Tropicalizing the Portable Radio

by

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ABSTRACT

During the Second World War, the U.S. military found that fungal growth put its portable radio equipment out of use at an alarmingly fast rate in the tropics. This paper follows radio engineers and biologists as they made sense of "'tropical deterioration" and devised techniques of "tropicalization" to counteract it. By tracking multiple materializations of air that carried not only radio signals, but also fungal spores, it shows how the categories of the portable radio and the tropics became recast in their encounter. If the portable radio was imagined to condition spatiotemporal experience so as to fold the tropical environment into the smooth space of military logistics, tropical deterioration ran counter to this imaginary. As air mixed radio and fungi, the decaying portable radio served as a trope around which these scientists and engineers pitched mechanical time of radio technology against organic time of fecund tropical nature, which ran faster than in the temperate zone. To protect the portable radio from dangerous tropical air, radio engineers came to see hermetic sealing as a preferred method for tropicalization—a choice that evinces their aspiration to keep technology and the environment apart.

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Tropicalizing the Portable Radio

"We were sitting around a short-wave radio in the North Burma jungle listening to reports of the great invasion of Europe," reminisced an American veteran of the Second World War, Adie Suehsdorf, who took up a literary career after returning. Much like news junkies at home, he and his compatriots-in-arms were tuning in to the radio to keep abreast of the global war, save that they found themselves in a tropical jungle rather than in domestic comfort. "Isolation," observed Suehsdorf, "was a burden imposed by the jungle itself. … In the jungle, you could live with a regiment and feel as though you were the last people on earth." It did not help that torrential rainfall would often wreck the Stilwell Road, the only "narrow ribbon of safety" cutting through the "prolific, dangerous jungle." Because bad roads made for "bad communications," it was as though invisible airwaves were the only thing tethering these American servicemen to the rest of the globe. All else were jungle noises, "the buzzes and hums and whirrs that were just a decibel away from silence." "From the standpoint of men, guns, planes, vehicles, equipment," remarked Suehsdorf, "[the Burma-China-India Theater] was small. The objective was big and tough: to drive superior Japanese forces out of North Burma."[1] To link the small to the big, the portable radio not only transmit news from afar, but also combatted isolation by connecting transplants to the jungle like Suehsdorf to the epic struggles on the global stage. To keep them constantly in touch through reliable communication, the portable radio removed unreliable roads from the equation by beaming messages through the air.

In the tropics, however, air not only facilitated communication, but also hampered it. The U.S. Armed Forces found this out the hard way. After the Japanese attack on Pearl Harbor in December 1941, the United States became embroiled in "jungle warfare" across Asia and the Pacific. The Guadalcanal campaign in August 1942 marked the Allies' first major offensive against Japan, but American servicemen soon learned that Japanese soldiers were not their sole enemies in the South Pacific. An official history of the U.S. Signal Corps recorded the following about the ill fate of radio equipment:

> Signal Corps field radio and wire equipment in the South Pacific Area first went into combat under extreme tropical conditions on Guadalcanal. The items originally used there, not having been waterproofed or protected by fungicides, suffered severely from dank heat and fungus growths. Metals corroded; insulating materials rotted and sprouted mold. Batteries were especially susceptible … . The heavy damp vegetation smothered radiations, reducing the weak output of small radios … to near uselessness in the jungle, which of course predominated in most areas.[2]

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[1] Adie Suehsdorf, "Burma Was Jungle Noises," *The American Scholar* 15, no. 3 (1946): 356–57.

[2] George Raynor Thompson and Dixie R. Harris, *The Signal Corps: The Outcome (Mid-1943 through 1945)* (Washington, D.C.: Office of the Chief of Military History, U.S. Army, 1966), 38, https://catalog.hathitrust.org/Record/000815545.

"In jungle warfare," stated a 1941 War Department manual, "the soldier fights two enemies: man and nature."[3] To fend off natural foes, the U.S. government sought help from scientists and engineers. In a well-worn colonial trope of environmental otherness, nature in the tropics teemed with poisonous plants, omnipresent pests, and febrile diseases—all of which conspired to menace human health, but particularly that of the white Euro-American body.[4] Tropical perils, however, also harmed technological equipment. In hot and humid air laden with fungal spores, portable radios went defunct with alarming rapidity. The U.S. military called this problem *tropical deterioration*, while *tropicalization* referred to its countermeasure. In this paper, I follow American engineers and scientists as they endeavored to make sense of tropical deterioration and to devise techniques of tropicalization, with special attention to the shifting *materializations* of air.[5] If air was not merely a medium for universal communication, in what other ways did the moldy radio in the tropics materialize air?

Why air? With its facility to transgress borders, air disarranges the boundary between nature and technology, acting as it does as the go-between through which one bleeds into the other. On the one hand, air forms part of the natural environment, from which technology stands apart. Not only does air aid in the technological endangerment of the environment (as in, for example, air pollution), but it also poses environmental hazards to technology (as in, for example, tropical deterioration). On the other hand, air is also folded into the operation of the technological apparatus. To name a few functions, it serves as an insulator, a conductor, a medium for wave propagation, and a cooling agent. Oscillating between natural and technological in these ways, air might be construed as a trickster-like element that both mediates and confounds the nature-technology dichotomy.[6] It breaches and redraws such a dichotomy in the same breath. Because foregrounding air forces us to return to the drawing board to figure out what counts as nature and what counts as technology, it checks our urge to blackbox "nature" and

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[3] U.S. War Department, *Basic Field Manual: Jungle Warfare* (Washington, D.C.: U.S. Government Printing Office, 1941), 1.

[4] On tropicality and modern empire, see David Arnold, *The Problem of Nature: Environment, Culture and European Expansion* (Oxford, England; Cambridge, MA: Blackwell, 1996), 141–68; David Arnold, "'Illusory Riches': Representations of the Tropical World, 1840–1950," *Singapore Journal of Tropical Geography* 21, no. 1 (March 2000): 6–18; Nancy Leys Stepan, *Picturing Tropical Nature* (London: Reaktion, 2002); Felix Driver and Luciana de Lima Martins, eds., *Tropical Visions in an Age of Empire* (Chicago: University of Chicago Press, 2005); David Arnold, *The Tropics and the Traveling Gaze: India, Landscape, and Science, 1800–1856* (Seattle: University of Washington Press, 2006); Nicolás Wey Gómez, *The Tropics of Empire: Why Columbus Sailed South to the Indies* (Cambridge: MIT Press, 2008); Hugh Cagle, *Assembling the Tropics: Science and Medicine in Portugal's Empire, 1450-1700* (Cambridge: Cambridge University Press, 2018). For a useful overview, see Paul S. Sutter, "The Tropics: A Brief History of an Environmental Imaginary," in *Oxford Handbook of Environmental History*, ed. Andrew Isenberg (New York: Oxford University Press, 2014), 178–204.

[5] On the concept of materializations, see Michelle Murphy, *Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers* (Durham, NC: Duke University Press, 2006).

[6] On the trickster, see, especially, Claude Lévi-Strauss, "The Structural Study of Myth," *The Journal of American Folklore* 68, no. 270 (1955): 428–44.

"technology," not to mention "science" and "society." If the sociologist Bruno Latour stipulates that "the equipment necessary to travel through science and technology is at once light and multiple," what would better suit this task than air?[7]

By tracing how air entered into perceptibility in the story below, I show how the discrete categories of the portable radio and the tropics became disassembled and reassembled in their encounter. First, I sketch a history of the portable radio immediately before the war and during the war, suggesting that it be viewed as a technology for modifying bodily experiences of the environment. Then, I ask how tropical thinking colored American engineers and scientists' perception of tropical deterioration. As air mixed nature with technology, fast-growing fungi on the portable radio, I contend, served as a trope around which pivoted their narration of the tropics as a place where organic time outpaced mechanical time. Lastly, I discuss hermetic sealing—which partitioned air into inside and outside the seal—as the preferred method for tropicalization. Rather than stamp out the environment from technology once and for all, hermeticity, I argue, tells us more about radio engineers' aspiration to parse the environment into inert background conditions that stood apart from technology.

A key goal of this paper is to demonstrate that the *elementality* of air furnishes theoretical and methodological resources for probing the nexus between nature and technology, a pressure point shared by environmental media studies and environmental history of technology. Expanding on their prior emphasis on materiality, media scholars have increasingly turned their eyes toward material entanglements between media and environments. An outgrowth of this environmental turn, *elemental analysis*, according to the media scholar Nicole Starosielski, has attuned media studies in the past decade "to constituent parts, especially to the substances and substrates that compose media." Attention to basic building blocks of the world such as air, water, light, and heat "can both destabilize traditional framings of the 'environment' as well as destabilize the understanding of 'media.'"[8] Indeed, media theorists have already begun to address

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[7] Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge: Harvard University Press, 1987), 6.

[8] Nicole Starosielski, "The Elements of Media Studies," *Media+Environment* 1, no. 1 (November 22, 2019). For state-of-the-field essays on environmental media studies, see Alenda Chang, Adrian Ivakhiv, and Janet Walker, "States of Media+Environment: Editors' Introduction," *Media+Environment* 1, no. 1 (November 22, 2019); Meryl Shriver-Rice and Hunter Vaughan, "What Is Environmental Media Studies?," *Journal of Environmental Media* 1, no. 1 (January 1, 2020): 3–13. For works in media studies that fall under the category of elemental analysis, see, for example, Jussi Parikka, *A Geology of Media* (Minneapolis: University of Minnesota Press, 2015); Nadia Bozak, *The Cinematic Footprint: Lights, Camera, Natural Resources* (New Brunswick, N.J: Rutgers University Press, 2012); Nicole Starosielski, "Thermocultures of Geological Media," *Cultural Politics* 12, no. 3 (November 1, 2016): 293–309; Melody Jue, *Wild Blue Media: Thinking through Seawater* (Durham: Duke University Press, 2020). For pacesetters of the elemental turn in the humanities, see David Macauley, *Elemental Philosophy: Earth, Air, Fire, and Water as Environmental Ideas* (Albany: State University of New York Press, 2010); Jeffrey Jerome Cohen and Lowell Duckert, eds., *Elemental Ecocriticism: Thinking with Earth, Air, Water, and Fire* (Minneapolis: University of

air as a medium.[9] The elemental, I propose, provides a stimulating angle into the interplay between nature and technology for envirotech history, which draws together environmental history and technology studies to weave nonhuman nature and the sociotechnical together into one framework. Conversely, media studies can look to envirotech history for strategies for bringing out the political dimensions of the elemental. Rather than stop at identifying an entity as a nature-technology hybrid, scholars in envirotech and adjacent fields model rich analyses that tease out larger political stakes of the specific constitution of such hybridity.[10]

As a natural process subject to technoscientific intervention, *rot* offers an occasion for rapprochement between these two fields.[11] If elements compose, decomposition shows how they come apart and, again, together. Indeed, tropical deterioration reveals air to be a crucial element in radio technology in more ways than one. Noting that "insulation is responsible for the most failures," a 1941 textbook on electrical insulation reminded the reader that air was a "universal dialectic" that "appears as an insulator in parallel, at least, in all devices." Because engineers did not know much about insulation in comparison to active parts (such as magnets and conductors),

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Minnesota Press, 2015); John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago: The University of Chicago Press, 2016).

