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BLIND FLYING ON THE BEAM: AERONAUTICAL COMMUNICATION, NAVIGATION AND SURVEILLANCE: ITS ORIGINS AND THE POLITICS OF TECHNOLOGY

PART II: POLITICAL OVERSIGHT AND PROMOTION

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ABSTRACT

Part II: Promotion and Political Oversight—The second paper considers the effect of Federal regulatory and administrative policy on the development of aeronautical communication and navigation in the United States. It wasn't until Herbert Hoover became the Secretary of Commerce in 1921 that any attempt at coordinating aeronautical telecommunications research was begun. By 1926, armed with a legislative mandate, Secretary Hoover achieved two very important political objectives in relation to aeronautical telecommunications and thereby insured interagency coordination. The Air Commerce Act of 1926 placed all research and development of communication and navigation within the jurisdiction of the Department of Commerce. This was followed by the Federal Radio Act of 1927 that provided the necessary Federal oversight of frequency allocation and protection for aeronautical frequencies.

RENEWED INTEREST

It was 1925 before the Post Office again took up aeronautical communication and navigation research. Carl Egge, General Superintendent of the Air Mail Service, persuaded Paul Henderson, now Second Assistant Postmaster General to establish an experimental operations route between Monmouth, New Jersey, and Chicago, Illinois. Based at the airfield in Monmouth, the research facility was to test radio

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direction finding, lighting devices, radio altimeters, earth induction compasses, radio communication and new ships. The new Development Division had as its technical advisor a distinguished aeronautical engineer, Professor Edward Warner of the Massachusetts Institute of Technology. “Professor Warner has agreed to become responsible of the technical direction of the work,” Henderson told Egge. The Division began operations in March 1925 under Air Mail pilot Harry G. Smith as superintendent with a small staff consisting of test pilot Frank Burnside, radio specialist Carl Hempel, and engine expert Oscar Wilke.

The staff lost no time in searching for a practical navigation aid. Hempel conferred with the Army Air Service technicians at McCook Field about their work with the directive radio beacon. The beacon, developed earlier by the Army and the National Bureau of Standards (NBS), produced specific courses that could be navigated. Between the times the Post Office had lost interest in electronic navigation and the establishment of its facility in Manmouth, progress had been made in electronic navigation. This newest beacon was an early prototype of the low frequency radio range.[1]

Hempel acquired components from the Army and constructed a radio beacon at the test facility in Monmouth. The antennas were energized by using a 1 kW Westinghouse Radio Telephone transmitter, employing the latest vacuum tube technology. Hempel’s design allowed him for the first time to transmit both voice and navigational signals. Another modification allowed the transmitter to be powered by a common power source—220 volt, 60 cycle, single-phase found almost anywhere in the United States. Test signals were broadcast on two frequencies: 285 and 374 kHz.[2]

A de Haviland airplane was selected for flight testing the beacon. Care was taken to shield all engine electrical components to reduce interference from the engine. Initially an Army SCBC 8A (Set, Complete, Basic Component),[3] amplifier and tuner were tested but very satisfactory results were obtained from a three circuit three tube regenerative receiver built by Hempel (see figures 1 and 2). A trailing wire antenna with a six-pound weight at the end to help keep it vertical was used.[4]

During tests two Army aircraft flying over 200 miles away received the signals. Post Office test pilot Frank Burnside flew round trip from Monmouth to Chicago with visibility less than a mile. “It was a very simple matter to stay on course,” he reported. There were problems. The $6,000 cost of installation was prohibitive. Static had caused interference, which was bad at times, and the transmitter antenna installation was located too close to the airfield, creating a hazard for aircraft. Further testing was planned.[5]

A month later the Division submitted *Report No. 7* to the Post Office which pointed to the importance of continued radio beacon research.

Analyzing flight data, the Superintendent of the Division Harry Smith examined the causes of forced landings for the period between July 1924 and June 1925. He pointed out that 77.6% of the forced landings were weather related while only 22.4% could be attributed to mechanical failure. "In view of these facts, it is obvious that the greatest field for improvements is in the conquering of bad weather," he wrote.[6]

Unfortunately for the Development Division, a Post Office inspection report released in October would be its death knell. The Air Mail's General Superintendent Carl Egge accused of misappropriating funds would resign. The most egregious example of waste, however, was the purchase of aircraft ill-suited for the mail service and money spent on unused aircraft radio equipment. Among other things, the report recommended closing the test facility. The recommendation was approved.[7]

In a letter to General Superintendent S.A. Cisler, Smith wanted to set the record straight and recounted the accomplishments of the Development Division in its short seven-month existence. The goals of the division had been to recommend equipment and methods which will improve the efficiency and safety in the Air Mail Service. He then pointed out the current lighted airway could not support the level of service required by Post Office patrons. "These lights do not secure for us the performance necessary. No light has yet been developed that can penetrate fog." The lighted airways were deficient. In bad weather they could not be seen, and in good weather pilots did not necessarily need them. The lighted airway found its utility at night in good weather, but a radio airway could be used at all flight altitudes, at night and in weather. "These advantages of the 'radio airway' are not just theories; they have been proven by actual flights on this division." But with the passage of the Air Mail Act of 1925, government operation of the airmail was coming to an end, and in 1926 development of airways would become the responsibility of a new government agency, the Aeronautics Branch.[8]

POST OFFICE POINT-TO-POINT COMMUNICATIONS SYSTEM

The Air Mail service began installing a series of spark transmitters in 1919 with the notion of creating a system of radio stations for air-ground, two-way communication and navigation. Airborne navigation and communication equipment was heavy and bulky and required a radio operator necessitating larger, twin-engine Martin aircraft. They were fitted with a Navy SE-1310 airplane spark transmitter (telegraphy) and a Navy 1605-B receiver. Flight tests looked promising, but the program was abandoned when Praeger focused his attention and resources on building the Transcontinental Airway between New York and San Francisco. James

Edgerton, Praeger's newly appointed head of the Air Mail Radio Division, then began building a point-to-point communication system.[9]

