

The **MICROWAVE AUDITORY EFFECT** **Project PANDORA**

RF Bioeffects, and the Cold War
Research Network.



A Verified History from Radar Research to
Directed Energy Bio-Effects
(1940s–2026)

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Preface

This book presents an evidence-controlled history of the microwave auditory effect—often called the Frey effect—and the larger network of radiofrequency bioeffects research in which it developed. It follows the story from wartime radar and the first post-war reports of unusual auditory sensations, through the Tri-Service microwave programme, Allan Frey's experiments, CIA-supported primate research, Project PANDORA, Walter Reed, the University of Washington, U.S.–Soviet scientific exchange, and the later institutional field of directed-energy bioeffects.

Part I

Origins – Radar, Biology, and the Discovery of Microwave Hearing

Chapter 1

Radar Creates a New Biological Environment

The microwave auditory story begins with radar. During the Second World War, microwave radar moved from experimental technology to a central military capability. High-power pulsed transmitters, waveguides and large antennas created electromagnetic environments that had

barely existed before the war. Personnel working around these systems were therefore among the first people routinely exposed to intense pulsed radiofrequency fields.

In 1947, complaints were recorded at the Airborne Instruments Laboratory in Mineola, New York, from people who reported hearing unusual sounds near a radar antenna. The observation later appeared publicly in a 1956 Airborne Instruments Laboratory advertisement in the Proceedings of the IRE. The report is historically important because it predates Allan Frey's experiments by more than a decade. It shows that radar-associated auditory sensations were known in engineering circles before a formal scientific literature on microwave hearing existed.

The early reports did not establish a mechanism. Radar installations also contain ordinary acoustic sources, electrical equipment and mechanical structures capable of producing noise. The significance of the AIL episode is therefore not that it proved the microwave auditory effect in 1947, but that it documented a recurring observation that later laboratory work would place on firmer ground.

During the 1950s military medicine increasingly treated microwave exposure as an occupational-health problem. The main concern was heating: radiofrequency energy absorbed by tissue can raise temperature, and sufficiently intense exposure can injure tissue. The question facing researchers was whether heating was the whole story or whether pulsed fields could produce more specific sensory or neurological effects.

That question drove a growing programme of military microwave-bioeffects research. By the end of the decade, the United States had moved from scattered observations to organized inter-service conferences, laboratory contracts and experiments on nerves, brain activity and whole-animal behavior.

Chapter 2

The Tri-Service Microwave Programme

In 1956 the Department of Defense assigned the Air Force responsibility for coordinating a Tri-Service programme on the biological hazards of microwave radiation. The first Annual Tri-Service Conference on the Biological Hazards of Microwave Radiation was held at Griffiss Air Force Base, New York, in July 1957. Later conferences brought together military, university and contract researchers working on exposure standards, tissue heating, neural effects, dosimetry and possible nonthermal responses.

Rome Air Development Center became an important coordinating node. Tulane University's Biophysics Laboratory, led by Robert T. Nieset and colleagues including Lawrence R. Pinneo, Robert Baus, John D. Fleming and R. D. McAfee, produced a substantial body of microwave-neurophysiology work. Their report *The Neural Effects of Microwave Irradiation* was published as RADC-TR-61-65 and later cited by Allan Frey.

The Tulane work was not a microwave-hearing programme. It examined peripheral nerves, central nervous system activity, penetration and dosimetry. Its importance to the MAE story is that it demonstrates the existence of a mature military scientific environment concerned with neural responses to microwaves before and during Frey's first publications.

A second branch of the same broad research world involved Maitland Baldwin, Sven A. Bach and Shirley A. Lewis. Their work on primate cerebral activity appeared in the Third Annual Tri-Service Conference proceedings in 1959 and in *Neurology* in 1960. This was a direct experimental effort to observe changes in primate brain activity during radiofrequency exposure.

The evidence supports a shared scientific environment and formal Tri-Service participation. It does not support a claim that every early microwave project was financed through one central fund or that the Tulane and Baldwin groups were one laboratory team.

Chapter 3

CIA-Supported RF Research on Primates

Declassified CIA records show that intelligence interest in radiofrequency effects on the nervous system was real before Project PANDORA. MKULTRA Subproject 62, begun in 1956, helped finance research on the effects of physical and chemical agents on the central nervous system of anthropoids. A status report states that certain forms of radiofrequency energy had produced reversible neurological changes in chimpanzees and that follow-up studies were under way.

CIA accounting material from the period includes references to an “RF project,” including travel associated with it. The surviving documents therefore establish an intelligence-funded RF-primate research node. This is stronger evidence than later speculation about what the CIA might have been interested in: it is an explicit archival record.

The broader archival history associates Maitland Baldwin with MKULTRA Subproject 62 and later MKSEARCH work. Baldwin’s published 1960 paper with Bach and Lewis fits the same scientific problem—radiofrequency effects on primate cerebral activity. Even so, the safest historical formulation is that the CIA financed RF-related anthropoid CNS research associated with Baldwin’s research environment. A surviving CIA page does not identify every published Baldwin experiment by title.

This distinction matters because the later PANDORA story also includes CIA participation. The fact that the CIA had an earlier RF research interest and later took part in the Moscow Signal investigation is a documented institutional continuity. It is not, by itself, proof that MKULTRA Subproject 62 was renamed or administratively transferred into PANDORA.

Chapter 4

Allan Frey and the Experimental Discovery of Microwave Hearing

The modern scientific history of the microwave auditory effect begins with Allan H. Frey. In 1961 he published a technical note on the auditory system’s response to radiofrequency energy, followed in 1962 by *Human Auditory System Response to Modulated Electromagnetic Energy* in the *Journal of Applied Physiology*.

