results. Dr. R. I. Bernstein, associate director of the Electronics Research Laboratories, and J. H. Bose, associate in electrical engineering and former assistant to Major E. H. Armstrong, explained that much of the theoretical basis for the work had been established by numerous researchers following World War II.

The problem solved by the Columbia group was to devise a means of generating and processing a signal with characteristics so distinct from atmospheric noise that it could be reinforced, amplified, and detected.

Heart of the system called ORDIR (omnirange digital radar) is based on a prior knowledge of the characteristics of the reflected signal. This is achieved through precise control of the carrier modulation so that the injected characteristic returns in the proper time-phase relationship. Through a method of storage of the reflected signal energy and a recovery system in the receiver employing a technique of "coherent integration" the signal is greatly enhanced and made to "stand still" long enough in the proper time-phase relationship so that the injected characteristic can be detected and amplified.

The achievement was hailed by Dr. J. R. Dunning, noted pioneer atomic physicist and dean of the Columbia School of Engineering as "an outstanding break-through" in radar since the start of World War II and the early British work."

The new Columbia analog computer and its other components perform the basic tracking and computing required in an over-all system which receives data from long-range radars, tracks potential hostile planes, and then automatically directs interceptors to the oncoming target for the kill. This latter project was also carried out in the Electronics Research Laboratories under Air Force sponsorship. The new defense system is the first operational ground control intercept system of the Air Force to work on the principle of electronic automation, furnishing signals which are automatically incorporated into the fire control system of the intercepting aircraft and thus automatically guiding its flight to "a terminal phase." It is now being produced in quantity by the GE Heavy Military Electronic Equipment Department, Syracuse, N. Y.

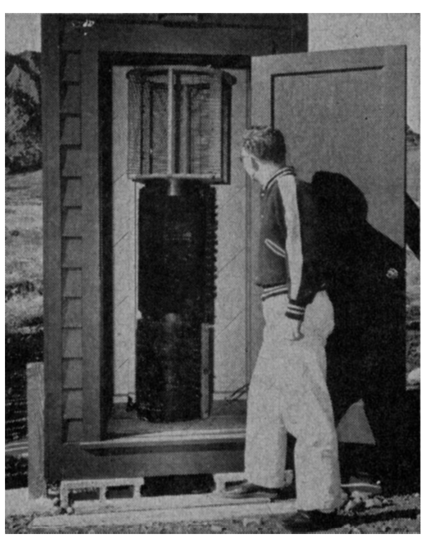
Experimental 60-Kc Standard Frequency Broadcast

Opening up several interesting applications, some of which are already in use, is an experimental 60-kc standard frequency broadcast, begun July 1, 1956, at the Boulder (Colo.) Laboratories of the National Bureau of Standards (NBS). A. H. Morgan, chief of the Radio Broadcast Service Section of the NBS Radio Standards Laboratory, is supervising the experiment.

The NBS has been broadcasting standard frequencies since 1923, when radio was in its infancy and very few people owned radio receivers. Through the years, higher power and more frequencies have been added until at present the NBS standard frequency broadcasts are on six high frequencies (2.5, 5, 10, 15, 20, and 25 mc) at WWV, Beltsville, Md.; and on three (5, 10, and 15 mc) at WWVH, Maui, Territory of Hawaii. Up to 10 kw are radiated on some of the frequencies. Specialized radio receivers for these broadcasts have been commercially available for many years.

Measurements by the Boulder Laboratories and others have revealed that the regular standard broadcasts at high frequency are subject to changes in frequency as they travel away from the transmitting antenna. These changes are caused by disturbances in the propagation medium, and the errors introduced may at times amount to ± 3 parts in 10^7. This is sufficient to make these h-f broadcasts unsuitable for many applications, e.g., rapid assessment of drift in the manufacture of high-precision quartz resonators, intercomparison of frequency standards, and accurate time measurement or synchronization of events at two or more locations which may be separated by thousands of miles. Two techniques are now available for precise frequency calibration, but both have limitations. One such technique, employing time comparisons, requires expensive terminal apparatus and a measurement time that extends over 1 to 10 days or even longer. The other makes use of a ground wave near the transmitter. This introduces an error in propagation of less than 1 part in 10^{11}, but is useful only to about 20 miles from the transmitter. At distances greater than 20 miles, the sky-wave must be used and calibrations made by means of this wave are not adequate for the ever-increasing precision required by an expanding science and technology.