These radio facilities were first called Air Mail Radio (AMR) Stations and were the predecessors of the modern Flight Service Station (FSS). The number of these radio stations increased as the transcontinental air mail route pushed its way westward. The first two stations, WWX in Washington, D.C., and WWQ, located in Bellefonte, Pennsylvania, the first stop on the westbound route, were commissioned in 1919. In September 1920 the Post Office officially began transcontinental service and continued building airmail radio stations to support this new service. Seventeen Post Office radio stations had been commissioned by 1921—one at each airmail landing field. Edgerton had no trouble defending the decision to use radiotelegraphy in support of the airmail because telegraphy over leased wire was much more expensive.[10]

Generally the airmail schedule was light with only two daily flights that had to be serviced, one airplane inbound from the east and another from the west. The cost-conscious Post Office hired only one operator for each station. Their duties included sending messages, keeping the runway clear, maintaining the transmitter, taking weather observations, and servicing the airplane.[11]

The station operator used radiotelegraphy to relay weather information and flight data to other stations down the line, on working frequencies between 71.39 and 199.9 kHz. Flight data included arrival and departure times of the airmail plane or aircraft number and time of observation for aircraft over-flying the airfield. When pilots landed the operator passed along the weather conditions encountered enroute to other stations and pilots. Pilots read the reports from other stations or phoned ahead to the next station to check weather conditions at their destination. They still had no idea of what to expect between takeoff and landing nor did they know if the weather had changed significantly since takeoff (see Figure 3).[12]

Operators employed a Morse code shortcut known as the Philips code of abbreviations in order to save time. Such acronyms as CAVU (clear, visibility unlimited), RON (remain over night), ETA (estimated time of arrival) and WILCO (will comply)—terms in common use by pilots and controllers today came from this code, according to Art Johnson, one of the original operators. The concept was to pass or receive messages from adjacent airfields, but if conditions allowed, operators would attempt to call the station to which the message was addressed. Operators worked on a system named *calling/working wave*. Stations would call one another on a common frequency and then shift to a frequency assigned to that station.[13]

The NBS were not the only ones experimenting with radio, according to Johnson. Heavy atmospherics created problems with the system. A 2 kW transmitter was unable to compete with the static a storm produced prompting Johnson and operator Phil Coupland to develop "a means of raising the power of these 2kW transmitters to 5kW." They accomplished this feat by using a different power supply, larger coils and putting together an improved water cooling system. Johnson credits Reno radio operator Hadley Beedle for using two quarter-watt vacuum tubes to build much-improved transmitters that were eventually installed at Reno, Sacramento, and the stations between Elko and Iowa City. Distance and increased power resulted from his and other operator's efforts. "Daytime work up to 600 miles was common. During night hours, any station could work any other station with ease,"[14] Johnson claimed. Other improvements included a knife switch that allowed changing frequencies without shutting the transmitter down. Equipment was designed and assembled in spare time and, due to the shortage of funds, improvisation was the order of the day.[15]

Post Office Inter-Departmental Cooperation

"For your information, the Air Mail Radio Service of the Post Office Department is operating a chain of radio stations across the continent," Postmaster General Burleson advised in letters to other cabinet officers. He pointed to the impending rate increase for leased wire service and offered the use of the radio stations for the mutual advantage of all concerned. He suggested forming a committee of all interested departments so that recommendations might be made to utilize excess capacity more fully and promote efficiency and economy of operation. The meeting was held in Edgerton's office and attended by representatives of the Coast Guard, Weather Bureau, Bureau of Markets and Treasury Department. Edgerton explained to the committee that, on the basis of an eight-hour day, the airmail stations had a capacity of 10,000 words. Post Office business required only 4,000 words a day, leaving an unused capacity 6,000 words for use by other departments.

The Weather Bureau was most interested in using the excess capacity. Its system of weather observations and reports were transmitted on wire circuits, and, because there were numerous reporting stations requiring wide distribution, the Post Office stations would not be an efficient collection and distribution system. The airmail radio stations could, "be used to excellent advantage in the distributions of forecasts and warnings," reported Weather Bureau meteorologist E. B. Calvert. The stations would be able to reach rural sections of the country where the bureau had difficulty supplying farmers with timely weather information. Edgerton supported the idea, stating it would be an easy task to transmit forecasts on fixed schedules. The arrangement with the Weather Bureau, begun in 1921, would soon lead to a marriage under the Air Commerce Act. Weather observers would augment the airmail radio sites, take observations and disseminate weather information and forecasts for aviators.[16]

The Post Office was using its airfield transmitter sites as point-to-point communication stations. Weather and flight data as well as other government message traffic found its way over this coast-to-coast radiotelegraphy system. The time was not too far distant that radio would be used for what Edgerton and Praeger had originally conceived—air-ground, two-way radiotelephony. Point-to-point message traffic and weather reports would migrate from radio to leased landlines and Teletype.

Yet, for all the discoveries and improvements in radio from World War I until 1925, few aircraft had radios and electronically defined airways did not exist. Europe had eclipsed the United States in building airways and providing communication infrastructure. In the U.S. there was no single administrative agency providing funds or leadership developing such a system as many countries in Europe enjoyed. Instead, the Bureau's role, up to this point, had been one of assisting other administrative departments in furthering their parochial interests.

Things were about to change. Though the financial famine of fiscal years 1923, 1924 and 1925 had slowed development of an aeronautical telecommunications system, the Bureau was about to experience a feast. The research completed during the famine was the foundation upon which a viable aeronautical infrastructure would be built. The Air Commerce Act provided the mandate and administrative oversight required to build the aeronautical telecommunications system. The Radio Laboratory of the NBS became the center for research and development of the system.[17]

The Bureau Mobilizes

Assistant Secretary of Commerce Walter Drake wrote to Radio Section chief John Dellinger in early 1926: "There is considerable probability of passage of the bill to create a Bureau of Civil Aeronautics in the Department of Commerce." With its passage, the task of developing an airway system with all the supporting communication and navigation infrastructure would fall to the Department, and Drake was anxious that the Department of Commerce be prepared technically to undertake such a task. The Assistant Secretary requested Dellinger prepare a report describing previous research and current application to aviation radio. Dellinger did so, informing his boss E. C. Crittenden, supervisor of the Electricity Division, that he was preparing to "make as rapid preparations as possible of active work in this field of aircraft radio which now seems to be a promising development."[18]

