RESISTANCE

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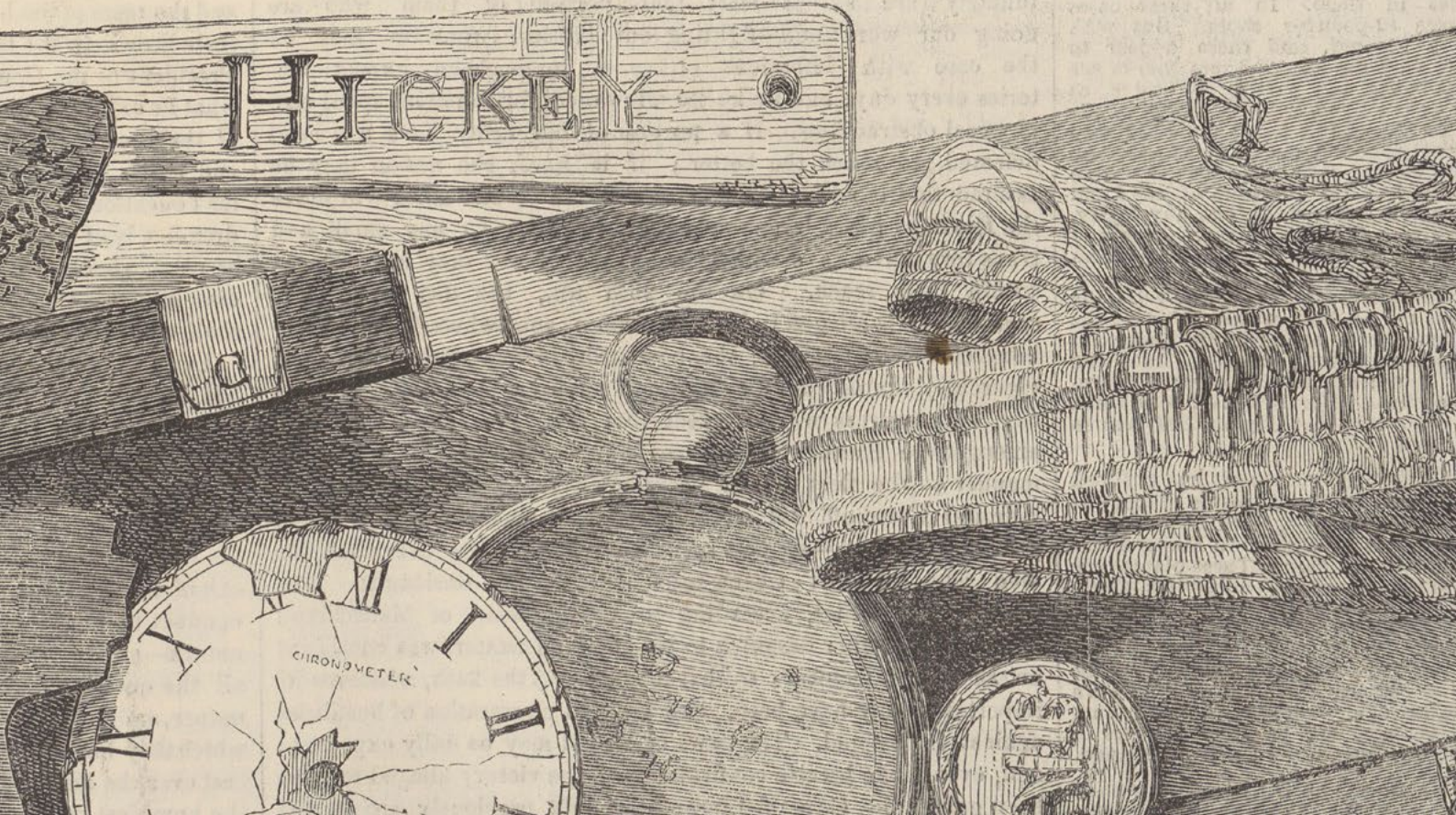

from VICTORIANS DECODED: ART AND TELEGRAPHY

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Designed by Olivia Alice Clemence

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

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RESISTANCE

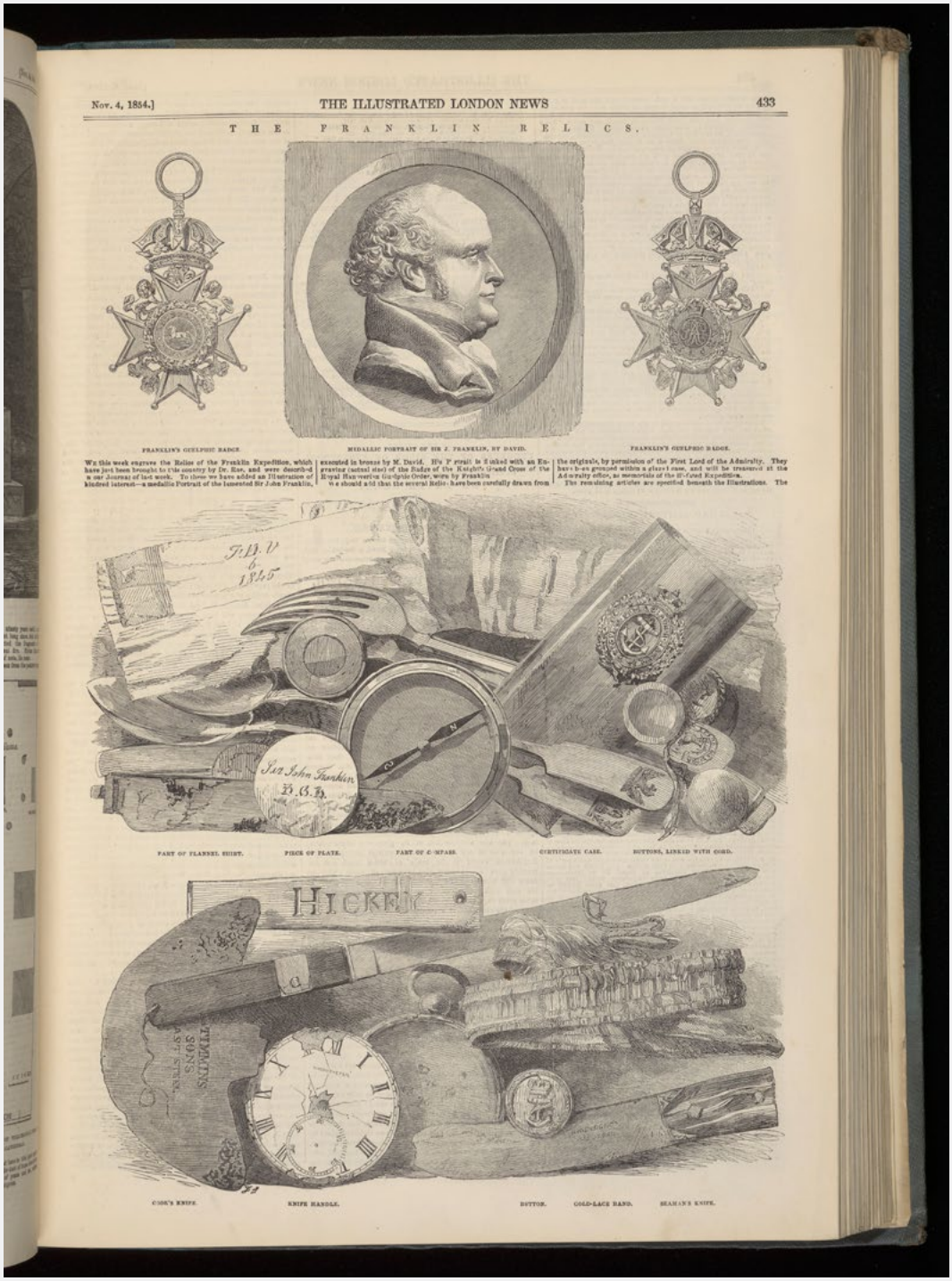
CLARE PETTITT

FRANKLIN'S MESSAGES: EDWIN LANDSEER'S *MAN PROPOSES, GOD DISPOSES*

Fig. 1, Edwin Landseer, *Man Proposes, God Disposes*, 1864, Royal Holloway, University of London. Image: Royal Holloway, University of London.

'Lurid' is a word which was used often in contemporary reviews of Landseer's painting 'Man Proposes, God Disposes'. The Illustrated London News described the action of the picture as taking place: '[u]nder the lurid sky of an arctic twilight, among the vast fantastic blocks of ice, green, or of livid pallor', and *The Times* similarly set the scene, '[u]nder the lurid light of the dawn blink and among the blocks of ice, a pair of polar bears are tugging and rending at an undistinguishable heap which was once a boat and a boat's crew'.[1] If the Arctic light is 'lurid' and 'livid', so were the wider associations of the picture, which critics at the time clearly identified as a commentary on the doomed Franklin Expedition.

Sir John Franklin had set off in May 1845 with two ships and 129 men to chart the Northwest Passage in the Canadian Arctic. Franklin was already famous for his privations and endurance on his two previous Arctic expeditions: the newspapers had dubbed him, 'the man who ate his boots', and his travels were disseminated in periodicals and in popular touring 'Arctic panoramas' so that Franklin's third Arctic expedition of 1845 left England in a glare of publicity.[2] Determined not to have to eat his boots again, Franklin had ensured that the ships were very well stocked with provisions: 32,289 pounds of preserved meat, 1,008 pounds of raisins and 580 gallons of pickles were on board. The expedition was reported as sighted by a whaling ship as Franklin's ships entered Lancaster Sound in late July 1845, and although it was subsequently seen by native Inuit people, no news would reach England of the fate of the Franklin expedition for nine years. It was only in 1854 that Dr John Rae, while travelling for the Hudson Bay Company, talked to Inuit people who reported that they had learned from other native peoples that about forty white men had been seen in 1850, dragging a boat south along the western shore of King William Island, and that later in the season the frozen bodies of those men had been found. A few years later, Captain Francis McClintock, sent out to find out more by Franklin's widow,


Nov. 4, 1854.] THE ILLUSTRATED LONDON NEWS 433

THE FRANKLIN RELICS.

FRANKLIN'S GUELPHIC BADGE. MEDALLIC PORTRAIT OF SIR J. FRANKLIN, BY DAVID. FRANKLIN'S GUELPHIC BADGE.