Frey exposed volunteers to pulsed radiofrequency fields at several carrier frequencies and found that subjects could perceive sounds described as buzzing, clicking, knocking or hissing even when no ordinary acoustic source was present. He tested alternative explanations, including the possibility that loose dental fillings or conventional radio detection were producing the effect. His experiments established that the phenomenon could be studied systematically and that perception depended strongly on pulse characteristics.

Frey's 1962 paper was submitted in September 1961 and listed his affiliation with General Electric's Advanced Electronics Center in association with Cornell University. The paper cited contemporary military microwave-neurophysiology work, including the Rome/Tulane report, but it did not cite Airborne Instruments Laboratory, the 1956 advertisement, or the names associated with that earlier observation.

The most defensible genealogy is therefore not a direct AIL-to-Frey transfer. The record supports an earlier radar observation at AIL and a later, experimentally rigorous rediscovery by Frey. A later recollection by Frey describes a General Electric radar technician telling him that radar could be heard, prompting Frey to investigate. That recollection helps explain how his work began, but the primary 1961–62 papers remain the foundation of the verified scientific record.

Frey's importance is difficult to overstate. After his publications, microwave hearing was no longer merely an engineering anecdote. It was a reproducible research problem linking electromagnetics, physiology, acoustics and neuroscience.

Chapter 5

From Mystery to Thermoelastic Sound

The existence of microwave hearing did not immediately explain how it worked. Early hypotheses included direct neural stimulation, interaction with the inner ear, and mechanical effects produced by rapid energy absorption.

A key theoretical foundation came from Richard M. White's work on elastic waves generated by transient heating. If energy is deposited rapidly enough in a material, a minute temperature rise can cause sudden thermal expansion and launch a pressure wave. In biological tissue, a short microwave pulse can therefore create a small but rapid mechanical disturbance.

Kenneth R. Foster and Edward D. Finch provided influential experimental support for this thermoacoustic or thermoelastic interpretation in 1974. Their work helped show that microwave-induced sound could be understood through ordinary physical processes: rapid energy absorption, thermal expansion and acoustic pressure generation.

The important point for a general reader is that the effect does not require the microwave field to "carry sound" through the air in the conventional sense. The electromagnetic pulse deposits energy in tissue; the rapid expansion creates a pressure wave; the auditory system responds to that internally generated mechanical signal.

Later work by Arthur Guy, C. K. Chou, James C. Lin, Richard Olsen and others refined the mechanism through measurements of cochlear responses, pressure waves, thresholds and absorbed energy. By the late 1970s and early 1980s, the thermoelastic model had become the dominant explanation for ordinary microwave hearing.

Part II

Cold War Junction – The Moscow Signal and Project PANDORA

Chapter 6

The Moscow Signal

For years the United States Embassy in Moscow was exposed to microwave radiation originating outside the building. The episode became known as the Moscow Signal. By the mid-1960s U.S. officials were sufficiently concerned about possible biological effects that the issue became part of a high-level interagency investigation.

The historical importance of the Moscow Signal is often obscured by later stories about microwave hearing. The surviving PANDORA documents show that the programme was not founded because officials wanted to reproduce Frey's effect. It was founded because the Embassy was being irradiated and the government wanted to know whether the exposure posed a biological threat.

Early U.S. estimates of the Embassy field were later revised downward. CIA representative Joseph Johnston recorded that initial estimates in the range of roughly half to one milliwatt per square centimetre were too high; later measurements were far lower, with typical averages in the microwatt-per-square-centimetre range.

This changing dosimetry shaped the interpretation of experiments. A monkey exposed at an initially assumed higher level appeared to show a behavioral effect, but experiments using corrected lower levels did not reproduce a comparable effect. Johnston ultimately concluded that the reported Embassy levels did not present an injury risk on the evidence then available.

That sequence is essential because it prevents selective retelling. PANDORA did not produce a simple finding that the Moscow Signal altered primate behavior. It produced an early suggestive observation, followed by revised exposure estimates and less supportive results.

Chapter 7

The Creation of Project PANDORA

On 15 October 1965 Richard S. Cesaro of ARPA's Advanced Sensors office prepared the Justification Memorandum for Project PANDORA. The memorandum described the Embassy irradiation, the White House-directed investigation and the broader national effort known as TUMS. PANDORA was ARPA's biological-effects component.

The plan was to expose primates under controlled conditions designed to reproduce relevant features of the Moscow environment and to observe behavior and physiology. The founding document assigned different tasks to several organizations. The Air Force would select and procure microwave equipment and control the RF environment. Johns Hopkins Applied Physics Laboratory would provide engineering consultation, design and fabrication. Walter Reed Army Institute of Research would provide laboratory space, primates, monitoring and data reduction. H. Mark Grove of the Wright-Patterson Avionics Laboratory would serve as ARPA monitor and coordinator.

The memorandum also named a small consultant group that included Ross Adey of UCLA, Milton Zaret, Herbert Pollack of the Institute for Defense Analyses and a CIA representative later identifiable in the PANDORA record as Joseph Johnston. The OCR of the founding memorandum also reads “Nat Baldwin NIH.” The historical fit with Maitland “Mat” Baldwin is very strong, but because a clean image has not resolved the name, this book does not treat that identification as certain.

Allan Frey is not named in the founding consultant list. Nor are Sven Bach, Herman Schwan, Sol Michaelson or the Tulane investigators. PANDORA drew selectively from the wider microwave-bioeffects community rather than simply absorbing the entire pre-existing field.

Chapter 8

Building the PANDORA Exposure Facility

PANDORA’s engineering history is unusually well documented. Johns Hopkins Applied Physics Laboratory reports from 1966 describe the operational procedure and final configuration of the microwave test facility. The Air Force Avionics Laboratory specified and purchased commercially available microwave equipment, while APL designed specialized components, evaluated the chamber and calibrated the exposure system.