[9] On air as a medium, see, especially, Eva Horn, "Air as Medium," *Grey Room* 73 (December 1, 2018): 6–25; Derek P. McCormack, *Atmospheric Things: On the Allure of Elemental Envelopment* (Durham: Duke University Press, 2018). Media scholars have also employed the atmospheric as a metaphor for contemporary media worlds. For instance, W. J. T. Mitchell and Mark B. N. Hansen suggest that "it would not be far-fetched to think, then, of the present project [a compendium of critical terms in media studies] as emulating meteorology's study of dynamic interactive weather patterns, as an effort toward a 'mediarology' that would track the pressure systems and fronts that crisscross the man-made world of symbols we have created." W. J. T. Mitchell and Mark B. N. Hansen, "Introduction," in *Critical Terms for Media Studies*, ed. W. J. T. Mitchell and Mark B. N. Hansen (Chicago and London: The University of Chicago Press, 2010), xiv. On the metaphor of the environment in media theory, see Ursula K. Heise, "Unnatural Ecologies: The Metaphor of the Environment in Media Theory," *Configurations* 10, no. 1 (2002): 149–68.

[10] On environmental history of technology, see Jeffrey K. Stine and Joel A. Tarr, "At the Intersection of Histories: Technology and the Environment," *Technology and Culture* 39, no. 4 (1998): 601–40; Edmund Russell et al., "The Nature of Power: Synthesizing the History of Technology and Environmental History," *Technology and Culture* 52, no. 2 (May 12, 2011): 246–59; Sara B. Pritchard, "Toward an Environmental History of Technology," in *The Oxford Handbook of Environmental History*, ed. Andrew Isenberg (Oxford: Oxford University Press, 2014), 227–58. See also Martin Reuss and Stephen H. Cutcliffe, eds., *The Illusory Boundary: Environment and Technology in History* (Charlottesville: University of Virginia Press, 2010); Dolly Jørgensen, Finn Arne Jørgensen, and Sara B. Pritchard, eds., *New Natures: Joining Environmental History with Science and Technology Studies* (Pittsburgh: University of Pittsburgh Press, 2013).

[11] On the reappraisal of rot, decay, and putrefaction not as abject, but as a productive site for scholarly inquiry and knowledge production, see Joanna Radin, "Rot," *The Multispecies Salon* (blog), December 2, 2014, https://www.multispecies-salon.org/rot/; Caitlin DeSilvey, *Curated Decay: Heritage Beyond Saving* (Minneapolis: University of Minnesota Press, 2017); Lucinda Cole, "Introduction: Putrefaction and the Ecologies of Life: Enter the Vulture," *Configurations* 25, no. 2 (March 30, 2017): 137–43.

they often designed insulation with "wide margins of safety."[12] These margins proved not wide enough, however, as seemingly innocuous air enveloping the portable radio quickly filled with threats of fungi in the tropics. Yet, if air facilitated decomposition, the manipulation of air through hermetic sealing also offered a means for curating decay.

The tropicalization of the portable radio provides a glimpse into the reconfiguration of the place of the United States in the world. The historian Daniel Immerwahr offers the *pointillist empire* as a formulation for the geography of American imperial power, which rested upon its logistical prowess honed in the Second World War. "The U.S. mastery of logistics," he elaborates, "would diminish the value of colonies and inaugurate a new pattern of global power, based less on claiming large swaths of land and more on controlling small points."[13] As a "space-hopping technology," radio, like aviation, was key to this geographical imaginary of power. As Immerwahr explains, "two transceivers were all that was required—there was no need to control the land in between. Radio not only put far-off locales in contact with one another, it allowed for communication with ships, planes, trucks, tanks, submarines, and men in the field."[14] Under this regime of spatial ordering, the portability of radio assumed paramount importance. In their map of mobile music studies, the media scholars Sumanth Gopinath and Jason Stanyek break down *portability* into three components: miniaturization, ubiquity, and the marketing catchphrase "anytime, anywhere."[15] Borrowing from the historian Christopher Sellers, I propose to reframe the catchphrase "anytime, anywhere" as *place neutrality* to lend weight to place as well as the endeavor to construct placelessness. Place neutrality names an aspiration "for a medicine in which patients' own places didn't matter to what doctors thought or did"—an aspiration that, crucially for Sellers, left material footprints in their clinics, hospitals, and tools.[16] Here, I modify

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[12] Douglas F. Miner, *Insulation of Electrical Apparatus* (New York and London: McGraw Hill, 1941), 1–2, 74. Miner explained that because insulating materials were often of organic origins, their complex structure made it harder to understand their electrical properties with precision.

[13] Daniel Immerwahr, *How to Hide an Empire: A History of the Greater United States* (New York: Farrar, Straus and Giroux, 2020), 216. Immerwahr borrows this term from the historian Bill Rankin and develops it further. Scholars in American studies offer the *archipelagic* as another formulation of empire that closely resembles Immerwahr's; see Brian Russell Roberts and Michelle Ann Stephens, eds., *Archipelagic American Studies* (Durham: Duke University Press, 2017).

[14] Immerwahr, *How to Hide an Empire*, 289. On spatiality and U.S. empire, see Paul A. Kramer, "Power and Connection: Imperial Histories of the United States in the World," *The American Historical Review* 116, no. 5 (December 1, 2011): 1348–91; Andrew Friedman, "U.S. Power in a Material World," in *A Companion to U.S. Foreign Relations*, ed. Christopher R. W. Dietrich, 1st ed. (Hoboken: Wiley, 2020), 652–81. On Allied engineers in the Second World War, see Paul M. Kennedy, *Engineers of Victory: The Problem Solvers Who Turned the Tide in the Second World War* (New York: Random House, 2013).

[15] Sumanth Gopinath and Jason Stanyek, "Anytime, Anywhere? An Introduction to the Devices, Markets, and Theories of Mobile Music," in *The Oxford Handbook of Mobile Music Studies*, ed. Sumanth Gopinath and Jason Stanyek, vol. 1 (Oxford: Oxford University Press, 2014), 1–34.

[16] A departure from the "ecological" understanding of the body, it gave license for doctors to treat the "inner parts and workings of the body" as "worlds unto themselves" that stood apart from their environments. Place neutrality, according to Sellers, was hardwired into doctors' workplaces, such as the clinic and the hospital, as well as their

his formulation of place neutrality by substituting the patient's body with the portable radio.[17] While scholars have tended to argue that portable sound media such as Apple iPod and Sony Walkman insulate users from their surroundings, the media scholar Jacob Smith shows that portable sound media could also "allow users to experiences both a sense of place and a sense of the planet."[18] Rather than users, I focus here on radio *makers*. Like doctors, they sought to remove place from the picture in order to attain portability, laying the infrastructure for the pointillist empire.[19] Foregrounding material processes, however, reveals that the tropical environment continued to foil attempts to make the portable radio approximate a dot. Far from heroes impervious to their surroundings, radio makers came to know the tropics in a specific manner in their quest to miniaturize and universalize radios.

War and the Environment of the Portable Radio

"The radio is a modern substitute for the hearthside," wrote the authors of the influential 1935 study, *The Psychology of Radio*.[20] Although early shipboard radios for naval and trade communications were portable, radios gradually lost portability as they became commonplace in the American home after the dawn of commercial broadcasting in the early 1920s. The domestication of radio notwithstanding, the radio industry maintained deep ties to the U.S. military, which would continue to demand outdoor uses of radio. After Woodrow Wilson nationalized the radio industry during the First World War, the Navy masterminded the incorporation of the Radio Corporation of America (RCA) in 1919 to prevent control over this medium of strategic importance from remaining in foreign hands. Thanks to RCA's dominance in the subsequent development of radio, no clear-cut line would separate commercial and military

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tools and training. Christopher Sellers, "To Place or Not to Place: Toward an Environmental History of Modern Medicine," *Bulletin of the History of Medicine* 92, no. 1 (2018): 7. For touchstone works on the "ecological" understanding of the body and the endurance of the airs, waters, places tradition in history of modern medicine, see Conevery Bolton Valenčius, *The Health of the Country: How American Settlers Understood Themselves and Their Land* (New York: Basic Books, 2004); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2006).

[17] In fact, radio makers sometimes addressed radio not only as *on* the body, but also *as* the body. To be fair, Gopinath and Stanyek argue that "just as crucial [to the catchphrase 'anytime, anywhere'] seems to be a sense that mobile music devices are capable of withstanding radically different environments, including hostile ones." Nevertheless, they treat this ability to withstand diverse environments more as a marketing strategy, whereas I turn to Sellers in order to highlight that radio engineers worried quite a lot about *how* to implement this ability. Gopinath and Stanyek, "Anytime, Anywhere?," 16.

[18] Jacob Smith, *Eco-Sonic Media* (Oakland, California: University of California Press, 2015), 80.

[19] On how materiality of radio foils the imaginary of rule, see, especially, Rudolf Mrázek, *Engineers of Happy Land: Technology and Nationalism in a Colony* (Princeton, N.J: Princeton University Press, 2002); Brian Larkin, *Signal and Noise: Media, Infrastructure, and Urban Culture in Nigeria* (Durham: Duke University Press, 2008).

[20] Hadley Cantril and Gordon W. Allport, *The Psychology of Radio* (New York and London: Harper & Brothers, 1935), 15.

radio.[21] Through a history of the portable radio before and during the Second World War, I show how the portable radio served to condition the spatiotemporal experience of mobile bodies to ease their movement through different environments.

