Analysis of Hedy Lamarr's Contribution to Spread-Spectrum Communication

David Rand Irvin*

7 February 2024

Abstract: Analysis of primary-source documents archived by the Smithsonian's National Museum of American History and the U.S. Patent Office refutes the widely accepted legend that actress Hedy Lamarr and musician George Antheil invented frequency hopping spread spectrum (FHSS) communication. Particular attention is called to the prosecution history of the seventh claim of their original patent application, which claim could well serve as the definition of FHSS. Claim 7 was properly denied by the patent office based on prior art. The six allowed claims of US patent 2,292,387 describe Lamarr and Antheil's actual invention – an insignificant player-piano-like synchronization mechanism.

Introduction

The legend that glamorous actress Hedy Lamarr invented the communication method now called "frequency-hopping spread spectrum" (FHSS) is deeply ingrained in our culture. Some versions of the legend assert that her work was *sine qua non* for Bluetooth, GPS, cell phones, even the internet, and that without her essential contribution we would not have these.

The operation of FHSS is straightforward in concept. In an FHSS link, the receiver and the transmitter can be tuned over a large set of radio frequencies. At the start of communications, both the transmitter and the receiver operate on the same one of these frequencies. From that point on, as communication progresses, the receiver and the transmitter move together – i.e., hop, repeatedly and synchronously – from one frequency to another. This hopping can be seemingly at random, driven by an algorithm known to both the transmitter and the receiver, but unknown to a potential eavesdropper or jammer. Thus, FHSS provides a level of secrecy and resilience.

The legend that Hedy Lamarr invented FHSS flows from US Patent 2,292,387, "Secret Communication System" – filed 10 June 1941, granted 11 August 1942 – to inventors Hedy Kiesler Markey (Lamarr's legal name, at the time) and George Antheil. In order to evaluate this legend, the analysis presented here considers Lamarr and Antheil's pursuit of their invention, explains their granted patent, and clarifies what the patent actually conveys.

This analysis is based on primary-source documents preserved by the United States Patent and Trademark Office (USPTO) and the Smithsonian Institution's National Museum of American History (called here the "Archive").[1] Correctly understood, these documents unambiguously show that Hedy Lamarr did *not* invent FHSS. In reality, FHSS was already known by 1929.

---

* *David Rand Irvin was admitted to practice before the U.S. Patent Office in 1998 as an agent.*

We begin with a brief overview of the domain of patents for non-specialists, how they come about and what they actually mean, since, at minimum, an elementary knowledge of this specialized domain is prerequisite to understanding Lamarr and Antheil's contribution. Attention then turns to the scope of the particular invention conveyed by the Lamarr-Antheil patent, followed by a discussion of inventorship, attribution, secrecy, seizure, and royalties.

Patent Preparation, Prosecution, and Examination in the United States

The journey leading to a patent starts, of course, with the conception of an invention. Usually, the next steps are for the would-be inventors to write an *invention disclosure* describing their work – often an informal document – and to engage an attorney to prepare a *patent application* from the invention disclosure.

The attorney then files the application with the United States Patent and Trademark Office (USPTO). At this point, the would-be inventors may be called *applicants*.[2] The Patent Office classifies each incoming application according to its technological species, and assigns an *examiner*. Examiners are specialists. They know their assigned fields of technology, and are presumed to be fully competent by courts of law.

An important part of an examiner's job is to determine whether the purported invention clears several thresholds, two of which are (1) the invention must be novel, meaning that the same thing is not already known, and (2) the invention must not be obvious to those of ordinary skill in the art. The test for obviousness is neither explicitly defined nor straightforward. Rather, the question of obviousness is considered with reference to the USPTO's *Manual of Patent Examining Procedure,* which incorporates the body of pertinent case law (court decisions) and regulations.[3]

In order to determine whether the purported invention clears these two thresholds, the examiner searches for *prior art*. Prior art comprises relevant teachings – patents, journal papers, textbooks, commercial offerings, and so forth – that predate the application under examination. In other words, the examiner looks for earlier work along the same lines. Based on the results of the search, the examiner then determines the patentability of each claim of the application under review, and communicates this to the applicants' attorney in a *first office action*. The first office action may allow all of the applicants' claims, or allow only a subset of the claims, or reject all of the claims.

