NAVIGATING (THROUGH) SOUND. AUDITORY INTERFACES IN MARITIME NAVIGATION PRACTICE, 1900–1930

By Christoph Borbach

"THE most common-place and often one of the most urgent of the problems which confront the sailor is the determination of his position upon near approach to the coast. [...] The special difficulties sometimes attending the solution of this problem are known only to those who have endeavoured to make a landfall or pick up a lightship in wild or thick weather or in the calm obscurity of a fog."

– *John Joly, Scientific signalling and safety at sea.* The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science *36 (1918), pp. 1–35, here p. 1.*

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From Sight to Sound

On October 6, 1920, in the waters off the east coast of the United States, a simulation took place as a part of a public demonstration. What was simulated was fog, the 'old enemy of ship navigation,' with its interfering effects on safe pathfinding. The aim was to demonstrate that this crucial, nature-induced influence on navigation had now been media-technically overcome. A ship, the destroyer *USS Semmes*, was entering Ambrose Channel, which is the central entrance to the harbour of New York and New Jersey. The windows of the ship's bridge were veiled with canvas so that the ship's navigator couldn't obtain any visual information from the surrounding. Put differently, the simulation took away his hitherto-essential knowledge of how to navigate. He nevertheless was able to guide his ship into the channel entrance and along the harbour with a newly designed interface with which he was *listening*–an ability that had formerly been of mere subordinate importance for him–to the signals of a so-called leader cable. The demonstration ended successfully and proved that, with this new auditory interface, safe navigation in times of little or no visibility had been become a hearing operation. A contemporary witness in December 1920 euphorically described the experiment by focusing on the newly discovered importance of hearing for navigational purposes as follows:

> *A few weeks ago a U.S. destroyer sailed up into the port of New York in an artificial fog. The 'fog' was formed by stretching a sheet of canvas in front of the navigator's bridge so that the pilot could not see the buoys that marked the Ambrose Channel, and yet the vessel kept faithfully to a true course. The pilot did not need to use his eyes, because he was looking through his ears; in fact, a totally blind man would probably have guided the vessel even more accurately, because of his keener and more sensitive hearing.*[1]

Auditory Interfaces

An interface, which is not only the connection between two entities such as machine/machine or human/machine, but also a specific medium for representation, is not restricted to visual displays. Media research, on the other hand, often only focusses on human-computer interfaces, and this discourse, in turn, is marked by a kind of 'screen essentialism.' Representatives from the field such as Matthew Kirschenbaum have acknowledged the tendency in media studies to focus almost exclusively on "the phenomenological" side of media, which is, in most cases, the "digital event on the screen"[2]–that is, everything what can

1 A. Russell Bond, The radio pilot-cable. *St. Nicholas* 48 [2] (1920), pp. 173–174, here p. 173.

2 Matthew G. Kirschenbaum, *Mechanisms* (Cambridge, MA 2008), p. 4. In this regard, see also Jan Distelmeyer's paper "Drawing Connections" in the first volume of this journal, in which he states that "[g]raphical user interfaces are but one of the multilayered aspects characterizing interfaces [...]." Jan Distelmeyer,

be seen—but not on the underlying code structure of, for example, digital images.

However, screen essentialism is not restricted to the study of digital objects but can also be identified in interface research. Most of the current interface research is aimed at visual effects and most papers on the history of interfaces concentrate implicitly or explicitly on their visual constitution, haptics, and design.[3] This has a technical cause, since most media actually base their operability and human-machine interaction on the crucial aspect of visual displays, as Erkki Huhtamo argued when he proposed the term "screenology" for a field of research that focusses on screens as "information surfaces."[4]

Research into auditory interfaces and into their history from the perspective of the humanities remains a scientific lacuna.[5] This paper partly addresses this gap, since it focusses historically on sonic interfaces within maritime navigation practices that were theoretically conceptualised around 1900 and later realised, but which became obsolete around 1930 when they were replaced with optical wayfinding techniques. Taking two case studies as examples—so-called "leader cables" and the infrastructure of "submarine signalling"—it can be shown that certain navigational media for seafaring addressed the human as a listener, thus evoking elaborate forms of hearing practices for navigational purposes.[6]

Newer navigation media, so-called Personal or Portable Navigation Devices (PNDs) by prominent corporations such as Garmin, TomTom or Magellan, or software, for example, Google Maps, include additional auditory indications, but these are verbal in any case (they give auditory information such as 'turn left in 100 metres'). The interesting fact about the auditory interfaces that this paper deals with, is that they communicated information by nontextual and nonverbal means and that their acoustic channel was not an addition to a visual-based navigation but its sole way of communicating navigationally important information. This is not only of interest from an interface perspective, but also from the perspective of the history of technology, media history, media archaeology, sound studies, and the history of acoustic knowledge. Interestingly, the sonic interfaces that allowed for navigation using sound and their

Drawing connections – How interfaces matter. *Interface Critique Journal* 1 (2018); http://interfacecritique.net/journal/volume-1/distelmeyer-drawing-connections, access: October 11, 2018, 2:18pm.

