12

At M.I.T. and Home During World War II

The outbreak of World War II in Europe was an unmitigated disaster for Poland, France, and Great Britain: Hitler overran Poland in short order and divided it up with Russia. Turning west, he outflanked the "invincible Maginot Line" by advancing through Belgium and Holland, taking Paris and pushing the British into the sea at Dunkirk. The heroic evacuation of the British Army by an all-out effort of the British Navy and a fleet of small craft manned by volunteers --inspired by Winston Churchill's indomitable courage and rhetoric -- left England ready for a last-ditch stand. Göring's Air Force had practically destroyed Coventry and bombed London nearly every night, but it suffered great losses inflicted by the gallant English fighter pilots. A primitive first form of radar helped warn the population of the approaching German bomber fleet.

The Development of Dielectric Spectroscopy

Foreseeing the coming need for microwave dielectrics, I had started in 1939, with I.T.& T.'s support, to develop techniques for measuring dielectric constants and losses in the wavelength region from the d.c. towards the centimeter region. The Varian brothers had just developed their new oscillator tubes, the "Klystrons." We advanced from lumped circuits to distributed circuits and waveguides. My excellent student, Sheppard Roberts, and I pushed into the 10-cm region with a "Standing Wave Method" and Dr. Chu of Professor Stratton's group developed a theoretical treatment of the problem of "Wave Guides with Dielectric Sections."

After a preliminary presentation of our techniques at the Washington Meeting of the American Physical Society in April 1940, our paper, "A New Method of Measuring Dielectric Constant and Loss in the Range of Centimeter Waves," was printed as an Electrical Engineering Department report in March 1941. It was

immediately classified as "Restricted" and only released for publication in 1946.[1] Yet -- with this paper -- the main role of the Laboratory for Insulation Research in World War II had been decided.

Working Our Way Through World War II

The destruction of our Pacific Fleet in the Japanese sneak-attack on Pearl Harbor (Sunday, December 7, 1941) pushed a hesitant United States into World War II with a crash. In contrast to my experience in Germany at the outbreak of World War I, the mood was very angry -- but somber, without any hysterical outbursts. A few days later, a false air-raid alarm at M.I.T. -- caused by claims of an impending German air strike -- resulted in everyone being ordered into the basement of Building 4. Brushing up my previous experience with anti-aircraft gunnery and the use of gas grenades, I suggested to Dr. Compton that we set up a flak battery at M.I.T. and use shells which would bring the planes down by causing misfiring of their engines.* Nothing came of this scheme except the feeling that I could be trusted.

Some neighbors in Weston rumored spy stories for a short while but, due to my involvement with radar dielectrics, I was made a U.S. citizen at the earliest possible date, in September 1941. Soon the communities in Weston and at M.I.T. grew together in shared joys and sorrows.

Role of the Laboratory for Insulation Research in World War II

Radar, a radio system using ultrashort electromagnetic waves for the location and identification of targets, had been developed on a small-scale and tentative basis in England and in the United States shortly before the war. During World War II, it proved a decisive weapon and its development for military purposes was concentrated in the "Radiation Laboratory" at M.I.T., which was manned by several thousand scientists and engineers. The Laboratory for Insulation Research (L.I.R.) took responsibility for the development and measurement of radar dielectrics as

* The shells were apparently to be filled with a "knock compound" that was supposed to cause the delicate aircraft engines to fail -- possibly allowing the bomber crews a chance for a safe landing.

well as for the initiation of their technical application and commercial manufacture. L.I.R. remained an independent laboratory with its own contracts, which later included also the development of infrared photocells. I was simultaneously appointed a member of the Radiation Laboratory.

These new responsibilities saddled our laboratory with a host of problems normally unknown in the academic world. For example, we had to create standard measurement techniques and equipment to determine the dielectric properties of all kinds of materials as a function of temperature and of frequency, from D.C. through the microwave region. The decimeter and centimeter range at that time were practically unexplored territory. New types of standing-wave precision instruments, such as our M.I.T. Coax Instrument, had to be developed, their commercial manufacture arranged, and their distribution organized to government and industrial laboratories in our own and allied countries.

