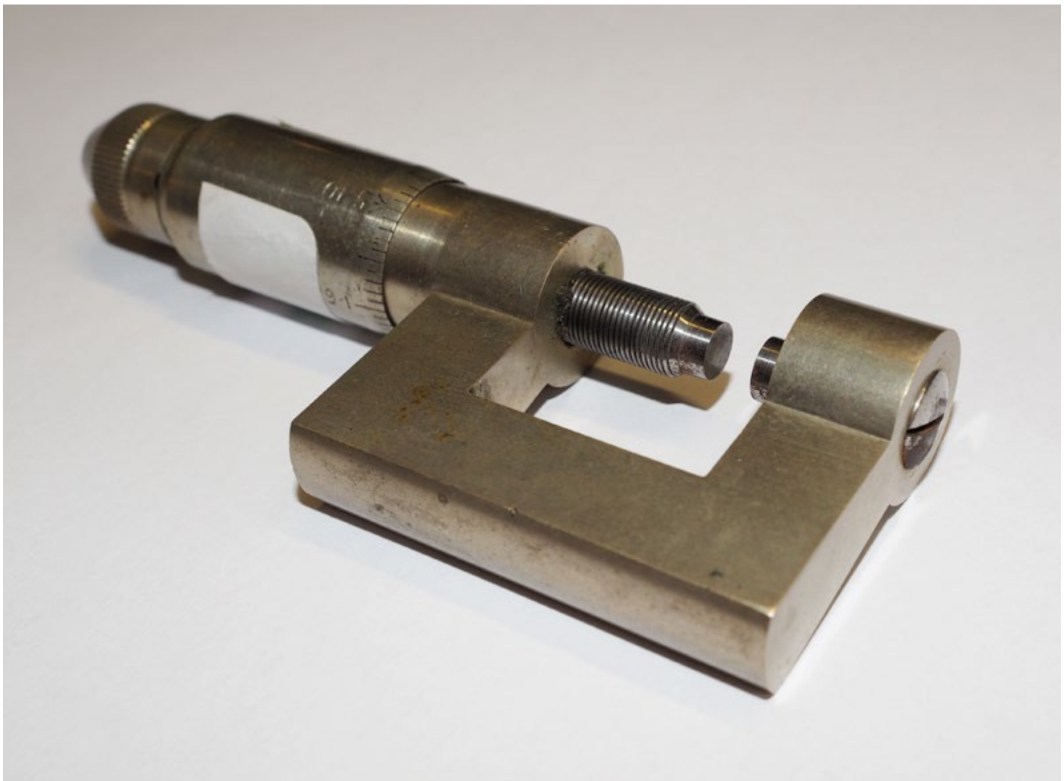
CATALOGUE ENTRY D16 | DISTANCE

NICKEL SILVER MICROMETER, ELLIOTT BROTHERS, LONDON

KING'S COLLEGE LONDON ARCHIVES K/PP107/11/2/4



What separates Victorian engineering from that which had gone before is scale. Big projects, such as the Atlantic Telegraph, needed not just big ideas but new kinds of engineering. The micrometer brought the precision and attention to detail which made large, ambitious projects possible.

The micrometer began its life as a seventeenth-century tool for astronomers to measure the distance between stars. Its popularity increased through the eighteenth century in other precision industries such as machine tool making, screw-thread cutting and die making. Up until the mid-nineteenth century micrometers were large bespoke specimens only to be found mounted on the chief engineer's bench in specialist workshops. The best of these bench-mounted units, such as Henry Maudslay's 'Lord Chancellor' could measure accurately to one ten thousandth of an inch (0.00254mm).[1] The first hand-held micrometer was patented in 1848 by Jean Laurent Palmer of Paris and was capable of measuring to 0.05mm. The micrometer is still referred to as a 'Palmer' in France.

The micrometer in the exhibition is made by Elliott Brothers, a long-established London instrument makers.[2] Elliott Brothers offered a wide range of surveying, navigational, and philosophical instruments and produced a large proportion of the standard instruments sold to both home and overseas customers. Elliott Brothers worked closely with academics and engineers to remain at the forefront of instrument making. Their customers included James Clerk Maxwell, Charles Wheatstone, Lord Rayleigh and other leading scientists. The micrometer from Wheatstone's collection is engraved Elliott Bros London, a mark used between 1873 and 1916. As Wheatstone died in October 1875 it serves to illustrate how Wheatstone remained research-active; purchasing cutting-edge engineering tools right up to his unexpected death on a work trip to Paris.

Perhaps more than any other instrument, the micrometer underpinned the nineteenth-century doctrine of Interchangeability; the idea that each component could be replaced by an exact copy without it having to be specially made. Previously, if a part broke or wore out, a new, bespoke part would be machined to replace it. A standard component, however, could be quickly swapped for a new one, 'out of the box'. Objects taken for granted today, such as the humble nut and bolt, became possible for the first time.