3 See for example Erkki Huhtamo, Elements of screenology. Navigationen. *Zeitschrift für Medien- und Kulturwissenschaften* 6/2 (2006), pp. 31–64; Lev Manovich, Towards an archaeology of the computer screen, in: *Cinema futures*, ed. Thomas Elsaesser (Amsterdam 1998), pp. 27–43; Lev Manovich, *The language of new media* (Cambridge, MA. 2001), esp. pp. 94–111; Anna Friedberg, *The virtual window* (Cambridge, MA. 2009); Sabine Wirth, To interface (a computer), in: *Sichtbarkeiten 2*, ed. Martin Beck (Zürich 2004), pp. 151–166.

4 Huhtamo, Screenology, pp. 31–32.

5 The anthology with the programmatic title Auditory display. Sonification, audification, and auditory interfaces deals comprehensively with fundamental issues of auditory interfaces, but lacks a historical reflection or more theoretical investigation or contextualisation. See Gregory Kramer (ed.), *Auditory display* (Reading 1994).

6 I owe thanks to Asher Boersma, Jan Distelmeyer and especially to Timo Kaerlein for fruitful discussions, literature advices and the workshop "Interface-Geschichten" that took place in May 2018 at the university of Paderborn.

systematic infra-structuring has not yet been investigated, which is even more surprising since these infrastructures reconfigured seafaring practice between 1900 and 1930. Due to this fact, this paper is based exclusively on primary materials for the investigation of both technologies.

This paper first focusses on leader cables and then on submarine signalling. For both technologies, I will explain their general principles, focus on their interfaces and describe how important and widespread they became. Finally, I will make some concluding remarks about the status of their interfaces.

Sonifying Electricity: Leader Cables

Electric current in cables has as effect the electromagnetic field around the cable. Until about 1900, this electromagnetic field was considered an unwanted but unavoidable physical phenomenon, something that had to be inevitably accepted. The concept of leader cables, however, turned this allegedly useless by-product of electric transmission in cables into a strategy. In general, a leader cable is an isolated electrical cable that is laid at the bottom of a channel, harbour entrance, or difficult passage point along a course that a ship might take. The sea end of the cable must be earthed and the other end of the cable connected to a transmitting station where alternating current is induced. When this cable is electrified, a ship with appropriate receiver technology is able to pick up its electromagnetic field and follow the cable, so that the ship's navigator doesn't need to have any visual indications from the outside. This principle proves practical in fog and heavy rain, when usual navigation aids such as buoys, light vessels, landmarks, and lighthouses fail.

Put differently, the electrical cable in the leader cable system does not serve as a transmission means – as is usual – but fulfils its purpose in an autotelic manner. The cable is not a passive vector for sending electrical signals from one point to another, and it is not the condition for communication, rather the leader cable's electric charge has an end in itself. Referring to Friedrich Kittler's identification of three basal media functions–storage, transmission, and processing–the cable in this system does not transmit electricity but stores it insofar it spreads electricity spatially.

Since the frequency of alternating current in a cable corresponds with its electromagnetic field, this field can be rendered audible with an appropriate receiver and a telephone, if the frequency of the electric current lies within the area of human perception. A ship's navigator who wished to navigate with a leader cable needed to install two coils of wire as receivers for the electromagnetic field–one located on either side of the ship, viz. starboard and port side, respectively. These coils were connected to an amplifier and finally to an interface which was located on the vessel's bridge or

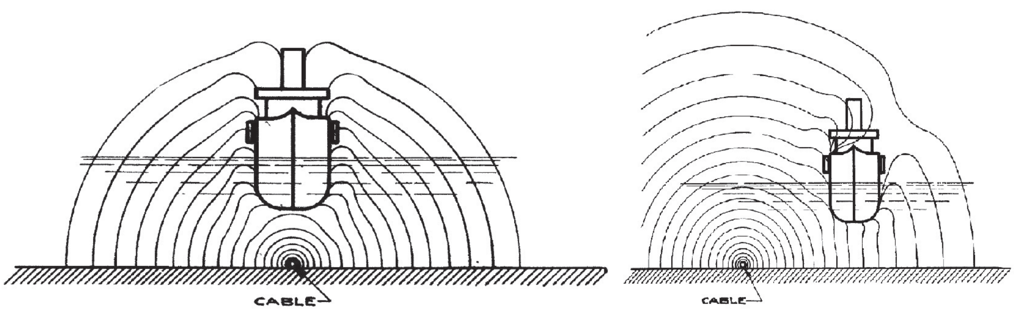

Fig. 1: Principle of cable navigation as illustrated in 1921.

chart room, where the navigator operated. As figure 1 shows, when a ship with receiving instruments was near the cable, the electromagnetic field of the cable was received more strongly by the starboard coil when the cable was on starboard side and vice versa, and the ship was directly above the cable when both coils received the electromagnetic field with equal strength.