We this week engrave the Relics of the Franklin Expedition, which have just been brought to this country by Dr. Rae, and were described in our Journal of last week. To these we have added an Illustration of kindred interest—a medallic Portrait of the lamented Sir John Franklin, executed in bronze by M. David. His Portrait is linked with an Engraving (actual size) of the Badge of the Knights Grand Cross of the Royal Hanoverian Guelphic Order, worn by Franklin. We should add that the several Relics have been carefully drawn from the originals, by permission of the First Lord of the Admiralty. They have been grouped within a glass case, and will be preserved at the Admiralty office, as memorials of the ill-fated Expedition. The remaining articles are specified beneath the Illustrations. The

Sir John Franklin K.C.B.

PART OF FLANNEL SHIRT. PIECE OF PLATE. PART OF C-MPASS. CERTIFICATE CASE. BUTTONS, LINKED WITH CORD.

HICKEY

THOMAS JONES & SON'S

CIGAR'S KNIFE. KNIFE HANDLE. BUTTON. GOLD-LACE BAND. SEAMAN'S KNIFE.

Fig. 2, *Illustrated London News* (4th Nov 1854), p. 433. Photo: Wellcome Library, London.

discovered a written record of the expedition, some pieces of personal property belonging to the crew, and the skeletons of some of the men.[3] McClintock sent a confidential report to the Admiralty, '[f]rom the mutilated state of many of the bodies, and the contents of the kettles, it is evident that our wretched countrymen had been driven to the last dread alternative as a means for sustaining life'.[4] This report of cannibalism among Franklin's crew was leaked to the press, and, perhaps as a consequence, McLintock's subsequent book, *The Voyage of the 'Fox' in the Arctic Seas: A Narrative of the Discovery of the Fate of Sir John Franklin and His Companions* ran rapidly through six editions. McClintock included an 'Appendix' which gave a comprehensive list of all the miscellaneous material remains that he had discovered: 'a small bead purse, a piece of red sealing-wax, stopper of a pocket flask, German silver top and ring, brass matchbox, one of the glasses of a telescope, a small tin cylinder, probably made to hold Lucifer matches …. Five watches'.[5] McClintock provided colour plates of these objects, and they were widely reproduced in periodicals in Europe and America (Fig. 2). Landseer's picture shows a telescope lying on the ground, a notebook, a tatter of blue serge from a naval uniform, and a ragged red flag. The *Athenaeum* was explicit in connecting Landseer's picture of 'an Arctic incident' to McClintock's book, saying the subject was 'suggested by the account of finding relics of the Franklin Expedition', although it also felt that the picture was tasteless, '[a]s to his choice of subject, we protest against it'.[6] The *Illustrated London News* agreed that the subject was possibly 'too purely harrowing for the proper function of art'.[7]

Why did the picture appear tasteless and lurid? Why did it elicit such strong reactions when it was exhibited at the Royal Academy Exhibition in May 1864? At the opening of the Exhibition, Franklin's widow refused to enter the room in which the 'offensive' picture was hung, whereas she had been part of an illustrious group of 'Arctic luminaries' celebrating the opening of American Frederick Church's elaborately orchestrated show of his large canvas *The Icebergs* (Fig. 3) at the German Gallery in London the year before.[8] Landseer's portrayal of the Polar bears chewing on the bones of the dead explorers was graphic and uncompromising, for sure, but it also shocked by obliquely evoking the allegation of cannibalism among the survivors. Lady Franklin had asked no less a powerful figure than Charles Dickens to refute these stories in his immensely popular journal, *Household Words*, and he had done so, strenuously dismissing, 'the wild tales of a herd of savages'.[9] With his friend, Wilkie Collins, Dickens subsequently reimagined the Franklin expedition as a heroic tale of manly sacrifice in their jointly-authored play, *The Frozen Deep* (1856). Recent research has established that the survivors of the Franklin expedition did, indeed, eat their dead colleagues, just as the Inuit had reported.[10]

Fig. 3, Frederic Edwin Church, *The Icebergs*, 1861, Dallas Museum of Art, gift of Norma and Lamar Hunt, 1979.28. Image courtesy Dallas Museum of Art.

It was Alfred Tennyson who famously wrote of 'Nature red in tooth and claw' in his long poem of loss and grief for his friend Arthur Hallam, *In Memoriam A.H.H.* By the time the poem was published to enormous acclaim in 1850, Tennyson was Poet Laureate, and the Franklin expedition had been missing for five years. The colour red, and teeth and claws would all feature in Landseer's remarkable canvas which, like Tennyson's poem, pits the amoral logic of the wild against the survival and endurance of the human, 'the two white polar bears feasting in ghastly voluptuousness on the bones of our lost seamen, amongst great opalescent masses of ice'.[11] Like Tennyson in *In Memoriam*, Landseer also uses scale to dramatic effect in his eight-foot wide canvas and this was also noticed at the time as critics described the 'great…masses of ice'; 'cold mountains of ice, vast and desolate' and 'the wild, desolate, icy desert'.[12] But it is not just scale but also substance that has fatally blocked Franklin's attempt to establish a northern route from the Atlantic to the Pacific. The painting insists on the recalcitrance of a densely material world massed against puny human force. In the 1860s, materialism, the idea that the world exists only as material and has no spiritual form or purpose, seemed to some to be the fearful and logical consequence of Darwin's recently published ideas of evolution and survival.[13] Tennyson's *In Memoriam* is already haunted by the appalling meaninglessness of materialism, as when the poet asks if the mortal remains of his friend are to 'Be blown about the desert dust, / Or seal'd within the iron hills'.[14] The rhyming in Landseer's painting of the bones of the human ribcage and the wreckage of the wooden vessel suggests a disturbing structural similarity between these dead materials. The reduction of human life to mere substance or matter, the lack

of spiritual agency, and the dizzying power of the natural environment to disperse or absorb human meaning: all of these return forcefully in Landseer's Polar landscape.

The *Athenaeum* registered the immensity of Landseer's *Man Proposes, God Disposes* when it admitted that, 'it would be pedantry to reserve consideration of its merits until we come to the class of paintings of animals'. Landseer was famous for his moralised portraits of anthropomorphized animals, such as *Dignity and Impudence* (1839) (Fig. 4), but in his later work he is moving away from this genre, as was half-noticed at the time. Of the Polar bears in his 1864 canvas, the *Reader* asked, '[w]hich of us…has ever seen so deeply into [the Polar bears'] nature as to conceive with magical truthfulness the very conditions and course of their lives, and their relationship to the barren desolation and wilderness of ice in the midst of which they were born and nurtured'. William Rossetti noted this shift too, 'it places the painting of brute life upon a new and higher platform, hardly inferior in lofty suggestiveness to human subjects'.[15] It is precisely because the bears are *not* moralised and emphatically not anthropomorphised that the picture troubled many contemporary viewers. The picture reverses the logic of Landseer's earlier paintings. Instead of asking us to understand an animal from a human perspective, Landseer rather asks us to understand the world from a Polar-bear perspective, and in so doing, forces us to understand that in this environment and from this point of view the human is nothing but irrelevant carrion. The Polar bears are shown simply doing the things that Polar bears do.

Broken and failed communication was very much in the public mind in the early 1860s. The Franklin expedition was attempting to open up a new channel of marine communication between the Atlantic and the Pacific oceans. Landseer represented its dramatic failure just as the failures of the repeated attempts to lay a Transatlantic Telegraph Cable were being reported in the press. One of the problems of the first transatlantic cabling attempts was the enormous resistance of the 2,754 km-long cable. The cable project elicited new research on electrical resistance. Resistance is a property of all materials and denotes how difficult it is to push electricity through them. High resistance is a good thing for an insulator (e.g. gutta-percha), but conductors need low resistance (e.g. copper). Too much resistance makes it impossible to get a current, or in telegraphic terms, a message, through. The recalcitrant landscape of Landseer's painting has blocked and obstructed the passage of Franklin's route-finding mission. The torn flag, the red British Naval Ensign, is suggestive of spilt blood on the snow, but it is also eloquent as a failed signal. Art historian, Diana Donald has argued that this flag stands in for 'a deliberate tearing of the fabric of patriotic rhetoric'.[16] Tension was another vital concept for nineteenth-century telegraphy, as too much tension could snap the cable, but too little could cause it to tangle and retard its proper functioning. Landseer visualizes tension in the pull of the Polar bear's teeth on the taut red flag that reminds us of the material properties of the wreckage and their breaking points.

Fig. 4, Georg Zobel Edwin Landseer, *Dignity and Impudence*, mixed method engraving, published London: Graves & Co., 1871, image: ©Trustees of the British Museum.

The *Reader* felt that Landseer's painting 'lifts the veil of distance from our eyes' and the *Athenaeum* agreed that, 'a purple veil of mist is drawn aside – as if a secret were displayed, and in order that we might see what became of our long-lost countrymen'. Swinburne's 1860 poem 'The Death of Sir John Franklin' similarly meditates on distance, the passing of time, and delayed communication:

> So winter-bound in such disastrous place,
> Doubtless the time seemed heavier and more hard
> Than elsewhere in all scope and range of space;
> Doubtless the backward thought and broad regard
> Was bitter to their souls, remembering
> How in soft England the warm lands were starred
> With gracious flowers in the green front of spring

Swinburne's poem inhabits a disjunctive double-time when all communications were impossible for Franklin and his stranded crew, so that back in Britain, 'No man made count of those keen hopes and fears/ Which were such labour to them'.[17]

When McClintock discovered the remains, human and inanimate of the expedition, they were so well-preserved by the cold that it was as if he had found a message that had been stored for a long time, and he was finally able to transmit it.[18] The message that he discovered was scrambled: it was unclear what exactly had happened to the men, although their disastrous end was clear. The dispersed and incongruous fragments of the expedition: human bones and bone-handled knives, sealing-wax, skulls half eaten by animals and the glass from a telescope cannot coalesce into a story, scattered out of time and out of sequence. Landseer's painting therefore likewise resists coherent narrative. William Rossetti called the relics that featured in Landseer's painting, 'the saddest of *membra disjecta*' because he saw that *Man Proposes, God Disposes* shows us a history that has been scrambled and dispersed by nature.[19] In the entanglement of arctic, bear, and man, Landseer shows us how geological, zoological and climatological factors are part of the making of a history that can not always be understood as exclusively 'human'.[20]

1. 'Fine Arts: Exhibition of the Royal Academy', *Illustrated London News* (7 May 1864), p.454 and 'Exhibition Of The Royal Academy', *The Times* (30 April 1864), p. 14.

2. Scott Cookman, *Ice Blink: The Tragic Fate of Sir John Franklin's Lost Polar Expedition* (New York: John Wiley and Sons, 2000), p.23.