Dellinger's strategy was based on the premise that communication and navigation were critical to the success of commercial aviation. Thus, whatever system was to be created, it must be built on electronic communication and navigation. "Aviation will depend increasingly upon radio, since radio is the only instrumentality thus far developed which can be relied upon regardless of weather, particularly fog, and in the nighttime,"[19] wrote Dellinger. The physicists and researchers at the Laboratory took up their work where they had left off after the budget cuts of the early 1920s. Their more recent work in commercial radio broadcasting research and past work with the Air Mail Service and the Army's Air Service had laid the necessary groundwork. However, more planning, development and engineering would be required in order to deploy a practical and safe aeronautical telecommunications system. Issues such as communication and navigation frequencies had to be resolved. Transmitter power requirements had to be defined. Practical antenna systems had to be developed for ground as well as aircraft. Aircraft ignition noise had not yet been mitigated. The Dellinger agenda included developing a localizer landing system and radio altimeter. Other aids such as the direction finder were worth consideration. Dellinger informed Crittenden that the system would be developed in cooperation with the Post Office and War Department.[20]

Air-ground communication and navigation were not the only systems Dellinger was interested in. He viewed the terrestrially-based communication system as part of the overall communication infrastructure. The Post Office had used radiotelegraphy for relaying flight data and meteorological reports from airport to airport. Dellinger proposed a system that would employ radio transmitters differently. In a memo to George Burgess, Director of the NBS, he recommended that radio equipment at airports support both radiotelegraphy and telephony. However, radiotelegraphy was to be used as an emergency backup for point-to-point communications where wires could not be provided. Radiotelephony was to be for air-ground, two-way communication for relaying instructions, weather information and warnings to aircraft.[21]

Dellinger's concept included a double-beam radio beacon at each airfield and an airfield localizer. Cockpits would be equipped with a compatible radiotelephony transmitter and receiver, a visual indicator for navigation and an indicator for a localized landing system. Burgess forwarded Dellinger's memo to Drake informing him that the NBS could begin some preliminary work immediately, but would require an additional $50,000 to fund further experimental work for proper planning of the airways and aircraft radio equipment. A plan now existed. It was built on previous work with the Post Office and Army and was acceptable to those agencies. What was needed was a congressional mandate and funds for research. The NBS did not have to wait long.[22]

The Legislative Mandate

The passage of the Air Commerce Act in 1926 brought about bureaucratic reorganization in the Department of Commerce and the transfer of the lighted airway system and 17 radio stations from the Post Office to the newly created Aeronautics Branch. Within the Aeronautics Branch maintenance for the airways systems fell to the Airways Division. Research and development came under the Aeronautics Research Division and it was within this division that the NBS expanded its research responsibilities. Development, construction and maintenance for aeronautical telecommunications now rested in one administrative agency—the Aeronautics Branch. More importantly, funding and coordination decisions affecting the continued improvement of the system were coordinated within one agency. By placing responsibility for the development of the communication and navigation system under the Department of Commerce, the new law eliminated the uncoordinated efforts of different administrative departments and with it the effect that multiple agendas had on its development.[23]

New-found Federal support for commercial aviation had an immediate effect on both commercial aviation interests and the radio industry. Within a few short weeks Dellinger reported commercial radio manufacturers were visiting the NBS questioning staff about radio technology and frequency assignments. "The passage of this Act," Dellinger reported, "is greatly stimulating the interest and activity of all concerned with aviation." The Army and Navy were extremely interested in developing a common radio so that it would be compatible with the new civilian radio standards. Dellinger and Dunmore visited McCook Field in June and test flew the Army's double-beam radio beacon. The use of a goinometer and the Bellini-Tosi antenna system worked well, but the Army had not done quite as well with a visual indicating system. The Army approach had depended on a number of relays that made the system too complicated to be of practical use. The visual system was important, Dellinger believed, because it would help eliminate pilot fatigue among other things.

Dellinger reported, "It seems clear that the radio beacon is the primary aid required for aviation…[but]…the principal unsolved problem is providing a practical aid for landing in fog."[24] One solution was to use the beacon as a type of field localizer. As the aircraft flew over the airfield, an observer could estimate the altitude of the aircraft and radio it to the pilot. "This, successfully accomplished, would be a great step on the outstanding problem of landing."[25] Other recommendations included an immediate attack on the problem of airborne transmitters and receivers. Enabling pilots to communicate, Dellinger said, is "in itself a powerful aid to air navigation."[26] His report recommended calling a conference of those interested in radio aids to aviation. He believed, as did Secretary of Commerce Herbert Hoover, that nothing but gain could come out of such a meeting. "We can proceed much more rapidly with assistance in certain quarters."[27] The conference was held in June and attended by representatives from the War, Navy and Post Office Departments as well as representatives of commercial air transport companies, the NACA and Guggenheim Foundation. The conferees reached fifteen conclusions that set both direction and priority for developing the aeronautical telecommunications system.[28]

Consensus was reached on the following issues: air navigation is dependent on radio aids; they should be established and maintained solely by the government; a communication system between airports supporting air traffic control and meteorological reporting system should be established and maintained by the government; and the most essential radio aid to navigation is air-ground, two-way communication. The air carrier operators considered this last point a high priority. Without two-way radiotelephony it would be difficult to maintain schedules, receive in-flight weather information and pass along emergency information.[29]

Other items included establishing flying routes based on the double-beam directive beacon. The group did not expect aircraft direction finders would be used to any extent on airplanes in the near future, but that ground direction finding should be tried. Low power, non-directional beacons should augment navigational beacons as markers for emergency fields and airfield localizers.[30]

The group recognized an inherent problem with the navigation beacon system early on. Beacons produced four beams that could be used for defining airways. These four courses limited the flexibility of the beacon and forced pilots to navigate only on established airways. Without a large number of established four course beacons, electronically navigating to any airport would prove difficult. The goniometer and Bellini-Tosi antenna system allowed bending the beam, but were not the optimal solution to a multi-course navigation aid. A better solution would be a beacon that could support any number of courses.