Of special interest is the interface with which a navigator was able to differentiate on which side of the ship the leader cable lay. The interface consisted, basically, of a telephone with two earpieces, which could be connected with a change-over switch to *either* the starboard *or* port receiver. Since the received strength of the electromagnetic field corresponds indexically with the loudness of the tone in the telephone, a navigator could determine the ship's relative position to the leader cable by comparing loudness: If the tone was perceived louder when the starboard receiver was connected to the telephone, the cable laid on starboard side, and vice versa. In this setting, the in other respects mostly useless or even unwanted phenomenon of the electromagnetic field around electrified cables transformed normal cables into a means for safe pathfinding which was realised through an auditory interface. Put differently, the interface translated navigation into the realm of tonality as it had already been pointed out in contemporary literature in 1921, which also indicated the newly implemented tonality of navigation: "In the telephones the signals given out by the cable are heard as a sharply pitched musical note."[7] The enormous significance of the auditory interface also played a central role in the contemporary coverage of leader cables. For example, after the above-mentioned simulation of fog that proved the system's efficiency, the New York Times wrote: "Ship Steered Entirely by Sound."[8]

The acoustic interface of the leader cable system can be seen as a strategic misuse of the telephone, since standard telephone receivers proved to be absolutely sufficient for hearing the cable's electromagnetic field after it is amplified. Thus, in this setting the telephone was not used for the purpose of two-way communication, but as a listening-only medium that interfaced human ears with the presence of an electromagnetic field. In

7 Anonymous, The leader cable system. *Nature* 106 (1921), pp. 760–762, here p. 760.

8 Anonymous, Warship guided into port by radio piloting cable. The New York Times, October 7, 1920, pp. 1 and 6, here p. 1.

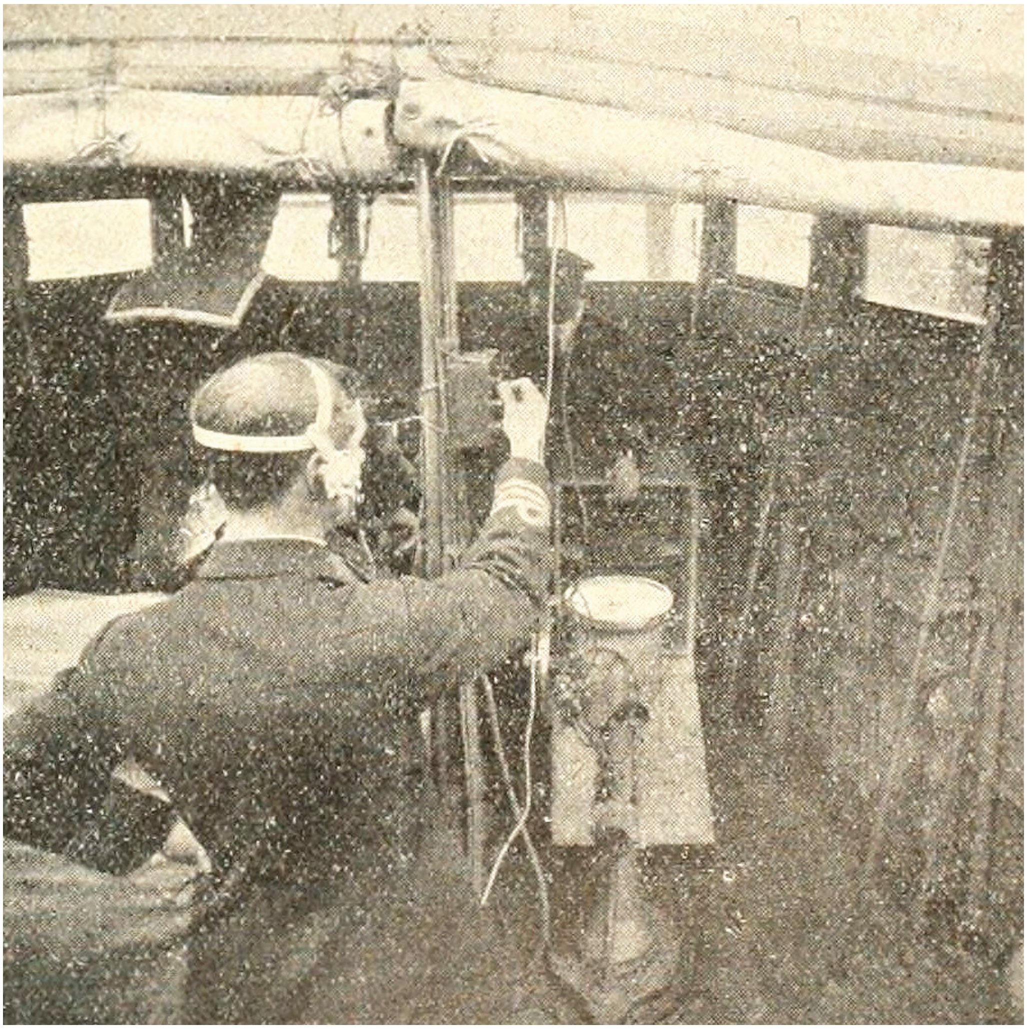

Fig. 2: Officer on a ship's bridge operating the change-over switch for navigating with a leader cable.

this new utilisation of telephone technology, the telephone is not meant to be a medium for semantic communication but to function as a part of an interface that makes otherwise imperceptible signal rooms sensible to humans: The telephone functioned as sensor for the electromagnetic field. Leader cables are thus the first technology to employ sonification–that is the conversion of something non-sonic into acoustic waves–for the purpose of maritime navigation.