3. See B. A. Riffenburgh, 'Sir John Franklin', *Oxford Dictionary of National Biography* http://tinyurl.com/jolsj2q (consulted 1 September 2016). For further details see also Francis Spufford, *I May Be Some Time: Ice and the English Imagination* (London: Faber & Faber, 1996); Owen Beattie and John Geiger, *Frozen in Time: The Fate of the Franklin Expedition* (London: Bloomsbury Press, 1987); Janice Cavell, *Tracing the Connected Narrative: Arctic Exploration in British Print Culture 1818-1860* (Toronto, Buffalo, London: University of Toronto Press, 2008); some of the Franklin relics that are held by the Royal National Maritime Museum at Greenwich can be seen online: http://tinyurl.com/h2vudqk (consulted 1 September 2016).

4. 'John Rae', *The Oxford Book of Exploration*, selected by Robin Hanbury-Tenison (Oxford: Oxford University Press, 2005), p298.

5. Francis McClintock, *The Voyage of the 'Fox' in the Arctic Seas: A Narrative of the Discovery of the Fate of Sir John Franklin and His Companions* (London: John Murray, 1859), p.286.

6. 'The Royal Academy', *Athenaeum* (May 7, 1864), p.650.

7. 'Fine Arts: Exhibition of the Royal Academy', *Illustrated London News* (7 May 1864), p.455.

8. Ken McCoogan, *Lady Franklin's Revenge: A True Story of Ambition, Obsession and the Remaking of Arctic History* (Toronto: HarperCollins, 2005), p478.

9. Charles Dickens, 'The Lost Arctic Voyagers', *Household Words*, vol. 10 (2 December 1854), p. 363.

10. For recent archaeological evidence of cannibalism on the expedition see: http://tinyurl.com/hoeyg5u and http://tinyurl.com/zgd3z25 (consulted 1 September 2016).

11. 'Exposition Universelle de 1867 a Paris', *Quarterly Review*, vol. 29.57 (October 1867), p.96.

12. 'The Royal Academy', *Art Journal* (June 1864), p.168 and 'The Royal Academy', *London Review of Politics, Society, Literature, Art, and Science*, vol. 8:201 (7 May 1864), p.487.

13. Although Darwin himself refuted the materialism of his theories.

14. Alfred Tennyson, *In Memoriam A.H.H.*, LVI, line 15 and lines 19-20.

15. W. M. Rossetti, 'Art Exhibitions in London', *Fine Arts Quarterly Review*, vol. 3 (October 1864), p.23.

16. Diana Donald, 'The Arctic Fantasies of Edwin Landseer and Briton Rivière: Polar Bears, Wilderness and Notions of the Sublime', http://tinyurl.com/zlhy9gp (consulted 1 September 2016).

17. Algernon Charles Swinburne, 'The Death of Sir John Franklin' in *The Complete Works of Algernon Charles Swinburne, Poetical Works* (London: W. Heinemann Limited, 1925).

18. Adriana Craciun has recently read the far-away Arctic as an 'eclectic archive…comprising religious, navigational, institutional, textual and personal detritus, publicly referred to as "the Franklin relics"'. Adriana Craciun, *Writing Arctic Disaster: Authorship and Exploration* (Cambridge: Cambridge University Press, 2016), p.34.

19. W.M. Rossetti, 'Art Exhibitions in London' (1864), p.23.

20. Benjamin Morgan has written that, 'entanglements of human action with geological and climatological events [can be] understood as motive forces of history'. Benjamin Morgan, 'After the Arctic Sublime', *New Literary History*, vol. 47 (2016), p.2.

RESISTANCE

NATALIE HUME

RESISTANCE AND BOUNDARIES: PETER GRAHAM'S *RIBBED AND PALED IN BY ROCKS UNSCALEABLE AND ROARING WATERS*

Fig. 1, Peter Graham, *Ribbed and Paled in by Rocks Unscaleable and Roaring Waters*, 1885, Guildhall Art Gallery, City of London Corporation.

The location of this painting of untrammelled nature, located in the part of the exhibition that explores resistance, acts as a reminder that electricity is a natural as well as a man-made phenomenon, and that its behaviour can be inconvenient, frustrating and dangerous. Electrical resistance is the opposite of conductance, a gauge of how difficult

(or easy) it is for a current to pass through a medium. Resistance is a result of both material and form: the core of the transatlantic telegraph cable was made of copper, which is a good conductor with low resistance, but the core had to be thick because resistance increases as diameter decreases. As well as in the context of electricity, resistance is a term used extensively within physics, as in thermal or geological resistance for example. Resistance is also a word with a range of meanings in other contexts, including politics, the military and psychoanalysis. The connotations of the word shifted following its specific usage in the Second World War for the French Resistance to the Nazi occupation, while more recently there has been growing concern about the phenomenon of pathogens' acquired resistance to antibiotics. Returning to nineteenth-century usage, a Google Ngram shows that 'resistance' appeared ever more frequently in published English between 1870 and 1895, a period of growing imperialism matched by heightening unrest overseas.[1] During this period the term was also used in a more general military context, as well as for electrical and geological resistance. This multivalence is relevant because it demonstrates the way that electrical resistance participates freely in intercontextual relationships, lending itself to metaphor, analogy and mapping.

Ribbed and Paled In by Rocks Unscaleable and Roaring Waters is one of a series of unorthodox paintings depicting the coast of the Scottish Highlands. As a wild, dramatic landscape it references the sublime, but in place of the conventional awe-inspiring view, lavishly depicting a mountain peak or great valley, it offers an uncompromising wall of rock and bad weather, fierce yet understated. The low, myopic viewpoint, causing the rock to loom ominously over the scene, elicits an abject rather than an exhilarated response; and for a Western audience accustomed to reading towards the right, the position and scale of the dark cliff is profoundly threatening, frustrating the eye. The unusual framing is emphasised by the portrait format and a distorted, vertically stretched perspective, so that the viewer has the impression of looking straight at the side of the cliff and simultaneously down into the turbulent sea.

These subtle resistances of form – to genre and convention – are compounded by the distinct visceral resistances offered by the three materials: the cloud is a heavy, wet curtain obscuring the horizon; the waves are made opaque by their powerful currents; and the hard rock is broken by angular fissures etched over centuries. Each of the three elements exerts a force upon the others, illustrating a slow, massive, endless struggle for geological supremacy. The resistance between the different elements depicted, though, is secondary to the one that meets the viewer. Fields of cloud, sea and rock – gas, liquid and solid – form a layered, impenetrable skin. Their interaction is seamless: the pattern made by the illumination of the rain in the sky is echoed by the sea foam, while the pocked surface of the rock is a gradually evolving imprint of the rushing water and pounding rain. The severely limited palette, dominated by black, white and grey, enhances the scene's

austere harmony.

On one level, Peter Graham's painting – an apparently direct, detailed representation of a windswept, coastal view – embodies resistance by resisting interpretation. There are no people, whose dress and body language would offer a narrative, and each bird and natural feature is authentic, without intrusive symbolism or obvious significance. The uncompromising, closely described landscape suggests Graham's affinity with recent trends in British art, going back via John Ruskin's 'truth to nature' and the Pre-Raphaelites' *plein-air* practice to the stormy skies of John Constable and J. W. M. Turner. One critic, however, comparing the painting unfavourably with the looser brushstrokes of the French Impressionists, complained that Graham 'offers, in place of outdoor work direct from nature, the artifice of the studio'.[2] This accusation implies that there is something disingenuous about the careful selection and portrayal of this particular stretch of coast under these weather conditions; that the brutality on the canvas is something more than a trace of the environment's indifferent resistance to the artist.

The oblique title leaves no doubt that this is indeed the case. It deliberately connotes the violent power of the elements with their painful laceration of pallid human flesh and brittle bone, although the body is mentioned directly neither in word nor in image. The title also introduces humanity via a cultural framework, since it quotes the English Queen in Shakespeare's *Cymbeline*, persuading her husband to fight Roman taxation:

> Remember, sir, my liege,
> The kings your ancestors, together with
> The natural bravery of your isle, which stands
> As Neptune's park, ribbed and paled in
> With rocks unscalable and roaring waters,
> With sands that will not bear your enemies boats,
> But suck them up to the topmast.
>
> (*Cymbeline*, Act III, scene 1)

This appeal to the King's self-importance convinces him to challenge Roman law, putting England in jeopardy. In light of this reference, the wall of rock suggests a national border, while the birds across the surface of the rock stand for citizens oblivious to the royal drama endangering their lives.

Cymbeline's mistake, persuaded by his wife and stepson to embrace vainglorious nationalism and nostalgia while neglecting tactical diplomacy, resonates strikingly with the recent UK 'Brexit' fiasco. It must have offered an equally relevant comment upon Britain's international status in the 1880s, a period of rapid imperialist growth accompanied by tension with other colonial nations and committed challenges from a range of colonised peoples. In the twenty years prior to 1885, when Graham produced this painting, there

had been resistance to British settlers from indigenous populations in Australia and New Zealand (1860s and 1870s), the fighting of the Second Anglo-Afghan War (1878–1880) and the early years of the long and violent 'Scramble for Africa' (from the 1880s). There was also organised opposition to British rule in Ireland and India during the mid-1880s.[3] Ancient Roman imperialism offered a useful analogy for British expansionism throughout this period, particularly for those critical of the brutality and waste that were the corollary of aggressive foreign policy.

Graham identified strongly as Scottish rather than British, with his work consisting overwhelmingly of representations of wild Highland landscapes. In light of this, the quotation may have expressed sympathy with the position of the Queen in *Cymbeline*, comparing the present-day pseudo-colonial relationship between Scotland and England with England's previous subservience to Ancient Rome. From the middle of the nineteenth century Scotland's growing industrial success and increasingly confident political and cultural identity (following the international success of Walter Scott, for example) led to calls for Home Rule; these were met with a compromise in 1885 – the year Graham made this painting – when Prime Minister Lord Salisbury revived the post of Secretary of State for Scotland. In an alternative reading, the Queen's words emphasise the natural isolation of the British Isles, surrounded by treacherous rocks and rough seas; Graham might be inverting this observation, querying the wisdom of violating the nation's inherent geographical seclusion in the pursuit of power and influence abroad.