A possible solution was developing a continuously rotating beacon modeled after the Telefunken navigation system used in World War I. This required the use of a stopwatch in the cockpit and Dellinger correctly observed such a system would be complicated in use, and that it did not appear to be a promising answer. The multi-course problem could be solved with the radio direction finder but at this stage of development such receivers continued to pose a weight problem. They would not be practical on smaller aircraft.[31]

The Laboratory would rely on its past research and work accomplished by radio manufacturers and the military. Manufacturers were the key. They were needed to produce radios and electronic equipment for both aircraft and the air navigation system, and towards this end the NBS maintained a close relationship with them. For instance, the Bureau received help from American Telephone and Telegraph Company in the form of a transmitter. “This is to advise we can place at your disposal for daily use in aircraft experimentation, up to a period of one year, the old WCAP transmitter,”[32] AT&T Assistant Vice President, J.C. Lynch wrote. The transmitter would be maintained by AT&T employees and the necessary cabling would be supplied by the company between the College Park facility, the NBS, Department of Commerce, and the transmitter facility at Thirteenth Street in Washington. There would be no charge for the use of the equipment Lynch assured the Bureau. On the other hand AT&T wanted to team up with researchers at the Laboratory to accelerate the development of aeronautical communications. The objective was, in the shortest time possible, to gain “knowledge with reference to the various phenomena to be encountered in the practical operation and dispatching of planes” using airway routes that were interconnected by wire.[33]

Other companies were beneficiaries of research conducted at College Park. Haraden Pratt and C. B. Hempel met with manufacturers in April 1927. “The trip was made primarily for the purpose of exchanging information regarding various phases of radio aids to air navigation,” they reported upon their return. The exchange of information was a two-way street. During the trek representatives from General Electric, Westinghouse and Ford Motor Company were consulted, and research progress made at the NBS was also discussed. Information garnered from the Post Office proved helpful as well as a trip to the Signal Corps Laboratories at McCook Field. Manufacturers were not the only industry stakeholders assisting the NBS. National Air Transport[34] offered their aircraft and pilots for flight tests as did Ford.[35] Cooperation from Westinghouse produced assistance for rebuilding a 1 kW radiotelephone transmitter for placement at the Bellefonte site. Westinghouse supplied the Radio Laboratory with information about their company’s current aeronautical radio development. Even though their engineers believed that Westinghouse would probably not enter aircraft radio development to any great extent, they did agree to supply a marker beacon for use at Bellefonte. General Electric, on the other hand, had invested in a test aircraft and were developing aircraft radios.[36]

Bureau and manufacturers needed to cooperate. Once the aeronautical telecommunications devices were designed, manufacturers were needed to build them. Commercial aircraft operators needed radios and the government required transmitters for the airways. The Technical Radio

Committee of the Aeronautical Chamber of Commerce helped coordinate cooperation between government agencies, Bell Telephone Laboratories, Westinghouse, Radio Corporation of America, Western Electric, General Electric, Radiomarine and the research staffs of the airline transport companies.[37]

The exchange of information, ideas and technology brought about synergy and reduced development time. Pratt and Hempel reported that visits to Ford, Westinghouse and General Electric "were beneficial through bringing about an exchange of view and technical information on the radio beacon and allied problems." The trip had helped establish cordial relations between the Radio Laboratory and their engineers. Private industry and government agencies did work together closely and within two years were ready to begin deployment of the technologies that would become the aeronautical telecommunications system.[38]

1926-1928—Setting the Direction

Once the bureaucratic structure was in place and funding for research had been approved, the Radio Laboratory began building a test facility at College Park, Maryland, just northeast of Washington, D.C. Laboratory personnel began construction of an experimental radio beacon based on Engel and Dunmore's 1921 design used by the Army at McCook Field. Two single-turn antennas, supported at their apex by a 70-foot wooden tower, were placed at right angles (see Figure 4). The beacon operated on a frequency of 290 kHz and was powered by a 500-watt transmitter. A 500-watt radio telephone transmitter was also constructed and operated on a frequency band between 500 and 550 kHz. The researchers installed a 5-watt marker beacon operating at 290 kHz.[39]

Christmas came early for the researchers of the Radio Laboratory. December 1926 saw the commissioning of the Radio Laboratory's first experimental beacon as well as completion of research facilities at its College Park site. The package included aircraft for test flights. The staff lost little time completing test flights of the vibrating reed visual system, directive beacon and radiotelephony. The NBS established a second research facility at Bellefonte, Pennsylvania, in March 1927. The site was chosen because the mountainous terrain contrasted greatly with the flat fields surrounding College Park and because it defined a portion of the transcontinental airway "where service tests can be conducted over the New York-Cleveland section of the transcontinental air mail route."[40]

During October and November 1927, the International Radio Conference was held in Washington, D.C. A number of Radio Laboratory members attended the sessions. The most important objective, as far as the laboratory's members were concerned, was securing assigned international aircraft communication and navigation frequencies favoring research begun by the laboratory. They were not disappointed. Aircraft communication and radio beacon frequencies were allocated bands of 285 to 350 kHz for beacons and 315 to 350 kHz for telephone.[41]

RADIOTELEPHONY

At the American Society of Mechanical Engineers meeting in Philadelphia in September 1926, Dellinger explained the importance of aeronautical radiotelephony and its advantage over the simpler telegraphy. While it was true that telegraphy could be accomplished using smaller transmitters and a narrower frequency band, most commercial aircraft carried only one pilot and that pilot had enough to do without attempting to communicate in Morse code. Dellinger recounted the problems the laboratory was facing in attempting to make air-ground communication practical. Power supplies for radios also posed an engineering problem as well as reducing both the size and weight of radios. The use of higher frequencies needed to be investigated. They were deemed more appropriate for aircraft because they would require shorter antennas and eliminate the current need for long trailing wire antennas. Experimental work with frequencies above 3000 kHz as well as piezo control of transmitting and receiving sets, and improved antenna systems would occupy much to the Bureau's research effort. There was some urgency associated with the work because the need for radiotelephony, Dellinger believed, would only increase especially as airway development progressed and the airlines began carrying passengers.[42]

Dellinger's initial assumptions guided the work of the physicists and researchers in the laboratory. Their objective was to insure radios were available to all aircraft flying the airway system. The radios would serve a dual purpose by receiving both navigation and radiotelephony broadcasts. Additionally radios needed to be small, inexpensive and simple. Where sophistication and complexity were required they would be built into the ground portion of the system, which was to be maintained by the Government. Ground station power was planned to be between 1kW and 2 kW with a projected range of 100-200 miles. The College Park laboratory would become a model for future installations, allow experimentation under actual flight and weather conditions and could be used by the airlines operating in the Washington, D.C., area. The Radio Laboratory was anticipating swift progress. "It is hoped that funds will be available to provide for beacon and radio telephone installations at three to seven airports before the end of the fiscal year."[43]