The attorney, with the advice and consent of the applicants, then responds to the examiner, either accepting the examiner's judgement or presenting a reasoned argument as to why the examiner has erred. The examiner replies with another office action, which may be final (although the process can iterate through further cycles of examination if need be, and is further subject to appeal). Ultimately, if and when the examiner allows any of the applicants' claims, a patent is issued in the name of the applicants, who may now properly be called *inventors*. This back-and-forth between attorney and examiner is known as the *prosecution* of

the patent application. Such records of the USPTO are open to the public once a patent is granted – these are the patent's "prosecution history" or its "file wrapper."

The Structure of US Patents

United States patents comprise three parts: (1) a set of claims, which define the patented invention, (2) a set of drawings when appropriate, and (3) a specification, which explains the claims and drawings.

The specification often makes up the bulk of a patent's word-count. It serves several purposes. The most important of these is to define and circumscribe the language used in the claims. Further, the specification must convey the claimed invention in sufficient detail to enable a person of ordinary skill in the art to make and use the invention without undue experimentation. Yet another purpose is to disclose the applicants' *preferred embodiment* or *best mode* of the claimed invention, so as to prevent applicants from obfuscating and thereby hiding their real invention by describing only an embodiment that they know to be sub-optimal.

Just about anything can be included in the specification. It is critical, however, to understand that the specification provides only descriptive material – it does not define the scope of the invention. For example, specifications may recite prior art in order to establish context for the claimed invention, or to aid in its description, or to provide a point of reference used to illustrate its superiority over what has come before. The inclusion of *something* in the specification, however, is no indication whatsoever that the applicants invented that *something*. Rather, the boundaries of an invention are defined solely by a patent's claims. Here is an example directly to the point: a mention of FHSS in the specification of the Lamarr-Antheil patent would *not* necessarily indicate that Lamarr and Antheil invented FHSS. Again, the invention is defined solely by the patent's claims.

Claims sometimes fall into groups lead by an "independent" claim followed by sequence of progressively narrower dependent claims. By way of illustration, consider the following hypothetical invention (not to be taken seriously):

> We claim:
> 1. A solid state junction comprising a crystalline base and two alloy beads disposed on said base.
> 2. The junction of claim 1, wherein said crystalline base comprises germanium.
> 3. The junction of claim 2, wherein said junction is encapsulated in a metal case having three wires extending therefrom, said three wires connecting to said base and to said alloy beads, respectively.
> 4. The junction of claim 3, wherein said metal case is blue.

Here, in this hypothetical example, claim 1 is the broadest – and therefore the most valuable and generous – statement of the invention. Claims 2 and 3 are narrower than claim 1, and claim 4 is the narrowest of all. In this particular example, claim 4 is intended to read on (to

cover) Raytheon's pioneering CK722 transistor of the 1950s. A casual observer might conclude that claim 4 would consequently be the most valuable of all the claims, as it covers (reads on) a valuable commercial product. This would be quite incorrect: claim 1 covers many transistors including the CK722, not just the CK722, and would therefore be more valuable than the narrower fourth claim.

This arises from the legally-accepted meaning of the word "comprise." In patent work, "to comprise" means "to include *at least*."[4] Thus, a patent's claim for an invention comprising elements A, B, C, and D, would "read on" a commercial product having elements A, B, C, D, and E. In other words, this commercial product would *infringe* such a patent, despite the presence of the additional element E. On the other hand, a commercial product having elements A, C, and D, but lacking B, would not infringe the patent.

The Ghost of Claim 7 and the Definition of Frequency-Hopping Spread Spectrum

The file wrapper of the Lamarr-Antheil patent includes the original application as filed with the USPTO on 10 June 1941 by the Los Angeles law firm Lyon and Lyon, and six claims that were allowed in their original form. The application also shows a seventh claim, however, which could well serve as the definition itself of frequency hopping spread spectrum (FHSS):

> *7. In a radio communication system comprising a radio transmitter tunable to any one of a plurality of frequencies and a radio receiver tunable to any one of said plurality of frequencies, the method of effecting secret communication between said stations which comprises simultaneously changing the tuning of the transmitter and receiver according to an arbitrary, nonrecurring pattern.*

In the first office action, dated 13 August 1941, the patent examiner cited US patents 1,869,659 to Broertjes[5] and 2,134,850 to Baesecke[6] against the Lamarr-Antheil application, and rejected claim 7 as "fully met by each of the citations for obvious reasons."