Commercial suppliers provided major hardware. Microwave Associates supplied a high-power traveling-wave tube; Alto Scientific supplied power equipment; Emerson & Cuming supplied the anechoic chamber. APL designed items such as the transmitting horn, monitoring dipoles and a field traverser.

The facility was designed primarily for S-band work, with potential conversion through X-band. Its engineering specifications allowed controlled power-density fields suitable for biological experiments. These were facility capabilities, not a statement that every PANDORA exposure used the maximum available field.

No verified evidence shows that Tulane or Rome Air Development Center physically transferred its earlier apparatus into PANDORA. The engineering record instead shows new procurement and assembly. This is a useful example of how scientific continuity can exist without equipment continuity.

Chapter 9

What PANDORA Actually Studied

PANDORA's best-known experiments involved primates, but the programme was broader than a single behavioral test. Walter Reed carried out in-house work, while external contracts examined histology, cardiovascular responses, epidemiology, behavior and other possible microwave effects.

Ross Adey's UCLA work was relevant to the programme and assisted Walter Reed with EEG and data-processing expertise. Kenneth Brizzee at Tulane carried out quantitative histological studies of microwave-exposed central nervous system tissue under an Army Medical contract supported by ARPA. Milton Zaret's foundation received an ARPA-supported Army Medical grant to test a Soviet low-level microwave heart-rate claim in rabbits.

A Johns Hopkins School of Medicine programme led by Joseph F. Dardano established a laboratory for studying low-level microwave effects on primate performance. It was a real parallel Army Medical microwave-behavior effort. No document located, however, shows that Dardano was assigned to replicate Joseph Sharp's exact Walter Reed protocol or that his laboratory received the same special signal.

Another contract, associated with Bernice Cohen at Johns Hopkins, examined parental radiation exposure and Down's syndrome with particular attention to ionizing radiation and radar. The range of these contracts illustrates how the PANDORA-era research environment expanded from one question—could the Moscow exposure have biological consequences?—into a broader biomedical investigation.

Chapter 10

PANDORA as an Information Programme

Project PANDORA also had a formal literature-analysis component. ARPA Order 791 supported Allied Research Associates in reviewing, analyzing and classifying domestic and foreign literature on the biological effects of microwave radiation. Janet Healer and colleagues assembled hundreds of documents and analytical records, drawing in part on translated foreign scientific material.

This function is important because Cold War microwave research was not isolated within national borders. U.S. officials were actively trying to understand Soviet and Eastern Bloc claims about low-level microwave effects, while American researchers were publishing their own experimental work.

Order 791 should not be described as a Soviet-only intelligence project. Its remit included domestic as well as foreign literature. What it demonstrates is that PANDORA combined laboratory experimentation with systematic scientific-information gathering.

Other ARPA orders supported instrumentation and electronic support. By 1969–70 PANDORA was an administrative umbrella containing multiple kinds of activity rather than a single experiment.

Chapter 11

The 1969–1970 Reassessment

By late 1969 the accumulated PANDORA evidence was being reviewed critically. Samuel Koslov's RAND review did not find convincing proof of a behavioral effect. He raised questions about possible EEG artifact and regarded histological and chromosome evidence as inadequate. At the same time, he considered the facilities and experimental capability valuable enough to justify broader microwave research.

Minutes from January 1970 show a programme trying to separate suggestive findings from reproducible effects. Joseph Brady, Joseph Sharp, H. Mark Grove and others appear in the PANDORA record, but the early behavioral signal had not matured into a robust demonstration of a Moscow-like field causing reliable behavioral change.

This is a pivotal moment in the history. PANDORA did not end because microwave bioeffects were considered scientifically meaningless. Instead, the narrow threat question became less persuasive while the infrastructure and broader research problem remained useful.

Chapter 12

The Formal Transfer to Walter Reed

In March 1970 ARPA and the Army prepared an agreement to transfer Project PANDORA to Walter Reed Army Institute of Research. The transfer became effective on 1 July 1970. This is the strongest administrative continuity in the entire history.

The agreement states that ARPA had supported PANDORA for four years and that a new research facility had been created at Walter Reed for studying biological effects of electromagnetic radiation, especially microwaves. The facility included capabilities for photography, neurochemistry, neurophysiology, behavioral work and computer-supported data processing.

The agreement transferred equipment and facilities to the Army and made Walter Reed responsible for continuing research. It explicitly identified ARPA Orders 791, 792, 945 and 1508 as parts of PANDORA. Unliquidated funds under Orders 792 and 945 were retained for "PANDORA and follow-on efforts," and ARPA transferred \$200,000 in fiscal-year 1971 funding.

The historical conclusion is direct: PANDORA did not simply disappear. Its institutional capability was transferred to Walter Reed. What has not been located is a formal sentence saying that PANDORA was renamed the Department of Microwave Research. The later department belongs to the institutional succession, but the evidence does not support a literal renaming claim.

Part III

After PANDORA – Walter Reed, Microwave Acoustics, and Open Science

Chapter 13

Walter Reed's Broader Microwave Research

After the transfer, Walter Reed's microwave work broadened. A 1973 report by T. Daryl Hawkins, H. Mark Grove, Thomas Heiple, John Schrot and colleagues studied biological effects of microwave irradiation in rats. One line examined lethality at 3 GHz; another examined behavioral performance as a function of wavelength and power density.

This was no longer simply the Moscow Signal problem. The research asked general questions about frequency dependence, absorbed energy, performance decrement, thermal loading and biological hazard. Later Walter Reed work increasingly emphasized exposure geometry, calorimetry and dosimetry.