After having been pushed to the fringe by the popularity of domestic nonportables, the portable radio found mass appeal in the period from 1938 to 1942, according to the archaeologist Michael Brian Schiffer.[22] American radio makers marketed portables as companions in outdoor leisure activities, now a symbol of class mobility.[23] By this time, radio technology had advanced sufficiently to reach respectable quality. While not yet pocket-size, commercial portable radios had become small enough for a person to carry. For example, the Emerson 432 from 1941, billed as the "world's smallest and lightest," "[weighed] but three pounds and [took] up less than eighty cubic inches (8-1/2″ × 4-1/2″ × 2-1/8″ maximum dimensions)."[24] Other models ranged between eight and thirteen inches in their largest dimension.[25] Four million portables were sold during this period, but their brief spell of popularity soon came to an abrupt halt. In April 1942, the Roosevelt administration suspended the production of civilian radios in order to mobilize all factories for wartime production as the United States entered the Second World War.[26]

As it accompanied globe-trotting American servicemen much like it did American outdoorsmen, the portable radio aided in not only tactical communication, but also morale boosting. Thanks to the vogue that the portable radio enjoyed late in the interwar period, "the availability of miniature tubes and other diminutive components made possible military transceivers of unprecedented portability. Two kinds of portable radios were carried by troops on front lines: Handie-Talkies, which were small (3″ × 3″ × 12″) and could be easily held in the

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[21] On radio before the broadcast era in the 1920s, see Hugh G. J Aitken, *Syntony and Spark: The Origins of Radio* (Princeton: Princeton University Press, 1985); Susan J. Douglas, *Inventing American Broadcasting, 1899–1922* (Baltimore: Johns Hopkins University Press, 1989); Susan J. Douglas, "Before the Broadcast Era," in *A Companion to the History of American Broadcasting*, ed. Aniko Bodroghkozy (Hoboken: John Wiley & Sons, Ltd, 2018), 25–46. On radio in the broadcast era, see Michele Hilmes, "The Broadcast Radio Era," in *A Companion to the History of American Broadcasting* (Hoboken: John Wiley & Sons, Ltd, 2018), 47–70. On Signal Corps portable radio sets that could travel on mules and specialized trucks during the First World War, see Michael Brian Schiffer, *The Portable Radio in American Life* (Tucson: University of Arizona Press, 1991), 28–29. Although the present study remains mostly in the domain of science and technology, new work in radio studies has moved beyond the domain of science and technology to topics such as radio aesthetics, listening cultures, and intermedial relationships.

[22] Outside of mass consumption, portable radios were manufactured for specialized business and military uses in the interwar period; see Schiffer, *The Portable Radio in American Life*, 95. Furthermore, "ham" radio amateurs, toymakers, and hearing aid designers also continued to make their own portables; see Schiffer, 32–47, 152–54; Kristen Haring, *Ham Radio's Technical Culture* (Cambridge: MIT Press, 2007); Mara Mills, "Hearing Aids and the History of Electronics Miniaturization," *IEEE Annals of the History of Computing* 33, no. 2 (February 2011): 24–45.

[23] Schiffer, *The Portable Radio in American Life*, 120–22.

[24] Schiffer, 124.

[25] Schiffer, 123.

[26] Schiffer, 127.

Figure 1: An advertisement for a portable radio. *Radio Craft* 11, no. 12 (June 1940): 709.

The SCR–300, better known as the walkie-talkie; below, *radioman with handie-talkie (SCR–536) on Okinawa.*

Figure 2: The Walkie-Talkie and the Handie-Talkie. Rebecca Robbins Raines, *Getting the Message Through: A Branch History of the U.S. Army Signal Corps* (Washington, D.C.: Center for Military History, 1996), 278.

hand, and Walkie-Talkies—somewhat larger (17″ × 12″ × 7″)—carried on the back."[27] Aside from tactical communication, the portable radio also served to build morale.[28] As one psychologist wrote in 1941, "radio, because it finds its way directly into so many millions of homes, enjoys a unique power to marshal the spiritual and ethical forces of the nation." In addition, he suggested that radio be used in "morale-promoting techniques" aimed at "roughly a million and a half young men taken from their homes and introduced into military camps."[29] In line with this suggestion, the War Department established the Armed Forces Radio Service (AFRS) to create a "touch from home" for American military men deployed abroad.[30]

Both on the frontline and in recreation, the portable radio did not merely convey information, but also *conditioned* the spatiotemporal experience by mediating between bodies and their surroundings. As is perhaps particularly true in the tropics, it helped facilitate mobility by blunting the effects of adverse environments through which these bodies moved. "Wherever man goes … even when he's slashing through primeval jungle in some remote corner of the South Pacific," went a 1943 advertisement in *Electronics*, "he is not alone, thanks to the existence of the two-way radiotelephone."[31] Radio, however, also counteracted isolation away from the battlefield. The South Pacific Theater also had its own radio stations for recreation known as the Mosquito Network, which broadcast news, sports, music, and variety shows. Onsite broadcasters would intersperse amusing announcements between these contents. "From a fungus-festooned Fern Room, high atop the elegant Hotel DeGink in downtown Guadalcanal,"

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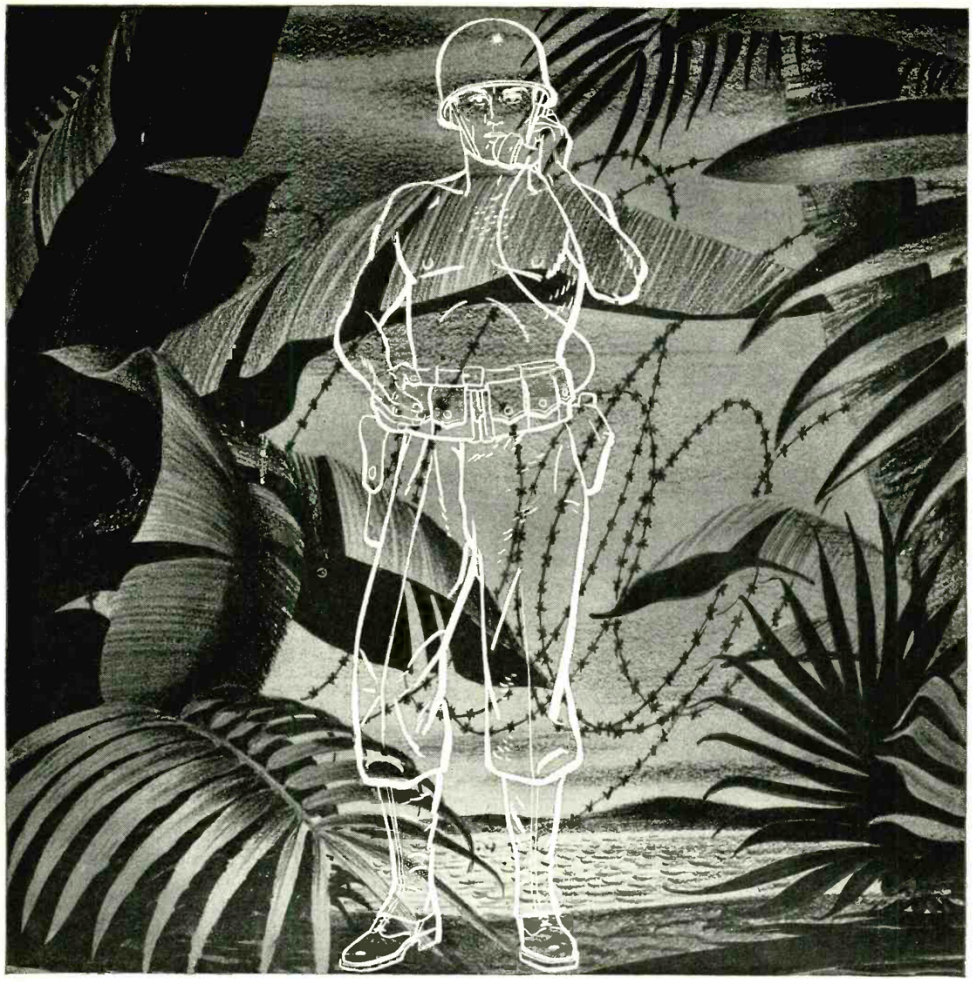
[27] Schiffer, 130.

[28] By the time it entered the Second World War, the U.S. military had identified morale—among both civilians and troops—as an entity subject to modulation, for which radio emerged as a powerful instrument. See Ben Anderson, "Modulating the Excess of Affect: Morale in a State of 'Total War,'" in *The Affect Theory Reader*, ed. Melissa Gregg and Gregory J. Seigworth (Durham: Duke University Press, 2010), 161–87. While the Morale Branch in the War Department was created on March 8, 1941, it had a historical precedent in 1918, which went away after the First World War. On the eve of the war, sociological and psychological studies on this topic proliferated; see, especially, Edward A. Shils, "A Note on Governmental Research on Attitudes and Morale," *American Journal of Sociology* 47, no. 3 (1941): 472–80. See also other contributions to this issue of the *American Journal of Sociology.*

[29] James Rowland Angell, "Radio and National Morale," *American Journal of Sociology* 47, no. 3 (1941): 357.

[30] It is not always straightforward, however, to distinguish the delivery of tactical information from morale boosting. The first American military radio stations for entertainment, after all, were created in Panama in early 1942 to fill the dead air with music, so that servicemen would keep their "'picnic type' radio receivers" on while waiting for the next command. *History of AFRTS, the First 50 Years* (Alexandria, VA: American Forces Information Service and Armed Forces Radio and Television Service, 1993), 7, http://hdl.handle.net/2027/mdp.39015032443833. For a brief overview of the history of the Armed Forces Radio and Television Services (AFRTS), see Stacy Takacs, "Radio, Television, and the Military," in *A Companion to the History of American Broadcasting*, ed. Aniko Bodroghkozy (Hoboken: John Wiley & Sons, Ltd, 2018), 263–66.

[31] "Wherever Man Goes...," *Electronics*, April 1943, 135.