GE offered their RT-12-A 500-watt transmitter as a possible candidate for ground-to-plane communication. Operating on frequencies between 125kHz to 500 kHz, it boasted a high degree of frequency stability with variation not exceeding 350 Hz. The Coast Guard had taken delivery of 11 of the transmitters and had placed an order for 6 more. GE stood ready, if the Radio Laboratory was interested, to ship orders within six weeks. The transmitters included "full instructions at our factory and could be supplied at a low price of $5,000."[44]

Size limited the practicability of cockpit mounted transmitting and receiving sets. The Radio Laboratory solved the problem by mounting the radio set in a remote section of the aircraft and installing a remote control panel on the cockpit instrument panel. Early panel mounted prototypes contained a toggle switch for switching between navigation and radiotelephone reception, a headphone jack, a volume control and a neon light indicator. Flight tests using a 100-watt transmitter in the airplane were successful. Communication up to 50 miles was attained and the Bureau was ready to demonstrate it to the public.[45]

May brought the All America Aeronautical Exhibition to Washington, D.C. and the Radio Laboratory was ready for its first public demonstration of radiotelephony. The Ford Motor Company supplied one of its Ford Tri-Motor airplanes for use in the trials. The Ford produced very little ignition noise due to its all-metal construction. Trials through the first week in May were impressive. One of the first of such tests was a radio call to Assistant Secretary MacCracken in his office at the Department of Commerce. His secretary Jo Anne Murphy walked into his office and told him that Dr. Delligner wanted to speak with him.

> I picked up the phone and he said something, then there was a pause and a funny rumbling noise. Finally I said "Where in the world are you?"
>
> "I'm above the world," he said, "between Washington and Baltimore." He had been able to rig a telephone in his plane, and to carry on this two-way conversation with me. If that seems commonplace now, it was certainly remarkable then.[46]

MacCracken arranged for a public demonstration the following day. He assembled reporters and photographers at his office for the event. During the demonstration MacCracken noticed thunderstorms forming on the horizon and warned the airplane crew they might want to turn around and fly back to the field. MacCracken touted the benefits of two-way communication by voice explaining to the press that they had just witnessed a successful practical application of its importance "even if I did have some trouble convincing the reporters I hadn't arranged for the storm to happen at just that time."[47] On May 5, 1927, a similar event was arranged with Director Stratton of the NBS. The two-way conversation was broadcast on radio station WRC. Listeners from Washington and Baltimore were impressed with the clarity of what they heard.[48]

The airplane returned to Dearborn, Michigan, on May 7 with Radio Laboratory staff member Pratt aboard. Pratt continued to test the radio and was able to transmit and clearly receive the experimental station at College Park for 100 miles. Radiotelegraphy was tested with an effective range of 225 miles. Passengers on the Ford requested telegrams be sent to friends from the air. The messages were transmitted to the ground using radiotelephony where they were phoned to the telegraph company. Some of the recipients actually reversed the procedure and had messages sent to the plane. A few passengers took advantage of the radiotelephone and made arrangements to be met when the airplane landed. Pratt commented that the flight had demonstrated "the practical utility of radiophone airplane communication other than its primary purpose as an aid to navigation." Passengers and crew were able to receive radio stations WTAM in Cleveland, WWJ in Detroit and the telegraph signals from vessels on the Great Lakes. "Thus," Pratt reported, "entertainment and baseball scores were provided by radio."[49]

Coverage of Lindbergh's return from Europe aboard the *USS Memphis* brought another first for aeronautical radio. "Journalistic and scientific progress reached a new milestone today," began the United Press story. "For the first time in newspaper and radio history the story of a great event was reported from an airplane by radiophone," boasted the United Press. As the Navy cruiser made its way up the Potomac River, William J. McEvoy, a Washington staff correspondent for United Press, made history when he became the first journalist to report live from an airplane. Dellinger's assistant C. B. Hempel accompanied McEvoy in the Ford. McEvoy's report was broadcast from the airplane to the College Park facility and from there the report was transmitted via telephone lines directly to United Press and simultaneously rebroadcast on local radio stations.[50]

By 1928, the NBS began placing greater emphasis on radio beacon research and development than on radiotelephony. Manufacturers were conducting research and development of radio equipment. "An effort was…made to interest equipment companies in the design and manufacture of sets so that airplane operators would have a source of supply,"[51] the NBS reported. The Bureau's efforts paid off and interest was stirred within the industry. Radiomarine Corporation of America, a subsidiary of the Radio Corporation of America (RCA), began the development and manufacture of aircraft communication and navigation radios. Representatives of RCA and Radio Frequency Laboratories consulted with the Radio Laboratory in February to "discuss detail concerning receiving set models particularly suited for aircraft use."[52] National Air Transport worked with RCA conducting tests of its radiotelephone products. Others working toward developing aircraft radio transmitter and receiving sets included Westinghouse and General Electric. Pan American Airways provided a test bed for many of the radios that were built.

Early receivers were able to pick up both navigational signals and weather reports broadcast from the new experimental navigation beacons. Aircraft transmitters being tested ranged in power output between 10 and 300 watts. Most radios required an A and B battery[53] as a power supply, but Bell Telephone and Western Electric developed a small, twelve-pound receiver that could be powered by a wind generator mounted on the airplane thus eliminating the need for batteries (see Appendix D). Radio engineer Lawrence Hyland disliked generators powered by wooden propellers. Writing in *Aviation* he explained wooden propellers were cheaper and weighed less but the drag they produced more than offset their inexpensive price. He concluded the "wooden propeller, then, is not practicable as a means for driving the radio generator."[54] He reported on the advantages and disadvantages of direct drive and gear driven generators and ultimately recommended a single blade, self-regulating propeller generator. Its weight and consistent voltage and frequency output made it the best source of power in his estimation.[55]

Progress and Overcrowding

The Technical Radio Committee of the Aeronautical Chamber of Commerce worked with transport operators to develop requirements for radio transmitters and receivers. The result, it boasted, was a coordinated development effort among all radio manufacturers, government and research staffs of commercial operators. By the end of 1929 development of radiotelephony had advanced to the point that installation of radios in aircraft was practical. Improvements and further refinement were still needed but their use by the airlines had begun and the assigned frequency range became crowded.[56]