In any case, it seems that the challenging, uncompromising landscape of Scotland provided Graham with a useful political metaphor, and it is likely that his outlook was specifically Scottish rather than British. He frequently depicted rushing water and wild coastal weather, as in *'Lashed by the Wild and Wasteful Ocean'* (n.d., Temple Newsam House, Leeds), for example, which shares a compositional structure with *Ribbed and Paled:* sea, sky, cliffs and birds, as well as a Shakespearean reference.[4] *An Iron Bound Coast* resembles *Ribbed and Paled* even more closely, with its obdurate wall of dark rock rising to the right and thick stormy sky. Its title emphasises the moated geographical isolation that colours the rhetoric of *Cymbeline*. After the Roman envoy has been denied his taxes, Cymbeline's scheming stepson Cloten cannot resist provoking the ambassador further:

> … Make
> pastime with us a day or two, or longer: if
> you seek us afterwards in other terms, you
> shall find us in our salt-water girdle: if you
> beat us out of it, it is yours; if you fall in
> the adventure, our crows shall fare the better
> for you; and there's an end.
>
> (*Cymbeline*, Act III, scene 1)

The 'salt-water girdle' describes a natural enclave, affording strong defence but not necessarily encouraging foreign expansion. In the wake of the emergence of geology as a science, heated debate over the continuing relevance and accuracy of Christian doctrine had heightened the place of symbolism and ideology in landscape painting. The Shakespearean reference underscores Graham's apparent depiction of a Godless world, in which Nature is harsh and merciless and man must struggle for survival as well as self-determination.

Fig. 2, Peter Graham, *An Iron Bound Coast*, 1872, Atkinson Art Gallery Collection, Southport, image © The Atkinson, Southport

The mention of murderous crows, too, would seem to cast the seabirds in *Ribbed and Paled* in a sinister light, but their participation in the scene is much more ambivalent than Cloten's words would suggest. Graham has faithfully represented cormorants, guillemots, kittiwakes and common gulls, all species that colonise Scottish coastal cliffs. Regardless of their alien, almost prehistoric appearance, these birds are the only living creatures depicted, aside from some primitive splashes of lichen on the rocks. Populating an otherwise uninhabitable terrain and gazing out to sea, the birds stand in for human intelligence. Graham, an avid painter of local nature, was likely to be well aware that most seabirds return to one breeding site every year, and gulls tend to mate for life. The birds' connection to place and to one another gives them a fellowship with humanity too, particularly in connection to *Cymbeline* and its preoccupation with political and familial allegiances and betrayals.

Cloten's image of a girded island chimes with another Shakespearean quotation, when Puck promises Oberon, 'I'll put a girdle round about the earth/In forty minutes' (*A Midsummer Night's Dream*, Act II, scene 1). This couplet was frequently alluded to in nineteenth-century commentary on the telegraph, for example in an 1858 poem by T. Buchanan Read: 'Speed, speed, speed the Cable; let it run,/ A loving girdle round the earth,/ Till all the nations 'neath the sun/ Shall be as brothers at one hearth'.[5] This Utopian vision channels the supernatural speed of Puck, in stark contrast to Cloten's girdle as impenetrable moat guarded by aggressive birds.

Shakespeare's girdle, then, facilitates Puck's longitudinal travel, affording frictionless efficiency through its length like electricity passing through a thick copper cable, but in another context (the encirclement of an island) the girdle becomes a moat or barrier to thwart transverse passage. These properties correspond interestingly with the technical functioning of the telegraph cable. The result of minimising resistance along the cable's length was that electromagnetic induction increased, causing distortion of the signal.[6] In this process, the large longitudinal current flow enhanced the electromagnetic field surrounding the cable (a force that was effectively transverse, orbiting the main direction of current). The interaction of current and field produced additional voltage, with the troublesome effect that messages lost their clarity and became difficult to decipher. Such effects had to be mitigated using a variety of means, including the introduction of capacitors.[7] In Graham's paintings, the clashing range of currents suggests something of this complexity and negotiation: not only does the water travel around the coast, but it swirls, splashing and dispersing as it dashes against the rocks. As with electrical induction, these splashes and swirls are liable to increase with the magnitude of the current around the coast.

The tension between free flow and interference also reflects the telegraphic project more generally. Its initiators encountered resistance from cynics, while cable engineers had to grapple with logistical challenges such as difficult terrain and stormy weather as well as electrical resistance and induction, both in laying the cable and in maintaining it as demand increased. The effects of telegraphy, too, involved improvements in some capacities but created new problems in others: for example, communication was much faster, but often less detailed and more vulnerable to error and misinterpretation; and while the telegraph was hailed as an aid to peaceful diplomacy, it equally offered new opportunities for espionage and sabotage.

Ribbed and Paled is an apparently naturalistic portrayal of a wild, stormy landscape, inert to interpretation and resistant to occupation. If the sublime is a landscape suffused with the majestic power of God, Graham's painting evokes a natural world in which God

– like humanity – is conspicuous by His absence. As such it appears to offer an image of consummate resistance to human presence, a world without meaning or purpose; even its portrait format seems to act as a full stop. But resistance can be useful in its obstructiveness. Many electrical devices, such as those for measuring voltage, work using resistance. The violent, impassable water around Graham's coast may look impassable, but it acts as a conduit: it not only demonstrates his skill and dedication as an artist, but participates in a complex and apparently uninhibited flow of meanings. Like Shakespeare's girdle, the picture can be approached as a simple landscape or as a relatively frictionless 'open text'. In promiscuously transcending context and crossing boundaries, this unpeopled scene is inscribed with layers of human association in the form of references to geography, politics, science and literature. The painting's ostensible resistance – from its hostile terrain to the implicit challenges it poses to its audience – nevertheless invites interpretation and extrapolation. Like the telegraphic network as a whole Graham's painting has both a resistant face and layers of fluent connections.

1. The Ngram can be found at http://tinyurl.com/h28hyn7 (consulted 31 August 2016). For an example of 'resistance' used in an imperial context during the 1880s: 'Within these limits British authority is for the time established, and may be maintained by the punishment of offences, including that of resistance to the ruling power'. 'The Hanging Policy', *The Friend of India & Statesman*, no. 2,345 (28 January 1880), p. 78.

2. *Blackwood's Magazine*, vol. 138, no. 837 (July–December 1885).

3. A failed bill to establish Home Rule in Ireland was put to Parliament in 1886. The Indian National Congress was founded by seventy professionals and intellectuals in 1885.

4. The phrase 'Swill'd with the wild and wasteful ocean' occurs in Act III, scene 1 of *Henry V*.

5. T. Buchanan Read, 'The Cable', *The Living Age*, *Third Series*, vol. 2 (July–September 1858), p. 831.

6. For a straightforward definition of electromagnetic induction, see Wikipedia: 'Electromagnetic or magnetic induction is the production of an electromotive force or voltage across an electrical conductor due to its dynamic interaction with a magnetic field'. https://en.wikipedia.org/wiki/Electromagnetic_induction (consulted 1 September 2016).

7. For a straightforward definition of capacitors, see Wikipedia: 'A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to temporarily store electrical energy in an electric field. ... In electric power transmission systems [capacitors] stabilize voltage and power flow'. https://en.wikipedia.org/wiki/Capacitor (consulted 5 September 2016).

RESISTANCE

CASSIE NEWLAND

GUTTA-PERCHA

Gutta-percha is a natural plastic that was employed by telegraph cable manufacturers to insulate the copper core of the cable. It is a tree sap, which when heated becomes plastic and workable into almost any shape. Importantly, gutta-percha retains this new shape as it cools and hardens to a consistency like thick leather. It is thought that the cabinet of curiosities collected by John Tradescant in 1656 contained a sample of gutta-percha described as 'mazer wood' and that 'being warmed in water [it], will work to any form'.[1] From Tradescant's Cabinet to the mid nineteenth century gutta-percha remained nothing more than a little-known curiosity.

Michael Faraday first published observations on the electrical properties (or rather the lack of them) of gutta-percha in a letter to the *Philosophical Magazine* dated 1 March 1848. He finds gutta-percha to be an excellent insulator and suggests multiple uses for it in the manufacture of electrical equipment and the undertaking of electrical experiments.[2] The idea of insulating copper wires with it appears to have been made by William Henry Hatcher, Civil Engineer and Secretary of the Electric Telegraph Company who in 1846 had suggested its possibilities for insulating cable to Charles Vincent Walker, Electrician to the South Eastern Railway company.[3] In 1847 Walker, along with J. & T. Forster and Co., patented a machine which sandwiched copper wire between two fillets of gutta-percha.[4] Walker is also credited with mentioning gutta-perhca's insulating potential to Charles Hancock of the Gutta Percha Company who in 1848 designed a superior machine for covering wires seamlessly through a process of extrusion.[5] Other early adopters were Werner von Siemens, who is credited with insulating an experimental wire with gutta-percha in 1847.[6] These early insulated cables were so effective that gutta-percha became a very sought-after material.

The tree is described as 'a tree of large size, attaining a diameter of 4 to 5 feet, and a height of between 100 and 200 feet… It has large thin buttresses around its base'.[7] It is slow-growing and gutta-percha cannot be harvested until the tree is around 30 years old.[8] Gutta-percha is traditionally harvested by felling the entire tree, rather than tapping as is commonly practiced with other sap-producing trees, such as rubber. The tree is felled several feet from the ground using a *biliong* or axe. The bark of the trunk was then ringed at intervals of approximately 15 to 30cms to allow the latex to run out and the crown removed to encourage the flow. Coconut shells, leaves or a hole in the ground were used to collect the dripping sap. Each tree produced very little (gutta-percha coagulates very quickly on exposure to the air) and the vast majority of the gutta-percha remained undrained inside the trees. Tully estimates that as little as 11 ounces (312g) of latex could be gathered on average from any one tree.[9]

As Collins estimates British imports for 1877 alone as 1.34 million kilograms (approximately 4 million trees)[10] and Sérullas gives the figure for 1891 at a staggering 1.8

million kilograms (5.5 million trees), the traditional method of gathering quickly became unsustainable.[11] Scarcity drove prices through the roof. In 1844, before its discovery by the telegraph industry, gutta-percha was 8 Spanish Dollars per *picul* (60 kilos).[12] By 1848, shortly after its debut as an insulator, it had risen to 13 Spanish Dollars per *picul*. By 1853, after the successes of the first gutta-percha insulated cables the price rocketed to 60 Spanish Dollars per *picul*.[13] The extraordinarily high price that the material commanded meant that every gutta-percha tree was effectively subject to a bounty. Collection soared and the tree was soon facing threats of extinction.