Wherever man goes • • • even when he's slashing through primeval jungle in some remote corner of the South Pacific, he is not alone, thanks to the existence of the two-way radiotelephone. In tomorrow's world, this new medium of communication will become an active part of your business and social life. And when hostilities cease you can look to Jefferson-Travis for the finest radiotelephone equipment made. As pioneers in this field we have developed new and exclusive improvements for this remarkable electronic achievement. Today they are employed by the United Nations everywhere — tomorrow they will be yours!

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NEW YORK • WASHINGTON • BOSTON

ELECTRONICS — *April 1943* 135

Figure 3: Portable radio in the jungle. *Electronics*, April 1943, 135.

Figure 4: RCA advertisement. *Electronics*, October 1943, 283.

went a particular memorable line, "we bring you the dance music of the Quinine Quartet."[32] Indeed, reminders to take preventive measures against tropical ills would frequently go on air. In these ways, the portable radio modified the soldier's experience of the tropical environment, bringing about a smooth space for mobility. As tropical fungi made fodder out of radio equipment, however, they also revealed that such a smooth space of circulation abetted by the space-annihilating power of radio remained a fantasy.

Deterioration and Timekeeping in the Tropics

"Immediately after Pearl Harbor," recalled the microbiologist Selman A. Waksman in his autobiography, "it became evident that a major war would have to be fought under tropical conditions." He was soon "called upon to assist in the development of a program of protection of service materials against [tropical] deterioration," thanks to his knowledge about soil fungi which would also qualify him for his Nobel Prize–winning research on antibiotics.[33] "Various service materials are subject, under favorable conditions of moisture and temperature, to deterioration by a large number of organisms, comprising fungi, bacteria, actinomycetes, as well as certain animal forms, namely, mites, termites, shipborers," wrote Waksman in his 1944 manual on tropical deterioration. "Among these," he continued, "the organisms which are of the greatest significance as agents of deterioration are the fungi or molds."[34] While Waksman was but one among many biologists enlisted to tackle tropical deterioration, fungi emerged as their common talking point, one that radio engineers also echoed. "A key characteristic of all molds," offers the anthropologist Alison Kenner, "is that they are biodegraders that participate in the *slow* process of death and deterioration."[35] Yet, stories from the battlefield about tropical deterioration often expressed incredulity at the blistering *speed* with which fungi sprouted, as though nature ran on a faster clock in the tropics. With attention to temporal dimensions of spatial imaginaries, I describe how the Euro-American discourse on tropicality framed American scientists and engineers' narration of the tropics as a place where organic time encroached upon mechanical time. The clash between these competing temporal forms, I argue, found articulation in the fungus-sprouting portable radio. As it rotted, the portable radio turned from a technology for environmental conditioning into a medium for attuning to the atmosphere that was thick not only with messages, but also with microscopic plant life.[36]

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[32] Martin Hadlow, "The Mosquito Network: American Military Radio in the Solomon Islands during World War II," *Journal of Radio Studies*, no. 1 (2004): 73. See also Mark Durenberger, "Meet the Mosquito Network," *Radio World*, September 4, 2019, http://www.radioworld.com/columns-and-views/meet-the-mosquito-network.

[33] Selman A. Waksman, *My Life with the Microbes* (New York: Simon and Schuster, 1954), 198–99.

[34] Selman A. Waksman, "Fungi and Tropical Deterioration: A Manual," OSRD Report, July 1944, 3.

[35] Ali Kenner, "Mold," *Fieldsights*, Theorizing the Contemporary, June 27, 2019, https://culanth.org/fieldsights/mold. Emphasis mine.

[36] For scholarship on atmospheric attunement in cultural anthropology that inform this line of inquiry, see Kathleen Stewart, "Atmospheric Attunements," *Environment and Planning D: Society and Space* 29, no. 3 (June 1, 2011):

How, furthermore, did the moldy radio figure in the *chronopolitics* of the American wartime production drive during the Second World War? In the anthropologist Jerry Zee's definition, chronopolitics describes "the various ways in which the political does not merely operate in 'empty, homogeneous time,' but rather, tacitly and sometimes explicitly, makes the manipulation, acceleration, or projection of time both the condition and ongoing goal of political and governmental intervention." Following Zee, I suggest that fast-growing tropical fungi furnished one a chronopolitical form that "[displaced] the open, linear future of political time."[37] As such, they dislodged the linear temporal form of technological progress that was to secure victory for the United States and the Allies under wartime industrial mobilization. "Powerful enemies must be outfought and outproduced," Franklin Delano Roosevelt set the national agenda in his address to Congress on January 5, 1942. "We must outproduce them overwhelmingly, so that there can be no question of our ability to provide a crushing superiority of equipment in any theater of the world war."[38] Under this imperative, the Roosevelt administration set out to maximize productivity and efficiency, turning the whole nation into a well-oiled machine that pumped out an endless stream of matériel.

Radio, too, attested to the crushing technological superiority. To convince radio magazine readers to purchase war bonds, RCA and other radio firms ran advertisements that not only highlighted the critical role of radio innovation in the war, but also promised postwar civilian application. "Research fortifies the nation's communications, and under the impetus and demands of war, achievements of scientists are multiplied. Research engineers are soldiers of science in modern war," went the column "RCA's All-Out for Victory" in the September 1942 issue of *Radio Craft*. "When peace comes," it predicted, "the radio swords which are now being forged on the anvil of science will be beaten into ploughshares useful in normal life. Then there will be a new era in the radio transmission of sound and sight, and in the industrial uses of radio and electronic devices."[39] An emblem of technological modernity, radio promised to overcome the obstacle that the jungle posed. In a 1944 advertisement on *Electronics*, a serviceman was pictured holding a Handie-Talkie in a leafy jungle. Whereas, in 1898, it was only "after weeks of

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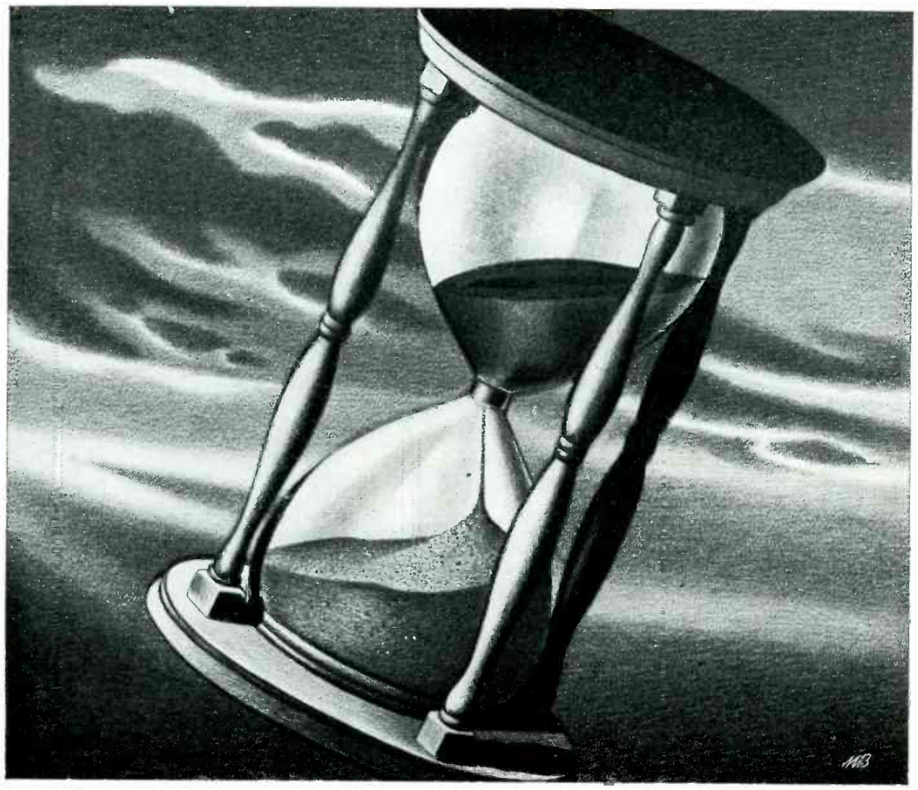
445–53; Timothy K. Choy, *Ecologies of Comparison: An Ethnography of Endangerment in Hong Kong* (Durham, NC: Duke University Press, 2011); Nicholas Shapiro, "Attuning to the Chemosphere: Domestic Formaldehyde, Bodily Reasoning, and the Chemical Sublime," *Cultural Anthropology* 30, no. 3 (August 10, 2015): 368–93; Timothy Choy and Jerry Zee, "Condition—Suspension," *Cultural Anthropology* 30, no. 2 (May 25, 2015): 210–23; Alison Kenner, *Breathtaking: Asthma Care in a Time of Climate Change* (Minneapolis: University of Minnesota Press, 2018). See also Gernot Böhme, "Atmosphere as the Fundamental Concept of a New Aesthetics," *Thesis Eleven* 36, no. 1 (August 1, 1993): 113–26; Ben Anderson, "Affective Atmospheres," *Emotion, Space and Society* 2, no. 2 (December 2009): 77–81.

[37] Jerry C. Zee, "Holding Patterns: Sand and Political Time at China's Desert Shores," *Cultural Anthropology* 32, no. 2 (2017): 219–20.

[38] Franklin D. Roosevelt, *The Public Papers and Addresses of Franklin D. Roosevelt. 1942 Volume, Humanity on the Defensive*, ed. Samuel I. Rosenman (New York: Harper, 1950), 6–7, http://name.umdl.umich.edu/4926593.1942.001.

[39] "RCA's All-Out for Victory," *Radio Craft* 13, no. 12 (September 1942): 750.



RADIO'S ELECTRONIC HOUR-GLASS

Electrons—infinitesimal bits of electricity—are grains of sand in the hour-glass of science.

Today, radio's hour-glass—the electron tube—is turned so that the electron stream flows day and night to help win the war. Unlimited, it will run on and on until Victory is measured out on land, at sea, and in the air.

Only Time and Peace can tip this glass and reverse the flow of magic into new products and services for civilian use. Then, in the hour-glass of progress, will flow television and other new miracles of radio as the electronic sands of science flow again in new directions.

BUY U.S. WAR BONDS

RADIO CORPORATION OF AMERICA

PIONEER IN RADIO, ELECTRONICS, TELEVISION

RCA BUILDING, NEW YORK, N. Y.

The Services of RCA: RCA Manufacturing Company, Inc. • RCA Laboratories
R. C. A. Communications, Inc. • National Broadcasting Company, Inc. • Blue Network Company, Inc.
Radiomarine Corporation of America • RCA Institutes, Inc.

