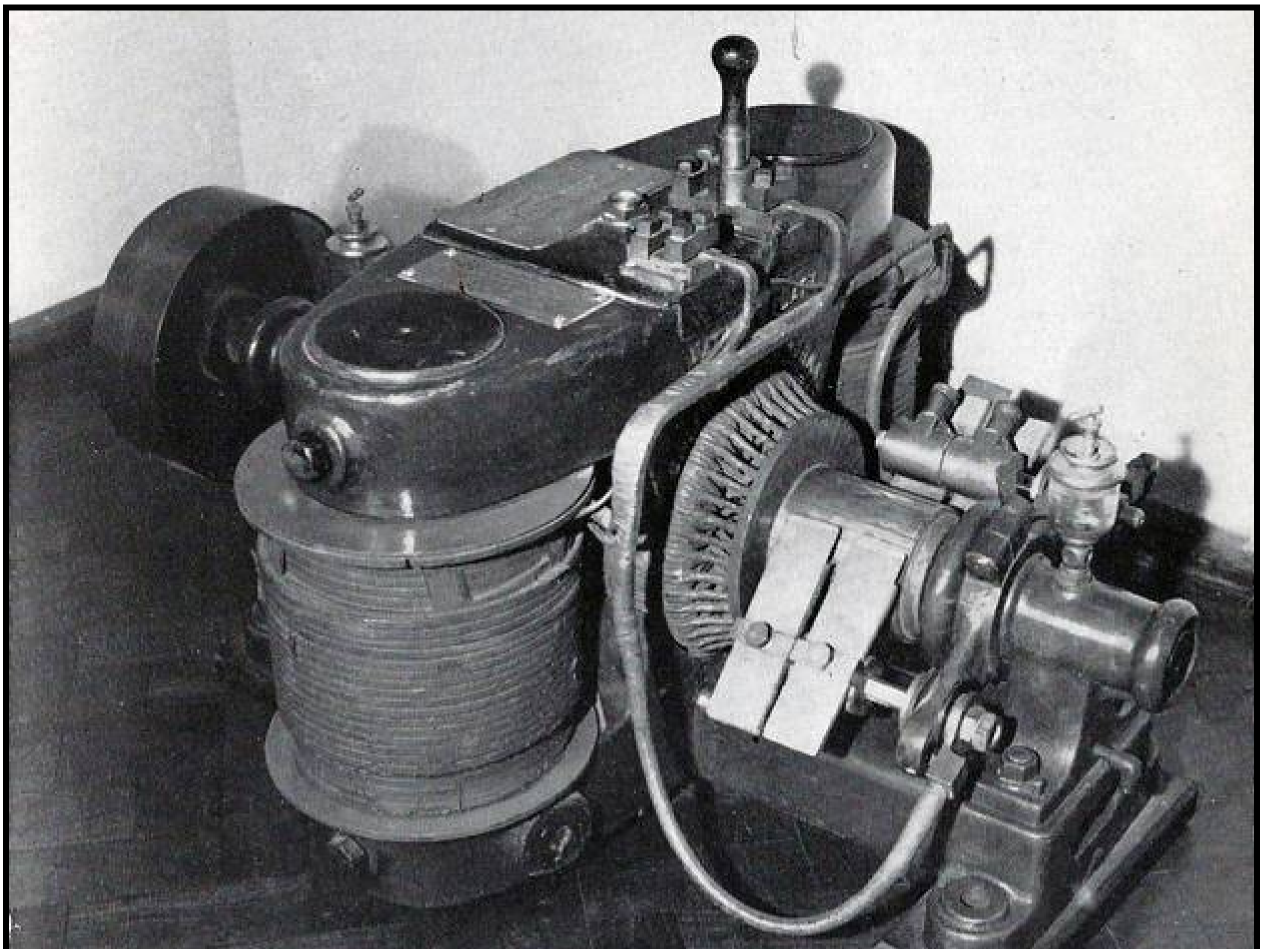
on the edge of the exhaust orifice furthest from the valve, so as to obtain the greatest leverage without increasing the small movement of this part of the valve.

The valve, as may be clearly seen, consists of a simple casting with one face, and the exhaust steam is removed from contact with the cylinder barrel, while the valve face is brought close up to the cylinder and the

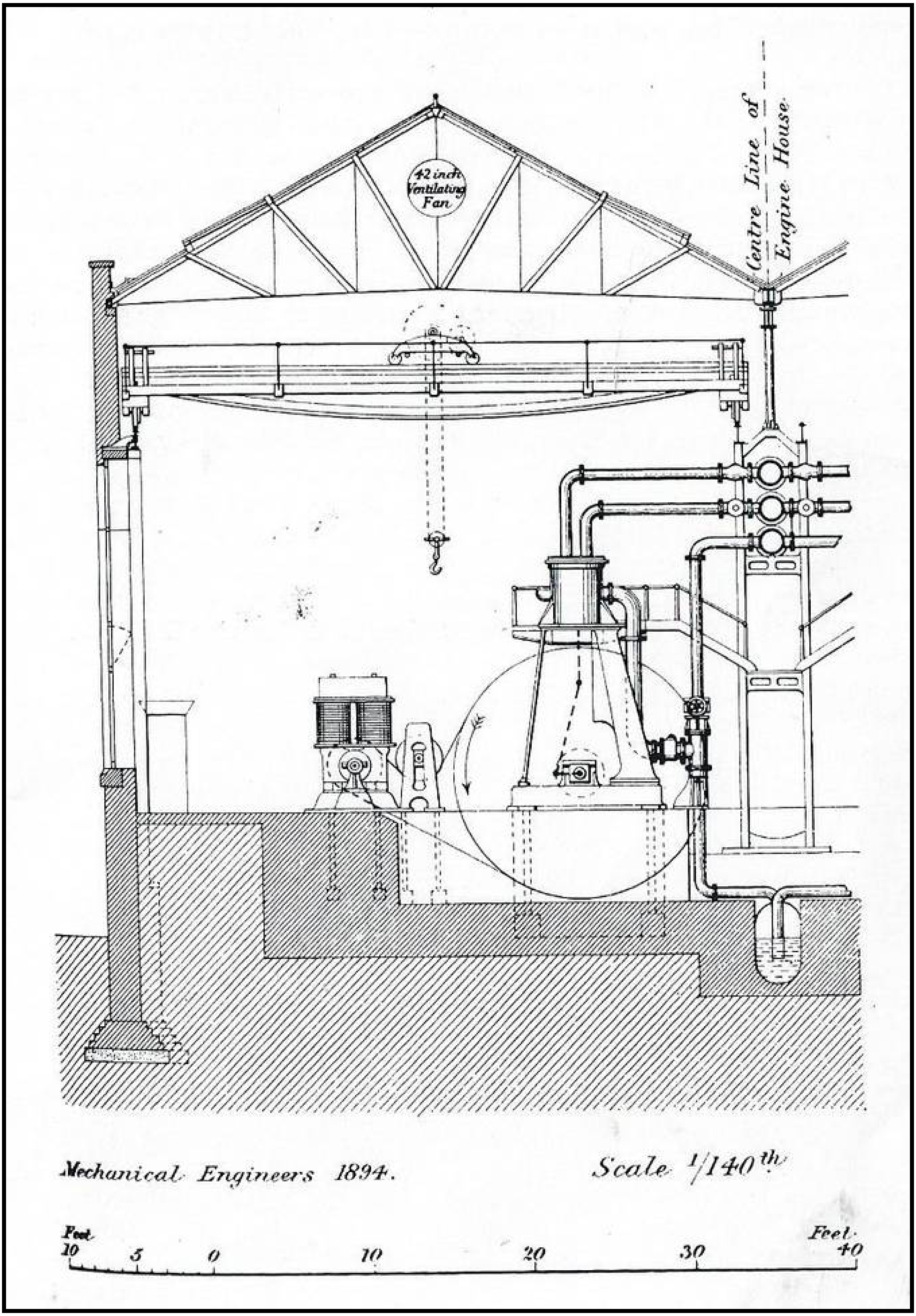
*The Edison-Hopkinson Dynamo from **The Engineer**, 27th February 1885*