The personnel continuity is nevertheless clear. Grove had been the founding PANDORA monitor/coordinator and remained part of Walter Reed microwave research. Hawkins also crosses from late PANDORA into the post-PANDORA programme. Joseph Sharp appears in Walter Reed microwave progress reports in 1973 and 1974.

The exact hardware continuity is less certain. The 1970 agreement proves that PANDORA equipment and facilities were transferred to Walter Reed. It does not prove that every later experiment used the same original horn, chamber or transmitter. The institutional inheritance is verified; the apparatus-by-apparatus history is not.

Chapter 14

Joseph Sharp, H. Mark Grove, and Om Gandhi

The Walter Reed network also produced an important bridge into the open microwave-acoustic literature. Om P. Gandhi, an academic specialist in electromagnetic dosimetry, served as a microwave-research consultant at Walter Reed in 1973. In 1974 he coauthored with Joseph C. Sharp and H. Mark Grove a short IEEE paper titled Generation of Acoustic Signals by Pulsed Microwave Energy.

The paper was about acoustic generation and mechanism. It was not the famous speech-transmission report. That distinction matters because later accounts often merge the two.

The scientific significance of the 1974 paper is clear from what happened next. The University of Washington group led by Arthur Guy, C. K. Chou and James C. Lin explicitly cited Sharp, Grove and Gandhi in its 1975 work on microwave-induced acoustic effects. The citation creates a direct intellectual bridge from the Walter Reed-associated acoustic work into the mature academic MAE literature.

Gandhi and Grove continued to collaborate on microwave applications after 1974. Gandhi's later career became particularly important in RF dosimetry and computational modeling, areas central to understanding how electromagnetic energy is absorbed in biological tissue.

Chapter 15

Morse Code and the Sharp–Grove Speech Demonstration

Don R. Justesen's 1975 article *Microwaves and Behavior* brought two information-bearing demonstrations into the public scientific discussion. The first involved Arthur W. Guy, an experienced telegrapher, receiving microwave pulses keyed in Continental Morse code. The demonstration showed that a sequence of individually perceived microwave clicks could carry symbolic information.

The second demonstration involved Joseph Sharp and H. Mark Grove. Justesen described recorded spoken digits being processed so that brief microwave pulses represented selected features of the speech waveform. The listeners reportedly recognized the resulting words.

The most important source detail was clarified during this research: Justesen's reference list identifies "Sharp, J. C., & Grove, M. Personal communication, September 28, 1973." This means the published historical source was a communication from Sharp and Grove themselves, made about eighteen months before Justesen's article.

The 1974 Sharp/Grove/Gandhi IEEE paper is not the speech paper. Nor has a document been found assigning the speech demonstration to Project PANDORA as an official deliverable.

The correct historical description is therefore narrower and stronger: by 28 September 1973, Sharp and Grove had communicated a microwave-auditory speech demonstration to Justesen; Justesen published the account in 1975. The demonstration belongs chronologically to the post-PANDORA Walter Reed era and involved people with direct PANDORA history.

Chapter 16

The University of Washington MAE Programme

During the 1970s the University of Washington became one of the most important centres of microwave-auditory research. Arthur W. Guy, C. K. Chou, James C. Lin, Richard Lovely and colleagues combined engineering, dosimetry, physiology and acoustics.

A 1975 *Annals of the New York Academy of Sciences* paper by Guy, Chou, Lin and Christensen explicitly cited Frey's early papers, Frey and Messenger, Foster and Finch, and Sharp, Grove and

Gandhi. This single bibliography demonstrates the convergence of research lines that had begun separately.

A companion study by Chou, Galambos, Guy and Lovely measured cochlear microphonics generated by microwave pulses. Such work helped move the field away from speculation about direct “radio reception” by the brain and toward measurable mechanical and auditory-system responses.

Funding also became more diverse. The 1975 Guy–Chou–Lin–Christensen work was supported principally by the National Science Foundation, with additional support from the Office of Naval Research, the FDA’s Bureau of Radiological Health and rehabilitation funding. A companion cochlear study also received ONR support.

This is scientific continuity, not a PANDORA contract continuation. The open academic MAE programme inherited published questions, methods and citations from earlier work, while drawing on its own mixture of civilian and military funding.

Chapter 17

Lin, Chou, Olsen, and the Pressure-Wave Model

James C. Lin became one of the central figures in the later MAE literature. His work examined thresholds, dosimetry and the physical conditions required to generate microwave-induced sound. His 1978 book *Microwave Auditory Effects and Applications* consolidated much of the field’s knowledge.

C. K. Chou contributed both to MAE experiments and to the broader science of RF bioeffects and exposure standards. Richard G. Olsen, associated with the Naval Aerospace Medical Research Laboratory, worked with Lin on microwave-induced pressure waves in mammalian brains.

The 1983 Olsen–Lin study directly measured pressure-wave behavior associated with pulsed microwave exposure. Related work in the 1980s examined auditory responses in animals and pressure propagation in the head.

By this stage, the durable scientific line was clear: pulsed RF energy could create rapid thermoelastic expansion, pressure waves and auditory-system stimulation. The field continued to investigate detailed thresholds, geometry and physiology.

What did not emerge from the verified record was a continuous engineering programme devoted to microwave speech. The speech and Morse demonstrations remained historically striking, but the mainstream research trajectory focused on mechanism, dosimetry, safety and biological response.

Part IV

The Soviet and Russian Connection

Chapter 18

Soviet Microwave Bioeffects Before the MAE

Soviet microwave-bioeffects research (non-MAE) did not begin with Allan Frey. Historical reviews place Soviet work on radiofrequency biological effects in the late 1940s and 1950s, including occupational-health studies of radar and communications workers and laboratory investigation of nervous-system responses.