The basic principle of the leader cable dates back to Robert Owens, a former Professor of Electrical Engineering at McGill University, who started research into the domain of cable navigation around 1900. In March 1902, he applied for a patent for an "Apparatus for Ascertaining Position Relative to a Prearranged Guiding System"[9] that

9 US patent no. 736,432. Application filed March 11, 1902, patented August 18, 1903.

proposes to translate maritime navigation practices into hearing operations. Owens, with his colleague L. H. Herdt, operated a trial installation of a leader cable, which was about ten miles in length, in the Canadian St. Lawrence River. This experimental cable was indeed unsuccessful, mainly because amplifiers were not available at that time, meaning that the electromagnetic field could not be heard in the telephone.[10]

The first vacuum tube for amplification was not invented until 1906 by radio pioneer Lee De Forest and was put into practical operation around 1912. During the First World War, when in the discourse of radio technology amplifiers came into broader practical use, several states took up the idea of leader cables, but it is hard to historically reconstruct these first implementations. It is understood, that in Germany, one cable was used for secure navigation through mined fields. It was laid from the island of Borkum in the North Sea and was 120 nautical miles in length (about 222km).[11] Also, leader cables came into use in British and French harbours.[12] The first leader cables for non-military purposes were used around 1920, for example for the harbour entrances to Portsmouth, Cherbourg, Brest, and New York, with lengths varying from 20km to 100km.[13]

All these leader cables were implemented to keep harbour entrances passable in cases of fog or heavy rain, since fog turned out to cause severe financial problems for merchant shipping. For example, ship navigators were not allowed to enter the Ambrose Channel in foggy weather until sight improved. The resulting shipping delays caused losses of $500 to $4,000 per hour, depending on the ship and its cargo, whereas the receiver technology for the leader cable cost only $1,000[14] and thus was a profound investment. Furthermore, the leader cables proved to be very efficient as amplifier technology progressed. The Portsmouth leader cable, for example, could be used for precision navigation in 1920 even when it was 500 yards (about 457 metres) away from a ship,[15] and a German report stated one year later, in 1921, that leader cables could be made audible at a distance of 0.75 nautical miles (about 1.4km).[16]

10 C. V. Drysdale, The eleventh Kelvin lecture. *Journal of the Institution of Electrical Engineers* 58/293 (1920), pp. 572–597, here p. 582.

11 Johannes Müller and Joseph Krauß, *Hilfsbuch für die Schiffsführung* (Berlin and Heidelberg 1925), p. 115.

12 A. S. Eve, McGill, Physics and the War. *The McGill News* 2/1 (1920), pp. 5 and 37, here p. 37.

13 BArch R 4701 (Reichspostministerium)/35339.

14 Donald Wilhelm, The audio piloting cable in the ambrose channel. *Radio Broadcast* 1/3 (1922), pp. 249–251, here p. 249.

15 Anonymous, The Portsmouth leader cable. *The Electrical Review* 86 [2209] (1920), p. 392.

16 BArch R 4701 (Reichspostministerium)/35339.

Sonic Ecology: Submarine Signalling

The leader cable system, however, was neither the only nor the first technology for maritime navigation that used auditory interfaces. The first interfaces for sonic wayfinding were used in "submarine signalling," which is not a term that denotes techniques of underwater communication in general, but which refers to a geographically situated submarine infrastructure for the transmission and receiving of underwater signals. Submarine signalling can be seen both as a kind of early warning system (warning ships of their proximity to dangerous coasts or passage points) and a navigation system in the case of thick weather when navigation by visual means is not possible any longer.

Artificial visual aids to navigation are as old as seafaring itself and are, basically, lighthouses, fire beacons, light vessels, and light buoys. However, these marks only served their purpose in clear weather and were useless in thick weather, especially in fog. Since about the middle of the 19th century, acoustic warnings were explored as a more efficient means of guiding vessels in fog. Examples are sirens, gun-cotton detonations, trumpets, steam whistles, and bells with which lighthouses or lightships were equipped in order to function as fog signal stations. However, the transmission of sound in air depends heavily on meteorological conditions such as rain and fog, so aerial fog signals could not be heard over long distances and the position from which the signals were sent out could not always be distinguished. This unreliability of air as medium for the transmission of sound signals shifted the research into early warning signals for maritime navigation at the end of the 19th century to the water itself, since the good conductivity of water as a medium for the transmission of sound had been known ever since the experiments of Charles-François Sturm and Jean-Daniel Colladon at Lake Geneva in 1826. Put in the words of 1910, water is the ideal 'agency for sound transmission': "Water is a less mobile medium than air, less responsive to marked variations of density arising through changes in temperature and pressure, and, therefore less subject to variations of homogeneity and more reliable as an agency of the transmission of sound waves."[17]