*Two Edison-Hopkinson machines on test*



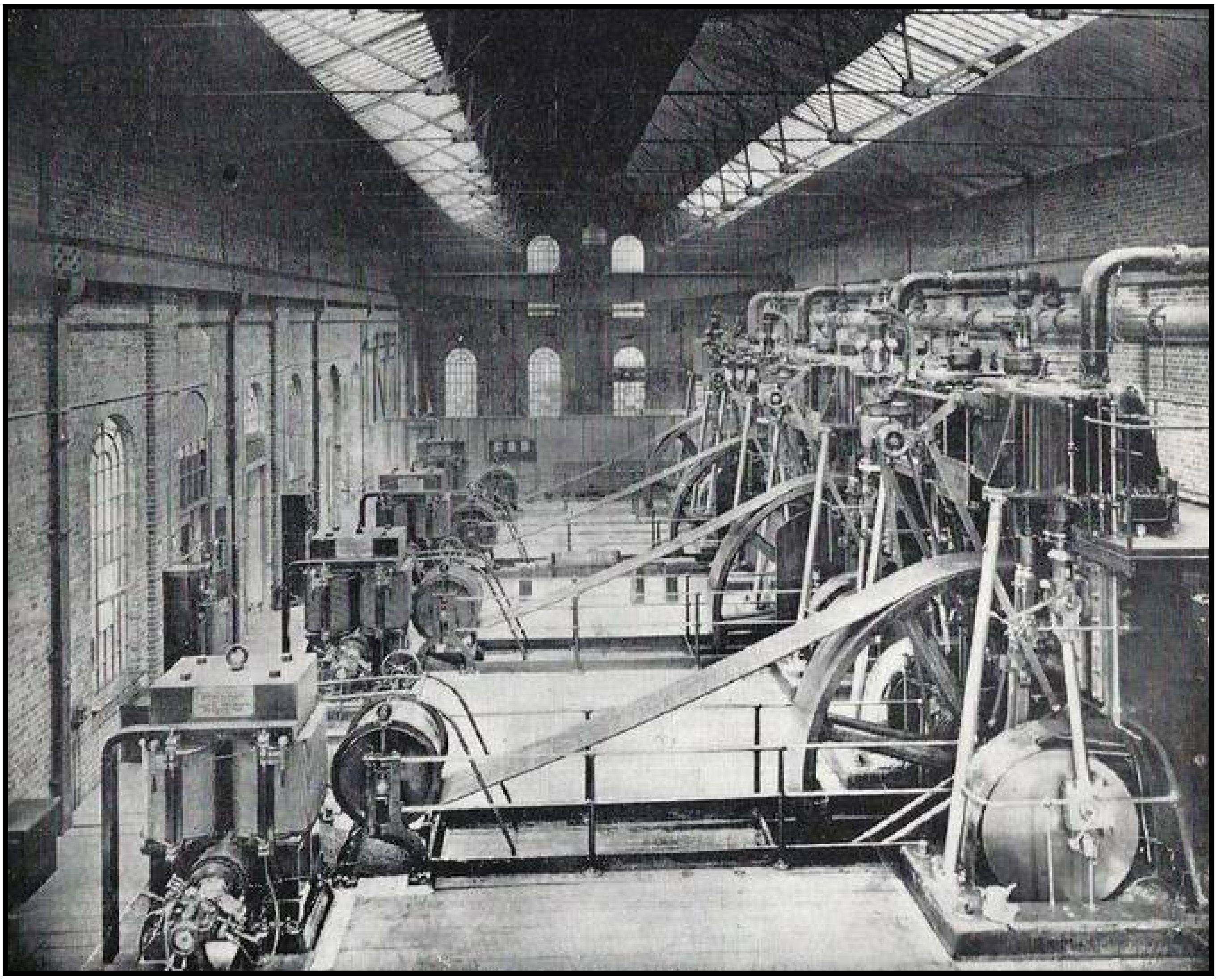
*Manchester Dynamo (Compound wound, 105 V, 130 A at 1050 rpm)*




*Engine House of the Manchester Electric Lighting Works at Dickinson Street, opened 1893*

In July 1894, at the Institution of Mechanical Engineers, Hopkinson described the direct current installation at the Manchester Electric Lighting Works which has been reported by James Greig in his Science Museum booklet.

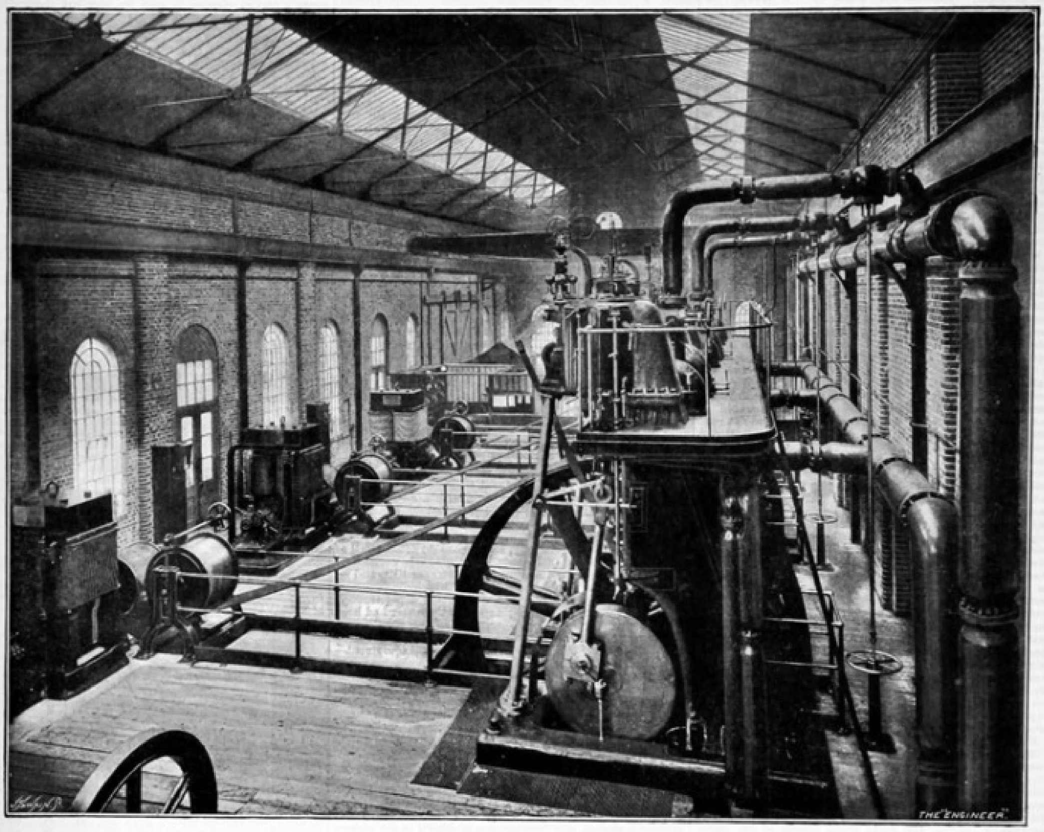
“The initial installation comprised four main bipolar generators producing 600 amperes at 400 volts. Distribution was by five parallel conductors, middle conductor earthed providing four 100-volt circuits, balance being maintained by four small 100-volt machines…..(a modification of Hopkinson’s three-wire system). Connected to the mains were 18,000 incandescent lamps of 16 candle power, together with 250 arc lamps and motors totalling 16 horse power.”



*The City of London Railway generating station at Stockwell in 1899 (opened in 1890)*

THE CITY AND SOUTH LONDON ELECTRIC RAILWAY.

VIEW OF INTERIOR OF GENERATING STATION.