The examiner's rejection of claim 7 was clearly on target, in view of the following excerpt from Broertjes' specification, which was filed at the USPTO on 14 November 1929:

> *"The known methods of maintaining secrecy operate, in most cases . . .with a periodically modified transmission frequency, which is received by means of receiving apparatus, the tuning of which is modified in synchronism . . . The essential feature of the invention* [i.e., Broertjes'] *resides in the fact that messages are transmitted by means of a group of frequencies (working frequencies) known to the sender and receiver alone, and alternate at will during transmission of the message. . ."* [7]

Correspondence Concerning the Lamarr-Antheil Patent

The Lamarr-Antheil file wrapper includes the attorney's response on 31 October 1941 to the USPTO examiner's first office action. As documented, this reasoned response was to cancel the

broad claim 7, which, *had it been allowed*, would have entitled Lamarr and Antheil to legitimately claim inventorship of FHSS. Instead, only the much narrower claims 1-6, which do not entitle them to claim inventorship of FHSS, were allowed.

The Museum's archive is more extensive than the file wrapper, however, as it further includes material that would often be considered confidential, and would not be part of the USPTO's records: the correspondence between applicants Lamarr-Antheil and their attorney. A letter on 3 October 1941 from the Lyon and Lyon attorney to Lamarr and Antheil says ". . . we rather doubted at the time that method claim 7 would be considered patentable, since the invention appears to reside more in a new apparatus than in a new method." Thus, the attorney representing the applicants agreed with the patent examiner that the evidence was against Lamarr-Antheil's definitive method claim to FHSS, which was claim 7.

The letter of 3 October 1941 goes on to say "We are very much surprised that the Patent Office did not discover more pertinent patents than those cited." As this remark is quite apropos, the attorney himself may have been well acquainted with the prior art.[8] A recent forward-and-backward search indeed reveals prior art – early US patents in this case – which the examiner should have found and cited during the examination of the Lamarr-Antheil application, but did not. For example, the patent office's examination leading to US 2,707,208, "Secrecy Facsimile System,"[9] which was granted to James Smith *after* the Lamarr-Antheil patent (and therefore not *prior* art to Lamarr-Antheil), cited the Lamarr-Antheil patent as prior art against Smith (the "forward" component). The same examination of Smith also unearthed an *earlier* work which predates both Smith and Lamarr-Antheil (the "backward" component): US 1,598,673, "Secrecy Communication System," to Blackwell, et al. (filed 18 December 1920). Blackwell teaches:

> *"In the present invention secrecy is obtained by the transmission of signals on a plurality of waves of different frequencies, successive portions of a message being transmitted on waves of different frequencies whereby a station tuned to one of said waves receives only a partial and therefore unintelligible disclosure of the communication.*"[10]

Blackwell and several other patents found this way are clearly material to the patentability of Lamarr-Antheil's rejected claim 7. Moreover, these references provide further evidence that the basics of FHSS were known well before Lamarr and Antheil's efforts. Nevertheless, these references were not cited during the examination of Lamarr-Antheil. Perhaps the examiner simply missed them. Perhaps the examiner was satisfied with the Broertjes reference, which was right on target, and saw no need to dig any deeper. We have no way to know.

Although allowance of claim 7 would have legitimately enshrined Lamarr and Antheil as the inventors of FHSS, this was not the case, since, for good reason, claim 7 was not allowed. Rather, in the judgement of the USPTO's examiner and the applicants' attorney, Lamarr-Antheil actually invented only an apparatus for synchronizing a frequency-hopping transmitter and receiver, i.e., the invention described in their claims 1-6. This apparatus is a mechanism that is, conceptually, the inner workings of a player piano. Thus, the actual Lamarr and Antheil invention is a particular player-piano-like apparatus based on a record strip (like a player-

piano's roll) for controlling frequency hopping spread spectrum (FHSS), not the conception of FHSS itself. Tellingly, the patent office classified the Lamarr-Antheil application as "Encryption being effected by mechanical apparatus, e.g., rotating cams, switches, keytape punchers" (H04L9/38).