Figure 5: "Radio's Electronic Hour-Glass." *Electronics*, August 1942, 18.

Figure 6: "A Message to Garcia." *Electronics*, February 1944, 317.

tortuous travel at sea and matted jungles [that] the famous message was delivered to General Garcia," in 1944 "military messages of vital importance are delivered in a split second by means of modern radio and electronic devices."[40] In contrast to the slouched, tattered serviceman from the turn of the century in the small oval panel, the confident-looking modern serviceman stood upright with his matériel intact, seemingly unencumbered by the jungle around him. Implicit in this advertisement was the belief that modern technology had annihilated time and space. In an iteration of what the historian Paul Sutter calls American tropical triumphalism, radio reached deep into the jungle, folding it into the smooth space of logistics that extended from the mainland.[41]

These self-congratulations of the radio industry notwithstanding, radio did not fare well in the tropics. As late as April 1945, the president of a radio firm grumbled that "here in this country we still cannot realize the great distances and the tropical hazards that are so perplexing in maintaining communications."[42] Rather than the speed of communication, it was the speed of fungal growth on equipment that elicited wonder. Mycologists sneaked tall tales of fast-growing fungi into their otherwise sober accounts of tropical deterioration. "In the moist heat of the tropics," a mycologist recalled, "molds grow so rapidly that they cover shoes with a green felt overnight."[43] As another mycologist reported, textiles were "rapidly weakened and disintegrated by the action of cellulose-destroying fungi and bacteria."[44] While tropical fungi ravaged a wide range of materials, it was the deterioration of electronic equipment that threw a genuine curve ball. "More unexpected during World War II," recounted the mycologist Walter N. Ezekiel of the Navy Bureau of Ordnance, "was the damage in connection with the increasing use of electrical and electronic communication, detecting, computing, directing, and other mechanisms used ashore and afloat. The Signal Corps and the Marines found that signal equipment taken into the jungles might go out of action within a few hours."[45] Fungi also posed a serious problem to the Mosquito Network. Not only did they grow on microphones, but they also "limited the useful life of radio receivers to about four months before their innards simply rotted away."[46] Indeed, fungi came to stand in for the failure of radios in the tropics, even though many later argued that it was

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[40] "A Message to Garcia...," *Electronics*, February 1944, 317.

[41] On American tropical triumphalism, see Paul S. Sutter, "Nature's Agents or Agents of Empire?: Entomological Workers and Environmental Change during the Construction of the Panama Canal," *Isis* 98, no. 4 (2007): 724–54.

[42] Wesley N. Angle, "A Long and Difficult War," *Radio Craft*, April 1945, 425.

[43] Ralph Emerson, "Molds and Men," *Scientific American* 186, no. 1 (January 1952): 31.

[44] W. G. Hutchinson, "The Deterioration of Materiel in the Tropics," *The Scientific Monthly* 63, no. 3 (1946): 165.

[45] Walter N. Ezekiel, "Mycological Problems in Deterioration of Military Equipment," *Transactions of the New York Academy of Sciences* 12, no. 7 Series II (1950): 225.

[46] Trent Christman, *Brass Button Broadcasters: A Lighthearted Look at 50 Years of Military Broadcasting* (Nashville, TN: Turner Publishing Company, 1992), 44.

Figure 7: "Deadly Agents of Destruction." *Electronics*, November 1944, 268.

merely the most eye-catching aspect of it.[47] Indeed, as hard as these scientists and engineers were fighting against fungi, they could not help but marvel at their enemies. As one Bell Laboratories engineer noted, "the web-like networks of these minute plants, shown growing on the surfaces of apparatus in the accompanying illustrations, are often spectacular in appearance. … From these pictures it can be readily understood why attention was directed to the fungus [instead of moisture]."[48]

The mixture of disgust and awe at fungi bespeaks the deep ambivalence that Europeans and Americans had long held towards the tropics, imagined to be a global, environmentally and epidemiologically uniform zone that seesawed between the Edenic garden and the green hell. An exotic foil for its temperate counterpart, tropical nature was rich with flora and endowed with special fecundity. "It is the vegetation," the German naturalist Alexander von Humboldt wrote of the tropics in the early nineteenth century, "that determines the character of a landscape and acts on our imagination by its mass, the contour of its forms, and the glow of its colours."[49] In his equally influential 1878 essay, *Tropical Nature*, the British naturalist Alfred Russel Wallace affirmed Humboldt's portrayal of tropical plants. A co-founder of evolutionary theory, Wallace saw the tropics as a place where "evolution has had a fair chance." "The equatorial regions are … ," he wrote, "a more ancient world than that presented by the temperate zones, a world in which the laws which have governed the progressive development of life have operated with comparatively little check for countless ages, and have resulted in those infinitely varied and beautiful forms."[50] In the tropics, cycles of growth and decay in nature unfolded unimpeded, albeit at the expense of human civilization. "The tropics," the historian David Arnold puts it in a nutshell, "were represented as a landscape in which the power of nature dominated human existence."[51]

In light of the emphasis on lush vegetation in the tropics, it is little surprise that exuberant fungal growth would catch attention. Indeed, tropical thinking was well and alive in the United States by the beginning of the Second World War.[52] Although it ran rampant especially in popular

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[47] "During the early periods of the war, there was a general attitude of dismay at the mere presence of fungi growing on delicate electrical equipment" even when it only presented a cosmetic issue. Walter N. Ezekiel, "Problems in Fungus and Moisture Deterioration," *Electrical Manufacturing* 45, no. 3 (March 1950): 79–80.

[48] John Leutritz, Jr., "Protecting Communications Equipment for the Tropics," *Bell Laboratories Record* 23, no. 4 (April 1945): 106.

[49] Quoted in Stepan, *Picturing Tropical Nature*, 37.

[50] Alfred Russel Wallace, *Tropical Nature, and Other Essays* (London: Macmillan and Company, 1878), 123.

[51] Arnold, "'Illusory Riches,'" 7.

[52] In the first half of the twentieth century, the jungle in popular culture came to represent a wilder, more pristine extension of American wilderness in what Kelly Enright calls the "maximum of wilderness"; see Kelly Enright, *The Maximum of Wilderness: The Jungle in the American Imagination* (Charlottesville: University of Virginia Press, 2012). On American servicemen's encounters with the South Pacific, see Judith A. Bennett, *Natives and Exotics: World War II and Environment in the Southern Pacific* (Honolulu: University of Hawai'i Press, 2009), 11–27. To be sure, the dividing line between "users" and "makers" in the case of radio and electronic equipment in the Second

culture, scientists were far from immune from it. As the historian Megan Raby suggests, Wallace's emphasis on lush vegetation framed the endeavors of American tropical biologists throughout the twentieth century.[53] Fungi, often described as lower plants, channeled the special intensity of tropical nature. As one RCA engineer remarked, "under tropical conditions of high temperature and humidity, nature seems to have no difficulty developing prolific fungus growth."[54]

Woven together by air, the portable radio and the tropics colluded to create conditions propitious to fungal growth. In high humidity, diurnal variation in temperature, which spans wider in the tropics due to the angle of sunlight, resulted in heavy condensation of moisture on any surface that air could reach, but especially inside the encasement that would then trap the resulting water. Moist surfaces, in turn, became fertile grounds for minute fungi, whose spores air also carried. Often made of cellulosic materials of biological origins such as cotton, linen, and wood, insulating surfaces in electronic equipment proved particularly susceptible. Not only the ensuing change in electrical characteristics of insulating materials, but also sometimes the mycelium itself would lead to current leakage. "The insulation resistance of a fungus hypha was reported to be .3 to .004 megohms," reported Waksman.[55] Once animal or casein glue rotted, the whole structure would collapse. Either organic or synthetic, plastics, too, perished. Fungi on the "Bakelite insulation of switches, plugs and sockets, cause minor electric shocks to personnel."[56] Even metal parts did not remain safe from fungal growth, which, though thriving in adjacent parts, not only acted as nuclei for moisture condensation, but also secreted corrosive by-products from its decomposition. Indeed, components that did not readily became fodder for fungi could still act as depositories for their food.[57] However, it was the U.S. military's demands for increasingly smaller and lighter radio sets that made matters worse. As the media scholar Mara Mills explains about the miniaturization of electronics, "the interconnections between components have been miniaturized in conjunction with the components themselves; the steady

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World War was never clear. In their civilian life, many Signal Corps personnel were either "ham" radio amateurs or radio professionals. Indeed, the majority of radio professionals got started as amateurs. Radio magazines also ran several advertisements to recruit hams to join the Signal Corps as well as to affirm the importance of radio amateurs during and after the war.

[53] Megan Raby, *American Tropics: The Caribbean Roots of Biodiversity Science* (Chapel Hill: The University of North Carolina Press, 2017), 4–8.

[54] Clifford Eddison, "Fungus Fighters," *Radio Age* 4, no. 4 (July 1945): 29.

[55] Waksman, "Fungi and Tropical Deterioration," 11.

[56] Waksman, 12.