The commercial operators and representatives from the NBS, Army and Navy presented a frequency plan to the Federal Radio Commission (FRC) in September 1929. The Aeronautical Chamber of Commerce was instrumental in coordinating the plan that recommended that 273 kHz be used for airports and that higher frequencies be assigned to the transport companies. It also recommended that 3106 kHz be set aside as a national calling frequency. Dellinger represented the NBS and Hingsburgh the

Airways Division. Herbert Hoover Jr. represented the interests of Western Air Express (WAE).[57]

The FRC approved the plan and established four colored airways, or chains. Airlines operating on the chain shared the frequency and the expense of maintaining the ground-based stations. The owners of aircraft using the chain were to "co-operate among themselves as to the operation, maintenance, operation and liability of the stations."[58] The plan allocated two operating frequencies for each chain, one for night and the other for day operations. Other services such as point-to-point communications were allocated frequencies. The FRC viewed the stations as a public trust and the operators were to assist other intenerate (non-commercial or non-scheduled) flyers without charge. As more aircraft used radio, the colored airway design would change to meet the needs of the transport companies.[59]

Radio was still considered a newcomer in aviation, according to the *Aircraft Year Book, 1932*. But its development "has contributed in a major way to the development of air transport,"[60] and it was sure to become an important addition in private and industrial aircraft. Radios were becoming smaller and more efficient. Numerous improvements were reported such as crystal-frequency control, easier ways to change frequencies and better headsets. Wesley Smith, former Aerial Mail pilot and Vice-President of National Air Transport in 1931, pointed out that "aircraft radio is developing so fast, the radio equipment of today will be obsolete tomorrow, which makes it very expensive for the air transport operator."[61] Radio equipment was expensive, but operators were looking to radio as a key to increasing schedule reliability and safety of operations.[62]

FROM CABINET MEMBER TO PRESIDENT

Herbert Hoover resigned his position as Secretary of Commerce in 1927 to seek the Republican nomination for president. Hoover handily defeated Al Smith in the 1928 election. As President, Hoover remained interested in the air transportation industry even though he was not as directly involved in its oversight as he had been when he was the Secretary of Commerce.[63]

The Great Depression began during his first year in office, and in 1930, aircraft production began to feel its effects. President Hoover met with Assistant Secretary Young, Charles Lindbergh and members of the Army, Navy and Post Office to discuss possible strategies the government might employ to stimulate the industry. The airlines had carried over 200,000 passengers that year. The industry had grown well beyond most predictions. In fact, as Hoover was told, the annual mileage flown in the United States had now exceeded all of Europe combined. *The New York*

Times reported that Hoover was much impressed with the advances made by the commercial aircraft industry but wanted to explore ways to help stimulate the production of aircraft. In true Hooverian style, the President wanted to extend an invitation to the aircraft manufacturers to join him in seeking a solution.[64]

The New York Times pointed to the fact that government assistance in the form of airways clearly played an important role in the utility of the airplane. "These trunk lines not only constitute the basis for air transportation service to a large portion of the country,"[65] *The Times* reported, but they also served as alternate routes. During the next year the Department of Commerce was planning to commission an additional 33 radio range beacons and 2,800 miles of Teletype circuits, *The Times* reported. Hoover clearly supported the growth of aeronautical communication and navigation infrastructure as well as the industry itself.[66]

The Aeronautical Chamber of Commerce received a message from the President during its 1931 National Air Show at Detroit's Municipal Airport. The letter from Hoover read in part "it is my great desire to see commercial aviation established on the right basis."[67] He believed the right basis was an aviation industry, as well as a national air force, built on the foundation of commercial air transport. When Hoover's Presidency ended in 1933, he left an industry that had grown under his policies. This industry had continued to expand even during the depression and had been transformed from flying the mail in single-engine, open-cockpit aircraft without radios to one that had begun passenger service in multi-engine, instrumented aircraft capable of electronically communicating and navigating through weather and at night.[68]

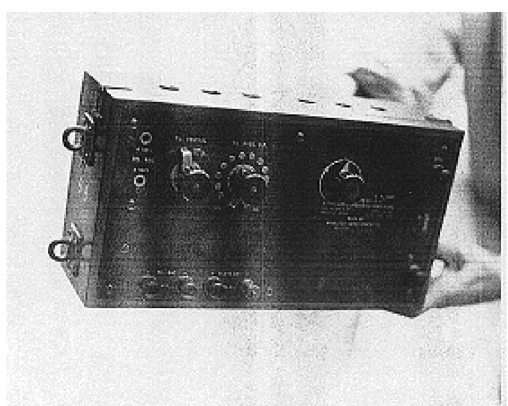

Figure 1—Army's SCBC 8A Radio[69]

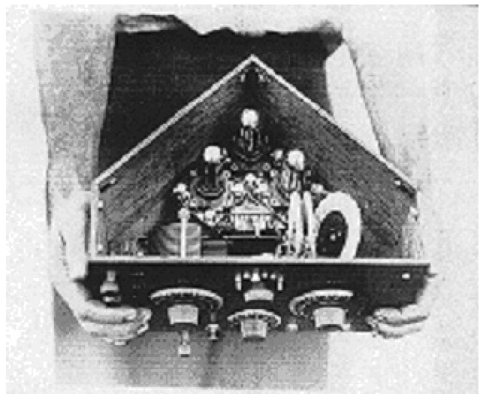

Figure 2—Hempel's Receiver Configured for Cockpit Mounting[70]