It is interesting to note the attorney's further comment to Lamarr and Antheil in the correspondence of 3 October 1941: "*We are inclined to believe that . . . a new apparatus claim* [should be] *inserted that is not limited to a record strip."* As far as the archived correspondence and the granted patent show, however, applicants Lamarr and Antheil did not follow-through with this. One explanation could be that they lacked the skill required to generalize their work.

Determining Inventorship

Each person listed as an inventor on a US patent must have contributed conceptually to at least one of its allowed claims. According to the USPTO: [11]

> *"The definition for inventorship can be simply stated: The threshold question in determining inventorship is who conceived the invention. Unless a person contributes to the conception of the invention, he is not an inventor. … Insofar as defining an inventor is concerned, reduction to practice, per se, is irrelevant . . . One must contribute to the conception to be an inventor."*

Numerous accounts suggest (correctly) that Hedy Lamarr posed the problem to be solved and suggested using the well-known technique of FHSS. *Nota bene*: (1) Posing a problem to be solved by an invention is not the same as conceiving an invention, and (2) The use of a known technique for its intended purpose does not constitute an invention. These points are important, as FHSS was indeed well known at the time of the Lamarr-Antheil patent application, and the long-established purpose of FHSS was to provide secure communication.[12]

Given George Antheil's knowledge of player-piano mechanisms, a question arises: "What inventive concept did Hedy Lamarr contribute to their efforts, and if she contributed anything, which claim of their patent reflects that contribution?" Unfortunately, there is no way to answer this question authoritatively. In reality, the question was probably never asked, as there would be no practical need to do so if Lamarr and Antheil were agreeable to joint inventorship. Patent examiners are not normally involved in sorting-out these kinds of questions. Rather, when a serious conflict arises, the matter is ultimately settled in Federal court.

Conclusion from the Archived Evidence

The following has now been established from primary sources:

> Broertjes' specification (US 1,869,659) clearly shows that frequency-hopping spread spectrum (FHSS) communication was well known at least twelve years before Lamarr

and Antheil's patent application was filed, and clearly shows that the intended purpose of FHSS was to provide secure communication.

On the basis of teachings of Broertjes' specification, the USPTO rejected Lamarr and Antheil's claim to having invented FHSS by rejecting their claim 7, which claim is the very definition of FHSS.

The patent attorney at Lyon and Lyon concurred with this rejection.

Applicants Lamarr and Antheil implicitly agreed with the rejection by their unwillingness or inability to attempt to refute the examiner's argument.

The unavoidable conclusion is that Lamarr and Antheil did not, in fact, invent frequency-hopping spread spectrum communication.

Further Considerations of Inventorship and Attribution

Determining inventorship raises an interesting aspect of the Lamarr-Antheil patent: another person helped them reduce the invention to practice.[13] This person was Samuel Stuart Mackeown. The word "help" suggests that Mackeown was simply a technician employed to work under the inventors' direction. In reality, Mackeown knew far more about these kinds of things than either Lamarr or Antheil. He earned a PhD in physics from Cornell University in 1923, and by 1941 was associate professor at California Institute of Technology (CalTech) teaching radio and communication engineering. Shortly thereafter, he reached the rank of full professor.[14]

An article in *American Scientist* suggests that "*Considering the familiarity with patent conventions and the technical radio concepts on display, it seems likely that Mackeown wrote the patent itself."*[15] This is an interesting idea. According to a letter in the CalTech archives provided by Dr. Mauro Piccinini, Professor Mackeown "*is considered as one of two of the best patent law experts in the country, his services being very much in demand in litigation of this kind."*[16] The letter was written by Robert Andrews Millikan, renowned physicist, Nobel Laureate (1923 – physics), Chairman of CalTech.

Moreover, Professor Mackeown and patent attorney Leonard Lyon were well acquainted, as they had a history of working together on other matters for CalTech. This raises another possible scenario: Mackeown wrote the invention disclosure for Lamarr and Antheil from which attorney Leonard Lyon prepared the formal patent application. Some support comes from comparing Antheil's notebook in the Museum's archive to the specification within the Lamarr-Antheil patent application. Antheil's notebook addresses only mechanical aspects, whereas the specification and drawings of the Lamarr-Antheil patent include radio apparatus, suggesting that this radio apparatus was developed entirely by Professor Mackeown.[17]

If Mackeown's only involvement in the project were to reduce Lamarr and Antheil's thoughts to practice, then he would not be entitled to claim inventorship, as explained above with reference to the *Manual of Patent Examining Procedure.* But given the immense difference in knowledge between a professor at CalTech working in his field of expertise, and a pair of uneducated amateur inventors, it may be only natural to ask just exactly how much – if anything – Professor Mackeown contributed to the invention beyond the routine work of a skilled technician. This question seems never to arise in the literature concerning the Lamarr-Antheil patent. Unfortunately, we shall probably never know the answer.