Soviet researchers often gave greater attention than their American counterparts to possible effects of chronic low-level exposure. This contributed to markedly different occupational standards and to recurring East–West disputes about whether reported symptoms represented specific microwave effects or nonspecific occupational complaints.

For the MAE history, the distinction is essential. The Soviet Union possessed an independent microwave-bioeffects tradition before Frey. What appears later is a narrower Soviet microwave-hearing branch that explicitly engages with Western MAE publications.

Chapter 19

Formal U.S.–Soviet RF Scientific Exchange

By the 1970s microwave bioeffects had become an area of formal scientific exchange between the United States and the Soviet Union. American delegations visited Soviet laboratories, Soviet scientists visited the United States, and joint work addressed nervous-system effects, chronic exposure, dosimetry and replication.

Donald McRee of the National Institute of Environmental Health Sciences played a major role in the cooperative programme. Arthur Guy participated as a U.S. expert in RF dosimetry. Joseph Elder, Richard Phillips, William Kaune and other researchers also took part. Ross Adey participated in Soviet scientific meetings and cooperative work.

The bilateral program was far broader than the microwave-hearing research, and it is therefore incorrect to reduce the whole U.S.–Soviet relationship to Frey and Lin. The overall bilateral program, however, was not MAE-related. The U.S.–Soviet microwave-auditory connection was narrower, later, and personal in character — a small branch within a much larger bilateral microwave-bioeffects tree, centered on the exchanges of Frey and Lin.

Chapter 20

Frey at Pushchino

Allan Frey later described spending about a month in the Soviet Union in the early 1970s at the invitation of the Soviet Academy of Sciences. At Pushchino he met Yuri Grigoriev and other prominent Soviet bioeffects researchers. Frey recalled Grigoriev as his host and said that Grigoriev was particularly interested in his findings concerning carrier frequency and modulation.

Frey and Grigoriev remained in contact for years. Frey also recalled that U.S. agencies were interested in what he had seen in Soviet laboratories. His account is valuable because it documents a personal bridge between the American MAE pioneer and the Soviet microwave-bioeffects community.

The verified conclusion is that Frey carried his published and experimental perspective directly into discussions with Soviet researchers during the period in which Soviet interest in microwave auditory phenomena was emerging.

Chapter 21

James C. Lin and the Soviet MAE Experiment

James C. Lin later recalled being invited to Pushchino in 1978 to discuss a microwave-hearing experiment being conducted by Soviet researchers. He saw a substantial laboratory setup and discussed possible mechanisms with the Soviet team.

His role was that of a visiting expert asked to interpret the phenomenon.

Lin and Yuri Grigoriev met repeatedly over the following decades, including in Moscow. Their relationship is one example of how a field shaped by Cold War competition also contained genuine scientific communication.

Chapter 22

The Pushchino Microwave-Hearing Papers

The clearest Soviet MAE publication located in the record is the 1979 Radio Science paper by V. V. Tyazhelov, R. E. Tigranian, E. O. Khizhniak and I. G. Akoev, Some Peculiarities of Auditory Sensations Evoked by Pulsed Microwave Fields. The researchers, based at the Institute of Biological Physics in Pushchino, studied microwave-induced auditory sensations in human observers.

The paper is important not only because it demonstrates direct Soviet MAE experimentation, but because its bibliography explicitly cites the Western literature: Frey, Frey and Messenger, Guy, Lin, Lebovitz and others. That creates an A-grade intellectual-transfer edge. The Soviet researchers were not working in isolation from the American MAE literature.

Related Soviet publications by Khizhniak, Shorokhov and Tyazhelov discussed possible mechanisms and distinguished different reported types of microwave auditory sensation. The work engaged with the thermoelastic explanations associated with Guy and Lin while considering whether all observations fit a single mechanism.

No verified record located in this project shows a Soviet reproduction of the Sharp–Grove speech demonstration, a Soviet microwave Morse-code experiment, or transfer of the American speech-processing method. The documented Soviet branch reaches perception, psychophysics and mechanism.

Chapter 23

Scientific Feedback Across the Cold War Divide

The flow of information was not one-way. American reviews in the early 1980s cited the Soviet MAE experiments, incorporating Pushchino results into the international literature. Guy, Chou and colleagues discussed Soviet findings as part of the evidence base for microwave-induced auditory effects.

C. K. Chou later described a long personal friendship with Yuri Grigoriev, first meeting him in Seattle in the early 1980s while Chou was associated with Arthur Guy's University of Washington laboratory. This further demonstrates that the U.S.–Soviet network cannot be reduced to only Frey and Lin.

The broader lesson is that Cold War microwave science combined competition, intelligence interest and ordinary scientific exchange. Researchers could be participants in national defence programmes and still cite, visit and debate their counterparts across the geopolitical divide.

Part V

Adjacent Programmes and the Limits of the Genealogy

Chapter 24

ARPA Order 2808 and Human Performance

A separate ARPA programme from the mid-1970s became relevant to this research because one of its reports had the striking title Sensitivity of Auditory and Vestibular Systems to Stimuli Other Than Sound and Motion. The report, written by Kenneth D. Fisher, C. Jelleff Carr and John M. Talbot of the Life Sciences Research Office at FASEB, was issued in 1975 under ARPA Order 2808.

The title makes it tempting to treat Order 2808 as a successor to microwave-hearing research. The wider record does not support that conclusion. Other reports under the same order addressed biological individuality, night vision, cognitive and motor abilities, learning and memory, and biological rhythms.

The programme is best understood as a broad human-performance and sensory assessment effort. Air Force administrative coding associated with the work belongs to a wider human-performance and sensory research family rather than to a microwave-specific code.