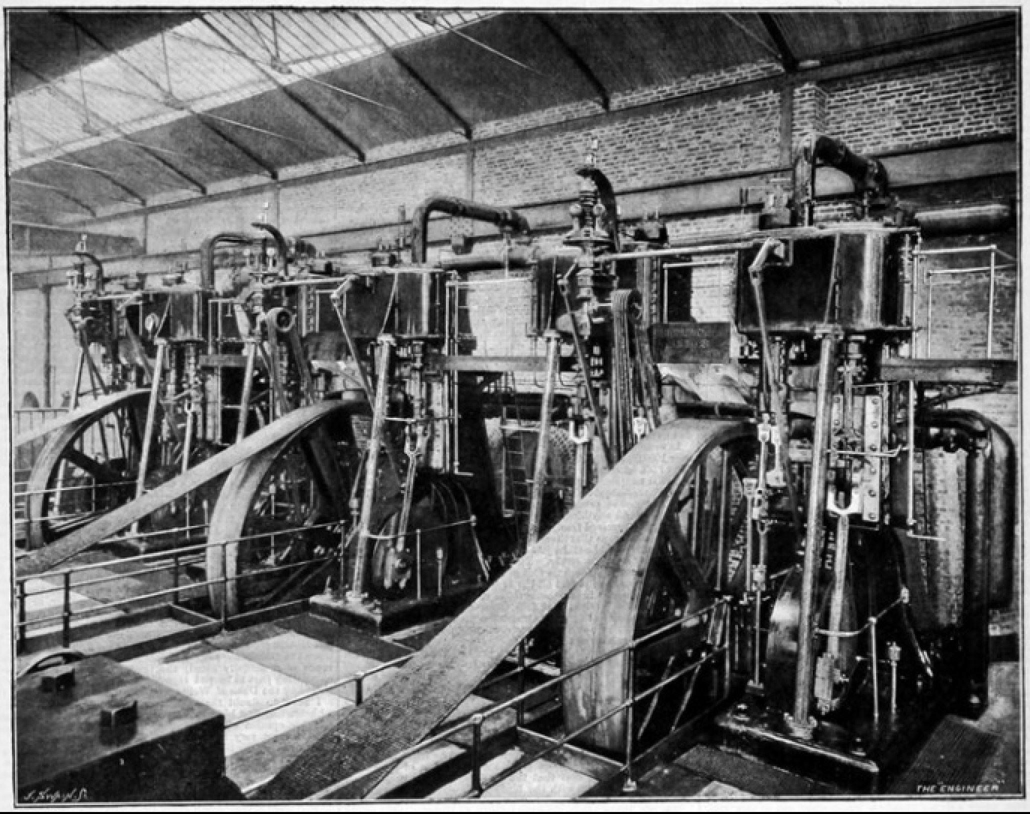



*1891*

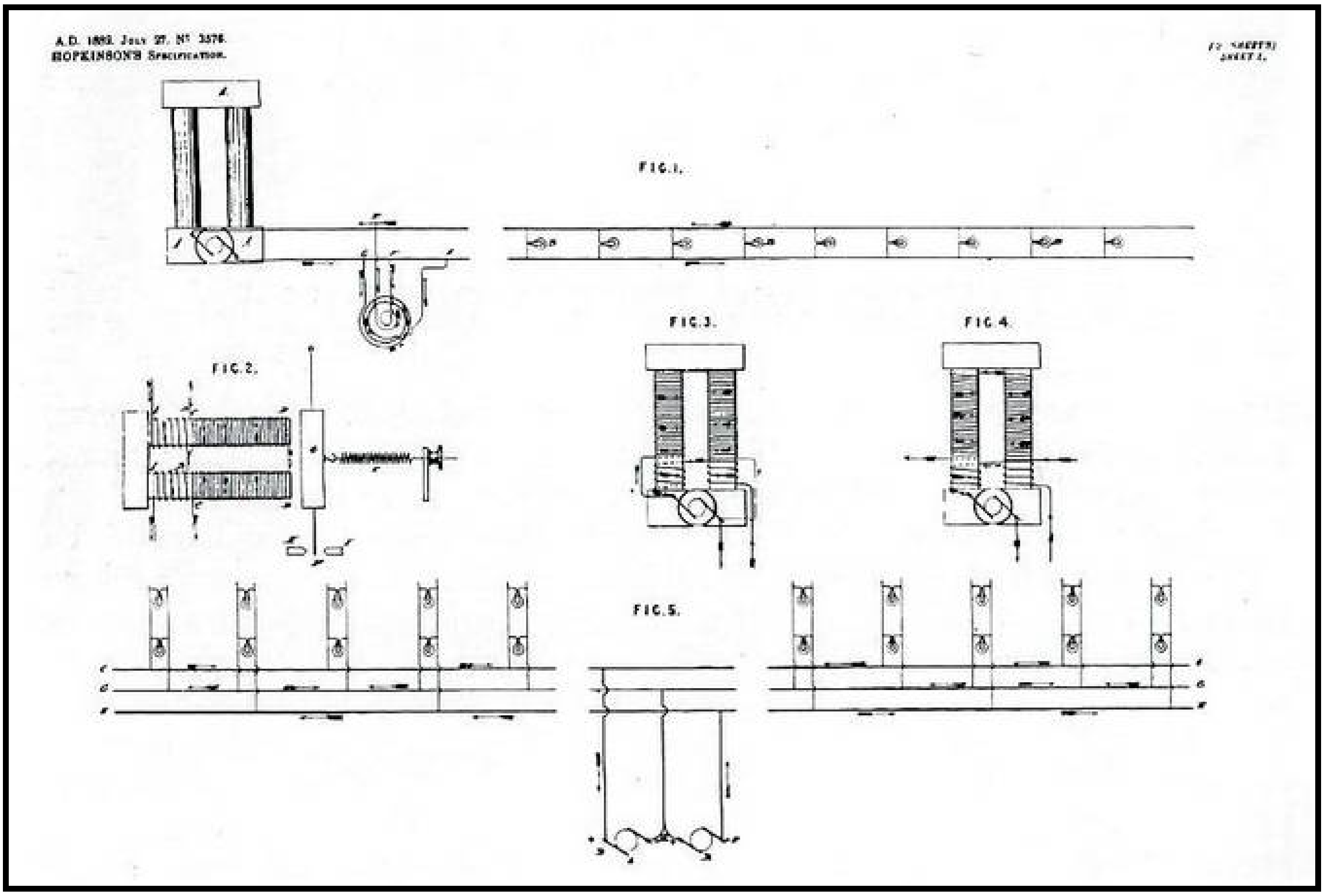
VERTICAL COMPOUND ENGINES, CITY AND SOUTH LONDON RAILWAY.

MESSRS. JOHN FOWLER AND CO., LEEDS, ENGINEERS.

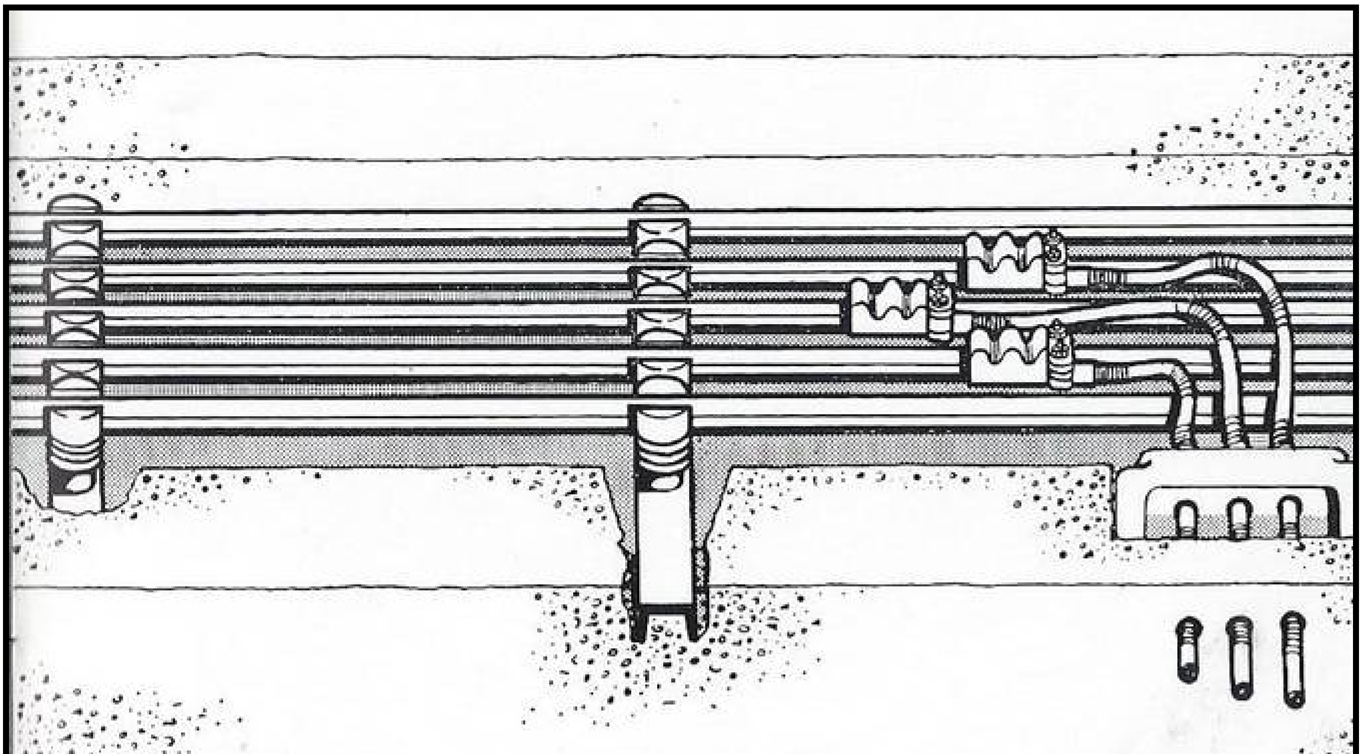
(*For description see page 182.*)




*1891*




*Drawing from Hopkinson's "3-wire" electricity distribution system, Patent 3576:1882*



*Hopkinson's "five wire" electricity distribution system*

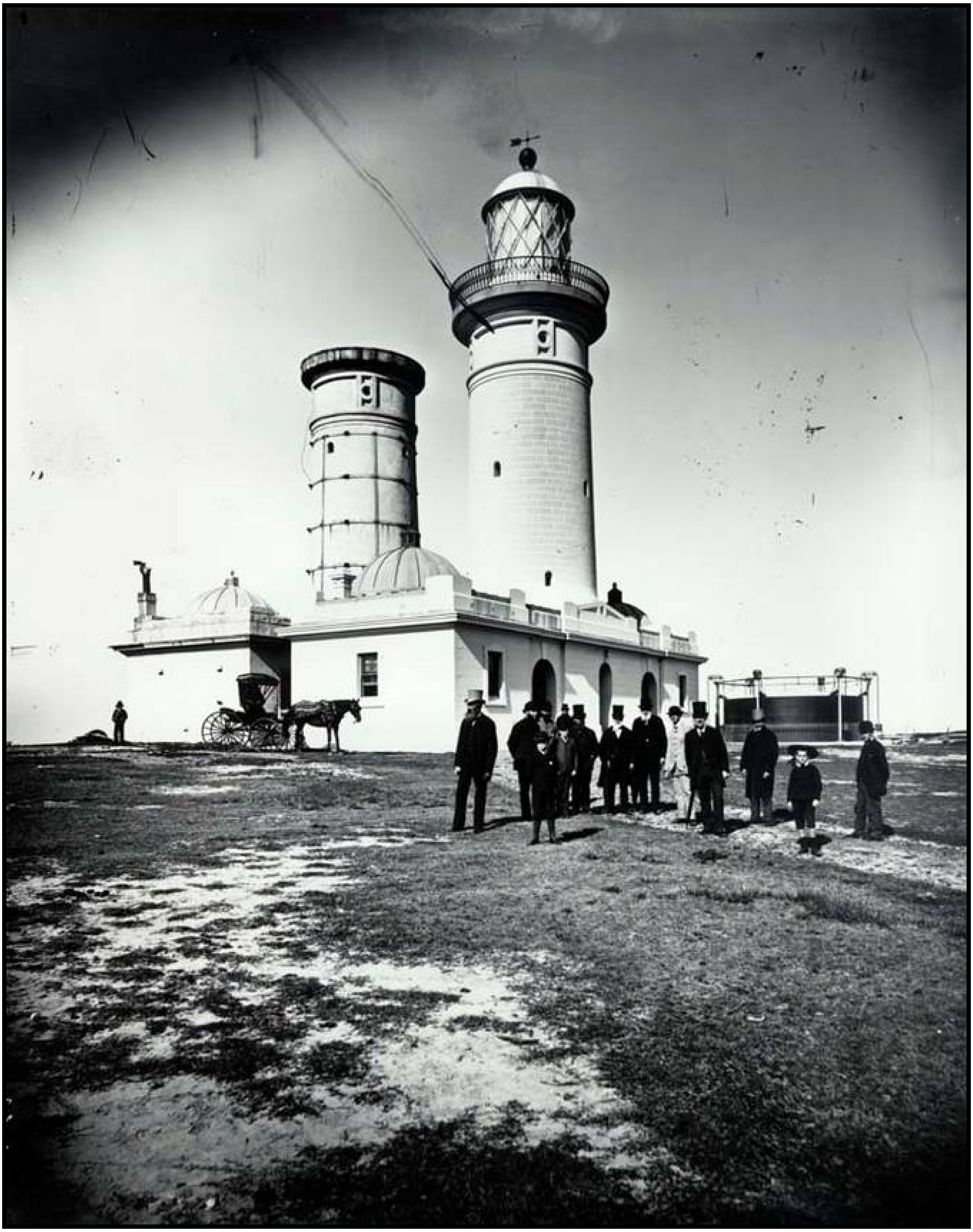
*John Hopkinson (seated 2nd left) with Senior Students at King's College London, April 1894*