Be that as it may, popular literature often refers to the Lamarr-Antheil patent as "Lamarr's patent," giving scant recognition to co-inventor George Antheil and none to the role of Professor Mackeown. Since the actual invention is a player-piano-like mechanism, and since experimental musician George Antheil had expertise in the inner workings of player pianos, and further since Hedy Lamarr evidently had no such expertise, it may be more appropriate to call the Lamarr-Antheil patent "Antheil's patent."

Citations and Influence

As of early 2024, the Lamarr-Antheil patent had been cited 75 times in the examination of other patent applications since it was granted in 1942. What does this mean? As mentioned earlier, the examiner searches for prior art in order to determine the patentability of new applications under examination. Prior art – when it is relevant to the question of patentability – is formally cited by the examiner.

Note the difference between patent citations and journal-paper citations. The author of a journal paper who cites an earlier work has presumably read the earlier work or at least has passing familiarity with it. This is not normally the case with inventors, as an examiner – a third party – provides the citations, rather than the inventor.[18] Thus, inventors are often unaware of earlier patents in the same field, and do not knowingly build upon a foundation laid by earlier patents.

Citation counts are, of course, cumulative, and a count of 75 is not at all remarkable for a patent as old as Lamarr-Antheil. Moreover, even a high citation count does not – unlike in the case of journal papers – suggest any special importance. Consider, for example, patent US-7,010,332, "Wireless headset with automatic power control," granted 7 March 2006. This work has been cited 195 times in the examination of other patent applications (early 2024). Nevertheless, the invention itself is not a technological breakthrough of any special importance, although it may well have practical and economic value. In any case, this particular patent is unlikely to have inspired any subsequent inventors.

Now consider again the Lamarr-Antheil patent. Although Lamarr and Antheil do not merit any credit for the invention FHSS, they should be recognized for inspiring an important design. This was the Sonobuoy by engineer Romuald I. Scibor-Marchocki, who was tasked by the United

States Navy in the mid 1950s to design a system for detecting underwater sounds like those emitted by submarines.

The Sonobuoy system used FHSS, controlled by a mechanical mechanism similar to the Lamarr-Antheil strip reader. The principal difference between the two seems to be that the Lamarr-Antheil mechanism is more like a player piano in concept, whereas the Sonobuoy mechanism is more like a music box (protrusions on a rotating cylinder activate switches). Because of this difference, the Sonobuoy did not infringe the Lamarr-Antheil patent.

Nevertheless, Scibor-Marchocki was directly inspired by the Lamarr-Antheil patent, and explicitly credited Lamarr and Antheil.[19] According to Scibor-Marchocki, however, the system "was not practical," one reason being that "*the mechanical frequency-hopper of the receiver . . . required constant maintenance.*"[20]

Secrecy Orders

A secrecy order may be imposed during the examination of a patent application that pertains to an aspect of national security. When a secrecy order is imposed, prosecution of the application continues until agreement is reached on which claims, if any, are to be allowed. At this point, the application is put in abeyance – a patent is not actually issued, and a patent number is not assigned, even though claims have been allowed. When the secrecy order is lifted, the patent is passed to issue, with a patent number that is current at the time of its issue.

For example, patent application 317,454 was filed 5 February 1940, but the resulting patent US-4,155,659, "Printing and Coding Machine," was not issued until 22 May 1979. Another example is patent application 02/568,368, "Control Circuits for Electric Coding Machines," filed 15 December 1944, issued as US-6,175,625 on 16 January 2001. These decades-long delays were imposed by secrecy order because of the nature of the inventions – they were cryptographic machines in the spirit of the German Enigma. Note that the filing dates of these two patents bracket the filing date of the Lamarr-Antheil application, thereby showing that secrecy orders were indeed being imposed at the time the Lamarr-Antheil application was under examination.