As a transmitter for submarine signals, underwater bells proved to be effective. However, the problem with the ocean, as a newly discovered signal space around 1900, was that the ocean surface functions as a kind of natural boundary that the underwater bell signals only cross to an extremely slight degree (in this respect it is worth mentioning that Branden Hookway has pointed out that such boundary conditions of fluids were called interfaces in the 19th century, from

17 Albert A. Hopkins (ed.), *The Scientific American Handbook of Travel* (New York 1910), p. 210.

which our modern interpretation of the term stems)[18]. In other words, it became necessary to use a technical interface to overcome the characteristics of the natural interface. Borrowing the terminology of Frieder Nake[19] and putting it in provoking terms, a technical interface had to be constructed as a connecting system that hardwired *surface* (of the ocean on which the human operator navigates) and *subface* (the fluid realm of ocean water in which acoustic signals propagate).

In 1898, Arthur Mundy and Elisha Gray, the co-inventor of the telephone, suggested a system and received a patent for it that used underwater bells as transmitters for maritime navigation. As its receiver and interface, the system used a new technology of its day: telephones and sensitive underwater microphones.[20] In September 1901, Mundy founded the Submarine Signal Company (SSC)–which was the first association to commercialise submarine acoustics–to market the technology for this system.[21] Already in the same year, the first underwater bell in service was laid down at Egg Rock, near Boston Harbour, where the SSC had its office. After the US government performed tests between the harbours of Boston and New York using equipment that had been developed by the SSC, submarine signalling as a navigation practice was established that year in the US. It continuously expanded in the following years, with underwater bells near lighthouses, on fire ships and light buoys, all of which were operated pneumatically or electrically (that is to say, submarine signalling was implemented below the already existing infrastructure that visual navigation had put up and was meant to compensate for its qualitative defects in cases like fog or heavy rain).

The British Admiralty tested the submarine signalling system in 1906 and reported that the "submarine bell increases the range at which the fog signal can be heard by a vessel, until it approximates to the range of a light-vessel's light in clear weather, and moreover its bearing can be determined with quite sufficient accuracy for safe navigation in fog, from distances far beyond the range of aerial fog signals if the vessel is equipped with receivers."[22]

Of crucial importance is this last clause, "if the vessel is equipped with receivers," which points to the critical module that materialises the condition of access to the submarine signals: the interface. For a navigator to operate his ship with submarine signals, the ship had to have, inside its hull on either side–starboard and portside, respectively–near the bow and below the water line, a small cast-iron tank filled with water, in which two microphones were placed (two, so that

18 Branden Hookway, *Interface* (Cambridge, MA. 2014), pp. 59–67.

19 Frieder Nake, Surface, interface, subface, in: *Paradoxes of interactivity*, ed. Uwe Seifert (Bielefeld 2008), pp. 92–109.

20 Elisha Gray and Arthur J. Mundy, Transmission of sound (US patent no. 635,519. Application filed April 14, 1899, patented November 7, 1898).

21 The right to sell and install the equipment was at all times exclusively owned by the SSC and their cooperating companies such as the German Atlas-Werke.

22 Cited after Joly, Scientific signalling, p. 9.

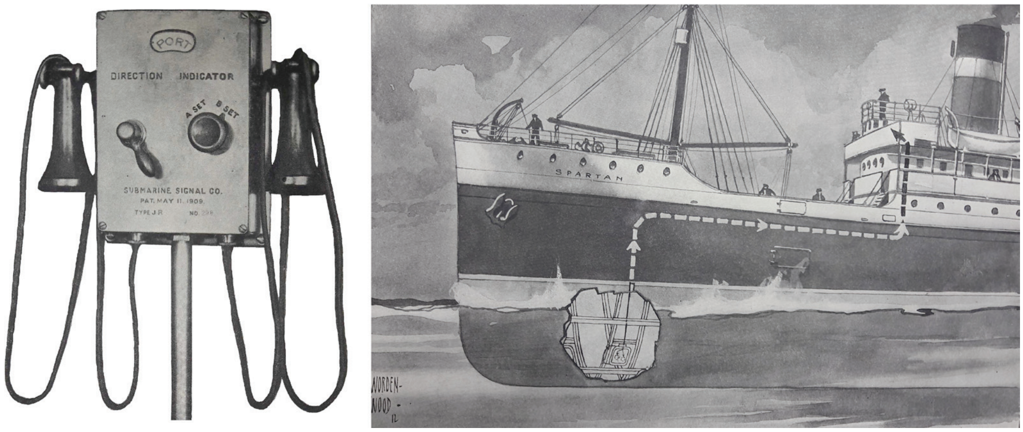

Fig. 3: Interface for having access to submarine signals from underwater bells on the left, and its implementation on the right. The interface was of such importance to the SSC that they used a drawn version of it as their company logo.