This trend was reflected across science and engineering and driven for a large part by the telegraphic industry. Landline engineers demanded - and received in 1883 - an agreed Wire Gauge as a measure of cable and wire diameter.[3] Atlantic cable engineer William Thomson lobbied parliaments for the standardisation of purity in metals, making telegraphic conductors reliable over long distances.[4] And, from 1862, telegraphic engineers and physicists strived to find ways to measure and define electrical engineering units; the volt, amp, ohm and farad. Interchangeability was not simply about standardisation, it was also about mass manufacture; bringing the costs of engineering down and allowing previously uneconomic projects – such as the Atlantic cable – to be undertaken.

The success of the telegraph rested upon the idea that every cable house, everywhere in the world had access to the same screws, the same clamps, and the same instruments, all manufactured to the same, micrometer-exact specifications. If any part failed, a new one could be taken from the store or sent from any other nearby cable house. Interchangeability underlies all large, networked technologies, which rely on each individual node being able to operate independently and at arms' reach.

CN

1. R. H. Maudslay, 'Henry Maudslay, Engineer: Paper prepared from a lecture given to the Newcommen Society, Manchester Assoc. of Engineers and Museum of Science and Industry, 29 Jan, 2008', http://www.mae.uk.com/Maudsley.PDF (consulted 4 September 2016).

2. Grace's Guide, 'Elliott Brothers', *Grace's Guide to Industrial History*, (8 August 2016), http://www.gracesguide.co.uk/Elliott_Brothers (consulted 4 September 2016).

3. Aashish Velkar, 'Accurate Measurements and Design Standards', *Working Papers on the Nature of Evidence:* How Well do 'Facts' Travel?, *London School of Economics*, Vol. 18, No. 07 (2007), http://www.lse.ac.uk/economicHistory/pdf/FACTSPDF/FACTs18AV.pdf (consulted 4 September 2016).

4. Bernard Crossland, 'Kelvin and Engineering', in Raymond Flood, Mark McCartney, Andrew Whitaker (eds.) *Kelvin: Life, Labours and Legacy* (Oxford and New York: Oxford University Press, 2008).

CATALOGUE ENTRY D17 | DISTANCE

THREE SAMPLES OF SIEMENS' ATLANTIC TELEGRAPH CABLES

KING'S COLLEGE LONDON ARCHIVES. K/PP107/11/1/18

The completion of the 1866 and recovery of the 1865 cables was inspiring. It showed that the great spanning of the Atlantic was possible. It gave governments and engineers confidence. It also gave them a test-bed on which ideas could be worked out, proved and disproved. Bandwidth – initially restricted to 8 words per minute – was in high demand and the market was ripe for expansion.

Siemens brothers had begun experimenting with submarine cables back in the early days of telegraphy. Indeed, in 1846, Werner von Siemens was already experimenting with gutta-percha (a natural sap, a bit like latex) sent to him by his brother William. Impressed with its insulative properties, Werner sought the support of the Prussian Telegraph Commission and trials took place, which were a resounding success.[1] His design for gutta-percha insulated cables formed the basis for most subsequent submarine cables.[2]

The successful Atlantic cables of 1865 and 1866 featured several innovations which were rapidly adopted throughout the industry. These included a double layer of armouring on the 1865 shore-ends and the introduction of stranded wires to provide a more flexible armouring. The Siemens brothers improved upon this successful design for their Direct United States and Compagnie Française Paris-to-New-York Atlantic cables.

The 1874 Direct United States Cable was the first to feature a larger diameter central wire surrounded by a number of smaller wires. More copper could in this way be fitted into a smaller volume which made for lower resistance, lower capacitance and better signalling speeds.[3] More words per minute meant better profits and at 50 words per minute in both directions (known as duplex working) the first of the new Siemens cables brought about a sea-change in telegraphy speeds.

Also built for the 1874 Direct United States cable was the CS (Cable Ship) Faraday, the first purpose built cable ship. Her design was highly innovative featuring a sharp, bow-like stern giving her distinctive lines. She was fitted with twin-screw propulsion for manoeuvrability and swinging sheaves at both the bow and stern to reduce strain on the cable during laying. The Faraday would go on to complete 50 years of cable work.[4]

The 'Direct', as it became known, was sold to the Anglo-American cable company in 1877 and bought again by the General Post Office in 1920. In 1943 the cable failed and engineers were not able to repair it until 1952 when it was finally put back into working order.[5] The cable continued in use well into the 1950s and is the only cable known to have had the shore end landed through a petrified forest.