Polymers like polystyrene and polyethylene -- quite new and used previously only as filler materials for rubber tires and in some household items -- also had to be upgraded to extremely low-loss dielectrics. Since the Navy persisted in pulling its radar cables through the boiler rooms of battleships, their useful temperature range had to be extended by proper addition agents. Plastics and rubbers, ceramics and glasses, single crystals and polycrystalline materials were all needed and prototype materials had to be made in our own laboratory or by allied industries. A newly formed "Dielectric Measurements Group" of the Laboratory, staffed by six girl operators under the supervision of a young bachelor student, Bill Westphal, had to determine the dielectric characteristics of these materials from d.c. through the microwave region as a function of frequency and temperature. The results were made available within the U.S. and the Allies in the classified "Tables of Dielectric Materials." Due to its general usefulness, this measurement activity under Bill Westfal was continued at the Laboratory of Insulation Research after the War.

The development of these needed materials required setting up inorganic and organic chemistry labs, X-ray and electron-diffraction facilities, and electric and optical spectroscopy. In producing high-dielectric-constant ceramics, we discovered the ferroelectricity of $BaTiO_3$ and made high-voltage condensers and ceramic delay lines. Our experience with selenium photocells pulled us into war research on infrared photocells of the thallous-sulfide type; and our dielectric studies led to the application of dielectric heating for rapid wood-curing. The classified reports of the Laboratory for Insulation Research (L.I.R.) during World War II summarize these activities by myself and my many cherished coworkers, some still close friends today.

Through all these activities, L.I.R. grew very large and very crowded. In our old location in the second floor of Building 4, with its high ceiling, we built

elevated platforms to accommodate a variety of activities. In addition, we had laboratories in Buildings 10 and 24, and also a large shop in a basement location.

Home-Life in Weston

One day in the fall of 1938, Daggie called me at M.I.T. to report that a terrible hurricane had arisen and I had better come home. When I walked out through the big entrance hall, its cavity sounded like an organ pipe. I had not driven more than two miles when a whole roof from the railroad yard came flying over my head. This I had always wanted to see! But now the sky grew dark and the storm more threatening: trees began to fall right and left. Since they were still full of leaves, they came down slowly and I could dodge them initially. Finally, however, I was completely hemmed in and had to abandon the car. It had become night and the sky was alive with flashes of lightning. I crouched behind windbreaks and ran forward for short distances when the hurricane temporarily subsided.

In this way, running and hiding, I finally reached home. Our house was in darkness and swayed under the impact of violent gusts; a big spruce tree hung over the edge of the roof. The family sat in the dark, looking out anxiously for their father. And across the street old man Jennings sat on the ruins of his chicken house, illuminated by lightning and frantically waving his arms,] to keep the chickens from following the roof, which had flown down the street.

Hundreds of fallen trees blocked our street, Glen Road, and it took a week to restore services and traffic. One beautiful old pine tree, which fell in the woods behind the house, still serves as my favorite seat for contemplation.

Old farmer Jennings, a slave driver, lived across the street. His son, Warren, with his lovely wife, Divina, lived next door to us. One day, working with my window open, I heard the following exchange between father and son as they walked by. The father said: "I wish I was dead!" and the son responded, "I wish you were too!" Well, old man Jennings died the year after and suddenly all hell broke loose on Glen Road. Our house and a number of others had been built on speculation with bank loans -- and now the various banks moved in. They even foreclosed on the well serving about twenty houses and our water supply was cut off.

That water supply had been precarious in any case. In the hot summer months, a rumbling noise would suddenly arise in the pipes, frogs would come out, and old man Jennings would switch us over to the water tower on the hill beyond our meadow. This water tower was owned by the ruling selectman. When the bankruptcy proceedings developed, the selectman wanted us as permanent customers, but our stranded community of neighbors organized a defense association and searched for a better solution. Mr. Byrnes, an Irish lawyer with a golden tongue who lived two houses down the street from us, took over as our legal counselor while I handled the technical aspects of the situation.