the system remained efficient when one microphone became defective). These microphones transduced the acoustic signals of underwater bells into electrical pulses. Each of the altogether four necessary microphones was connected to an "indicator box," usually located on the ship's bridge, in the pilot-house, or in the chart room, where the ship's navigator operated. The indicator box consisted of a conventional telephone receiver with two earpieces and a switching mechanism that controlled which microphones were connected to the telephone (see figure 3). Put differently, the indicator box is the instrument that transduces electric signals into acoustic ones and makes them available audibly for the operator. Of special relevance is that the acoustical signals that were received at starboard or portside could be made audible. The interface therefore consisted of two switches: the so-called "semaphore" switch for listening to the starboard or port microphones and the so-called "set" switch for listening to either the "A" or "B" set of microphones. Two earpieces were used so that the navigator could listen with both ears instead of only one, which also shut out other noises.[23]

As in the case of the leader cable, ship navigators accomplished safe wayfinding with submarine signals on an acoustic basis by comparing loudness. Since the microphones inside the ship were affixed in such a way that the ship's hull functioned as a kind of acoustic shield, the relative position of an underwater bell could be identified because its emitted signals were more intense on starboard when the bell was starboard, and vice versa. The direct course for a submarine bell was given when the acoustic signal was of equal loudness, no matter if the starboard or portside microphones were connected to the telephone receiver. Navigation was then appropriately carried out by continuous switching back and forth between both pairs of

23 Submarine Signal Co. (ed.), *Submarine signals* (Boston 1912), p. 20.

microphones. In order to get the exact course towards a submarine bell, the ship was swung until a bell signal was of equal loudness on both sides of the ship. Furthermore, the bell stations transmitted their signals in Morse code so that they could be identified.

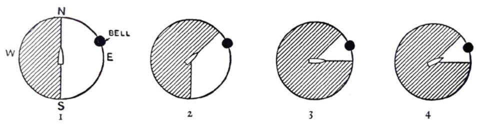

Fig. 4: Schematisation of the principle of navigating with submarine signals. The bell signals could be heard up to a range of 15km around a bell station.

This schematisation illustrates the sonically constituted principle of navigation using submarine signals. In the shaded areas, the bell sounds are quieter than in the unshaded sections. When submarine bells are more than one mile distant, their sound is only heard in the unshaded sections. In picture 1, for example, when the semaphore reads "starboard," the bell is heard clearly, but not when the semaphore shows "port." That the bell is dead ahead and not dead astern (picture 4) is known, since the receivers inside the ship are located in the front so that they pick up acoustic signals that come from the front but not the back side. When a bell is approached, the sound becomes louder; it is loudest when a bell is directly passed, and the volume decreases when a ship travels away from the bell. Furthermore, the illustrations implicitly show that–referring to Frieder Nake again–in order to have access from the surface of the sea to the submerged signal ecology of submarine signalling, it was necessary to have an interface that hardwired the aerial surface to the liquid subface. The material place where the acoustic space of the submarine signalling infrastructure and the human ear encounter each other is the interface. There, the acoustic signals and the human operator interact for safe wayfinding along coasts.

In September 1912, receivers for submarine signals were already installed on 949 ships. Even the famous *RMS Titanic* – which hit an iceberg the very same year – was equipped with receivers for this system. At that time, there were 53 bell signal stations in the USA, 27 in Great Britain, 16 in Germany, 12 in Canada, and further stations in France, Belgium, the Netherlands, Denmark, Sweden, Russia, Spain, Uruguay, and even China; all in all 135 around the world.[24] In 1920, about 3,500 ships were equipped with receivers.[25] The acoustic space of submarine signalling was established in such a way that it covered the physical underwater space along critical passages, and where desired, nearly completely. Especially along the British south coast, and the German North Sea coast, underwater bell stations were located in such a way that navigators could completely 'listen their way,' since they could steer from the signal realm of one bell station directly into the next. Also on the northern US east coast, the submarine bell stations formed a continuous network as can be seen in figure 5, which shows the