During the prosecution of the Lamarr-Antheil application, the attorneys of record at Lyon and Lyon asked the USPTO and the National Inventors Council to review the Lamarr-Antheil invention for potential use in national defense, and specifically asked whether a secrecy order would be imposed. In response, a letter from the Patent Office Defense Committee (7 June 1941) explained that "Should any secrecy order be issued in the application to which you refer, the inventor, attorney of record, and assignee will be duly notified."[21]

All evidence strongly implies that no such order was ever issued, despite numerous unsubstantiated reports to the contrary in the popular press. Simon, *et al.*, note (correctly) that "the Lamarr-Antheil patent appears to have been routinely issued and published, curiously without imposition of a secrecy order."[22] The banality here is clearly illustrated by the filing dates and patent numbers of the patents that immediately precede and follow Lamarr-Antheil

(all three issued 11 August 1942): US-2,292,386, US-2,292,387 (Lamarr-Antheil), and US-2,292, 388; filed 2 July 1940, 10 June 1941, and 23 May 1941, respectively. Simply put, Lamarr-Antheil was granted without secrecy-order delay, and received the next available patent number, just like any other ordinary patent.

Moreover, on 13 November 1941, the USPTO sent Lyon and Lyon a letter noting, *inter alia*, that six claims had been allowed, and that copies of the issued patent would be made publically available for ten-cents each, pending payment of fees due to the USPTO. The delay between this date, 13 November 1941, and the issue date of the patent, 11 August 1942, was due to procedural obstacles concerning legal names, signatures, and payments. Neither the invention nor the patent were "classified."

Seizure of the Lamarr-Antheil Patent

Much has been written about the Government's seizure of the Lamarr-Antheil patent. A typical comment, although not the most extreme of such comments, is: "Despite Lamarr helping to sell $343 million in WWII bonds, the US government seized her invention in 1942 . . ."[23]

"Seizing a patent" meant transferring – from the inventor (or assignee) to the Government – the right to grant licenses for the patented invention. It did not mean that the invention was sequestered and hidden away. Rather, patents were seized *"to make these patents freely available to American industry . . . for the general use in the national interest."*[24] The seized Lamarr-Antheil patent was not "thrown into a vault" as is sometimes claimed; the invention was openly offered to any legitimate American interest for a licensing fee of $50.

The law of the land in 1942 was clear:

> *"Acting under the authority of the Trading With the Enemy Act, as amended by the First War Powers Act of December 18, 1941, the President established the Office of Alien Property Custodian in March, 1942 . . . The Alien Property Custodian has the function of taking title to or controlling property in the United States which is owned or controlled by enemy nationals . . . Such property includes . . . patents . . . An enemy national* [is] *a national of a foreign country with which the United States is at war. . ."* [25]

Hedy Lamarr was a citizen of Austria at the time, which was part of the German Third Reich, and therefore an enemy national. The law applied to her, just as it applied to everyone else then present in the United States, regardless of how many war bonds she sold. All told, the U.S. Alien Property Custodian seized some 50,000 patents covering a wide range of technologies.[26] There was nothing special about the seizure of the Lamarr-Antheil patent.

Royalties: Lamarr and Antheil Were Not Unfairly Denied Compensation

Many instances of the popular literature, in the extreme, claim that Lamarr and Antheil were unfairly denied royalties on their patented invention, which, these sources claim, is essential to

a $30 billion market. Less extreme reports float the idea that the United States Navy unfairly used the Lamarr-Antheil invention without compensating the inventors. In any case, the point is raised that Lamarr and Antheil never received a dollar for their work. This is point correct; they did not.

But as explained above, anything that infringes a patent must include at least all of the elements of a claim. Note that every allowed claim of the Lamarr-Antheil patent includes the elements "a first elongated record strip" and "a second record strip." Thus any device that infringes the Lamarr-Antheil patent must necessarily include "record strips." Any device that does not include record strips does not infringe the Lamarr-Antheil patent. Neither the US Navy nor anyone else has ever made, used, or sold such a device for controlling FHSS radio communication using record strips and thereby infringed the Lamarr-Antheil patent. Thus, Lamarr and Antheil were not, in fact, entitled to receive anything for their patented work. They were not unjustly deprived.