[57] For summaries of the effects of fungi on electrical and electronic equipment in the tropics, see, for example, Waksman, 11–15; E. S. McLarn et al., "Tropical Moisture and Fungi: Problems and Solutions," *Electrical Communication* 22, no. 4 (1945): 303–13; Charles Heimsch, ed., *Tropical Deterioration of Equipment and Materials* (Washington, D.C.: U.S. National Defense Research Committee, 1946), 57–61; H. C. Gilbertson, "Electrical and Electronic Equipment," in *Deterioration of Materials: Causes and Preventive Techniques*, ed. Glenn A. Greathouse and Carl J. Wessel (New York: Reinhold Publishing Corporation, 1954).

increase in circuit complexity was always tied to new methods for compact assembly."[58] The interior with compactly packed components, however, made for poorly ventilated pockets of air in which molds thrived. "Confined atmospheres are the most difficult problems to solve," complained one radio engineer. "Compact, light-weight equipments make necessary the very thing which contributes to the equipment's failure: confined atmospheres which are good clinging places for the fungus. The points of concentration of fungus growth are readily illustrated to be the confined atmospheres: lacing of wire, switch contacts, meters, etc."[59] As another engineer noted, "the interior of electronic equipments, usually of the small portable type, became covered with a network of fungi."[60]

As air contaminated radio with plant life, the biodegradation by fungi brought *organic time* to bear on *mechanical time*. In the now-standard narrative of modernity, organic time gave way to mechanical time as natural rhythms made way for the abstract temporal regime, which wage labor and industrialization imposed with the aid of ever smaller and more reliable timekeeping devices such as the clock.[61] Often attached to the ideology of liveness, the radio might be construed as one such timekeeping device, insofar as it purported to put listeners in the same temporal frame. Nevertheless, organic time never quite disappeared. "Efforts to find order in the tumult of wind and leaves, frosts and thaws, floods, droughts, and harvests," argues the historian Kate Wersan, "are all part of [the history of timekeeping]. Seen this way, the history of time is, inherently, a history of environmental perception."[62] Unlike mechanical time, organic time did not march forward in a straight line, but rather unfolded in cycles. Fungi, I suggest, gave form to organic time, insofar as their decomposition put energy and substance back into the cycle of nature. Yet, in the tropics where nature held sway, this organic temporal form also spun faster. "Equipment with a predictable service life of months or years when used in temperate climates," two engineers later recalled, "became in the tropics inoperable in a matter of a few weeks."[63] In the chronopolitics of tropical deterioration, then, tropical fungi threatened to put constituents of the portable radio back into the natural circulation at a faster rate than anticipated by the carefully choreographed space of circulation of military logistics. "Tropical Deterioration,"

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[58] Mills, "Hearing Aids and the History of Electronics Miniaturization," 24. On the portable battery that was also developed during the Second World War, see Eric S. Hintz, "Portable Power: Inventor Samuel Ruben and the Birth of Duracell," *Technology and Culture* 50, no. 1 (2008): 24–57.

[59] H. A. Parker, "Tropicalization," *Radio* 28, no. 11 (November 1944): 31.

[60] Gilbertson, "Electrical and Electronic Equipment," 658.

[61] By timekeeping, I mean, following the historian Kate Wersan, "the practice of perceiving, interpreting, and situating the fluid relationships between phenomena in the world as they change over time into a matrix that is replicable, portable, and meaningful." See her "The Early Melon and the Mechanical Gardener: Toward an Environmental History of Timekeeping in the Long Eighteenth Century," *Environmental History* 22, no. 2 (January 20, 2017): 283.

[62] Wersan, 283–84.

[63] Glenn A. Greathouse and Carl J. Wessel, eds., *Deterioration of Materials: Causes and Preventive Techniques* (New York City: Reinhold Publishing Corporation, 1954), vii.

asserted one mycologist in his 1945 handbook, "has resulted in a loss of much valuable equipment, the waste of shipping space and of man hours."[64] In this way, tropical nature threw a wrench into the war machine hell-bent on producing its way to victory.

In transmuting into food for fungi, the decaying portable radio turned into a medium for attuning to the tropical atmosphere as a continuation of plant life. "The abundant and luxuriant growth of trees, plants, grass, and other tropical flora," a team of engineers wrote, "results in a high proportion of minute particles of vegetable organic matter being dispersed in the air. This dust or debris settles on surfaces, cracks, or in apertures of components and supports the growth of fungi."[65] If lush vegetation was a defining feature of tropical nature, it comes as no surprise that plants not only rooted themselves in the soil, but also saturated the air. The botanist Charles Heimsch, who was deeply involved in research on tropical deterioration, wrote about fungi in the air as follows:

> Fungi are encountered as mold and mildew on materials in temperate regions, but not nearly to the extent that is found in the tropics. The rapid growth and development which these organisms are able to make in the tropics present conditions and problems which do not occur in temperate zones. Although these organisms are characteristic of soils, reproductive structures or spores which they produce are airborne and are present in the atmosphere in large numbers. Anything exposed to the atmosphere becomes inoculated with such spores as a matter of course.[66]

"The air we breathe is not a purely geological or mineral reality—it is not just out there, it is not, as such, an effect of the earth—but rather the breath of other living beings," proposes the philosopher Emanuele Coccia. If "every day we feed off the gaseous excretions of plants," to be immersed in the atmosphere is to mix oneself with all other beings.[67] Though fanciful, his claim resonates with Heimsch's description of how microscopic plants pervaded the air in the tropics. Here, air's substantiations brought about transmutations that mixed plants with radio, nature with technology. Discrete categories came undone. If air dissolved the line between nature and technology in tropical deterioration, the next section probes how tropicalization sought to redraw it by partitioning air.

Tropicalization and the Insular Environment

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[64] Leland Shanor, "Handbook of Some Fungi Associated with Tropical Deterioration," OSRD Report, October 1945, 1.

[65] McLarn et al., "Tropical Moisture and Fungi," 305.

[66] Charles Heimsch, "History of Tropical Deterioration Committee," in *Chemistry: A History of the Chemistry Components of the National Defense Research Committee, 1940–1946*, ed. W. A. Noyes, Jr. (Boston, MA: Little, Brown and Company, 1948), 445–46.

[67] Emanuele Coccia, *The Life of Plants: A Metaphysics of Mixture*, trans. Dylan J. Montanari (Medford, MA: Polity, 2019), 47.

"A true conception of the number and rapidity of growth of these organisms [i.e., fungi and other microbial agents] is not common in the engineering world," reflected the engineers R. Proskauer and H. E. Smith of the Insl-X Company, which had been active throughout the war in devising tropicalization techniques, in their May 1945 contribution to *Electronics*. "It is difficult," they mused, "to look at a few drops of transparent water and realize the infinite number of living organisms present. It is even more difficult to realize the complex, intricate, and never-ending cycle of life taking place in such a small quantity of material."[68] This ignorance of microorganisms in the engineering world perhaps found justification in the domestication of radio in the interwar years. "In the case of electronic equipment which in pre-war years was normally well-sheltered," Proskauer and Smith wrote, "the whole technology of manufacturing components and assemblies grew up with no severe service conditions or exposure background."[69] To be sure, the Second World War by no means marked the first exposure of the portable radio to the tropics, but scattered pre-war efforts underwent centralization and consolidation in wartime exigencies.[70] Having carried on their own investigations separately, the Army, the Navy, and the National Defense Research Council (NDRC), and the radio industry joined force in February 1944 to establish the Tropical Deterioration Committee to coordinate their research.[71] Given these concerted efforts, did the problem of tropical deterioration actually

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[68] R. Proskauer and H. E. Smith, "Fungus and Moisture Protection," *Electronics*, May 1945, 123.

[69] Proskauer and Smith, 119.

[70] The Signal Corps had already faced the problem that hostile climates posed to communications technology by the turn of the century after its activities in the circum-Caribbean, the Philippines, and Alaska. In fact, it had already put wireless to use in these "extreme" environments. In 1904, wireless was employed to communicate across Norton Sound in Alaska across which it proved impossible to lay down wire. In 1906, portable radio sets were shipped to Cuba. See Rebecca Robbins Raines, *Getting the Message Through: A Branch History of the U.S. Army Signal Corps* (Washington, D.C.: Center of Military History, U.S. Army, 1996), 105, 108, 136–140. Radio also featured in the Mexican Border War (1910–19), where Signal Corps officers found that "atmospheric conditions in the Mexican mountains hampered radio transmissions." See Raines, 150. Furthermore, Welby E. Stewart, a naval radio engineer who had been stationed in Panama, observed in the March 1941 issue of *Electronics* that "although manufacturers of radio receivers have for years taken precautions with equipment designed for tropical climates, the problem remains far from resolved." Without elaborating further, Stewart mentioned that "some of the South American countries have resorted to their own ingenuity in overcoming the defects." Welby E. Stewart, "Receivers for the Tropics," *Electronics*, March 1941, 28. The botanist W. G. Hutchinson also remarked that "in spite of considerable experience in the use of military equipment in the Philippine Islands and in the Panama Canal Zone the United States approached World War II surprisingly unprepared to carry on military engagements in the humid tropics." It is indeed curious why the American Armed Forces were not better prepared, but neither am I to provide a convincing answer. Hutchinson, "The Deterioration of Materiel in the Tropics," 165. Failure in electronics was also noticed in oil prospecting in the southern United States, Mexico, and South America as early as 1925. McLarn et al., "Tropical Moisture and Fungi," 303.

[71] Heimsch, "History of Tropical Deterioration Committee," 446–47. Problem-oriented interdisciplinary research as a pattern of work organization became common under wartime mobilization of American science during the Second World War, but see Steven Shapin, *The Scientific Life: A Moral History of a Late Modern Vocation* (Chicago: University of Chicago Press, 2008), 64–65. While there is certainly much to be said about organizational forms and

convince the engineering world to appreciate the complexity of microorganisms teeming in the tropical environment? If so, in what manner? In this section, I draw attention to *hermetic sealing* as the preferred method, which, as a technique of insulation, sought to protect electronics and their components from the dangers of atmospheric air in the tropics through airtight packaging. As I argue, while this technique promised to extirpate environmental hazards, it did not jettison the environment from technology altogether. Far from it, it made durable in the design of the portable radio a place-neutral rendering of the environment, one that reduced its complex embeddedness in place to a set of relevant quantities reproducible anytime, anywhere.

The ostensible novelty of tropical deterioration in radio equipment notwithstanding, radio makers were far from helpless against fungi. Since molds feasted on organic materials, swapping them for more fungus-resistant materials seemed an obvious solution. Looking to past experience with fungus-proofing in agricultural and industrial research, furthermore, radio makers turned to fungicides to solve their problems.[72] While these solutions did work to some extent, radio makers came to see them as stopgaps. Made from materials of diverse kinds, different components of radio-electronic equipment often interacted in ways that baffled foresight. Fungicides not only wore away in heat and humidity, but also unevenly affected different species of fungi. Given all these headaches, a more airtight solution was needed.

Hermetic sealing fit the bill, since it purported to shut out dangerous atmospheric air altogether. "Adverse climatic conditions to which military electrical and electronic equipment was exposed during the war time," wrote one electrical engineer, referring to hermetic sealing, "caused a major change in assembling and 'packaging' of electric components. … Investigations of this problem … showed that the most satisfactory solution could be obtained by hermetic sealing of electrical components."[73] Though a centuries-old technique, hermetic sealing, particularly glass-to-metal and ceramic-to-metal, underwent significant improvement during the war.[74] While whole units were sealed when appropriate, hermetically sealed electronic

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behaviors of the Tropical Deterioration Committee, I am focusing here more on the cultural aspects of tropical deterioration.