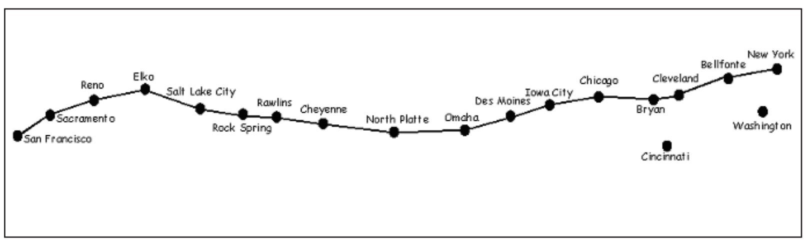

Figure 3—Transcontinental Air Mail Radio Stations

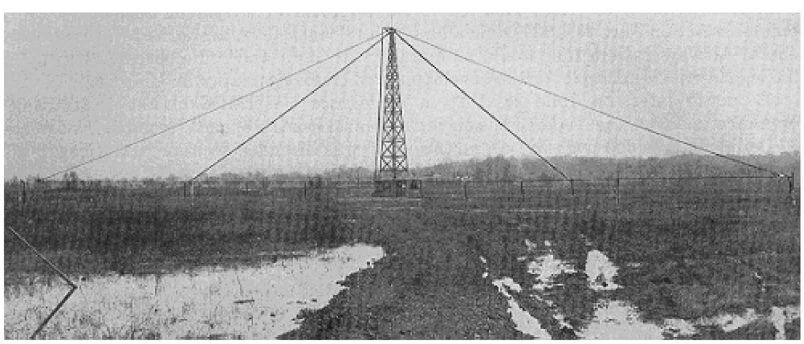

Figure 4—College Park Radio Beacon[71]

ENDNOTES

1. Post Office Files, "Report No. 6: The Equi-Signal Radio Beacon Using Wave Lengths of 807 and 1050 Meters," September 15, 1925 (PO Department—2nd Assistant Post Master General).

2. Ibid.

3. Alan Douglas, *Radio Manufacturers of the 1920's*, vol 1 (Chandler, AZ: Sonoran Publishing, 1988), 167.

4. Post Office Files, "Report No. 6: The Equi-Signal Radio Beacon Using Wave Lengths of 807 and 1050 Meters," September 15, 1925 (PO Department—2nd Assistant Post Master General).

5. Ibid.

6. Post Office Files, "Report No. 7," Smith to Post Office Department, November 7, 1925 (Interdepartmental Advisory Committee on Radio, PO Department—2nd Assistant Post Master General).

7. William M. Leary, *Aerial Pioneers: The U.S. Air Mail Service, 1918-1927* (Washington, D.C.: Smithsonian Press, 1985), 219-221.

8. See Leary, Aerial Pioneers, 214-216; and FAA Files, Smith to Cisler, November 28, 1925 (File I.4.a Air Mail Policy).

9. "FSS: Flight Service Stations Pioneers of Flight," *FAA Aviation News*, August 1970, 22; Nick A. Komons, *Bonfires to Beacons: Federal Civil Aviation Policy under the Air Commerce Act 1926-1938* (Washington, D.C.: Government Printing Office, 1978), 128, 147-149; and Don Downie, "First Fifty Years of FSS," *The AOPA Pilot*, August 1970, 50-51.

10. See Art Johnson, "50 Decades of Flight," *The Airway Pioneer*, September 1, 1970, 41; and Post Office Files, E.B Calvert Memo of March 3, 1921 (Box 72, Committee on Radio February 1921-April 1922).

11. Ibid.

12. Komons, *Bonfires to Beacons*, 148; and "FSS: Flight Service Stations Pioneers of Flight," 22.

13. Johnson, "50 Decades of Flight," 38.

14. Ibid.

15. See Downie, "First Fifty Years of FSS," 52; and Johnson, "50 Decades of Flight," 38.

16. See Johnson, "50 Decades of Flight," 42; Post Office Files, Letters to the Secretaries of Agriculture, Commerce, Agriculture and Treasury, February 17, 1921 (Box 72, Committee on Radio February 1921-April 1922); and Post Office Files, E.B Calvert Memo of March 3, 1921 (Box 72, Committee on Radio February 1921-April 1922).

17. See Edward P. Warner, "Commerce Seeking to Conquer the Air," *The Current History Magazine*, August 1925, 726; "A new Air policy for America," *The American Review of Reviews*, October 1925, 421; and Aeronautical Chamber of Commerce, *Aircraft Year Book: 1926* (New York: Aeronautical Chamber of Commerce, 1926), 154-157.

18. Dellinger Files, Memo-Dellinger to Crittenden, January 21, 1926 (Aircraft Radio Research 1926-1929).

19. Dellinger Files, Dellinger Memorandum, February 15, 1926 (Aircraft Radio Research 1926-1929).

20. Ibid.

21. Ibid.

22. Dellinger Files, Burgess to Drake, February 15, 1926 (Aircraft Radio Research 1926-1929).

23. Nick A. Komons, *Bonfires to Beacons: Federal Civil Aviation Policy under the Air Commerce Act 1926-1938* (Washington, D.C.: Government Printing Office, 1978), 91, 92, 94-99.

24. Dellinger Files, Memo-Dellinger to Crittenden, June 10, 1926 (Aircraft Radio Research 1926-1929).

25. Ibid.

26. Ibid.

27. Ibid.

28. See Komons, *Bonfires to Beacons*, 148; and Dellinger Files, "Conclusions of Conference on Radio Aids to Air Navigation at Department of Commerce, June 22, 1926" (Aircraft Radio Research 1926-1929).

29. Ibid.

30. Dellinger Files, "Conclusions of Conference on Radio Aids to Air Navigation at Department of Commerce, June 22, 1926" (Aircraft Radio Research 1926-1929).

31. See Dellinger Files, Dellinger Memorandum, February 15, 1926 (Aircraft Radio Research 1926-1929); and Dellinger Files, "Use of Radio in Air Navigation," June 22, 1926 (Aircraft Radio Research 1926-1929).

32. See Aeronautics Branch, *Annual Report of the Director of Aeronautics* (Washington, D.C.: Government Printing Office, 1927), 13; and Dellinger Files, Lynch to Burgess, December 2, 1926 (Aeronautical-Radio Research).

33. See Dellinger Files, Lynch to Burgess, December 2, 1926 (Aeronautical-Radio Research); and Dellinger Files, "Confidential—Research at the Bureau of Standards Under the Fund 'Aircraft in Commerce,'" January 7, 1927 (Aircraft Radio Research 1926-1929).

34. National Air Transport, under the Air Mail Act of 1925, was awarded the mail route from New York to Chicago. NAT was the progenitor of United Air Lines. See Komons, *Bonfires to Beacons*, 86.

35. Ford Motor Company was the first to be awarded a domestic airmail route in 1926. It carried the mail between Detroit and Cleveland. See Komons, *Bonfires to Beacons*, 85-86.