Concluding Remarks

The legend that Hedy Lamarr "invented spread spectrum" is simply wrong. Unfortunately, this bad history is being propagated vigorously.[27] Lamarr did not, in fact, invent FHSS, and may have contributed little to the insignificant invention actually taught by the Lamarr-Antheil patent. In fact, FHSS was well known by 1929 at the latest. There is no record of Lamarr's invention's ever having been used, although it did inspire the design of the Sonobuoy; the invention certainly was not used by the US Navy to control torpedoes during WW2 as is sometimes claimed. Although George Antheil may well have contributed more than Lamarr to their joint enterprise, he is almost forgotten. There is no mention of what Professor Mackeown might have contributed.

More importantly, exaggerating the significance of Lamarr and Antheil's work gives an unrealistic view of how spread-spectrum technology actually evolved, and how technology progresses in general. A plausible argument can be made that the journey to today's FHSS began with one of Nikola Tesla's inventions.[28] From Tesla's starting point, professionals working at AT&T, Bell Labs, Western Electric, RCA, Siemens, Sylvania, and the like, were the real innovators who carried things forward, step-by-step, not Hedy Lamarr.

Acknowledgements

Many thanks to Dr. Tony Rothman for his thoughtful and generous review comments, and to Dr. Mauro Piccinini for providing the letter regarding Professor Samuel S. Mackeown.

Biographical Note

David Rand Irvin was admitted to practice before the United States Patent Office as an agent in 1998. In recognition of his own work as an engineer, he was honored by the Ericsson laboratory at Research Triangle Park, NC, with the Master Inventor's Award, having received 44

US patents with numerous foreign counterparts. David is a graduate of Johns Hopkins University (*Phi Beta Kappa*), North Carolina State University (National Science Foundation trainee), and the University of Wisconsin at Madison. He has published a number of papers, one of particular relevance being "Recognizing Inventors as Contributors to Knowledge" (*Journal of the Patent and Trademark Office Society;* Vol. 82, No. 10, October, 2000).

---

[1] *Hedy Lamarr and George Antheil Papers*; repository: Smithsonian Institution, National Museum of American History, Archives Center; edan.si.edu/slideshow/viewer/?eadrefid=NMAH.AC.1590_ref7

[2] The use of the word "applicant" here is appropriate for independent inventors like Lamarr and Antheil. However, in the case where an inventor transfers rights to an assignee such as a corporation, the assignee is often formally listed as the applicant.

[3] *Manual of Patent Examining Procedure (MPEP)*; uspto.gov/web/offices/pac/mpep/index.html

[4] "Comprising" is in contrast to the occasionally used "consisting of," which means "having exactly – nothing more, nothing less" in patent practice.

[5] *Method of Maintaining Secrecy in the Transmission of Wireless Telegraphic Messages*; US patent 1,869,659 to Willem Broertjes of Amsterdam, Netherlands; filed 14 Nov 1929 (USA), granted 2 Aug 1932 (USA).

[6] *Signal Transmission*, US patent 2,134,850 to Martin Baesecke of Berlin; filed 14 Sept 1935 (USA), granted 1 Nov 1938 (USA); assigned to Siemens & Halske Aktiengesellschaft (Germany).

[7] *op. cit*., Broertjes, page 1, col. 1, lines 6-11, 33-38, and 44-47.

[8] Attorneys admitted to practice before the United States Patent and Trademark Office (USPTO) must have a degree in engineering or science, must be a member of the appropriate state bar and therefore (normally) have a law degree, and must pass a rigorous examination administered by the USPTO that extends well beyond the state bar's general examination. In the course of their work, patent attorneys often specialize, and thereby accumulate knowledge of various fields of technology.

[9] *Secrecy Facsimile System*, US patent 2,707,208 to J. E Smith; filed 31 March 1945, granted 26 April 1955; assigned to Radio Corporation of America.

[10] *Secrecy Communication System*, US patent 1,598,673 to Otto B. Blackwell, et al.; filed 18 Dec 1920, granted 7 Sept 1926; page 1, col. 1, lines 20-28; assigned to American Telephone and Telegraph Company.

[11] *op. cit*., *Manual of Patent Examining Procedure*, 2109 Inventorship [R-07.2022].

[12] *op. cit.,* the patents of Broertjes, of Baesecke, and of Blackwell.

[13] Tony Rothman; "Random Paths to Frequency Hopping," *American Scientist*, Vol. 107, January-February 2019, pp. 46-53.