## APPENDIX I: JOHN HOPKINSON and LIGHTHOUSES

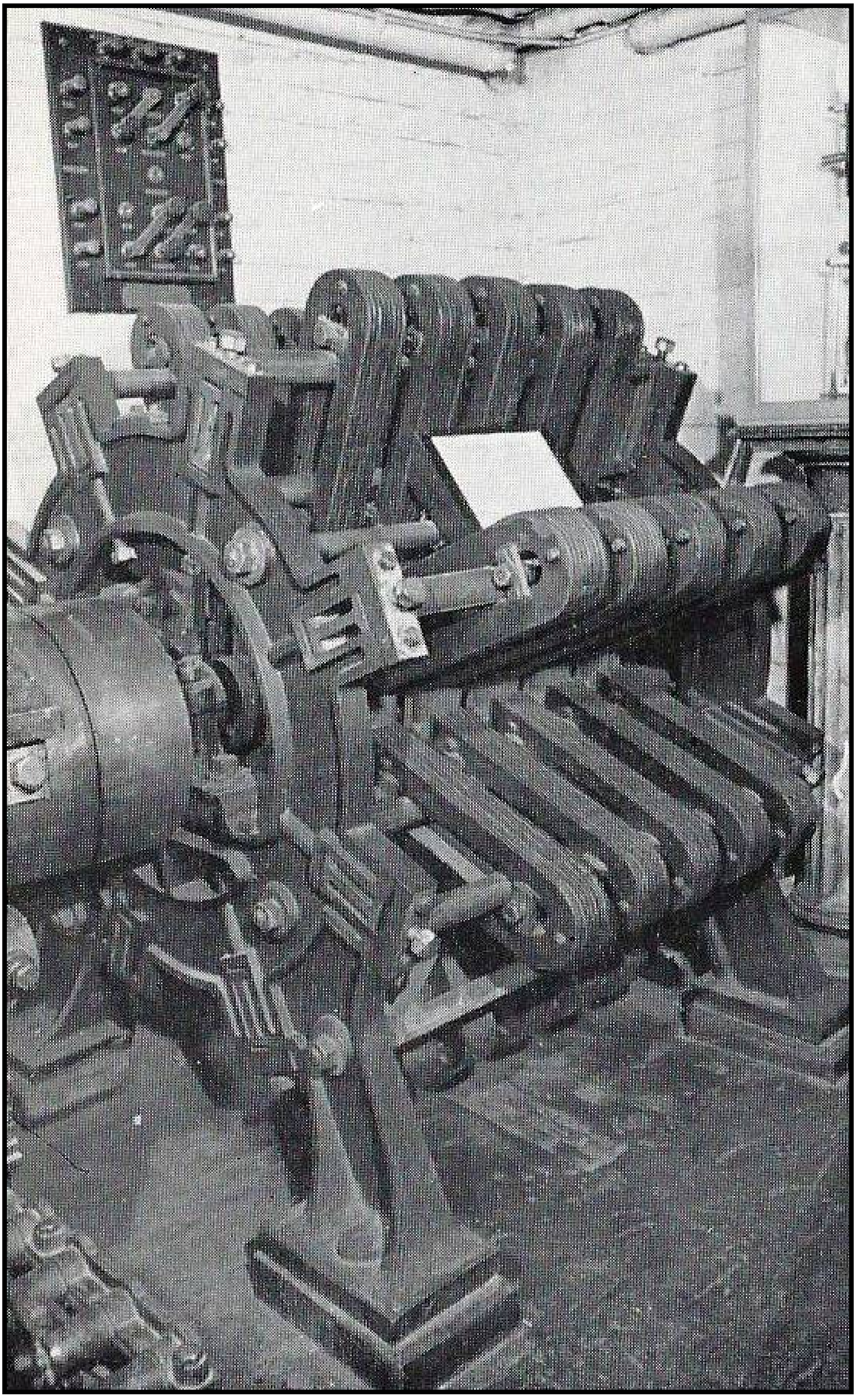
In 1872, Hopkinson became Manager and Engineer to the Lighthouse & Optical Departments in the glass works of Chance Brothers near Birmingham (the firm that supplied the panes of glass for the Crystal Palace). During the five years he spent with Chance he became an expert in the design of lighthouse optical equipment and devised improvements in catoptric and dioptric lens for concentrating and directing the beam. He also developed the system (first suggested by Lord Kelvin) of distinguishing one light from another by flashes following at different intervals and in 1874 he published *Group Flashing Lights.* This work led to Hopkinson developing an interest in electrical theory, in electrical machines and in lighting

**THE MACQUARIE LIGHTHOUSE, AUSTRALIA**

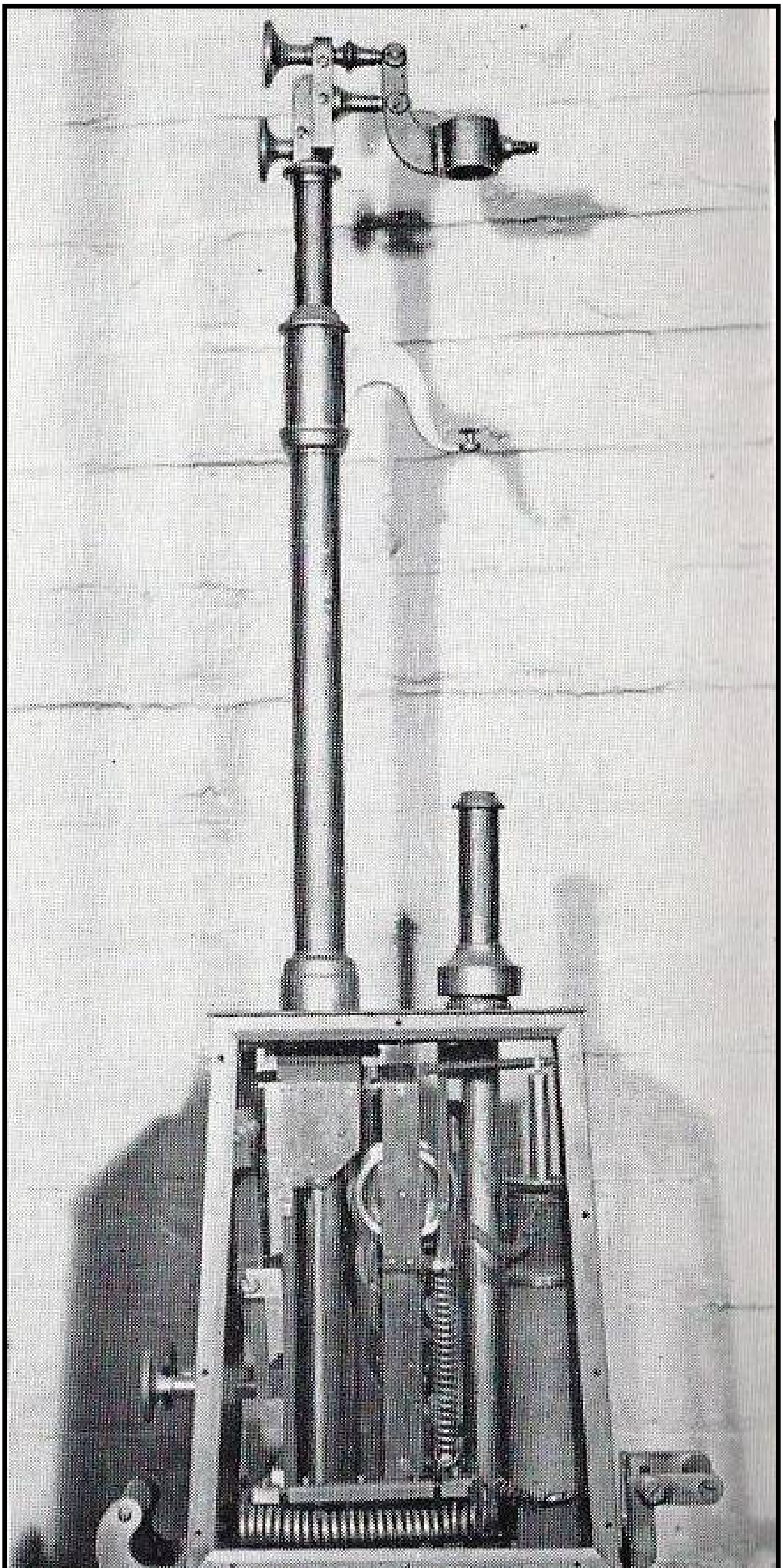
Situated near the entrance to Sydney Harbour the original lighthouse dates from 1818. Its replacement was completed in 1883. Hopkinson's Paper *The Electric Lighthouses of Macquarie and Tino* (Proc. ICE) was given in 1887.