[72] "Except for the rather widespread damage to crop plants," wrote Heimsch in 1946, "[fungi] are of relatively of minor economic significance [in the temperate regions]." Heimsch, *Tropical Deterioration of Equipment and Materials*, 7. It is no coincidence, then, that both Waksman and Ezekiel were specialists in soil fungi prior to the war. While Waksman worked on hummus and soil fertility at the New Jersey Agricultural Experiment prior to his involvement in the wartime efforts, Ezekiel's prior research, which he carried out at the Texas Agricultural Experiment Station, was on cotton root rot. See Waksman, *My Life with the Microbes*, 183–95; Walter N. Ezekiel, "The Cotton Root-Rot Tour and Conference of 1940," *Science* 92, no. 2397 (1940): 533–34. Aside from biologists, chemical engineers, too, were familiar with molds in lumber and textiles. Heimsch, *Tropical Deterioration of Equipment and Materials*, 27.

[73] E. B. Steinberg, "Hermetically Sealed Components for Industrial Control," *Electrical Manufacturing* 46, no. 1 (July 1950): 110.

[74] McLarn et al., "Tropical Moisture and Fungi," 312.

Figure 8: "Hermetically Sealed with Kovar." *Electronics*, June 1944, 366.

components also enjoyed increasing popularity among radio makers.[75] Among these components were relays, capacitors, resistors, and transformers. In the hermetic seal, the medium in which the active circuit was suspended ranged from vacuum, oil, to gas. Due to their inert nature, dry air, nitrogen, helium, and hydrogen were popular choices.[76] With hermetic sealing, "the cleanliness and atmospheric conditions which surround the electrical components can be accurately controlled and maintained throughout the life of the equipment."[77] If atmospheric air in the tropics proved deleterious to portable radios, it made sense to create a safe, controllable atmosphere enveloping them wherever they went.

Technical reasoning goes some way to explaining the trend toward hermeticity, but does it suffice? Though undoubtedly effective, hermetic sealing was hardly faultless. Chief among its cons was its incompatibility with portability, as radio makers soon realized. As one radio engineer observed, "this [i.e., the complications from use of fungicides] leads to one conclusion: all components should be hermetically sealed where possible. This is in conflict with our first statement that equipments must be small and compact."[78] Aside from making portable radios bulkier, hermetically sealed components made them more prone to overheating. Once miniaturized, electronic components not only had reduced surface for emitting heat, but also crowded close to one another, leading to increased heat density. That the hermetic seal also shielded them from the cooling effects of air currents further exacerbated the problem.[79] In these ways, environmental concerns continued to plague radio makers. What else, then, might account for the appeal of hermetic sealing?

One answer lies in different understandings of technology *vis-à-vis* the environment. The interdisciplinary nature of research on tropicalization notwithstanding, engineers resisted biologists' insistence on the place specificity of tropical deterioration. Since the turn of the century, as Raby shows, American tropical holdings in the circum-Caribbean had helped foster the conviction for place-specific research in tropical biology, since they allowed American biologists to return to the same place to study tropical flora and fauna.[80] This conviction explains why biologists on the Tropical Deterioration Committee plotted a scientific mission to the South Pacific to conduct research on tropical deterioration *in situ*.[81] Yet, the military commanders in

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[75] My own survey of radio magazines reveals that the number of advertisements of hermetically sealed components noticeably went up by late 1943.

[76] Steinberg, "Hermetically Sealed Components for Industrial Control," 112.

[77] Steinberg, 110.

[78] Parker, "Tropicalization," 29.

[79] Gilbertson, "Electrical and Electronic Equipment," 654.

[80] Raby, *American Tropics*.

[81] Manning this mission would be a mycologist, a microbiologist, an entomologist, and a soil bacteriologist. The competition with their Australian colleagues, who had established field stations in New Guinea, might also play a part. The original list of personnel comprised the mycologist W. G. Hutchinson of the University of Pennsylvania; the microbiologist E. S. Barghoorn of the Office of Field Service, OSRD; the entomologist E. W. Baker of the

charge of the South Pacific Theater never greenlighted it.[82] "The cancellation was a bitter disappointment to all those concerned with the activities of the Tropical Deterioration Steering Committee," Heimsch voiced his frustration, "particularly since the importance of reliable information from the field under Service conditions had been realized early in the course of these activities." The Theater's reason for the cancellation reveals its disagreement with the biologists' understanding of the tropics. "No problems are obvious in this operational Theater which are not common to other tropical areas in which research is feasible and in which facilities are adequate," communicated the Theater. Yet, this assumption about the uniformity of the tropics, though a feature of Humboldtian tropicality, did not quite satisfy the biologists. "Not infrequently," wrote Heimsch, "important questions were raised which could have been properly answered if there had been available to the Steering Committee full knowledge of field conditions or how protective treatments of items of equipment perform in the field."[83] Indeed, it is telling that these biologists saw the rerouting of the mission to the Panama Canal Zone as a compromise. For them, the Barro Colorado Island could not stand in for the South Pacific.[84] "[The mission's] makeup, as proposed, does not meet the needs of the Theater," the commanders gave another justification, "since the personnel are all biologists whereas the problems involve design and implementation rather than a study of cause of fungal damage."[85] The prioritization of quick technological fixes, then, came at the expense of fundamental biological research on tropical deterioration, the full scope of which, Heimsch and his colleagues believed, was possible only with fieldwork. Such place-specific knowledge, for which biologists advocated, evinces what we might call an "ecological" understanding of technology, on which the boundary remains porous between technology and the environment.

Such an ecological understanding of technology ran counter to a place-neutral understanding of technology, on which technology works identically regardless of place. Yet, here, place neutrality was sooner an achievement than a fact. Faced with a choice between different methods of tropicalization, the engineer Albert C. Titus and his colleagues at General Electric opted for hermetic sealing as "a far more desirable, permanent, and completely

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Bureau of Entomology and Plant Quarantine, U.S. Department of Agriculture, U.S. National Museum Division of Insects; and the soil bacteriologist H. W. Reuszer, U.S. Department of Agriculture. One or two officers from the Army and the Navy were also expected to join. Heimsch, "History of Tropical Deterioration Committee," 451.

[82] Heimsch, 451–53; Richard A. Howard, "The Role of Botanists during World War II in the Pacific Theatre," *Botanical Review* 60, no. 2 (1994): 241.

[83] Heimsch, "History of Tropical Deterioration Committee," 452–53.

[84] It is hardly surprising that they would settle on the Panama Canal Zone, since the Barro Colorado Island had historically been a popular destination for scientific missions. On environmental histories of the Panama Canal Zone, see Ashley Carse et al., "Panama Canal Forum: From the Conquest of Nature to the Construction of New Ecologies," *Environmental History* 21, no. 2 (April 1, 2016): 206–87.

[85] Heimsch, "History of Tropical Deterioration Committee," 452.

satisfactory solution."[86] After taking stock of the ways in which the use of fungicides had gone awry under actual tropical conditions, he offered the metaphor of electronics as "ecologies":

> It is not news to engineers to be told that wherever some difficulty is overcome by a treatment of some sort, new troubles may crop up or be amplified by the modification. We see it too in the biological world. When English Sparrows were imported to improve our esthetic American world, they then multiplied out of bounds in the absence of their natural environmental checks, the result being anything but esthetic. … What may result from using the insecticide DDT in America? To kill our mosquitoes would be nice, but there are good bugs as well as bad ones—and does DDT know the difference? Similarly it has been found that the most promising fungicides bring various difficulties in their wake.[87]

Titus likened the delicate electronic components to the native elements in a fragile ecology. The introduction of foreign elements like fungicides (not to mention tropical fungi themselves) threatened to put it off balance, since they could interact with native elements in unpredictable, complex manners. In an inverted preservationist ethos, hermetic sealing guarded against this complexity. By preempting any interactions between technology on the inside and the environment on the outside, it strove to harden place neutrality into a fact. Nevertheless, hermeticity could never completely shut out the environment from technology, any more than national borders could ever wall off fluxes of species. As such, it tells us more about these engineers' aspiration toward place neutrality, which they had built into the very design of the portable radio.

If the encounter between the portable radio and the tropics led to hermeticity in the design of electronics, how did it rematerialize the environment? Rather than expunge the environment from the engineering perspective, it parsed the "tropics" into a set of parameters, thereby casting the environment into an inert, homogeneous background instead of an active force with agency. "Fungus attacks upon [more fungus-resistant insulants]," wrote Waksman, "are particularly difficult to duplicate in the laboratory, due possibly to lack in the latter of the proper fungus spores found in the tropics, and the great difficulty of simulating natural conditions."[88] Whereas Waksman, much like the biologists on the Committee, worried about how accurately the laboratory simulated the field, radio engineers did not always share this concern. In the July 1943 issue of *Electronics*, the Rauland Corporation ran advertisement boasting that it

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[86] O. G. McAninch and L. F. Perott, "Hermetically Sealed Instruments," *General Electric Review* 48, no. 11 (November 1945): 29.
[87] Albert C. Titus, "Fungus Growths and Electric Apparatus," *General Electric Review* 48, no. 8 (August 1945): 20–21.
[88] Waksman, "Fungi and Tropical Deterioration," 12.

—so we brought the jungle to Chicago

Sweltering jungle heat and ever-dripping moisture is a real test of endurance for our fighting men. But how about the *Communications* equipment upon which their very lives often depend? To find the answer, RAULAND engineers brought the jungle right into our laboratories! They built a large, glass-enclosed, air-tight cabinet . . . provided it with the dripping wetness of saturated, super-heated air and tropical plants and lush vegetation, deep rooted in mossy loam. Into this "torture chamber" went RAULAND Communications equipment . . . to finally emerge with the correct answers to some very vital questions. A typical example of RAULAND engineering thoroughness in making certain that its precision instruments serve dependably under even the most trying conditions.