My former department head at M.I.T., Professor Moreland, had become Dean of Engineering and was simultaneously the water commissioner of our neighboring town, Wellesley. He arranged that we would receive water from Wellesley if we would build at our expense a connecting line to Glen Brook Road. However, we needed approval of the town meeting in Weston for this venture and there our selectman with the water tower was king. It was a dramatic occasion: The cards seemed stacked against us, but never discount the golden tongue of an Irish lawyer. Mr. Byrnes broke out in tears when telling the assembled citizens how our wives and children were nearly dying in the scorching summer heat and the town voted overwhelmingly in our favor. Suddenly, I found myself saddled with the responsibility of building a water system -- fire hydrants and all -- from the Four Corners to Glen Brook Road. But it worked. Later, when Weston extended its system into our area, we handed it over to the town free of charge.

Simultaneously, the ownership of our houses was solved: the banks -- not knowing how the water situation would turn out -- were anxious to sell. We therefore borrowed money, got a mortgage, and 265 Glen Road became our permanent home. It also became a haven of refuge for others -- beginning with Lore Misch, who had already lived with us in Copenhagen and now moved into our third floor. For her the water tower acquired special significance: Felix Bloch proposed to her up there. Next Harold Joachim moved in while studying art history and subsequently became a staff member of the Boston Fine Arts Museum. He left when drafted in World War II, and served with distinction in the Pacific War at Guadacanal. After Harold came Jim Davisson, who moved in while working on his Ph.D. thesis in the Laboratory -- and so on.

Daily living during the war was frequently difficult but sometimes also hilarious. A few short recollections may help illustrate the situation:

My working hours were very long. Driving home from M.I.T. around midnight after an exhausting day, I turned into a deserted street near Newton Corner when a policeman suddenly jumped out of hiding and claimed that I had not stopped properly at a red light. I told him that he should enter the war effort instead

of bothering people at such late hours -- and shortly thereafter got a summons to appear before the Court in West Newton. Instructed by my lawyer, I pleaded "*nolo contendere*,"* which the judge did not accept. Reluctantly, I pleaded "guilty," in order to avoid being dragged into a higher court. The judge was just starting to lecture me sternly when I heard the clerk whisper in his ear, "He is a professor at M.I.T." Changing his expression into a grin, the judge slammed his gavel down: "Case dismissed." Let us hope he knew about our war work and sympathized.

Soon the gasoline shortage became critical and we formed a driver's club of five to six M.I.T. professors for commuting together whenever our working hours allowed. When driving home one day, a pheasant flew into our windshield and was killed. As rationing was in full swing, everybody looked longingly at the bird, visualizing what a wonderful meal his family might have. Then our biologist spoke up in a cool voice: "The birds around here have a strange disease and cannot be eaten; I will dispose of it." And this he did -- with his family.

To help the family diet, we all started "victory gardens." The old barn behind our house still contained plenty of cow manure and, on Sundays, I pushed a wheelbarrow from the barn to the rocky backyard and started a tomato plantation on its sweet-smelling crest. Unfortunately everyone else had the same idea and the glut of tomatoes at harvest time was of minor assistance.

In spite of all difficulties, our children were growing up so happily that we decided near the end of the war to have one more -- hopefully a daughter.