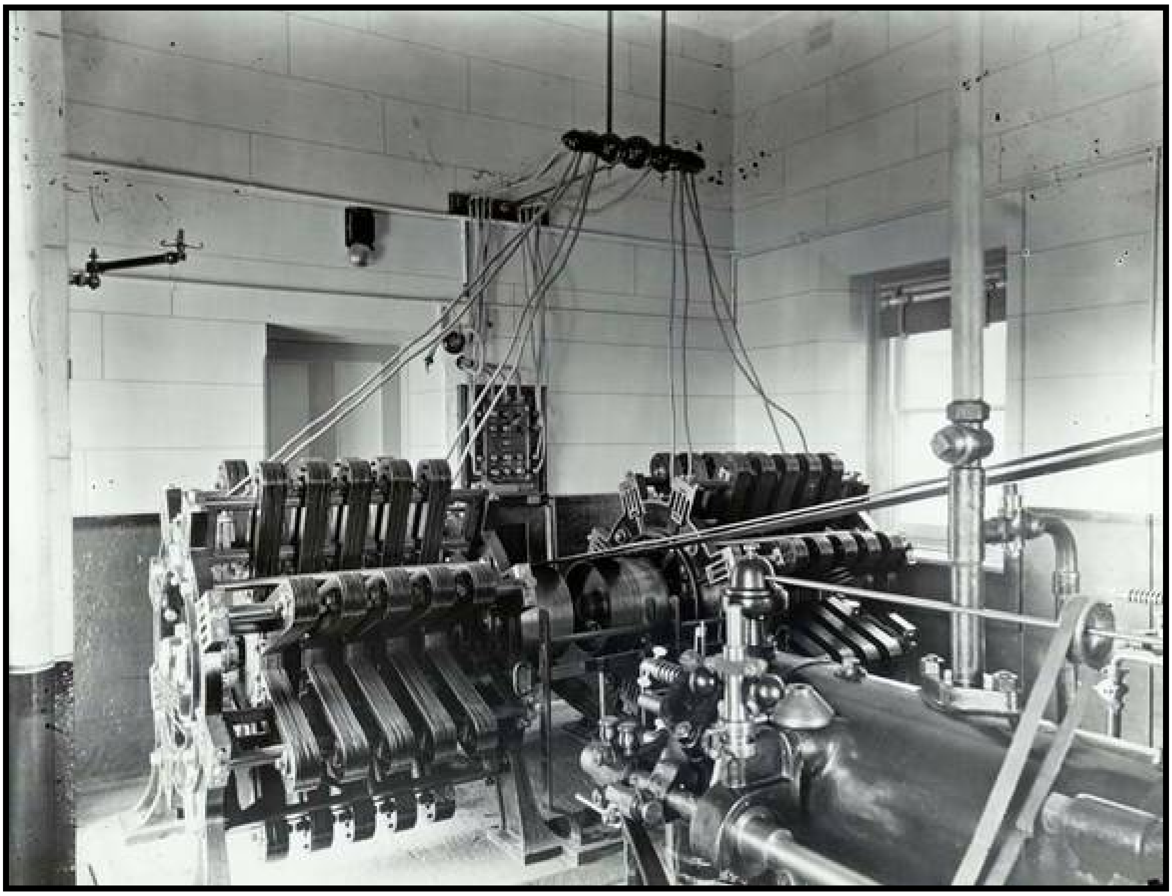
*The original Macquarie Lighthouse and its replacement (right)*



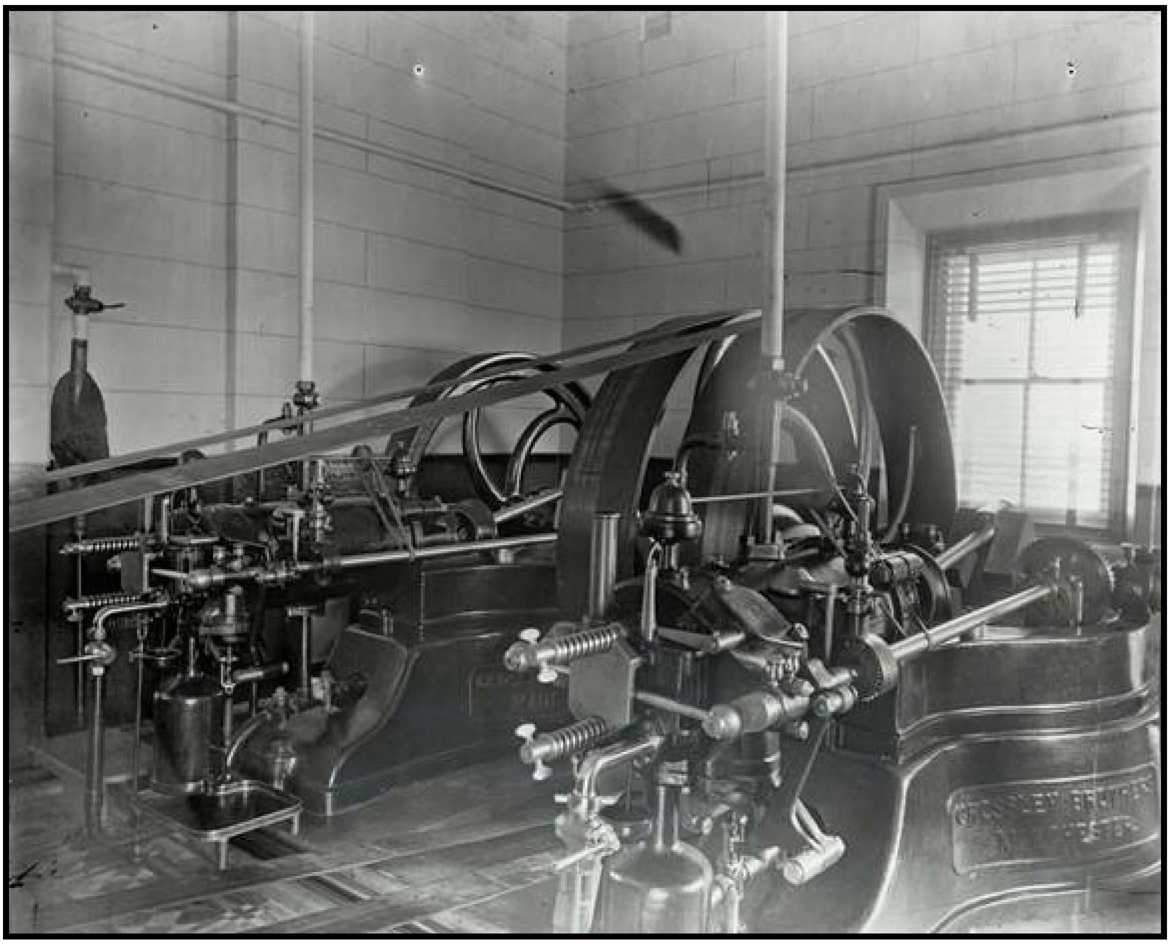
*The De Meritens Alternator installed at the Macquarie lighthouse*



*The Arc Mechanism of the Macquarie light*



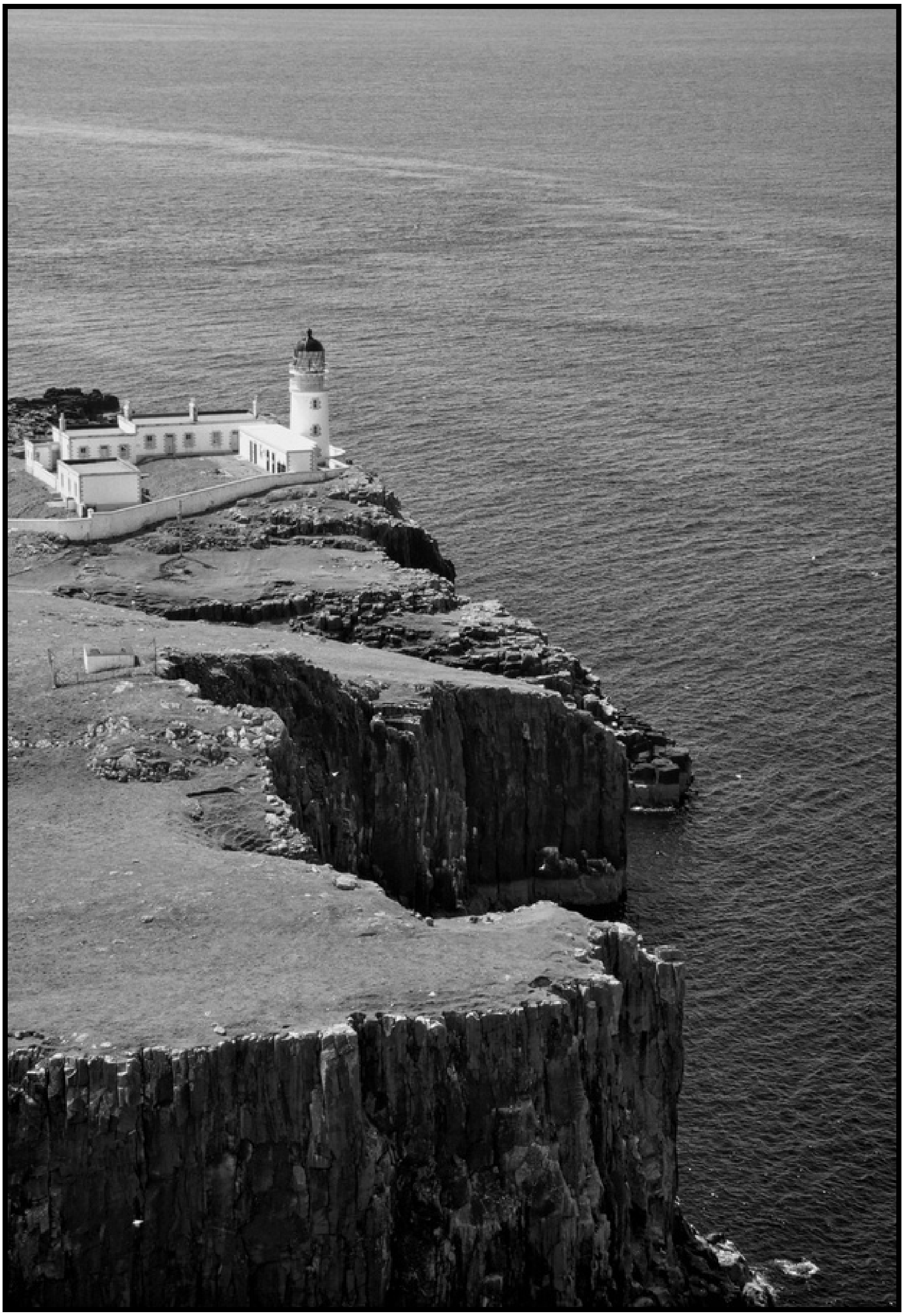
*The De Meritens Generators at the Macquarie Lighthouse Engine Room*