Gutta-percha was extinct on Singapore island by 1847,[14] from Malacca and Selangor by no later than 1875 and from Perak region by 1884.[15] When supplies were exhausted from British territories, the telegraph industry turned to imports from Borneo and Sumatra. In 1879 alone five million trees were cut down for their gutta on the island of Borneo.[16]

But cables were changing the world. Demand continued to soar. The British government, one of the greatest beneficiaries of the submarine cables, found itself increasingly addicted to a product over which it had little influence. Worries were voiced constantly and from the inception of the export industry about the unsustainable nature of the local collecting industry, the lack of foresight and the unmanaged and unmanageable forest system. Future supply problems were predicted 'if some more provident means be not adopted in its collection than that at present in use'.[17] The boom in the cable industry in the 1870s exacerbated the situation leading to calls to action from many writers including Collins,[18] Brannt[19] and telegraph engineer Séligmann-Lui.[20]

The powerhouse of economic botany, Kew, was mobilised into action to search for new sources of the rapidly disappearing plant. It quickly established that gutta-percha trees will only grow, on a narrow strip of land encompassing The Malay peninsular, Sumatra and what was the island of Borneo (today comprising Sabah, Sarawak, Brunei and the various Kalimantans). Once this extremely limited ecological band in which gutta trees grew naturally became known waves of panic spread throughout the telegraph industry.[21] Faced with a finite and rapidly shrinking natural resource the scientists at Kew turned to other, more imaginative means of continuing supply.

Kew requested – and were sent – thousands of specimins of gutta sapplings, leaves and seeds from all over the world. These were then sorted, identified, catalogued and named by William Hooker, Director of the Royal Botanic Gardens, Kew.[22] This allowed the collation and dissemination of information about exactly which species of gutta-producing trees were suitable for use as a telegraph insulator. It also reduced the amount of inferior gums accidentally entering the export market, allowing for identification and assessment of imported gutta samples in terms of their purity and likely properties. The impact

of identifying the correct tree for gutta-collection brought with it more selective felling, further impacting the *Palaquium gutta*.

The network of botanical and experimental Gardens was galvanized into action as Kew sought further regions in which *Palaquium gutta* would grow to increase supply. Seeds of the *Palaquium Gutta* were packed into tins and envelopes and sent out to the far reaches of the Empire. To no avail, in the *List of Economic Plants Native to or Suitable for Cultivation in the British Empire* gutta-percha is still listed as suitable for growing only in the British territory of Malaya and the foreign territories of Sumatra and Java.[23] Kew then attempted to find a suitable substitute tree that *could* be grown in British territories, trying *Bassia parkii* in British Africa, *Mimusops balata* in the Guianas (Royal Botanic Gardens, Kew, 1891) and *Dichopsis elliptica* in India.[24] The Kew Bulletin notes that without exception the gum from these plants failed as potential electrical insulators.[25]

With no good news from Kew, the British Government knew their only hope to maintain supply was to increase British presence in the growing region and create gutta-percha plantations. When gutta-percha first appeared on the market Britain held three, relatively small, trading colonies on the Malay peninsula: Penang Island, Province Wellesley, and Malacca and Singapore; an area of approximately 1276 square miles. Sarawak, on the north-west coast of the island of Borneo was also nominally under British 'White Raja' rule. In 1846 the Sultan of Brunei was persuaded to cede Labuan island off the Sabah coast to the British. In 1874 Pangkor island, the Dindings and Province Wellesley on the Malay peninsula were also ceded to the British. Finally, in 1881 the British North Borneo Company was formed with lands of 30 000 square miles encompassing the present day area of Sabah.

Even with territory established in the growing region, gutta-percha plantations were not easily encouraged. The unsuitability of the tree to less invasive 'tapping' methods and the slow growing nature of the plant ensured that any gutta-percha plantation would not realise any profit on the initial investment until the trees were mature; a delay of at least 30 years. Investors were understandably slow to appear while there existed an exploitable supply in the wild.[26] When prices finally went through the roof, around 1895, plantations became an economically viable prospect for first time. The first was set up by the Dutch in Java in 1895, which produced gutta from 1908.[27] The British followed in 1915 with production coming online in the late 1920s. Plantations were never to become even remotely successful at meeting demand; a case of too little too late.

Running in parallel to this typically imperial government enterprise was a stream of research being carried out in the laboratories of the cable manufacturers. Sérullas, for example, patented a process to recover gutta by macerating fallen leaves and twigs

then treated them with acid to recover the gum.[28] Attempts were also made to replace gutta-percha as an insulation material entirely. Thomas Christy, for example patented a 'bandage of animal glue and glycerine'[29] which could be used to cover cables, while Purcell Taylor invented 'Purcellite', the artificial gutta-percha.[30] Both these substitutes sank without a trace.

The most promising developments came at the turn of the nineteenth century in places such as TELCON. A nascent chemical industry emerged.[31] This industry worked with lower quality (read cheaper and more abundant) guttas. The individual chemical compounds comprising true gutta were slowly identified to provide an ideal recipe of resins, gums and plasticisers. Engineers could then use this recipe to manipulate lower quality guttas, removing unwanted elements and substituting the missing ingredients with ones derived from petrochemicals. More sophisticated understandings of the properties of materials rapidly developed and it was a short journey from manipulating existing materials to the synthesis of entirely new ones. In 1898 the first man-made plastic, polyethylene, was created. It would go on to replace gutta-percha as an electrical insulator. The Malaysian and Indonesian rainforests, having been selectively plundered began a slow decline. The days of gutta-percha were over, a victim of the telegraph engineer's success.

1. Tradescant quoted in T. Oxley, 'Gutta Percha', *Journal of the Indian Archipelago and East Asia* (1847), p. 29.

2. M. Faraday, 'On the use of gutta-percha in electrical insulation', *Philosophical Magazine*, Series 3, vol. 32, no. 214 (1848), p. 165.

3. In the nineteenth century the position of Secretary was the equivalent to our CEO.

4. S. Roberts, *Distant Writing: A History of the Telegraph Companies in Britain between 1838 and 1868* (2006), p.108, http://tinyurl.com/z6syctd (consulted 11 September 2016).

5. S. Roberts, *Distant Writing...* (2006), http://tinyurl.com/jk4fmj8 (consulted 11 September 2016).

6. W. Feldenkirchen, *Werner von Siemens: Inventor and International Enterpreneur* (Columbus Ohio: The Ohio State University Press, 1994), p. 46.

7. J. S. Gamble, 'Gutta Percha Trees of the Malay Peninsula', *Bulletin of Miscellaneous Information, Royal Gardens, Kew*, vol. 4 (1907), pp.113-114.

8. J. Tully, 'A Victorian Ecological Disaster: Imperialism, the Telegraph, and Gutta-Percha', *Journal of World History*, vol. 20, no. 4 (2009), p. 575.

9. Ibid., p. 571.

10. J. Collins, *Report on the Gutta Percha of Commerce* (London: George Allen,1878).

11. E. Sérullas, 'On Gutta Percha', *India Rubber Journal*, vol. 7, no. 6 (1891), p. 162.

12. At the time the Spanish Dollar was the most widely accepted coinage in the region. It remained so until the introduction of the British Trade Dollar in 1895.

13. C. B. Buckley, *An Anecdotal History of Old Times in Singapore* (Singapore: Fraser & Neave, 1902), pp. 405-406.

14. Sérullas, 'On Gutta Percha' (1891), p. 163.

15. Ibid.

16. Ibid.

17. Oxley,'Gutta Percha' (1847), p. 24.

18. Collins, *Report* (1878).

19. W. T. Brannt, *India Rubber, Gutta Percha and Balata* (London: Sampson Low, Marston, 1900), pp. 233-235.

20. Seligman-Lui et al, 'Le gutta-percha au point de vue de la telegraphie sous-marine', *Traite de telegraphie sous-marine* (1888), pp. 69-70.

21. H. L. Terry, *India Rubber and Its Manufacture, with Chapters on Gutta-Percha and Balata* (London: Archibald Constable & Co., 1907), p. 272.

22. Royal Botanic Gardens, Kew, 'Rediscovery of gutta percha tree at Singapore', *Bulletin of Miscellaneous Information CCXIII*, vol. 57 (1891), p. 231.

23. Royal Botanic Gardens, Kew, 'A List of Economic Plants Native or Suitable for Cultivation in the British Empire', *Bulletin of Miscellaneous Information*, vol. 7, no. 8 (1917), p. 263.

24. Royal Botanic Gardens, Kew, 'Indian Gutta Percha', *Bulletin of Miscellaneous Information CCLXXXIV*, vol. 72 (1892), pp. 296-7.

25. Royal Botanic Gardens, Kew, 'Rediscovery of gutta percha tree at Singapore', *Bulletin of Miscellaneous Information CCXIII*, vol. 57 (1891), p. 230.

26. Terry, *India Rubber* (1907), p. 273.

27. Tully, 'Ecological Disaster' (2009), p. 578.

28. Anon., 'Notes on Gutta Percha', *The Engineer* (6 May 1898), p.417.

29. T. Christy, 'A New Material', *India Rubber Journal*, vol. 5, no. 2 (1891), p. 107.

30. P. Taylor, 'Artificial Gutta Percha', *India Rubber Journal*, vol. 6, no. 10 (1890), p. 260.

31. D. Headrick, 'Gutta-percha: A Case of Resource Depletion and International Rivalry', *IEEE Technology and Society Magazine* (1987).

CATALOGUE ENTRY R1 | RESISTANCE

WILLIAM LIONEL WYLLIE (1851 – 1931)

SCENE ON THE LOWER THAMES, 1884

46 X 81 cm
GUILDHALL ART GALLERY, CITY OF LONDON CORPORATION

William Lionel Wyllie was recognized as the leading British marine artist of the late nineteenth century: as one reviewer put it in 1905, 'Mr. Wyllie has…for many years been the leading painter of the lower reaches of the river. He has, indeed, almost reduced them to a symbol'.[1] Wyllie's interest was in the lower Thames estuary where the river runs out of the metropolis and towards the sea. This was the switch point where ships heading out to sea encountered those heading back into the Port of London. Wyllie is interested in the congestion of the working river with its 'vessels of all sizes, of every form and character, from every seaport of the globe'.[2] By the mid nineteenth-century the Thames was alive and bristling with boats, as one contemporary observer recorded: 'the river is crowded with shipping and steamers, and …[a] succession of vessels which affords the voyager so grand an idea of the vast trade of the British metropolis … Here are … the ships that bear "to and fro" the wealth of every civilized nation and people'.[3] Wyllie's first popular success was *Toil, Glitter, Grime and Wealth on the Flowing Tide* (1883), and this exhibition also includes his *Commerce and Sea Power* (1898) [cat. no. D2].[4] His interest in commerce and empire transform his seascapes into history paintings that record the agency of the sea in the industrialization of Britain.