CN

1. W. Feldenkirchen, *Werner von Siemens: Erfinder und internationaler Unternehmer* (Berlin: Piper, 1996).

2. G. Preece, 'On Underground Telegraphs', *Journal of the Society of Telegraph Engineers*, vol. 2, no. 6 (1873).

3. B. Glover, *Direct United States Cable Company* (2015), http://tinyurl.com/hb2pgu6 (consulted 4 September 2016).

4. W. Siemens, 'The Steamship 'Faraday' and her Appliances for Cable-laying', *Journal of the Royal Institution of Great Britain*, vol. 7 (1874).

5. Glover, Direct (2015).

CATALOGUE ENTRY D18 | DISTANCE

CHART SHOWING THE INTENDED TELEGRAPHIC COMMUNICATION BETWEEN NEWFOUNDLAND AND IRELAND, TRACKS OF STEAMERS BETWEEN EUROPE AND AMERICA AND THE ICE FIELDS IN THE NORTH ATLANTIC OCEAN (WITH SECTION OF THE BOTTOM AND OF THE CABLE TO BE USED). SCALE: 1 INCH TO ABOUT 150 MILES. SURVEYED BY CYRUS W FIELD. ENGRAVED BY DAY AND SON, ENGRAVERS AND PUBLISHERS. MADE FOR THE NEW YORK, NEWFOUNDLAND AND LONDON TELEGRAPH COMPANY, 1856

THE NATIONAL ARCHIVES, UK, MPG 1/392.

Maps are not neutral devices. Maps have power. They shape our understanding of places and of the relationships between those places. They tell us what is important and what may be disregarded. They determine our world view. Harley speaks of maps as 'a collection of codes' and urges us to deconstruct the map in search of the social forces that have structured cartography;[1] to read between the lines of latitude and longitude for the implicit politics, economics and cosmologies there printed.[2]

The two charts juxtaposed in this exhibition (D18 and D19) were chosen because they capture beautifully how the Atlantic Ocean was envisioned by people in Britain and America both before and after the laying of the Atlantic cable. In this, the first chart, Atlantic cable power-house Cyrus Field shows the intended telegraphic communication between Newfoundland and Ireland. His map depicts an Atlantic full of ice-flows, shoals, currents and wrecks. It is scrawled over by the wavering trails of ships, whose wind-driven paths meander, overlap each other and diverge. Superimposed over these comings and goings (for the benefit of potential investors), is the hard line of the proposed telegraph. It curves smoothly between Newfoundland and Ireland, slicing through, under and over the petty and frantic travellings of ships, currents and people; cutting edge and unstoppable. On land the telegraphs snake across Europe and the Americas, temptingly projecting the onward journeys for trans-Atlantic messages. The chart tellingly dates from 1856, the beginning of the Atlantic cable project and before the three expensive and high profile failures. It naively imagines the Atlantic telegraph cable as a serene triumph of Victorian engineering rather than the pitched and improvised battle against the elements it became. The message Cyrus Field intended this chart to convey was 'we understand this', 'we can do this' and, importantly 'give me all your money'.

CN

1. J. B. Harley, 'Deconstructing the Map', in T. J. Barnes and J. S. Duncan (eds.), *Writing Worlds: Discourse, Text and Metaphor* (London: Routledge, 1992), p. 238.