36. Dellinger Files, "Report of Trip of Investigation and Observation Relative to Radio Aids for Air Navigtion," May 4, 1927 (Aircraft Radio Research 1926-1929)

37. Aeronautical Chamber of Commerce, *Aircraft Year Book: 1930* (New York: D. Van Nostrand Company, 1930), 51.

38. Dellinger Files, "Report of Trip of Investigation and Observation Relative to Radio Aids to Navigation," May 4, 1927 (Aircraft Radio Research 1926-1929).

39. Snyder and Bragaw, *Achievement in Radio*, 153-154.

40. See Snyder and Bragaw, *Achievement in Radio*, 153-155; and Aeronautics Branch, *Annual Report of the Director of Aeronautics 1927*, 14.

41. See Aeronautics Branch, *Annual Report of the Director of Aeronautics 1927*, 13; Dellinger Files, Memo, "Radio Aids to Civil Airways," March 26 1928 (Box 2); and Dellinger Files, Memo, "Work During Fiscal Year 1928," June 25, 1928 (Aircraft Radio Research 1926-1929).

42. Dellinger Files, "Applications of Radio in Air Navigation," Speech by J.H. Dellinger, September 7, 1926 (Aircraft Radio Research 1926-1929).

43. See Dellinger Files, "First Monthly Report on Status of Work on Radio Aids to Navigation," October 1, 1926 (Monthly Reports 1926-1934); Dellinger Files, "Current Work of Bureau of Standards on Radio Aids to Air Navigation," October 27, 1926 (Aircraft Radio Research 1926-1929); Dellinger Files, "Memorandum on Method of Controlling a Radio Receiving Set on Aircraft," January 21, 1927 (Reports, Newsletters RE: Radio Navigation 1926-1934); and Dellinger Files, Press Release, "Aircraft Radio Beacon Development by the Bureau of Standards," April 15, 1928 (Box 2).

44. Dellinger Files, General Electric to Radio Laboratory, July 19, 1926 (Aeronautical-Radio Research).

45. Dellinger Files, General Electric to Radio Laboratory, July 19, 1926 (Aeronautical-Radio Research).

46. Michael Osborn and Joseph Riggs, *"Mr. Mac": William P. MacCracken, Jr. on Aviation, Law and Optometry* (Memphis: Southern College of Optometry, 1970), 128.

47. Ibid.

48. Dellinger Files, "Report of Radio Tests With Ford 3-Motored Plane April 30 to May 7, inclusive," May 13, 1927 (Aeronautical-Radio Research).

49. Ibid. See "Mail Planes Receive Weather Reports From Nuns' School: Sisters Give Exact Forecast 4 Times Daily; U.S. to Provide Complete Set of Instruments," *Washington Daily News*, October 29, 1929.

50. "How United Press Man Sent Out His Story From Plane," *St. Louis Star*, June 12, 1927.

51. Aeronautics Branch, *Annual Report of the Director of Aeronautics 1928* (Washington, D.C: Government Printing Office, 1928), 29.

52. Dellinger Files, "Applications of Radio in Air Navigation," September 7, 1926 (Aircraft Radio Research 1926-1929).

53. The A battery supplied power to the vacuum tube's filament and the B battery powered the tube's grid.

54. Lawrence A. Hyland, "Airplane Radio Sets," *Aviation*, December 26, 1927, 1526.

55. See Hyland, "Airplane Radio Sets," 1529.Aeronautical Chamber of Commerce, *Aircraft Year Book: 1929* (New York: Aeronautical Chamber of Commerce, 1929), 109-110; "Radio," *The New York Times*, March 25, 1930; J. H. Dellinger, "Uses of Radio as an Aid to Air Navigation," *Journal of the American Institute of Electrical Engineers* 48 (1929): 109; "Improved Radio for Planes Adds to Safety," *Popular Mechanics*, June 1929, 891; and Dellinger Files, "Monthly Report on Status of Work on Radio Aids to Air Navigation," February 29, 1928 (Airways Division Cooperation 1927-1934).

56. See "Agree on Channels for Airways Radio," *The New York Times*, August 8, 1929; and Federal Radio Commission, "Orders of Federal Radio Commission Affecting Air Transport," September 9, 1929 Reprinted in *Aircraft Year Book: 1930* (New York: D. Van Nostrand, 1930), 569.

57. "Agree on Channels for Airways Radio," *The New York Times*, August 8, 1929.

58. Federal Radio Commission, "Orders of Federal Radio Commission Affecting Air Transport," September 9, 1929 Reprinted in *Aircraft Year Book: 1930* (New York: D. Van Nostrand, 1930), 569.

59. Ibid.

60. Ibid.

61. Wesley L. Smith, *Air Transport Operations* (New York: McGraw-Hill, 1931), 90.

62. Ibid. See Eugene Sibley, "Aeronautical Radio Communications," *Journal of the A.I.E.E.* 49 (November 1930): 918.

63. Louis W. Liebovich, Bylines in Despair: Herbert Hoover, The Great Depression, and the U. S. News Media (Westport, CT: Praeger, 1994), 75.

64. "Hoover Keen To Help Commercial Flying," *The New York Times*, August 17, 1930.

65. "Nation's Air Strides Outlined To Hoover," *The New York Times*, August 25, 1930.

66. Ibid.

67. *Public Papers of the Presidents of the United States: Herbert Hoover, 1929-1933*, 4 vols. (Washington, D.C.: Government Printing Office, 1974-77), 177.

68. Ray Wilbur and Arthur Hyde, *The Hoover Policies* (New York: Charles Scribner's Sons, 1937), 221.

69. Ibid.

70. Ibid.

71. Ibid., 154.

BIBLIOGRAPHIC NOTES

An abbreviated form of citation has been used in all notes for the following sources:

National Institute of Standards and Technology, Dellinger Files, RG 167, National Archives, Suitland, Md, cited as The Dellinger Files, Title (location reference).

Records of the Post Office Department, RG 28, National Archives, Washington, D.C., cited as Post Office Files, File (location reference).

Records of the Army Air Forces, RG 18, National Archives, Suitland, MD, cited as War Department, Title (location reference).

Herbert C. Hoover Papers, Herbert Hoover Presidential Library, National Archives and Records Service, West Branch, Iowa, cited as Hoover Papers (followed by the file name).

Documents from the Federal Aviation Administration, 800 Independence Avenue, Washington, D.C., cited as FAA Files, Title (File number).