[14] *Bulletin of the California Institute of Technology;* Pasadena, California; years 1937 and 1944.

[15] *op. cit.* Rothman.

[16] Robert Andrews Millikan, Letter of 6 June 1942 regarding Professor Samuel S. Mackeown, et al.; provided by Dr. Mauro Piccinini, who is a scholar of musical history, especially the work of George Antheil.

[17] The Lamarr-Antheil specification does not address the critical problem of recovery when synchronization is lost between the transmitter and receiver, except to say "*the use of synchronizing impulses for correcting the phase relation of rotary apparatus at a receiving station is well known and highly developed in the fields of automatic telegraphy and television*." These solutions are not applicable when frequencies hop, however, as once synchronization is lost, the receiver cannot hear the transmitter's impulses – the transmitter and receiver are then operating on different frequencies. For this reason, it may be problematic whether the Lamarr-Antheil patent gives an enabling description.

[18] Inventors are required to disclose relevant prior art that they are aware of to the examiner, but are not required to search for prior art themselves. Usually, the law firm handling a patent application on the inventors' behalf conducts a search (but is not required to do so) and discloses the findings to the examiner. In all cases, however, the final responsibility for finding and citing prior art lies with the patent examiner.

[19] See, for example, Scibor-Marchocki's tribute to Hedy Lamarr, which can be found by Google search pointing to the "Wayback machine": https://web.archive.org/web/20041026223647/http://www.rism.com/atribute.htm

[20] *ibid.* see: "subsequent developments" paragraphs

[21] Archive: letters of (1) Leonard Lyon to Commissioner of Patents, 6 June 1941; (2) Leonard Lyon to Lawrence Langner (National Inventors Council), 17 June 1941; (3) H. H. Jacobs (USPTO) to Lyon and Lyon, 17 June 1941; and (4) Lawrence Langner to Leonard Lyon, 19 June 1941

[22] Marvin K. Simon, et al, "Spread Spectrum Communications Handbook," McGraw-Hill, 1994, p. 64

[23] Bruce Berman, Chair of the Center for intellectual Property Understanding, New York; "Torpedo invention laid foundation for WiFi and more;" *IAM magazine*; Nov/Dec 2018, p.18 (IAM-media.com)

[24] The Alien Property Custodian of the United States; *Patents at Work: A Statement of Policy*; Washington, D.C., January, 1943; letter from Leo T. Crowley, Alien Property Custodian, to Franklin D. Roosevelt, President of the United States, 7 Dec. 1942

[25] *ibid.*, pp. 3-4

[26] *op. cit.*, letter to President Roosevelt

[27] See, as examples chosen from a plethora of candidates:

> (1) *How the Pianola Played a Part in Hedy Lamarr's Invention. Bombshell: The Hedy Lamarr Story*; US Public Broadcasting System; program aired 18-19 May 2019; limited text available at http://pbs.org/wnet/americanmasters/blog/bombshell-hedy-lamarr-story-pianola-played-part-hedy-lamarrs-invention/ -- This text actually claims that Lamarr *"invented and patented a concept that **changed the course of history**"* (emphasis added).
>
> (2) "Hedy Lamarr," *Britannica Online Encyclopedia*, article 709741, found at: http://britannica.com/biography/Hedy-Lamarr -- This work claims that Lamarr's invention is "a component of present-day satellite and cellular phone technology," which is most assuredly incorrect – these technologies do not employ any player-piano-like apparatus.

(3) Matteo Sabattini, PhD., MBA, Director IPR Policy of Ericsson; *Austrian actress and inventor Hedy Lamarr inducted into the IP Hall of Fame*; ericsson.com/en/patents/articles/hedy-lamarr-ip-hall-of-fame); 2 May 2019. This unfortunate communique credits Lamarr with inventing FHSS, and goes on to say that her work "found applications in radio-controlled torpedoes," that her work is a "foundational technology for modern mobile communications," that FHSS is "based on musical concepts," that Lamarr's invention contributed in some way to the Allied victory in WW2, and that absent her "pioneering work," other innovators would "probably not have benefited." All of this is incorrect.

[28] *op. cit*.; Rothman suggests such an argument with reference to *Method of Signaling*; US patent 723,188 to Nikola Tesla; filed 14 June 1901, granted 17 March 1903.