24 Ibid., p. 36.

25 E. Lübecke, *Unterwasserschall-Signale* (Berlin 1920), p. 12.

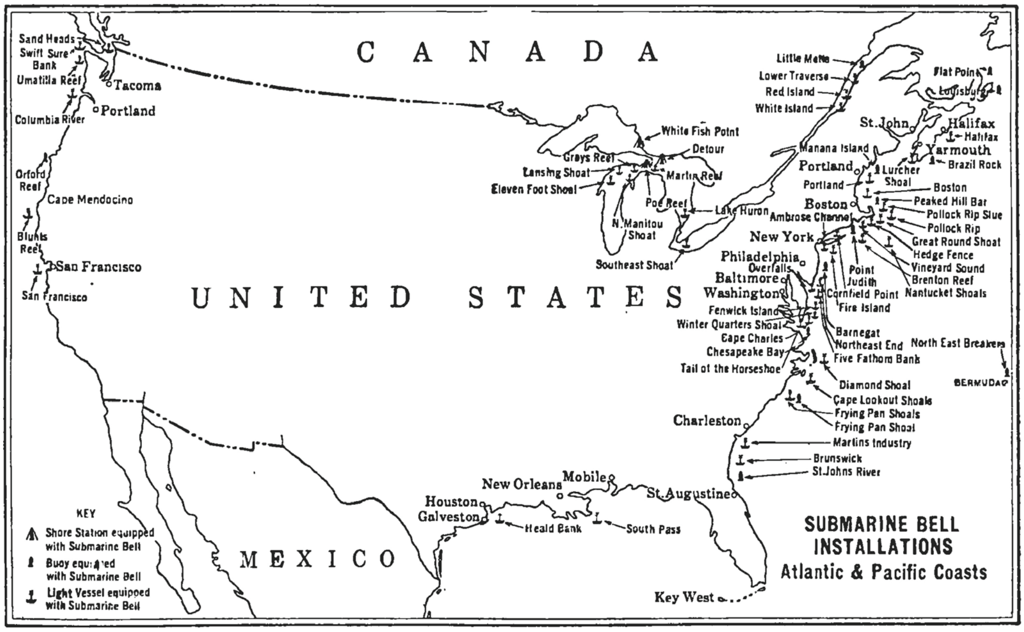

Fig.: 5 Caption Chart of submarine bell stations in the US in 1922.

submarine bell installations that were in use in the US in 1922.

In maritime practice, both technologies—leader cables and submarine signalling—were not in competition or rivalling discourses since they complemented each other and were seen as additive systems. With submarine signals, one the one hand, navigators could head for an underwater bell nearby the end of a leader cable and with the leader cable, on the other hand, they could afterwards find the exact entrance to a harbour or channel.

Certainly one could argue that the telephone in the submarine signal infrastructure does not seem to be part of an interface, since the signals from the underwater bells were acoustical in the first place and could also be heard by humans under water without any technical assistance. However, this is not the whole truth. The telephone and the two separated receivers actually *were* the essential interface for having access to the navigational logics inherent in the infrastructure of submarine signals because human binaural hearing does not work underwater. The specific positioning of *two* receivers and their connection to *one* telephone receiver realised the differences in volume and, as a consequence, made it possible to detect the direction of a sound source.

Résumé

Both maritime navigation technologies evoked a "complete revolution in the field of ship signalling," as it was described by contemporary observers.[26] Both techno-

26 BArch R 4701 (Reichspostministerium)/8934. My translation.

logies, however, were not only geographically but historically located. The leader cable and submarine signalling were already obsolete as maritime navigational technologies by the late 1920s because of the further development of radio technology, so-called wireless direction finding that became known as radionavigation and which is an important precursor to later radar technology.[27] Aerial directive radio beacons, which had been arranged as a radio beacon network since the second half of the 1920s,[28] replaced the leader cables and the submarine bells. This made maritime navigation silent again, since radionavigation relies heavily on a visual interface in the form of the radio compass, which allowed for a 'more instant sensemaking' than the use of earpieces.[29] The above-mentioned systems for acoustic navigation on the basis of auditory interfaces therefore represent a *historical interlude* in which navigation in fog and thick weather relied on sonic ecologies, auditory interfaces, and human ears. This period stands historically between well-known forms of maritime navigation–with compass, fixed stars, or visual checkpoints such as lighthouses and other beacons–and more media-assisted and therefore more elaborate forms of (mostly visual) navigation (with radio, radar, sonar, the Navstar GPS, and screen media). The leader cable and submarine signalling can thereby be understood as regional infrastructures that translated specific spatially situated tasks into hearing operations and thus mediatised maritime navigation and utilised auditory interfaces that addressed the human as a hearing subject.

In order not to exceed the scope of this article, in the following I will only briefly address five aspects of the interfaces and their status.

(1) Historicality

The auditory interfaces were, in their day, a new technological condition of maritime navigation and prove the thesis that interfaces are deeply historical artefacts or phenomena–as Florian Hadler and Daniel Irrgang argue[30]–since they are historically situated between 1900 and about 1930 and are totally unknown to ship navigators today. Furthermore, having an interface for the reception of submarine signals or the electromagnetic field of leader cables would be usel-

In the German original it reads that they provoked a "völlige Umwälzung auf dem Gebiete des Schiffs-Signalwesens."

27 F. G. Cooper, Aids to navigation. *Journal of the Royal Society of Arts* 78 [4055] (1930), pp. 990–1001, esp. 995–996. Leader cables came to be used in aviation after 1930. However, they had no auditory interfaces in this context. For a comprehensive overview of the importance of radionavigation see for example William Rankin, The geography of radionavigation and the politics of intangible artifacts. *Technology and Culture* 55/3 (2014), pp. 622–674.