Liaison Activities

In the course of our war activities, it became clear that a close liaison was required between our laboratory and the government agencies responsible for the procurement and application of dielectric materials. Therefore, we formed with the Army, Navy, and War Production Board the "War Committee on Dielectrics." Once a week during the later war years we met in Washington and -- after mutual trust had been established -- a number of emergency situations were handled successfully. I remember especially two occasions where decisive action was required:

The war in New Guinea had bogged down because, in the jungle climate, mite and fungi devoured uniforms and equipment. We proposed that the Quartermaster Corps change over to halogenated compounds, which could not be eaten, but met

* No contest. This means that the defendent neither admits nor denies guilt.

stubborn resistance for a while because the Corps had made long-range contracts with its suppliers. To settle the argument, I proposed to set out with an experimental trailer laboratory to the battle zone and prove my point. Instead a colonel was dispatched to investigate and came back after some time with the information that he had only found mites and fungi in his trunk after returning to Boston. This made us so mad that action was taken: Poly-vinyl chloride and other halogenated compounds were introduced and the purpose accomplished. The later abuse of such compounds in the form of halogenated pesticides here at home, with the resulting threat of Miss Carson's "Silent Spring," could not then be foreseen.

A still more hair-raising situation arose shortly before the Normandy invasion: The various Army, Navy and Air Force Units involved each needed a separate frequency band for undisturbed communication. Sharply-tuned quartz crystal filters had been prepared by the Signal Corps for this purpose, but these crystals had unfortunately been housed in plastic containers. When the filters were taken out of storage, their silver-plated electrodes were found to have been destroyed by the organic fumes emitted from the plastic. A desperate last-ditch effort to re-house the crystals in glass containers saved the day.

May 1945

As the end of the war in Europe approached, I volunteered to go to Germany after an armistice was achieved, in order to help with my knowledge of the country and its people. Simultaneously, I hoped to look after family and friends. For this purpose, one had to get some military commission. The Navy, bound by a rule that an officer had to have ten years of citizenship, could only offer the rank of "Seaman Second Class," while the Army offered me the rank of colonel. I accepted but fate intervened. Completely overworked, I got a case of acute hyperthyroidism, losing about a pound of weight per day and becoming terribly irritable. As a result, I found myself hospitalized for a thyroidectemy in Malden because our friend Brugsch had great confidence in the surgeon there. Simultaneously, my poor wife entered a maternity hospital in Boston. Our four boys trouped from one hospital to the other and Claire Campbell, a neighbor's daughter, took care of them.

It took several weeks before my thyroid-overstimulated body had slowed down sufficiently for the operation. On the critical evening before the surgery, Daggie’s cousin and very good friend, Heinz Kallmann, suddenly appeared at my bedside and told me in a conspiratorial whisper that he had located a doctor who could get me well without an operation and that his car was waiting outside to get me there. I

went through with the operation and came home after about two weeks to greet our new daughter, Marianne, alias Mai, who accepted me -- after some hesitation -- as her rightful father.

The War Ends

The Pacific War still went on for a few months (till August 1945) and the Laboratory for Insulation Research continued to play its role in radar, infrared detection and auxiliary efforts. Then the Office of Scientific Research and Development (OSRD) under Vannevar Bush suddenly disbanded. All the dislocated scientists and engineers in the defense laboratories had to return to their old universities or find new home bases with as much credit as they could muster. As a result, much pressure was put on us to help complete experiments in which we had not been involved and to publish our scientific findings in collaboration with others. We resisted these efforts because I had clearly perceived our challenge: to transform the whole field of materials research with our new basic approach, "the Molecular Designing of Materials and Devices."

I was still under great physical strain due to my thyroid operation and have never been a good politician. Also, dedication to a new cause makes enemies and meets much resistance until that war is won and everybody climbs on the bandwagon. We had gained the trust of the armed services through our wartime performance, however. The Laboratory for Insulation Research (L.I.R.) therefore received the first Army-Navy-Air Force contract to start its peacetime operations.

With the dropping of the two atomic bombs on Hiroshima and Nagasaki, World War II came to its horrible ending. Opa and friends at the Atomic Energy

Project in Chicago had tried to change the target site to an uninhabited island as a demonstration -- but without success.*

* The story of the "Franck Report" -- and the report itself -- may be found in *A Peril and a Hope: The Scientists' Movement in America, 1945-47* by Alice Kimball Smith (Cambridge, MA: M.I.T. Press, 1971).