The full bibliography of the auditory/vestibular report has not been recovered, so this book does not claim that it cited Frey, Sharp, Grove, Guy or Lin. Nor has a document been found linking Order 2808 administratively to PANDORA. The programmes belong to the same broad historical era of defence interest in human performance, but a direct succession is unverified and therefore omitted.

Chapter 25

Pinneo, Early Brain–Computer Research, and a Parallel ARPA Branch

Lawrence R. Pinneo provides another example of real institutional continuity that should not be mistaken for microwave continuity. Pinneo had been part of the Tulane neural-effects group whose work Frey cited. In the 1970s, at Stanford Research Institute, he led an ARPA-supported feasibility study for a biocybernetic communication system.

The project explored two-way communication between humans and computers using overt or covert speech and EEG signals. It belongs to the early history of brain–computer-interface research. Pinneo also worked on implanted electrical stimulation as a possible brain prosthesis for stroke.

These projects demonstrate a genuine career path from military-supported neurophysiology into later neurotechnology. They do not demonstrate that microwave hearing evolved into implanted stimulation or EEG communication. The physical mechanisms, apparatus and programme lines were different.

The same caution applies to later ARPA biocybernetics work by Jacques Vidal and Emanuel Donchin. They are important to the history of human–machine communication, but the verified record does not make them descendants of PANDORA.

Chapter 26

From Microwave Research to Directed Energy Bioeffects

Military research into RF biological effects did not end with PANDORA or the University of Washington MAE era. The Air Force maintained a substantial programme concerned with radiofrequency radiation, high-power microwave exposure, dosimetry, safety standards and biological mechanisms.

By the late 1990s and early 2000s the Air Force Research Laboratory's Human Effectiveness Directorate included a Directed Energy Bioeffects Division and a Radiofrequency Radiation Branch. Public National Research Council descriptions stated that the division conducted research and applied technology development to predict, mitigate and exploit the bioeffects of directed energy, recommend safety standards, provide system-design specifications and validate bioeffects relevant to proposed technologies.

Published work from this period included conventional and high-peak-power microwave bioeffects, exposure dosimetry, cellular responses and health-and-safety questions. The existence of this institutional field is documented and should not be confused with proof that every historical MAE concept became an operational system.

The continuity here is disciplinary and institutional: the military continued to study how directed electromagnetic energy interacts with biological systems. The questions ranged from protection and standards to understanding thresholds and possible applications.

Part VI

Anomalous Health Incidents and the 2026 Policy Shift

Chapter 27

Havana and the Return of Microwave Questions

Beginning in 2016, U.S. government personnel in Havana and later other locations reported unusual sensory events and health symptoms. The cases became widely known as Havana Syndrome and, in official language, Anomalous Health Incidents or AHIs.

The historical microwave auditory effect quickly entered public discussion because some people reported sounds, pressure sensations or other abrupt sensory experiences. The comparison was understandable but incomplete. Classical microwave hearing is a transient auditory perception produced under specific pulsed-RF conditions; the reported AHI cases often included persistent vestibular, cognitive, headache and other symptoms that microwave hearing by itself does not explain.

The National Academies' 2020 assessment judged directed, pulsed radiofrequency energy to be a plausible mechanism for some of the reported features, while emphasizing important uncertainties and the lack of direct exposure evidence.

Later intelligence assessments became more skeptical of a coordinated foreign attack. The 2023 Intelligence Community assessment judged it very unlikely that a foreign adversary was responsible for the reported events overall.

Chapter 28

The 2025 Intelligence Community Update

On 10 January 2025 the Office of the Director of National Intelligence released an updated assessment covering new information through December 2024. Most Intelligence Community components continued to judge it “very unlikely” that a foreign adversary was responsible for the events reported as possible AHIs.

The update was not identical to the 2023 position. Two components changed parts of their judgments after considering new reporting about foreign scientific research and weapons development. Those components assessed that a foreign actor might possess or be making progress toward a capability capable of producing some relevant biological effects, while still not concluding that such a device had been used in the reported incidents.

This is an important distinction. A judgment about technical capability is not a judgment that an attack occurred. The official assessment continued to separate feasibility from attribution.

Chapter 29

Compensation, Care, and the HAVANA Act

Whatever the ultimate cause of individual incidents, the U.S. government created compensation and care mechanisms for affected personnel. The HAVANA Act of 2021 authorized agencies to make payments to qualifying employees and others who sustained specified brain injuries in connection with anomalous health incidents.

A 2024 Government Accountability Office report documented patients pursuing both workers’ compensation and HAVANA Act payments. Among the 65 patients interviewed by GAO, some had already received payments, while others reported difficulties navigating agency procedures.

The existence of compensation is a policy and medical-support fact. It does not constitute a government finding that a directed-energy weapon caused a recipient’s condition. Compensation rules and intelligence attribution answer different questions.

Chapter 30

From AHI to Directed Energy Bio-Effects in 2026

On 10 July 2026 the U.S. Department of Defense’s successor organization announced that the Anomalous Health Incidents Cross-Functional Team had been officially renamed the Directed Energy Bio-Effects Cross-Functional Team, abbreviated DEBE. The announcement placed the team under the Office of the Under Secretary for Research and Engineering and described an expanded focus on non-kinetic threats, medical care, research coordination and warfighter protection.

The same announcement stated that nearly \$3 million in compensation had been disbursed, describing these as the first HAVANA Act payments made under a presidential administration through that department.

The terminology change is historically significant because it moves the institutional label away from the symptom-based phrase “Anomalous Health Incidents” and toward the broader scientific and operational category “Directed Energy Bio-Effects.” It also echoes a much older Air Force research vocabulary: a Directed Energy Bioeffects Division existed at Brooks Air Force Base decades earlier.