Wyllie's father was the coastal and maritime painter William Morrison Wyllie and he was encouraged to sketch and paint from early childhood. He studied at the Heatherley School of Fine Art and then the Royal Academy Schools, where he won the Turner Medal in his final year. Walter Sickert remarked on his considerable financial success, that '[n]oone ever thought of forming a society to protect the interests of a painter who understands the sea and shipping as does W.L.Wyllie'.[5] Wyllie studied the history of shipbuilding

to help him with his painting, and all his life he was an enthusiastic sailor of yachts and of his barge, *Ladybird*. He was greatly admired for his technical skill in painting: '[Mr. Wyllie] …is in some sort master of the contrasts and conflicts between surface waves and the under-strength of the invincible ocean roll; and he can draw with singular skill a certain heavy, lumpy, storm-wave'.[6] Wyllie's pictures do not etherealize the sea, but rather render it fully material, with its traffic, its smoke and its 'lumpy' waves. His compositions are often concentrated around 'lumps' of congestion on the river. In this *Scene* we see flat low barges being pulled by tugs alongside huge ocean-going ships being steered back into port. The perspective of the painting suggests the funneling of vessels into the city and the sense of difficulty in pushing through the dense water traffic suggests the problem of pushing a force through a resistant medium. This river is less an open channel of communication than a dense succession of material obstructions and potential delays.

Wyllie's scrupulous attention to detail was important to his commercial success and later in his career he established an official connection with the Royal Navy, moved to Portsmouth, and became the Marine Painter to the Royal Yacht Squadron and the Royal Victoria Yacht Club. Alert to the commercial possibilities for artists opened up by the new transport and tourist routes, he worked for many years as an illustrator for the *Graphic* and also designed advertising posters for the big passenger ship companies, including the Orient Company and the White Star Line. He published illustrated books with his wife, Marian, and he was early in taking up the new technologies of colour printing to make his work better known.

CP

1. E.V. Lucas, 'From France to the Thames', *The Speaker: The Liberal Review* (29 July 1905), p. 420.

2. Mr & Mrs S. C. Hall, *The Book of the Thames, From its Rise to its Fall*, (London: Arthur Hall, Virtue, and Co., 1859), p.469. Quoted in Professor John House, 'Monet: The River of Dreams' Gresham College Lecture, Museum of London, (15 March 2010). Transcript at: http://tinyurl.com/hfcvcyj (consulted 26th August 2016).

3. Mr & Mrs S. C. Hall, *The Book of the Thames* (1859), p.469.

4. *Toil, Glitter, Grime and Wealth on the Flowing Tide* (1883) can be viewed at: http://tinyurl.com/juttqeo (consulted 26th August 2016).

5. Walter Sickert, Walter Sickert: *The Complete Writings on Art*, ed. by Anna Gruetzner Robins (Oxford: Oxford University Press, 2000), p.324.

6. Harry V. Barnett, 'By River and Sea', *Magazine of Art*, (January 1884), p.314.

CATALOGUE ENTRY R2 | RESISTANCE

EDWIN LANDSEER (1802–1873)

MAN PROPOSES, GOD DISPOSES, 1864

91.4 X 243.7 cm
ROYAL HOLLOWAY, UNIVERSITY OF LONDON

Landseer's picture was painted in response to the ill-fated 1845 Franklin Expedition to the Canadian Arctic. The ice floes have wrecked the British ship and, '[t]wo hungry bears have come upon the relics of the expedition – a mast, a sail, a telescope. And a flag. One of the savage bears tears the red union jack, the other crunches the ribs of an unfortunate navigator'.[1] By the time he exhibited this picture, Landseer was famous as a painter of animals. He took great pains for this picture, studying polar bears from life at the Regent's Park Zoo in London. His depiction of the eerie reflections and colours in Arctic ice and the sense of the fragility of the wooden ship in this vast and remote landscape made the picture the, 'first for popularity…[t]he foremost picture of all' when it was exhibited at the Royal Academy in 1864.[2] But Landseer's choice of subject was also considered shocking by many.

The renowned explorer, Sir John Franklin, had led two ships and 129 men in 1845 to chart the Northwest Passage in the Canadian Arctic. But the expedition was to end in disaster. In 1854 news finally reached England of the grisly fates of the explorers who had left their ice-bound ships in search of food and starved to death. The native Inuit people reported that the final survivors had eaten their dead colleagues in an attempt to stay alive, even boiling down their bones for marrow. Remains found in the kettles suggested that this could have been true, and recent scientific analysis has since proved it beyond doubt. But in the nineteenth century the rumours of cannibalism were fiercely repressed. Perhaps one of the reasons that Landseer's picture created such a stir when it was first exhibited was because it obliquely invoked this spectre of cannibalism, by its use of the colour red, recalling spilt blood on the ice, and the two masticating bears, one 'crunching a blanched bone'.[3] The critics relished the goriness of the image, describing 'the frozen breath of the beast that crunches up a bleached bone as he sniffs the air with nose turned up in

an ecstasy of brutish relish'.[4] Some of their graphic descriptions even seemed designed to call to mind the possibility of cannibalism that they could not mention directly: 'Sir Edwin goes to the heart of the subject – animal life, ferocity and desolation. The ice even refuses a grave to those who braved its terrors, they are to have a living tomb in the maw of the wild beasts'.[5]

The failure of the Franklin Expedition and subsequent further discoveries of its remains in the 1850s and 1860s were being reported alongside the press reports of the attempts to lay the transatlantic submarine cable so that stories of remote communication and the battle with immense natural forces were vivid in the public imagination at this time. One critic remarked that *Man Proposes, God Disposes* 'pictured the utmost that Nature can do against human life and enterprise'.[6] The picture's title focuses on the hubristic nature of Franklin's attempt to establish a communications route to East Asia between the Atlantic and Pacific Oceans, but also on the grandeur of the ambition. Landseer became increasingly mentally ill throughout his middle age and his painting has been read as becoming correspondingly pessimistic.[7] However this painting suggests an ambivalence about the natural environment widely shared by scientists and artists in the Victorian period. They celebrated the human ability to master nature and to build technology that 'annihilated' distance, but at the same time, increased understanding of the physics of the universe called out a new awe and wonder at its complex and resistant materiality.

CP

1. 'The Royal Academy', *Art Journal* (June 1864), p. 168.

2. W. M. Rossetti, 'Art Exhibitions in London', *The Fine Arts Quarterly Review* (October 1864), p. 22.

3. 'Exhibition Of The Royal Academy', *The Times* (30 April 1864), p. 14.

4. 'The Royal Academy', *London Review of Politics, Society, Literature, Art, and Science* (7 May 1864), p. 487.

5. 'Exhibition Of The Royal Academy', *The Times* (30 April 1864), p. 14.

6. The Royal Academy', *London Review* (1864), p. 487.

7. See Richard Ormond, Joseph J. Rishel and Robin Hamlyn, *Sir Edwin Henry Landseer*, exh. cat. (Philadelphia Museum of Art and Tate Gallery, London: 1982).

CATALOGUE ENTRY R3 | RESISTANCE

JOHN LINNELL (1792 – 1882)

THE TIMBER WAGGON, 1872

103 X 132 cm
GUILDHALL ART GALLERY, CITY OF LONDON CORPORATION

The tree trunks that the workers are heaving onto the wagon are huge, mature and valuable hardwood, probably destined to be used for ship or house building. Despite the figures who look on from the sidelines, including a baby and a dog, the landscape is not one of ease and visibility, but rather a knotted, closely detailed, intricately-patterned environment which is resistant to passive looking and both forces our attention and disperses the viewers' eye uncomfortably across the canvas. In nature, Linnell was said to find, 'a brooding and indwelling presence, some of whose moods might, from time to time, be transferred to canvas'.[1] His insistence on the thick detail of the natural environment springs from his intense, almost visionary, religious belief in the visibility of God in the world. He shared this with his friend William Blake and his son-in-law the artist, Samuel Palmer. The emphasis on the difficulty of the labour of loading and the upcoming difficulty of moving the laden wagon, even with three sturdy horses, insists on the struggle of forging a path and deciphering the meaning of the natural world. The difficulty is reflected in a landscape which is resistant – the clouds which press down on the earth seem as thick and substantial as the brushy undergrowth and the wind-distorted hawthorn bushes. The dirt road is dusty, rutted and stony, and the roots of trees and bushes threaten to snag and delay progress. The strange stylization of Linnell's landscapes was noticed in his lifetime: 'that remarkable quality of Linnell's Art, which, for lack of a better term, I have called his style – a term not commonly applied to design in landscape, but distinctly

apt to the mode of Linnell'.[2] Linnell once remarked that 'painters generally represented the sky as flat, whereas, being concave, and the clouds floating beneath it, they ought to project and show the effects of light on all sides of them…hence arose the sculpturesque fidelity with which he was enabled to depict the scenery of cloud-land'.[3] That he 'sculpts' his clouds as much as his carts makes for this thick, resistant, encroaching landscape of tactile materiality through which the small human figures have to push themselves while constantly running the danger of being tripped, scratched and grazed.

This painting, which Linnell painted when he was eighty years old, recalls his earlier and very successful 'elaborately composed' canvas, *The Timber Waggon* of 1852, which was exhibited at the Royal Academy (no. 456), and the *Exposition Universelle* in Paris in 1853.[4] Linnell made several copies of this first painting and then returned to a similar subject in 1871 and 1872, producing two more differently composed paintings of the same name.[5]

Linnell was never elected to the Royal Academy even though, 'he kept his name among those of the candidates for election for more than thirty years'.[6] The son of an artisan carver and guilder in Bloomsbury, he worked as a jobbing portrait painter and engraver until his landscape paintings gained recognition and sales when he was in his fifties. Late in his life he was asked to stand again for the Academy, but he declined the offer.

CP

1. 'Review of Alfred Story, *The Life of John Linnell*', *Athenaeum* (17 December 1892), p.860.

2. F.G. Stephens, 'The Aims, Studies, and Progress of John Linnell, Painter and Engraver', *Art Journal* (February 1883), p.37.

3. Alfred T. Story, 'John Linnell's Country', *Art Journal* (October 1892), p.305.

4. Ibid., p.304.

5. Information on 1852, 1871 and 1872 versions of *The Timber Waggon* in Appendix to A. Story, *The Life of John Linnell* (London: Bentley and Son, 1892). Available online at http://tinyurl.com/jauk8f5 (consulted 26th August 2016). See also Evan Richard Firestone, 'John Linnell, English Artists: Works, Patrons and Dealers', PhD thesis (University of Wisconsin, 1971), p. 167.