RADIO . . . SOUND . . . **Rauland** . . . COMMUNICATIONS

Electroneering is our business

THE RAULAND CORPORATION . . . CHICAGO, ILLINOIS

Buy War Bonds and Stamps! Rauland employees are still investing 10% of their salaries in War Bonds

Figure 9: "—So We Brought the Jungle to Chicago." *Electronics*, July 1943, 135.

had "brought the jungle to Chicago" by building a "torture chamber" that simulated tropical conditions to test the endurance of its radio equipment.[89] In these torture chambers, which had become common in radio laboratories, tropical plants were placed in artificial hot and humid air, before the chambers were inoculated with fungus cultures.[90] If the laboratory simulation granted that the jungle could be reduced to a set of controllable parameters, the same premise also held outside the laboratory: it underpinned the place-neutral definition of the "tropical environment" widespread in articles on tropicalization that addressed radio engineers. "Fungus growths," wrote the GE engineer Titus, "are promoted by the combination of relative humidities of 85 per cent or more and temperatures of 25 to 35 C. Such conditions may be defined as 'tropical,' whether they occur in the tropics or inside an unventilated moisture-proof packing box on a loading platform in Nebraska in a dry period."[91] Note that, here, the category of "tropical" became untethered from the geographical region, morphing into a set of relevant quantities reproducible outside the geographical tropics. If fungus attacks threatened to strike anytime, anywhere, they were also located nowhere in particular. In these ways, the rich milieu that stood in dynamic relationships with fungal life turned into an empty container.[92]

Conclusion

"Radio, or, more strictly because more broadly, wireless signalling, unleashed a dream of absolute communication and universal contact," writes the literary scholar Steven Connor.[93] If air underlaid this dream, it also undermined it by folding tropical flora into this communion. As air's materializations multiplied out of control, it was ironically through the division of air into technological and environmental that fungi could be weeded out from this dream. Hermetic sealing made durable in the design of the portable radio a specific vision for the relationship between technology and the environment, one that aspired to keep them apart. This aspiration for place neutrality, in turn, stripped the environment of its agentive force and reduced it to an inert background through which the portable radio could travel unaffected. As the "tropics" became dislodged from its geography, the problem of tropical deterioration also lost its region specificity, let alone its place specificity. "Information gathered since the war, to the effect that moisture and microorganisms, particularly fungi, can and do cause just as serious damage (if not quite so rapidly) in areas far from the equator," wrote Ezekiel, "has made it desirable to drop the names

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[89] "—So We Brought the Jungle to Chicago," *Electronics*, July 1943, 135.

[90] See, for example, Eddison, "Fungus Fighters"; "Fungus: Enemy of Radio Sets," *Radio Craft* 16, no. 4 (January 1945): 208, 247; T.F. Cooke and R.E. Vicklund, "Tropical Testing Chamber," *Industrial & Engineering Chemistry Analytical Edition* 18, no. 1 (January 1, 1946): 59–60.

[91] Titus, "Fungus Growths and Electric Apparatus," 20.

[92] This rendering of the environment into a quantifiable entity that forms the homogeneous space in the background of life instead of an active force in life was neither new nor unique to the tropicalization of the portable radio. See, especially, James Rodger Fleming and Vladimir Jankovic, "Introduction: Revisiting Klima," *Osiris* 26, no. 1 (January 1, 2011): 1–15.

[93] Steven Connor, *The Matter of Air: Science and the Art of the Ethereal* (London: Reaktion Books, 2010), 198.

['tropical deterioration' and 'tropicalization'] in favor of terms such as 'moisture and fungus proofing' and 'deterioration prevention.'"[94] The new science of tropicalization, then, sought to find its bearings in the postwar years by universalizing the failure that it was designed to fix.

Portable failure also translated to portable expertise. "We can make isolationism as dead an issue as slavery, and we can make a truly *American* internationalism something as natural to us in our time as the airplane or the radio," Henry Luce set the agenda for the American Century in his 1941 editorial.[95] In his vision, the ubiquitous radio not only stood in metaphorically for internationalism, but also infrastructured it by airing messages of liberal democracy everywhere. "We are in a war to defend and even to promote, encourage, and incite so-called democratic principles throughout the world," declared Luce.[96] It is not without irony that hermetic insulation was lodged at the heart of this vision of internationalism. Indeed, tropicalizationalso insulated American aspirations projected onto the tropical world. Now climate-proofed, radios were advertised as companions to vacationing Americans in their "tropical" adventures. "Hams planning *safaris* into sections of country having high humidity," speculated one article, "may find it necessary to protect equipment against the ill effects of such climate."[97] A popular postwar model, the "sensational" Minerva Tropic Master was billed as "built for harsh and punishing use—ideal for vacationists and outdoor sportsmen. … Seldom do civilians have a chance to purchase a radio so well constructed."[98] Apart from tourism, the zeal for economic development also became tropicalized. "One of the reasons for the 'backwardness' of tropical territories," speculated a team of engineers about the future of tropicalization, "has been that much equipment and machinery was not usable because of climatic conditions. In the postwar era, industry will be able, to an extent not previously attained, to produce both capital equipment and consumers' goods capable of providing satisfactory service in tropical lands, thereby assisting in raising the standard of living." The tropics, then, provided not only a "new" locale for industrialization, but also a new market for American radios that would bring good life with them. "The beneficial economic effect of such a development may be equivalent to the opening of new frontiers."[99] Tropicalization helped recast the tropical world into a *tabula rasa* for ideological and economic expansion after the war by tuning out jungle noises, which would soon force their way back in.

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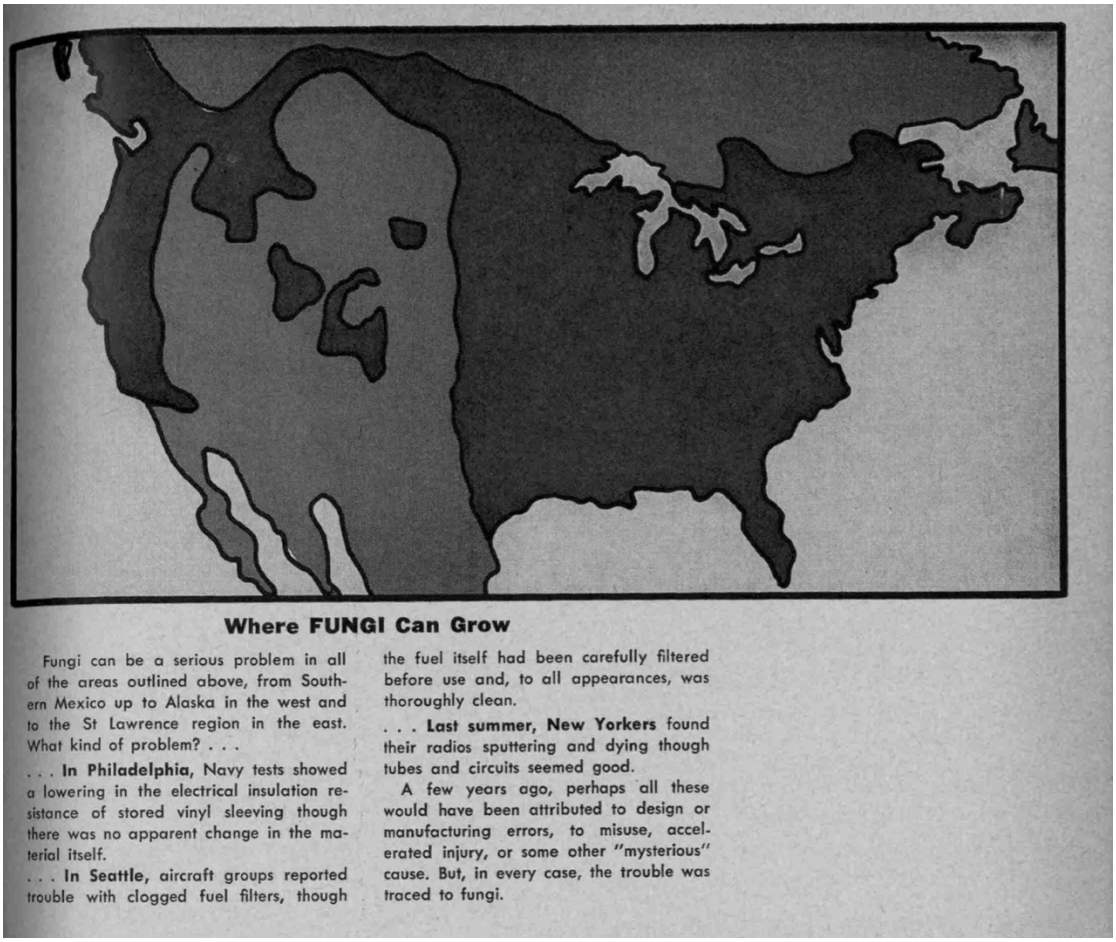
[94] Ezekiel, "Mycological Problems," 224.
[95] Henry R. Luce, "The American Century," *Diplomatic History* 23, no. 2 (April 1999): 166.
[96] Luce, 161.
[97] Reg Washburne and Archie Williams, "Ham Radio: Today and Tomorrow," *Radio News* 34, no. 6 (December 1945): 40.
[98] "Minerva Tropic Master," *Austin Daily Texan*, March 24, 1946.
[99] McLarn et al., "Tropical Moisture and Fungi," 313. On the tropical frontier after the Second World War, see Thomas Robertson, "New Frontiers: World War II Technologies and the Opening of Tropical Environments to Development," in *The Development Century*, ed. Stephen J. Macekura and Erez Manela (Cambridge: Cambridge University Press, 2018), 107–29.



Where FUNGI Can Grow

Fungi can be a serious problem in all of the areas outlined above, from Southern Mexico up to Alaska in the west and to the St Lawrence region in the east. What kind of problem? . . .

. . . **In Philadelphia,** Navy tests showed a lowering in the electrical insulation resistance of stored vinyl sleeving though there was no apparent change in the material itself.

. . . **In Seattle,** aircraft groups reported trouble with clogged fuel filters, though the fuel itself had been carefully filtered before use and, to all appearances, was thoroughly clean.

. . . **Last summer, New Yorkers** found their radios sputtering and dying though tubes and circuits seemed good.

A few years ago, perhaps all these would have been attributed to design or manufacturing errors, to misuse, accelerated injury, or some other "mysterious" cause. But, in every case, the trouble was traced to fungi.

Figure 10: "Where Fungi Can Grow." Annesta R. Gardner, "Fungi Are Your Product Problem," *Product Engineering* 31, no. 3 (January 1960): 53.

Figure 11: "Minerva Tropic Master," *Austin Daily Texan*, March 24, 1946.