The renaming should not be read as an official determination that directed energy caused every AHI. The January 2025 Intelligence Community assessment remained cautious about attribution. The verified point is institutional: by mid-2026, the department had chosen DEBE as the name for the cross-functional team responsible for this continuing mission.

Part VII

What the Verified Timeline Shows

Chapter 31

The Real Continuities

Across eight decades, several forms of continuity can be demonstrated without speculation.

- Scientific continuity: radar-associated auditory observations were followed by Frey’s controlled MAE experiments and then by increasingly sophisticated acoustic, physiological and dosimetric studies.
- Administrative continuity: Project PANDORA was formally transferred from ARPA to Walter Reed in 1970.
- Facility and equipment continuity: PANDORA laboratories and instrumentation were transferred to the Army for continuing microwave research.
- Personnel continuity: H. Mark Grove, Joseph Sharp and T. Daryl Hawkins connect the PANDORA/Walter Reed period to later microwave-bioeffects work.
- Intellectual continuity: Sharp/Grove/Gandhi and Frey are explicitly cited in the University of Washington MAE literature.
- International continuity: American and Soviet researchers met, cited one another and discussed microwave-bioeffects results, while maintaining distinct national research traditions.
- Disciplinary continuity: military research on RF and directed-energy bioeffects continued long after PANDORA, increasingly emphasizing dosimetry, protection, standards and high-power microwave effects.

These connections are substantial enough to tell a coherent history. They do not require a claim that one secret project ran continuously from the 1950s to the present.

Chapter 32

What the Verified Timeline Does Not Show

A rigorous history is also defined by what it refuses to claim. The documentary record assembled for this book does not verify that MKULTRA Subproject 62 was converted into PANDORA; that PANDORA was founded to develop microwave hearing; that Sven Bach was a PANDORA participant; that PANDORA was formally renamed the Walter Reed Department of Microwave Research; or that the Sharp–Grove speech demonstration was an official PANDORA deliverable.

It does not verify a direct PANDORA-to-ARPA-Order-2808 succession. It does not show that the Soviet Union copied the Sharp–Grove speech method or carried out a verified microwave Morse-code programme. It does not show that later brain–computer-interface research was descended technically from microwave hearing.

These are not minor qualifications. They define the boundary between a documented research network and a speculative grand narrative.

Chapter 33

A General-Audience Synthesis

The microwave auditory effect is real, but its history is more interesting than a simple weapon story. It began as an unexpected sensory phenomenon in the age of radar. Frey turned that phenomenon into a reproducible scientific subject. Military and university laboratories then worked out how pulsed microwave energy could generate mechanical pressure waves and stimulate the auditory system.

Cold War concern about the Moscow Embassy irradiation created Project PANDORA, which brought together RF engineering, primate experiments, biomedical consultants and foreign-literature analysis. PANDORA's narrow threat question did not yield a clear demonstration that the Embassy signal caused behavioral injury, but the programme created a sophisticated microwave research capability that was formally transferred to Walter Reed.

Some of the same people later contributed to open microwave-acoustic science. The Walter Reed-associated Sharp/Grove/Gandhi paper entered the University of Washington literature, where it joined Frey's line and the thermoelastic work of Foster and Finch. That published convergence—not a hidden administrative chain—is the strongest genealogy of mature MAE science.

The Soviet story is similarly nuanced. Soviet microwave-bioeffects research (non-MAE) was older than Frey, but Soviet MAE researchers later cited Frey, Guy, Lin and other Western scientists. Frey and Lin personally interacted with Soviet researchers. The documented exchange

concerned perception, mechanism, dosimetry and bioeffects; it does not establish transfer of a microwave speech system.

In the modern period, directed-energy bioeffects remained a recognized military research field. Anomalous health incidents revived public interest in the microwave auditory effect, but official assessments have not established a single directed-energy cause for the reported cases. By 2026, however, the policy apparatus had adopted the name Directed Energy Bio-Effects for the cross-functional team responsible for the issue, while compensation under the HAVANA Act had begun to be paid.

The result is a history with genuine continuity and genuine discontinuity. Radar, MAE, PANDORA, Walter Reed, academic bioelectromagnetics, Soviet exchange, directed-energy bioeffects and AHI policy are connected—but not all in the same way. Understanding those different kinds of connection is the key to understanding the record.

Appendix A – Verified Timeline

- 1947** — Auditory complaints associated with radar are recorded at Airborne Instruments Laboratory in Mineola, New York.
- 1956** — The AIL radar-hearing observation appears publicly in a Proceedings of the IRE advertisement; DoD assigns Air Force a Tri-Service microwave-bioeffects coordination role.
- 1957** — First Annual Tri-Service Conference on Biological Hazards of Microwave Radiation at Griffiss AFB/Rome.
- 1959** — Bach, Baldwin and Lewis present primate cerebral RF work in the Third Annual Tri-Service Conference proceedings.
- 1960** — Baldwin, Bach and Lewis publish Effects of Radio-Frequency Energy on Primate Cerebral Activity in Neurology.
- 1961** — Allan Frey publishes Auditory System Response to Radio Frequency Energy; Tulane/RADC neural-effects work appears in the military literature.
- 1962** — Frey publishes Human Auditory System Response to Modulated Electromagnetic Energy.
- 1965** — ARPA establishes Project PANDORA as the biological-effects component of the Moscow Signal/TUMS investigation.
- 1966** — Johns Hopkins APL documents the PANDORA microwave test facility and its operational procedure.
- 1969** — PANDORA includes literature analysis, instrumentation, electronic support and Army Medical work under multiple ARPA orders.
- 1970** — ARPA formally transfers PANDORA, facilities, equipment and follow-on responsibility to Walter Reed, effective 1 July.