*The Crosley Coal Gas Engine in the Macquarie Lighthouse*

**THE TINO LIGHTHOUSE, ITALY**

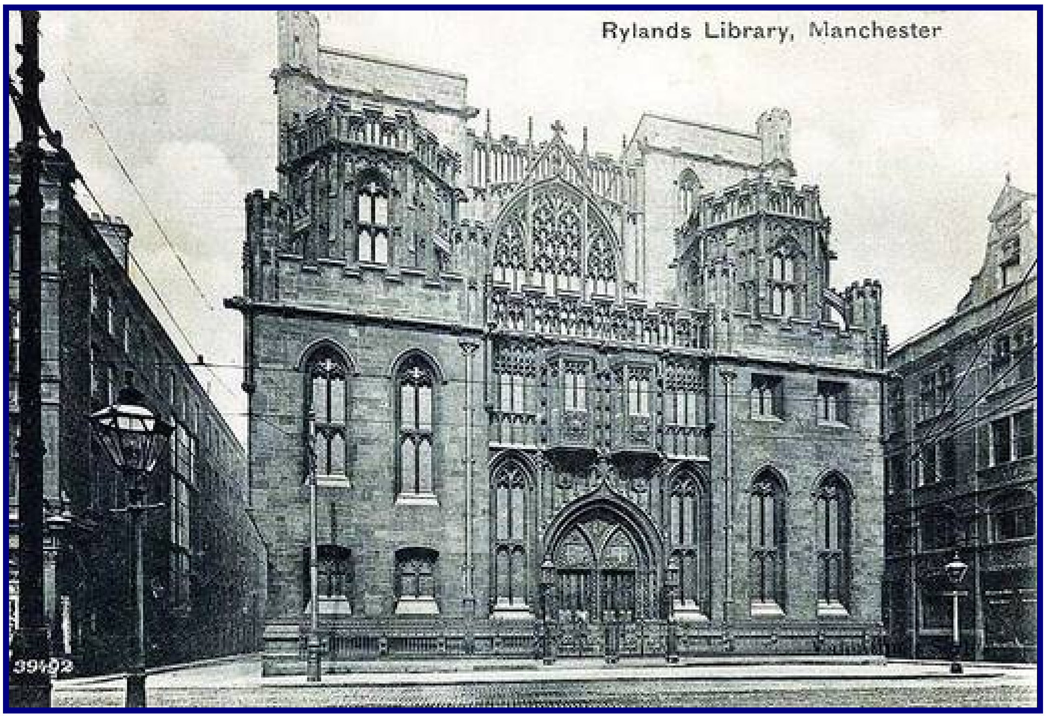
Located on Tino Island in the Gulf of Spezia in Liguria, Italy, the lighthouse of 1840 was replaced in 1884 by an electric light powered from two steam engines. Hopkinson's Paper *The Electric Lighthouses of Macquarie and Tino* (Proc. ICE) was given in 1887.