28 BArch R 5 (Reichsverkehrsministerium)/7725.

29 Whereas navigation with submarine signals demanded continuous listening and continual switching back and forth, not only of the change-over switch but also of the ship itself (see figure 4 again), the radio compass could be read off directly to see the direction to a radio beacon. I borrow the term "instant sensemaking" from Florian Hadler and Daniel Irrgang, Instant sensemaking, immersion and invisibility. *Punctum* 1/1 (2015), pp. 7–25.

30 Hadler and Irrgang, Instant Sensemaking. Also Galloway's research into interfaces is aimed at their existence for historical reasons, see for example Alexander R. Galloway, *The interface effect* (Cambridge 2012), p. vii.

ess today, since the underlying systemic components of both technologies no longer exist. However, what these historical interfaces have in common with modern interfaces is that they are the material place where signals are translated (from electric current into audible tones), where technological and human agencies meet (telephones, amplifiers, receivers, and navigators), and that they required interaction to generate value (via their change-over switches, which is one condition for hearing differences in loudness).

(2) Operativity

For a history of acoustic knowledge or even a cultural history of sound, it is worthwhile to acknowledge that the leader cable and submarine signalling evoked transformations of visual navigation into practices of what I want to call "operative listening to operative sounds" that took place where the interfaces were located. The term "operative sounds" is meant to be the auditory equivalent of what, for example, Sybille Krämer[31] or Harun Farocki[32]–both independently–termed "operative images" respectively "operative Bildlichkeit." As in the case of operative images, operative sounds do not *represent* something, but are more part of an operation. They are not aesthetic in any sense but are distinguished by their linguisticality; they serve practical purposes and are interwoven with specialised tasks. Here, the bell signals and the tone of leader cables are both "operative sounds" for the safe guidance of a vessel near the coast or in a channel through "operative listening."

(3) Access

The interfaces were the condition of access to the acoustic spaces that the leader cables and submarine signal bells implemented in the ocean. The interface in the case of submarine signalling provides access to underwater signals and therefore connects surface with subface, whereas in the case of leader cables, the interface materialises the condition for sensible access as such, since the electromagnetic field is not perceptible by humans without technical media to translate it into or onto visual or auditory displays. In both cases, the interface addresses its subject as a listener. As Branden Hookway pointed out, the interface is not a form of technology but more of *a form of relation to technology*.[33] In the above-mentioned case of maritime navigation, it is therefore an acoustic relation between navigators, telephones, receivers, and underwater bells or leader cables; a kind of network that bases its operability on a navigation through sound. If the screen is understood, according to Lev Manovich, as the material object that allows for the "illusion of navigating through virtual spaces,"[34] it is the interface of the leader cable and

31 Sybille Krämer, Operative Bildlichkeit, in: *Logik des Bildlichen*, ed. Martina Hessler and Dieter Mersch (Bielefeld 2009), pp. 94–123.

32 Harun Farocki, Phantom images. *Public* 29 (2004), pp. 12-22, here p. 17.

33 Hookway, *Interface*, esp. pp. 1–7.

34 Manovich, *New media*, p. 94.

submarine signalling systems that enables operators to literally navigate, viz. through territorial space in cases of fog. If our society is "a society of the screen,"[35] then the ship's operators, with appropriate interfaces to have access to submarine signals and leader cables, can be regarded—at least in cases of low visibility—as a small 'society of the earphone.'

(4) In-/Exclusion

The interfaces with which this paper has dealt had an economic and political dimension, as they represent a form of restricted access. On the one hand, only the navigator who paid for receivers, amplifiers, and telephones was allowed to participate in the acoustic spaces for navigation. On the other hand, in cases of fog or severe thunderstorm, only ships that were equipped with appropriate receivers were allowed to enter certain harbours whose entrance had a leader cable as, for example, was the case in Portsmouth.[36] Ships that had no interface had to wait (that is: lose money) at the harbour entrance until the meteorological condition was suitable for navigation by sight. That is to say, the interfaces made decisions about inclusion and exclusion (to acoustic spaces and harbours). Put differently, one can acknowledge that the political dimension that interfaces incorporate has historically evolved, as can be seen with these early technological navigation interfaces.

(5) Guidance

If interfaces guide the user insofar as they predetermine the choices that users have, the above-described interfaces also shape the possible behaviour of navigators if these wanted to have access to the new technologies of submarine signalling and leader cables: They had to listen and flip a change-over switch back and forth. However, also on a literal level, the interfaces guided users. In *The Interface Effect,* Galloway states that "an interface is not something that appears before you but rather is a gateway that opens up and allows passage to some place beyond."[37] Galloway's usage of the term "passage" constitutes the interface as a kind of portal. In nautical lingo, however, passage also means sea voyage or crossing, and this is what the interfaces characterises. They were literally "gateways," entry points that allowed for passage to some place beyond: coasts, harbours, or channels.

35 Ibid.

36 J. J. Bennett, Leader cables in navigation. *The Electrician* 87/7 (1921), pp. 202–204, here p. 202.

37 Galloway, *The interface effect*, p. 30.

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