2. J. B. Harley, 'Deconstructing the Map', *Cartographica*, vol. 26, no. 2 (Spring 1989), p. 3.

CATALOGUE ENTRY D19 | DISTANCE

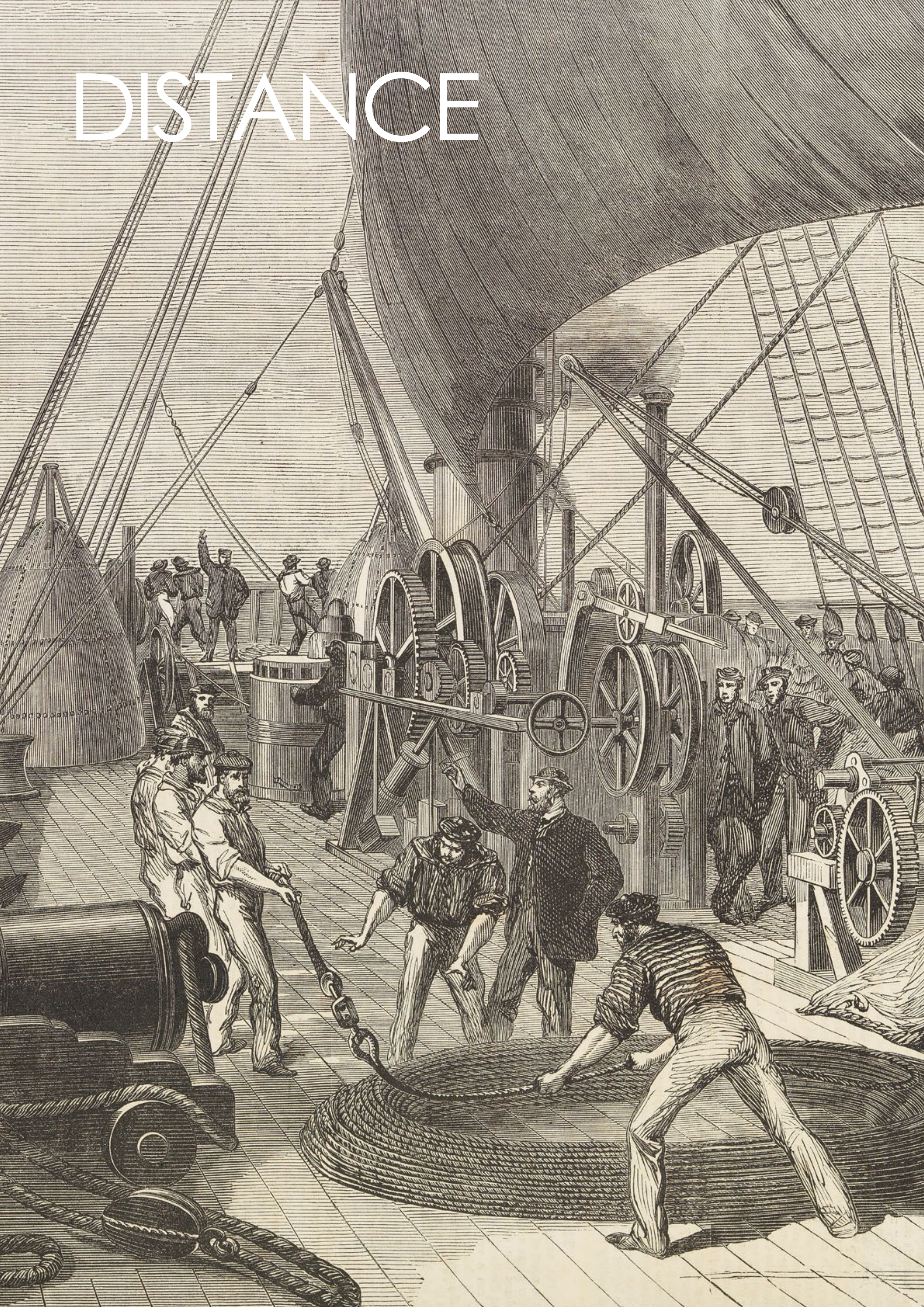
COAL AND TELEGRAPH CHART': SHOWING TELEGRAPHS AND COALING STATIONS. ADMIRALTY CHART 1188: ENGRAVED BY EDWARD WELLER; PUBLISHED, 8 AUGUST 1889.

THE NATIONAL ARCHIVES, UK, MPHH 1/454.

This chart, engraved for the Admiralty in 1889 shows overland telegraphs, submarine cables, steamer routes and coaling depots; an Atlantic criss-crossed by communications technologies. It was made twenty three years after the successful laying of the 1866 cable, which at this date figures as just one of several threads almost casually spanning the Atlantic Ocean. The world has been changed. Known infrastructure now takes the place of wild waves. Unpredictable ocean currents are replaced by calm electrical ones. Messages cast out into the sea are now tethered safely by the cable. The impossibly ambitious Atlantic cable project is now just one link in a near-global network; simultaneously indispensable and ubiquitous. In this chart, the novelty has worn off. The slim, pioneering thread now finds itself integrated into a wider-reaching network of landlines, direct steamship routes, forts, train-lines, ports and harbours. The telegraph has morphed from pioneer species to networked object; jig-sawed into an increasingly anthropocentric landscape. The chart speaks of the expansion of minds, the permeation of Admiralty views to land-lubbers; that oceans are traversable and vast distances communicable. These ideas now belong to everyone. We know that for the price of a telegram that infrastructure can be mobilised. For pounds, shillings and pence oceans can be shrunk and the least of our thoughts sent out to conquer icebergs, tides and storms.

CN

DISTANCE



from VICTORIANS DECODED: ART AND TELEGRAPHY

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Exhibition Catalogue for the exhibition *Victorians Decoded: Art and Telegraphy* held at The Guildhall Art Gallery, London from 20th September 2016 to 22nd January 2017.

Published by The Courtauld Institute of Art
Somerset House, Strand, London WC2R 0RN and King's College London, Strand, London WC2R 2LS.

ISBN: 987-1-907485-053

All sections of this catalogue are available for free download at the project website for *Scrambled Messages: The Telegraphic Imaginary 1857-1900*
http://www.scrambledmessages.ac.uk/
This website is hosted by King's College, London

Designed by Olivia Alice Clemence

BACK AND FRONT COVER:
James Tissot, *The Last Evening*, 1873 (details), The Guildhall Art Gallery, Corporation of London.