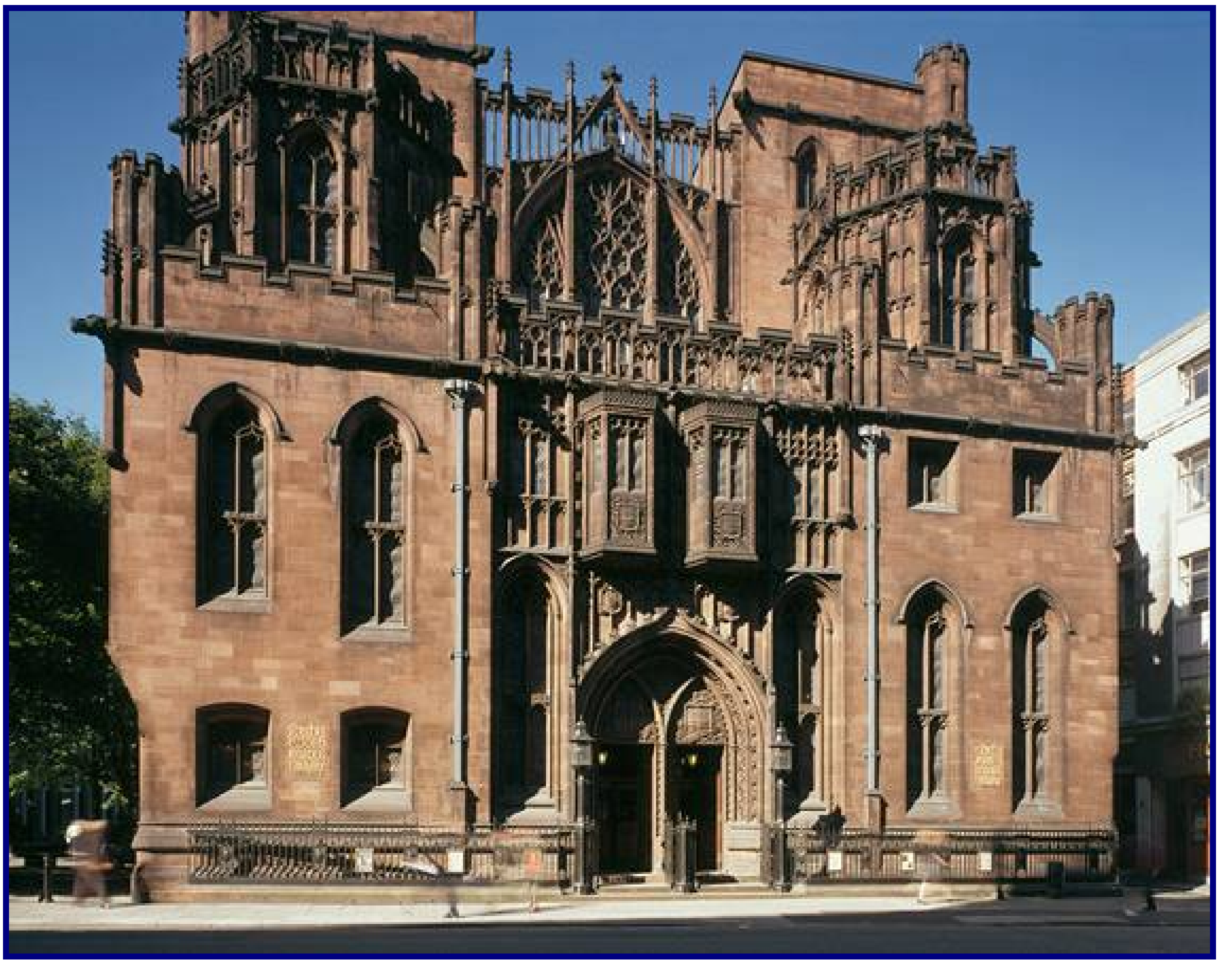


*Tino Lighthouse*

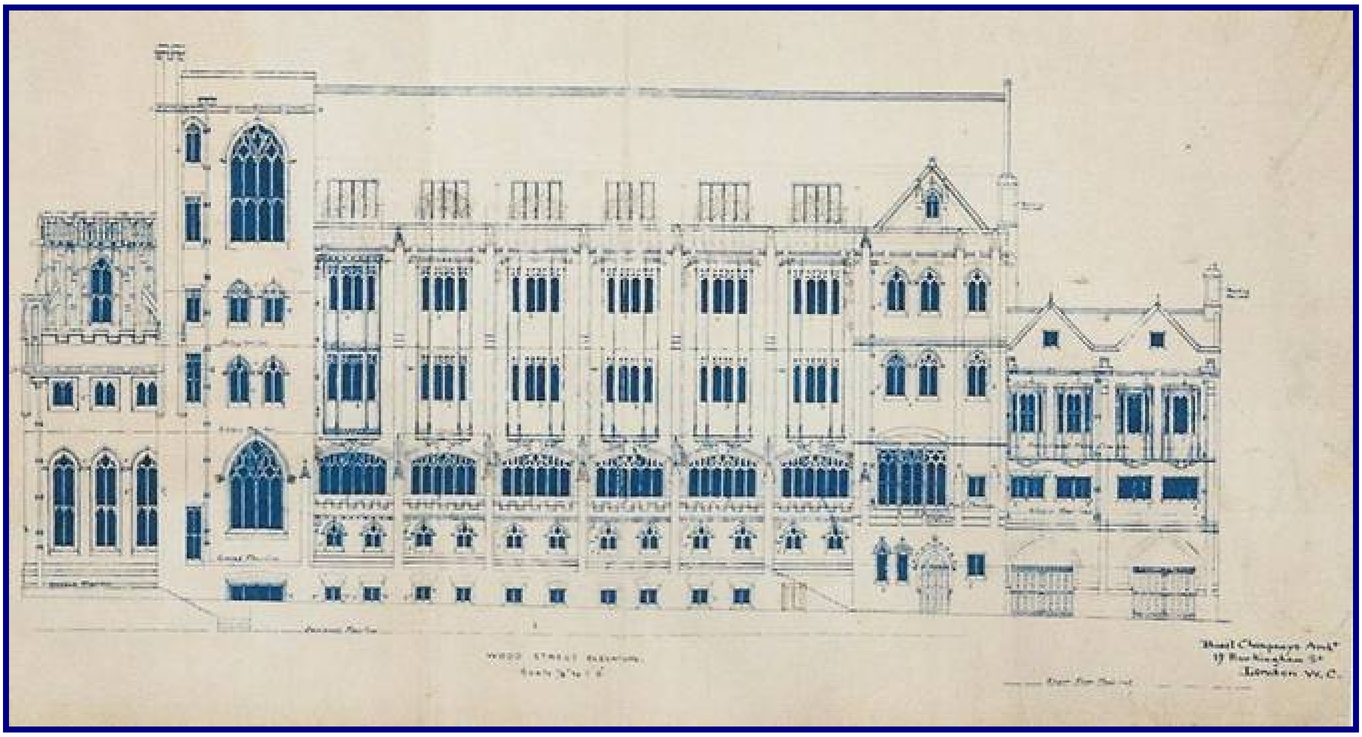
## APPENDIX II: CHARLES HOPKINSON

Charles Hopkinson was appointed the consultant for the John Rylands Library in Manchester which opened in 1900, the building being acclaimed as a leading example of neo-Gothic architecture in Europe.



*Rylands Library*



*Elevation of Rylands Library by the architect, Basil Champneys*

Rylands Library was one of the first public buildings in Manchester to have electric lighting, this being produced by its own generators driven by three gas engines. The distribution cables were run in gun-metal or bronze conduits depending on location.

*Electrical switches*

*Rylands Library lighting*

## RYLANDS HEATING & VENTILATION

A system of mechanical heating and ventilation was built into the structure. Fresh air was filtered through coke screens kept moist by water sprays and warmed by hot water pipes before being distributed around the building. The system was an early dual-duct arrangement with a hot duct and a cool duct allowing individual room temperature adjustment.

## BIBLIOGRAPHY

1887 *The Electric Lighthouses of Macquarie and of Tino*, John Hopkinson, Proc. ICE, Vol. LXXXVII, Session 1886-87, Part I

1901 *Original Papers by the late John Hopkinson*, Vol. I, *Technical Papers*, Edited with *A Memoir* by B Hopkinson, Cambridge at the University Press

1901 *Original Papers by the late John Hopkinson*, Vol. II, *Technical Papers*, B Hopkinson, Cambridge at the University Press

1970 *John Hopkinson, Electrical Engineer*, James Greig, Science Museum, HMSO

1985 *Show a Light*, Neville Billington, Building News (The CIBSE Journal), October [Written when the author was a member of the CIBSE Heritage Group]

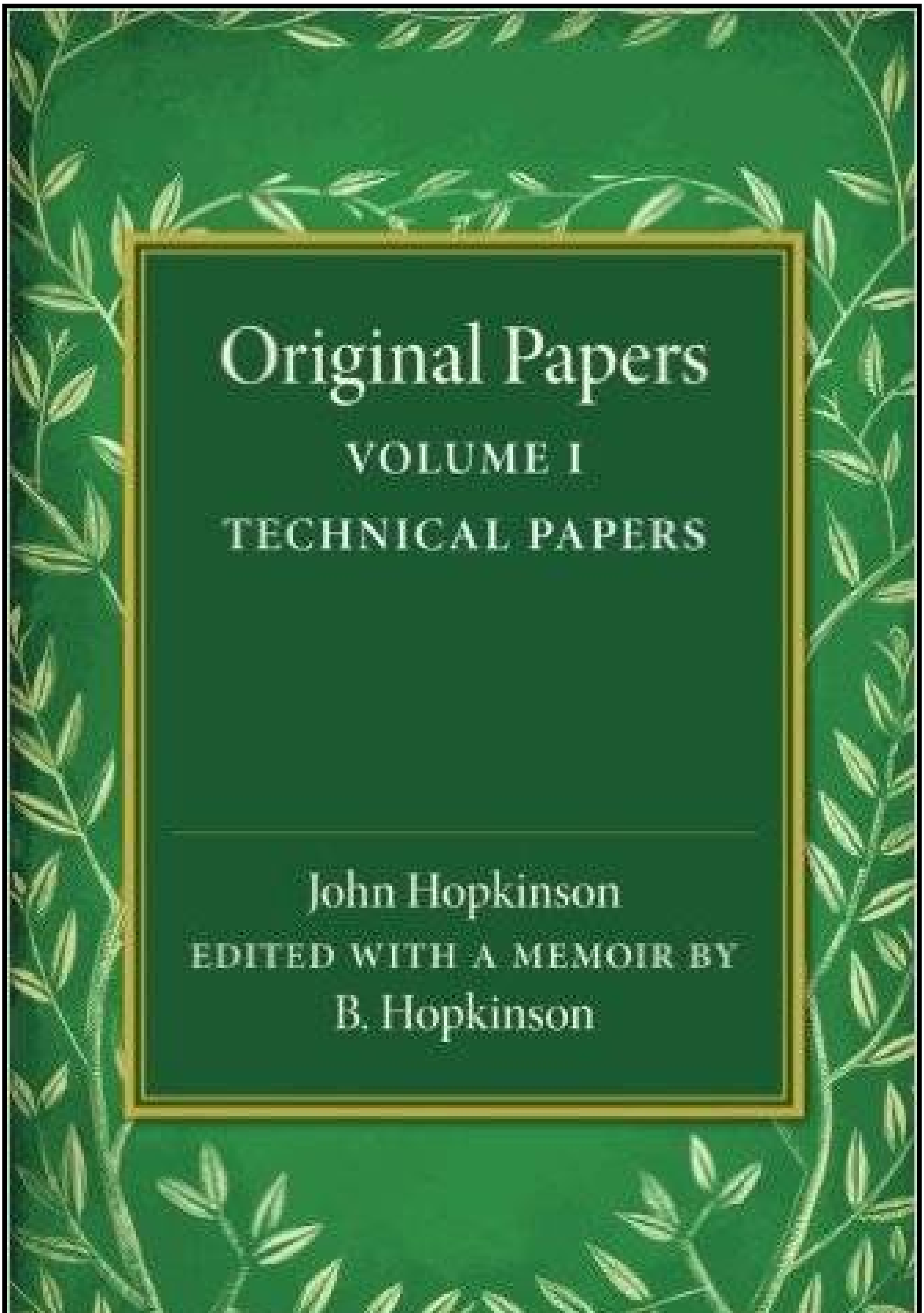
1987 *Electricity Supply in the United Kingdom*, 4th Edition: The Electricity Council