6. 'Review of Alfred Story, *The Life of John Linnell*' (1892), p.861.

CATALOGUE ENTRY R4 | RESISTANCE

JOHN MOGFORD (1821 – 1885)

RIVER SCENE, BEFORE 1885

66 X 97 cm
GUILDHALL ART GALLERY, CITY OF LONDON CORPORATION

River Scene is a picture about blockage, stagnation and resistance. Its confusing topography makes it unclear where the path over the bridge is leading, although it is clear that it has caved in and collapsed just ahead of the heavily-laden donkey. The seeming direction of the path conflicts awkwardly with the lines of the landscape and hills, and the 'river' of the title does not flow but sits in a stagnant pool dammed by a sluice gate. Although the peasant woman and donkey could belong to a pleasantly pastoral scene, this picture is telling us something rather different about the Cornish landscape. A clue is in the clotted red deposit that seems to float on the water's surface, lending it an unhealthy silted-up quality. It seems likely that this water pollution is a result of the Cornish metal mining industry that had reached its peak in the late eighteenth and early nineteenth centuries.[1] Copper and tin were mined all over Cornwall and exported all over the world. By the late nineteenth century, when it is likely that this picture was painted, the Cornish mining industry was in decline and '[i]n the first 6 months of 1875 over 10,000 miners left Cornwall to find work overseas'.[2] Global competition and cheaper extraction of mineral resources elsewhere in the world made the Cornish mines uneconomic.

Mogford's picture, therefore, is not about the power of industry and commerce as are, for example, Wyllie's depictions of the busy Thames. Mogford paints instead the residue of industry, both literally floating in the pooled 'river', and metaphorically, in the poverty and ruination of infrastructure: the sluice gate is decrepit and crumbling, its levers rusted

and its wood bleached, and the road is in a perilously neglected state.[3] The composition has a striking resemblance to twenty-first-century photographic views of the desolate and strangely coloured landscapes resulting from metal mining in Portugal.[4] The picture might be quietly suggesting that Free Trade Liberalism and the opening up of Empire by ship and telegraph creates global competition which can have unforeseen consequences for local economies.

With the appearance of the telegraph and new electrical technologies in the second half of the nineteenth century, the demand for copper accelerated as it is a highly effective electrical conductor. This incentivized the discovery of larger deposits of copper ore in Chile and Peru and the price of copper consequently decreased. Despite the fact that Porthcurno Bay in Cornwall was the landing point for the 1870 underwater cable to Bombay (Mumbai) in India and the site of an important Imperial training college for telegraphy engineers, Cornwall was losing its copper industry.[5]

Mogford shows us the effects on the local of the global. The peasant woman walking slowly with her donkey seems a long way from the state-of-the-art telegraph cabling in operation at this time, but Mogford shows us that the two are in fact connected.

Although he lived in London, Mogford became a regular visitor to Cornwall from 1862 and, between then and his death in 1885, he regularly exhibited both oils and watercolours of Cornish subjects.

Mogford was born in London but his family's background was in Devon. He studied at the Somerset House Government School of Design, and went on to exhibit at the Royal Academy, British Institution and Suffolk Street Gallery. He lived in Hampstead, and became a member of the Institute of Painters in Watercolours. As a day job, he taught at the Maddox Street art school, where his pupils included Emily Mary Osborn, one of the most important artists associated with the campaign for women's rights in the nineteenth century.[6]

1. The plot of the hugely successful BBC remake of the *Poldark* series pivots around Cornish mining in the late eighteenth century. Series One was broadcast in March and April 2015.

2. http://tinyurl.com/jcedchk (consulted 8 September 2016).

3. It is unclear from the internal evidence of the picture whether this is really a 'river'. I have been unable to establish whether Mogford named the painting himself or whether it was given this generic name by dealers. It seems that what may be depicted is an industrial sluice, or a purpose-built sump where mining effluvia was dumped.

4. For example a photograph by Gustavo Veríssimo from Setúbal, Portugal - lagoa vermelha, http://tinyurl.com/j9yzb89 (consulted 8 September 2016).

5. For further information and archive images, see the Porthcurno Museum site: http://telegraphmuseum.org (consulted 8 September 2016).

6. For more information on Emily Mary Osborn, see the Tate Gallery website: http://tinyurl.com/hqawpja (consulted 8 September 2016).

CATALOGUE ENTRY R5 | RESISTANCE

PETER GRAHAM (1836 – 1921)

RIBBED AND PALED IN BY ROCKS UNSCALEABLE AND ROARING WATERS, 1885

158 X 133 cm
GUILDHALL ART GALLERY, CITY OF LONDON CORPORATION

Graham's paintings emphasized the sublime scale of the landscapes they depicted, as critics at the time noticed, '[t]he majestic cliff scenery ... [has] an overwhelming effect of size and height. The grim face of sheer perpendicular rock, rising straight from the ocean's bed, almost made one shudder to look upon - so forbidding, so awful was it in its

stern supremacy'.[1] *Ribbed and Paled In by Rocks Unscaleable and Roaring Waters* is a large canvas that takes its title from Shakespeare's late play, *Cymbeline*. In the play, the English King, Cymbeline, is encouraged by his Queen to break from the Roman Empire and assert England's independence. She asserts the coastal and maritime geography of the British Isles as a defence in itself, recalling Caesar's struggle for a 'kind of conquest' when Britain was invaded by Romans:

> ….his shipping--
> Poor ignorant baubles!-- upon our terrible seas,
> Like egg-shells moved upon their surges, crack'd
> As easily 'gainst our rocks (*Cymbeline*, Act 3, Scene 1)

Graham's picture shows the power of the sea with its treacherous broiling waves and the obdurate granite rocks that prevent access or landing to all but the sea birds who calmly inhabit them. Its double perspective, which shows us the water roaring at the foot of the rocks as well as the tall rock face, is closer to that of a bird in flight than to a human observer. This is a picture of untrammelled nature able to 'crack' boats against her rocks and obliterate the human. Rocks and rough seas made laying submarine cables risky and difficult. On the second attempt to lay the transatlantic cable in 1858, the British cable-ship, the *Agamemnon*, nearly went down in a violent storm. The coil of cable stored in the main hold, 'had begun to get adrift…till some forty or fifty miles were in a hopeless state of tangle, resembling nothing so much as a cargo of live eels, and there was every prospect of the tangle spreading deeper and deeper as the bad weather continued'.[2] The fight with the elements and the ocean was an important part of the ongoing cable-laying drama and Graham's painting reminds us of the immensity of scale of the marine aspect of the undertaking.

By the time of Peter Graham's death in the early twentieth century, his rugged Scottish landscape paintings had fallen out of fashion. The new movements of Impressionism, Post-Impressionism, Cubism, and Futurism made Graham's canvases of Scottish landscapes seem old-fashioned and dull. One of his friends wrote that, '[i]t is the fashion to-day to deride 'Eminent Victorians' and their works. Peter Graham's cattle … have become a jest'.[3] Charles Lewis Hind wrote that by the 1880s, '[f]ew critics troubled themselves to say anything about Peter Graham's pictures of shaggy Highland cattle, in rough Scots weather, with the mist swirling up over the desolate hills. There was nothing to say about them. One picture was like another. Year after year he showed these same shaggy Highland cattle in the same "nasty" Scottish weather'.[4] There was already a certain weariness in the reports of Graham's works in exhibitions in the 1880s and 1890s: 'Mr. Peter Graham, another sea birds' haunt', and, 'Mr. Peter Graham has two very woolly pictures…harsh and crude in colour, and like so many other works by the Academicians, far below the mark.'[5]

But Peter Graham had once been credited with bringing landscape painting back into the repertoire of the Royal Academy. In 1866 he exhibited *A Spate in the Highlands* there and 'created much excitement'.[6] His paintings sold for high sums and were greatly admired for their unwavering fidelity to the Scottish coast and highlands, '[h]e will transport you to some rocky headland where you will feel the salt spray in your face, you will hear the call of the gulls as they sweep the waves, and watch the storm gather in the West'.[7] Born in Edinburgh and trained at the Edinburgh School of Art, Graham, 'brought home to the toilers in the cities aspects of the Highlands which had never before been depicted in paint, and with which the vast majority of people of this country were unfamiliar'.[8]

CP

1. This is a description of Graham's 1872 painting, *The Cradle of the Sea-Bird*. W.W. Fenn, 'Our Living Artists: Peter Graham', *Magazine of Art* (January 1879): p. 146.

2. 'Laying the Atlantic Telegraph Cable', *Illustrated London News* (31 July 1858), p. 111. On this second attempt, the worst storm the expedition encountered was on 20 and 21 June and the *Agamemnon* nearly went down.

3. Margaret Sparrow, 'The Pictures of Peter Graham', *Saturday Review* (5 November 1921), p. 532.

4. Charles Lewis Hind, *Landscape Painting, from Giotto to the Present Day*, 2 vols, (New York: C. Scribner's Sons, 1924), vol. 2, p.121.

5. 'Art in March', *Magazine of Art* (January 1885): p. [xxi]; 'The Picture Galleries-IV', *Saturday Review* 57 (31 May 1884), p.713.

6. W.W. Fenn, 'Our Living Artists: Peter Graham', *Magazine of Art* (January 1879): p.144. *A Spate in the Highlands* (1866, Manchester Art Gallery) can be viewed at: http://artuk.org/discover/artworks/a-spate-in-the-highlands-205094

7. Sparrow, 'The Pictures of Peter Graham' (1921), p. 533.

8. W. Matthews Gilbert, *The Life and Work of Peter Graham*, R.A. (London: The Art Journal Office 1899) / *Art Annual* 1899, p. 24.

CATALOGUE ENTRY R6 | RESISTANCE

THOMAS HOPE MCLACHLAN (1845 – 1897)

THE ISLES OF THE SEA, 1894

71 X 127 cm
GUILDHALL ART GALLERY, CITY OF LONDON CORPORATION

The title of McLachlan's canvas makes us wonder about the difference between land and water because the sea is painted to look as substantial as the rocks. The waves seem clotted and heavy, creating a substantial mass that looks difficult to traverse or travel through. The 'charm and subtlety of Mr. McLachlan's colour and tone' was noticed by critics at the time, along with his 'fondness for and power of depicting large spaces of sky, especially when heavy masses of cloud move swiftly across … Mr. McLachlan also has the gift (it is no very common one) of conveying to us a sense of solidity, of actual physical weight'.[1] Like other paintings in the 'Resistance' section of the exhibition, McLachlan's investigate the materiality of the physical world and ways in which its solidity both invites and impedes human passage. But McLachlan's paintings are also marked by a greater abstraction than others in this section. While his paintings show the influence of the Pre-Raphaelites, particularly Dante Gabriel Rossetti, and of the Barbizon painters, including Jean-François Millet, he is more involved with colour, form and light at an abstract level than these painters.