- 1973** — Sharp and Grove communicate their microwave-auditory speech demonstration to Don Justesen on 28 September; Walter Reed continues broader microwave bioeffects research.
- 1974** — Sharp, Grove and Gandhi publish Generation of Acoustic Signals by Pulsed Microwave Energy; Foster and Finch publish thermoacoustic evidence in Science.
- 1975** — Justesen publishes Microwaves and Behavior; Guy, Chou, Lin and Christensen publish a major MAE synthesis explicitly citing Frey and Sharp/Grove/Gandhi.
- 1978** — James C. Lin visits Pushchino while Soviet researchers are already conducting microwave-hearing experiments.
- 1979** — Tyazhelov and colleagues publish Soviet human microwave-auditory experiments in Radio Science, citing Western MAE literature.
- 1980s** — U.S. research continues on cochlear responses, pressure waves, dosimetry and microwave-hearing mechanisms; U.S.–Soviet RF exchanges continue.
- 1990s–2000s** — Air Force directed-energy bioeffects programmes study RF mechanisms, high-power microwave exposure, dosimetry and safety.
- 2016** — U.S. personnel in Havana report incidents later grouped under the term Anomalous Health Incidents.
- 2020** — National Academies identifies directed pulsed RF energy as a plausible mechanism for some reported AHI features, without establishing that exposure occurred.
- 2023** — Most of the U.S. Intelligence Community assesses that foreign-adversary responsibility for reported AHIs is very unlikely.
- 2025** — Updated Intelligence Community assessment maintains the overall judgment while two components adjust parts of their capability assessments.
- 2026** — The departmental AHI Cross-Functional Team is renamed the Directed Energy Bio-Effects Cross-Functional Team; nearly \$3 million in HAVANA Act compensation is announced.

Appendix B – Principal Researchers and Institutions

Allan H. Frey — Established the modern experimental literature on microwave hearing in 1961–62.

Maitland Baldwin — NIH neurosurgeon and coauthor of pre-PANDORA primate RF cerebral research; archival evidence also links his research environment to CIA Subproject 62.

Sven A. Bach — Coauthor of the Baldwin primate RF work and later Army microwave/life-science researcher; no verified formal PANDORA role.

Robert T. Nieset and Lawrence R. Pinneo — Tulane investigators in the RADC/Tri-Service neural-effects programme cited by Frey.

Richard S. Cesaro — ARPA Advanced Sensors official who authored the 1965 PANDORA justification memorandum.

H. Mark Grove — PANDORA monitor/coordinator and major personnel bridge into later Walter Reed microwave research and microwave-acoustic publication.

Joseph C. Sharp — Walter Reed/PANDORA-era researcher; coauthor of later microwave bioeffects work and participant in the 1973 speech demonstration reported by Justesen.

Ross Adey — PANDORA consultant and prominent neurophysiologist with later U.S.–Soviet microwave-bioeffects exchange involvement.

Milton Zaret — PANDORA consultant and later ARPA-supported investigator of low-level microwave claims.

Joseph Johnston — CIA representative in the PANDORA/BIZARRE record who documented changing Moscow Signal exposure estimates and experimental interpretation.

Don R. Justesen — Behavioral scientist whose 1975 review preserved the Guy Morse and Sharp–Grove speech demonstrations in the published record.

Om P. Gandhi — Walter Reed microwave consultant and coauthor with Sharp and Grove; later major RF dosimetry researcher.

Arthur W. Guy — Leader of the University of Washington microwave-bioeffects programme and participant in U.S.–Soviet scientific exchange.

C. K. Chou — University of Washington MAE researcher and later RF standards/bioeffects scientist.

James C. Lin — MAE researcher, author and later personal/scientific bridge to Soviet microwave-hearing researchers.

Yuri Grigoriev — Prominent Soviet/Russian microwave-bioeffects researcher with long scientific contacts with Frey, Lin and Chou.

Walter Reed Army Institute of Research — Host of PANDORA biological experiments and recipient of the formal 1970 transfer of the programme, equipment and facilities.

Johns Hopkins Applied Physics Laboratory — Engineering consultant and designer/fabricator for the PANDORA microwave test facility.

University of Washington — Major 1970s–1980s centre for MAE mechanism, cochlear, dosimetric and pressure-wave research.

Air Force Research Laboratory — Later institutional home of extensive directed-energy and radiofrequency bioeffects research.

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Glossary

Microwave auditory effect (MAE) — The perception of sound produced by pulsed radiofrequency energy under suitable exposure conditions; also called the Frey effect.

Radiofrequency (RF) — Electromagnetic radiation in the radio-frequency range, including microwave frequencies.

Thermoelastic expansion — Rapid expansion caused by a very small, rapid temperature rise; in MAE research this can generate a pressure wave in tissue.

Dosimetry — Measurement or calculation of the energy absorbed during electromagnetic exposure.

Specific Absorption Rate (SAR) — Rate at which RF energy is absorbed per unit mass of tissue, normally expressed in watts per kilogram.

PANDORA — ARPA biological-effects project created in 1965 in response to concern about microwave irradiation of the U.S. Embassy in Moscow.

TUMS — The broader U.S. national investigation within which PANDORA was the ARPA biological-effects component.

WRAIR — Walter Reed Army Institute of Research.

RADC — Rome Air Development Center, an important Air Force node in early microwave-bioeffects research.

AHI — Anomalous Health Incident, the official term used for reports popularly associated with Havana Syndrome.

DEBE — Directed Energy Bio-Effects; in July 2026 the departmental AHI Cross-Functional Team was renamed the DEBE Cross-Functional Team.