http://gracesguide.co.uk/Dickinson-Street-Power-Station

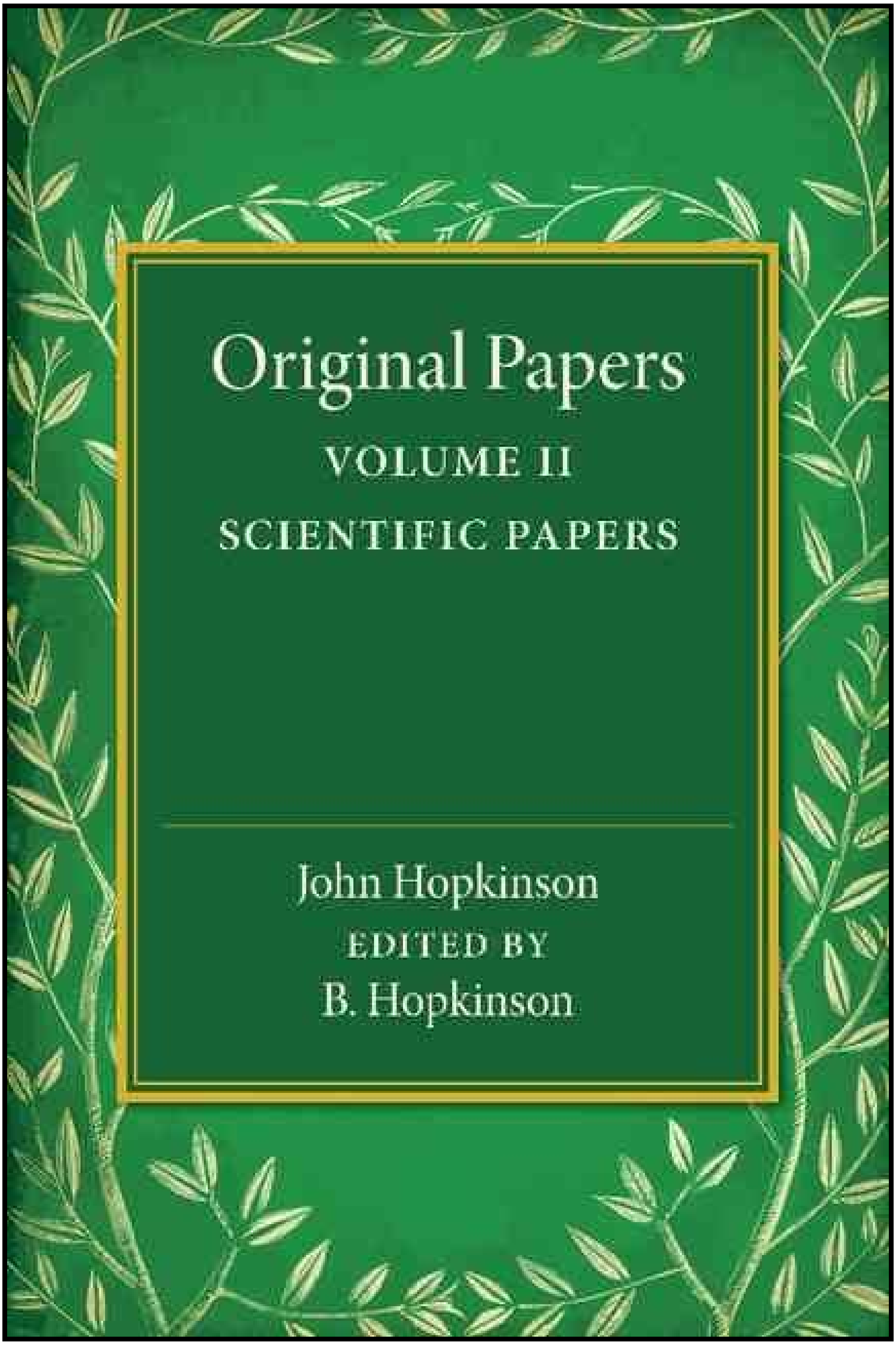
http://gracesguide.co.uk/John-Hopkinson-(1849--1896)

http://gracesguide.co.uk/City-and-South-London-Railway

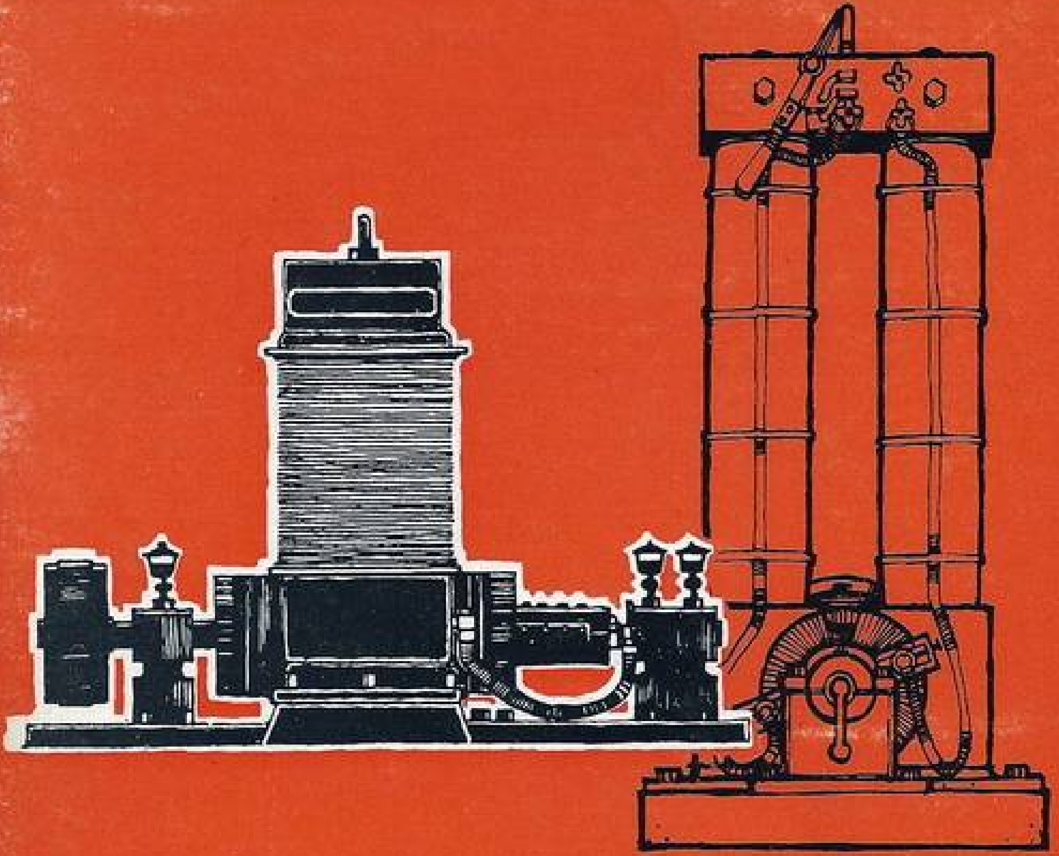
**POSTSCRIPT: FURTHER READING**




*1901*


Original Papers
VOLUME II
SCIENTIFIC PAPERS
John Hopkinson
EDITED BY
B. Hopkinson

1901



# John Hopkinson

## Electrical Engineer

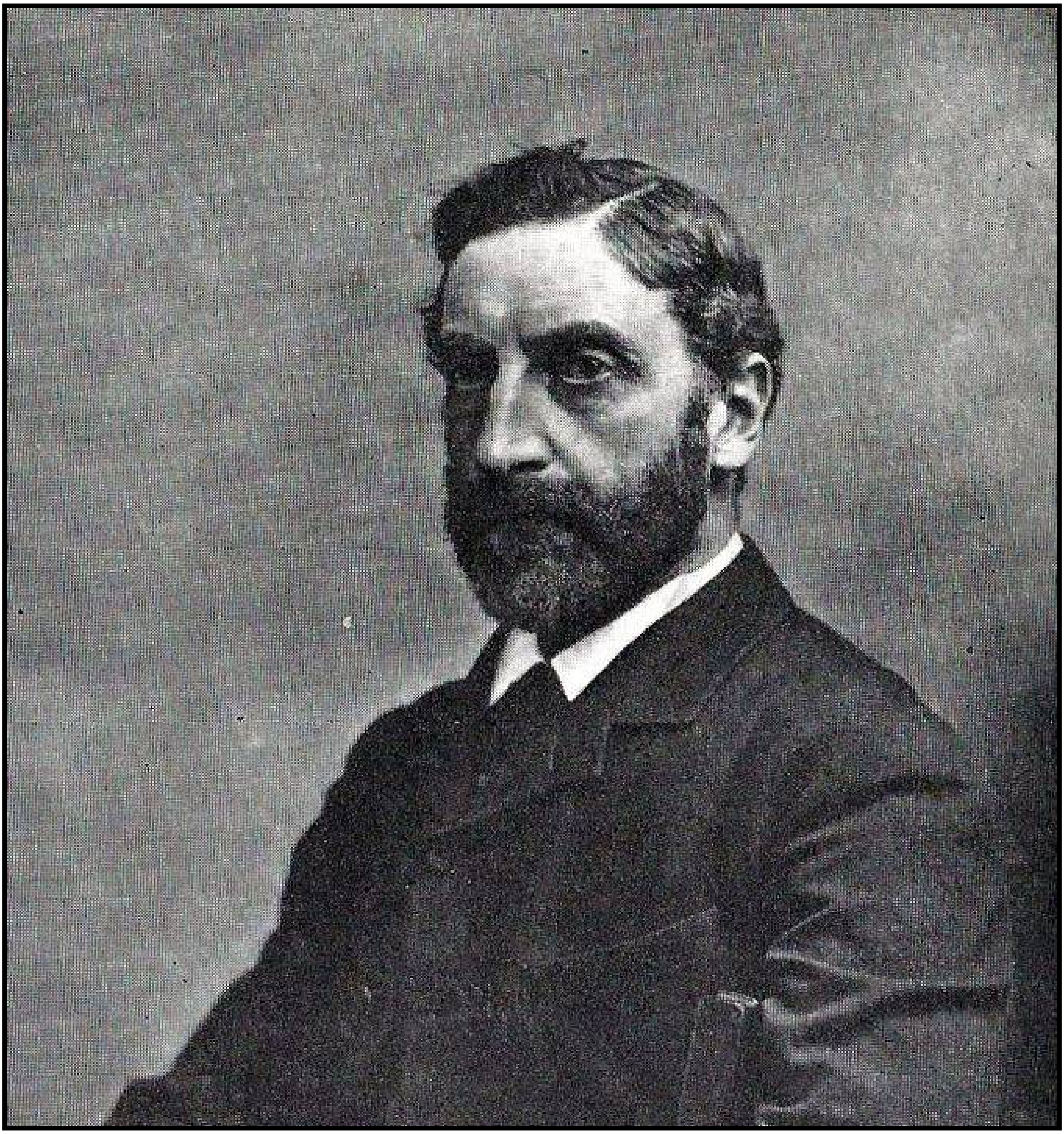
**JAMES GREIG**

**A Science Museum Booklet**

**HMSO 5s 0d [25p] net**

*1970*

**EPILOGUE**



John Hopkinson was at the height of his powers when in 1898 his life was cut short by a climbing accident in Switzerland. He was 49. His son John, and two of his daughters, also died in the accident.