'Above all things, he had design', announced one critic. McLachlan's later work was innovative in the way it moved away from 'realist' narrative.[2] Only a few critics discerned the novelty and originality of the landscapes that were 'skied' at the Royal Academy shows and appreciated McLachlan's ability to paint 'a picture which tells no story, a very quiet picture in its motive, colour, tone'.[3] These critics recognized McLachlan's intense, meditative inhabitation of his landscapes and seascapes: '[w]e see it in such a piece as "Ships that Pass in the Night", where the intensity of the starry sky seen between the breaks of the drifting clouds and the depth of tone in the purple sea are rendered not only with

truth, but with a sense of profundity and mystery which lifts the picture into the region of the imagination'.[4] Similarly, in *Isles of the Sea* McLachlan produces a mythologized almost magical landscape. The intense blues and yellows make us see the sea anew, not as a 'seascape' but as a strange viscous substance in motion under its own laws. The direction and motion of the water around the rocks suggests the treacherous depths below. In the 'gigantic undertaking' of laying the transatlantic cable, telegraph engineers conducted exhaustive depth soundings to establish the best route for the cable, avoiding rocks and reefs. They were surprised to discover what they called 'The Telegraph Plateau'. This was 'a great flat or level at the bottom of the ocean, unparalleled by anything on the surface of the earth … it appears as if nature had provided a bed "soft as a snowbank", … for the express purpose of receiving a telegraphic cable'.[5] In reality, it proved much more difficult to lay the cable than such providential language suggested.

McLachlan would probably be much better known today if he had not died young, suddenly and unexpectedly when he was only 52 years old. He was born in Darlington and educated at Merchiston Castle School, Edinburgh and then Trinity College Cambridge, where he came first in the Moral Science Tripos. He came to London and entered as a law student at Lincoln's Inn, was called to the Bar and practiced at Court of Chancery for some years before leaving the law to devote himself to painting.[6] In the 1890s, McLachlan's work was favourably compared to that of Peter Graham, as Graham was seen to be 'monotonously repeating his familiar Highland cattle and mountain scenery'. We can compare the styles of the two painters in this section of the exhibition.[7]

CP

1. Selwyn Image, 'Thomas Hope McLachlan', *The Magazine of Art* (January 1895), p. 57 and p. 62.

2. Herbert P. Horne, 'Thomas Hope McLachlan', *Saturday Review* (12 June 1897), p. 656.

3. Image, 'McLachlan' (1897), p. 57. Herbert P. Horne describes how McLachlan's canvases were 'skied' at the Academy exhibitions and Stanley Jas regretted that the 'lisping senilities' of the Royal Academy 'gave him scant encouragement during his lifetime', Horne, 'McLachlan' (1897), p. 655. Stanley Jas, 'The Art Exhibitions and their Lessons', *New Century Review* (June 1897), p. 442 and p. 452.

4. Horne, 'McLachlan' (1897), p .656.

5. 'The Recent Soundings for the Atlantic Telegraph', *Illustrated London News* (13 September 1856), p. 267.

6. Information from Horne, 'McLachlan' (1897), p. 656.

7. Jas, 'The Art Exhibitions' (1897), p. 450.

CATALOGUE ENTRY R7 | RESISTANCE

CHARLES WHEATSTONE'S WHEATSTONE BRIDGE

KING'S COLLEGE LONDON ARCHIVES. K/PP107/11/2/1

Of the many inventions that bear Charles Wheatstone's name, the Wheatstone Bridge is perhaps the best known. This is slightly ironic as it was in fact not devised by Wheatstone himself but by Samuel Hunter Christie.

Christie was interested in how the electrical and magnetic properties of a metal varied with mass and dimensions. He constructed a circuit to allow him to measure the electrical resistance (though he called it Magneto-electric induction) of wires of different thicknesses. In the 1833 lecture to the Royal Society in which he displayed the circuit, he called it the Diamond method, referring to the shape made by the wires.[1]

The diamond can be imagined as having two parts, the uppermost two wires (called 'legs') comprising one part, the lower two 'legs' the other. Across the middle of the circuit, joining these two parts is a bridging wire into which a galvanometer is connected. Galvanometers detect the flow of electricity. If the top part and the bottom part of the circuit are balanced (i.e. they have the same resistance) then no electricity will flow across the bridging wire and the galvanometer will stay at zero. If the two halves are unbalanced - if one part has a higher resistance than the other - then electricity will flow across the bridge and

be detected by the galvanometer. Importantly, if you know the resistance of three of the 'legs' you can work out the resistance in an unknown fourth one.

The Diamond method - though an interesting experiment - languished as a footnote in a paper about magnetism for ten years until 1843, when Charles Wheatstone (with his usual inventive pragmatism) saw the potential in it. In a lecture he delivered at the Royal Society (in which he fully cited Christie as the originator of the circuit) Wheatstone outlined several applications.[2] First, you could connect up far more useful things to the 'unknown' leg of the circuit than different bits of copper wire. You could connect it up to telegraph lines, submarine cables, electrical circuits, even entire telegraphic instruments and measure their resistance. This observation meant that, for the first time, telegraph engineers had a way to measure the electrical efficiency of their designs; an insight into how to hone and perfect their materials and apparatus. They could see the effect of impurities on the conductivity of copper wires, the extra capacitance effects of a thick insulation, or the resistance of a particular design of switch.

Moreover, it was suddenly possible to see the effects of other forces on telegraph equipment. For example, the same piece of cable could be tested at different temperatures or pressures to gauge the effect of the environment on it. The most important realisation - and perhaps the factor which best explains why it is Wheatstone who is remembered for his Bridge rather than Christie for his Diamond – Wheatstone pointed out that the galvanometer is not just as an instrument for measuring resistance. It can be used to measure any number of things including inductance, capacitance, impedance and frequency (including radio frequency). Wheatstone's observations led others to modify the Bridge and push it to new heights of usefulness. Indeed, William Thomson, gave his name to a modified form of the bridge, the Kelvin Bridge, which when hooked up to the incredibly sensitive mirror galvanometer, allowed him to continually monitor the electrical condition of the 1865 and 1866 Atlantic cables.[3]

CN

1. S. H. Christie, 'Bakerian Lecture: Experimental Determination of the laws of Magneto-electric Induction in different masses of the same metal, and its intensity in different metals', *Philosophical Transactions of the Royal Society of London*, vol. 123 (1833).

2. C. Wheatstone, 'Bakerian Lecture: An Account of Several New Instruments and Processes for Determining the Constant of a Voltaic circuit', *Philosophical Transactions of the Royal Society of London*, vol. 133 (1843).

3. M. Trainer, 'The Patents of William Thomson Lord Kelvin', *World Patent Information*, vol. 26, (Elsevier Ltd, 2004), http://tinyurl.com/hv4c2lk (consulted 4 September 2016).

CATALOGUE ENTRY R8 | RESISTANCE

RESISTANCE BOX

KING'S COLLEGE LONDON ARCHIVES. K/PP107/11/1/19

The resistance box is an interesting object. It is interesting because, unlike its more famous lab-bench counterparts (for example, the Daniell cell or galvanometer), very little is known about its origins or originator. Wheatstone is certainly using a 'variable resistor' to control the known but variable 'leg' of his Wheatstone bridge in 1843, though we don't know what this looked like.[1] The 'variable resistor' appears again in Kelvin's 1858 patent drawing for the marine galvanometer but as a set of spools in an open box.[2] Neither appear to have been as sophisticated as the box in the exhibition. We can, however, use what we know about the box to determine its probable use.

It is built solidly from well-used light oak. A deep, hinged lid reveals a brass plate set across the top half of the upper surface. The plate is split into eight rectangles. The outer two rectangles sport positive and negative terminal screws respectively. Each of the six inner rectangles is separated from the next by a gap of a few millimetres with a round hole in the centre, in which sits a brass peg.

Inside the box beneath the holes are hand-wound resistors. Wire (probably of German Silver, 60% copper, 25% zinc, 15% nickel) of an exact length and mass is wrapped around

a ceramic bobbin to give a known resistance.[3] Each of the resistors is connected to the next by a thin wire. When a peg is inserted into the hole above, it short-circuits the small connecting wire, and removes that resistor from the circuit. The idea of the instrument is that a piece of electrical equipment can be connected to the outer terminals and the pegs placed in the mileage holes to create any electrical resistance. In the lower, wooden half of the surface there are six holes in the wood to receive any unused pegs.

Resistance boxes were used for many different kinds of lab work as well as for activities of electrical and telegraphic engineers, however the construction of the box gives us some clues to its purpose and origin. The brass rectangles are marked 1, 2, 4, 8, 16 and 32 miles respectively, meaning that its purpose is to create resistances in miles rather than ohms. This suggests an application in telegraphy, rather than bench-based lab work. Submarine telegraphy is ruled out as a maximum of 63 miles resistance would be insufficient for most submarine systems. Certain possibilities are suggested.

The box could have been used to replicate 'real' conditions for the testing of prototype telegraphic equipment in the lab. Or it could be used to balance the resistance on the 'dummy' circuit used in Duplex telegraphy (where messages can be sent in both directions on a line simultaneously). However, the rugged, portable design (and well-used condition of the box) suggests it was carried around from place to place by engineers who needed to know about (a fairly limited number of) miles of resistance. In other words, fault finding.

When a line has a fault, engineers carry out a resistance check. The terminals of the resistance box are connected up to the variable resistance leg of a Wheatstone bridge. The faulty line is then connected up to the 'unknown' leg of the bridge. Pegs are placed in the holes of the resistance box until the resistance of the faulty wire and the resistance of the pegs are equal. Engineers can then be dispatched to the number of miles down the line as indicated by the resistance box and the fault repaired.

CN

1. C. Wheatstone, 'Bakerian Lecture: An Account of Several New Instruments and Processes for Determining the Constant of a Voltaic circuit', *Philosophical Transactions of the Royal Society of London*, vol. 133 (1843).

2. M. Trainer, 'The Patents of William Thomson Lord Kelvin', *World Patent Information*, vol. 26 (2004), http://documentslide.com/download/link/the-patents-of-william-thomson-lord-kelvin (accessed 22/08/2016).

3. Anon., *Laboratory Instruments and Measurements: Book 14* (New York: The Electrical Engineer Institute of Correspondence, 1904).