The principal reason for studying standard frequency broadcasts at frequencies below about 100 kc is to determine a practical method whereby the radio propagation errors are minimized and users may accomplish high-accuracy frequency comparisons in a shorter measurement time. Users also need a better time or phase reference to measure precisely the time between events which happen in relatively short intervals, for example, to measure the velocity of rapidly moving waves or objects.



INTERIOR of tuning house near NBS antenna base, showing tuning coils used in efficiently transferring power from transmitter (about 3,000 feet away) via overhead transmission line to antenna.

Several investigators, among them Prof. J. A. Pierce at Harvard University, have shown that for frequencies below 100 kc and for distances of 5,000 kilometers and greater, it requires only about 10 minutes to compare local frequencies with standard frequency transmissions to within 1 part in 10^9. This is an improvement of more than 100 over what can be obtained at h-f. Prof. Pierce has carefully determined that a high-accuracy standard frequency service can be given for all the world on a single very low frequency from a single high-power transmitting station.

The experimental broadcast on 60 kc, although on low power, has already presented several intriguing possibilities. With the co-operation of Prof. Pierce, it has been possible to compare the NBS primary frequency standard, broadcast on 60 kc, with the British standard which is broadcast on 16 kc and 60 kc, to an accuracy of comparison which is better than two parts in one billion. This has been done almost continuously since the broadcasts began in July 1956.

One of the lesser known services is the broadcasting of a musical tone of standard pitch—middle "A" at 440 cycles per second —over its shortwave stations WWV and WWVH. These broadcasts make standard pitch available day and night throughout the United States and over much of the world. Since a shortwave receiver is all that is needed, easy access to standard pitch is thus provided for piano tuners and amateur and professional musicians, as well as for makers of musical instruments.

A 600-cycle tone is also broadcast. This, together with the 440-cycle tone, is used by scientists, electronics engineers, and manufacturers in the measurement of short intervals of time and for calibrating instruments and devices that operate in the audio and ultrasonic frequency ranges. Both the 440- and 600-cycles tones are obtained from an electronic, crystal-controlled oscillator and are accurate, as transmitted, to better than 1 part in 100 million.

The two frequencies are broadcast alternately, starting with 600 cycles on the hour for 3 minutes, interrupted 2 minutes, followed by 440 cycles for 3 minutes and interrupted 2 minutes. Each 10-minute period is the same except that WWV is off the air for 4 minutes beginning at 45 minutes after each hour; and WWVH is silent, in addition, for a 34-minute period each day beginning at 1900 Universal Time (9 a.m. in Hawaii or 2 p.m. E. S. T.).

The National Bureau of Standards maintains the A equals 440 cycles standard as the one on which general agreement has been reached. The musical merits of any particular standard are, of course, outside its province.

Previous standards of pitch were defined in terms of the frequency of a particular tuning fork or bar, or the length of a specified vibrating air column (organ pipe). Inasmuch as the sound frequencies generated by these devices vary with the surrounding temperature, it is necessary to specify the temperature at which comparisons with these standards should be made.

In changing over to Standard Pitch, little or no alteration is necessary in adjusting instruments tuned to the older standard. Instruments tuned by string tension and the open vibrating air columns of pipe organs present no problems at all. Woodwinds can be corrected partly by the tuning adjustment of the instrument and partly by the breath control of the player; and changes required in the reed stops of the organ are within the range of the instrument's tuning adjustments.

Solid-State Devices for Microwave Radio Relays

Predictions of the impact of solid-state electronics on modern technology and the announcement of the development of a new microwave radio relay system using many of the new solid-state devices were made at a European Symposium on Radio Links which took place in Rome recently. Dr. M. J. Kelly, president of Bell Telephone Laboratories and M. B. McDavitt, director of transmission development of the Laboratories, presented papers at the Symposium, sponsored by the Italian National Research Council.

Mr. McDavitt's paper described a microwave radio relay system which has been under development at Bell Telephone Laboratories and which is called the "TH" System. This system takes advantage of much of the advanced solid-state and other electronic technology developed at Bell Laboratories in recent years.

It makes highly efficient use of the overcrowded radio spectrum, promising to increase more than three times the information-handling capacity of radio relay systems occupying comparable spectrum space.

The television programs could be either black-and-white or color for home reception or color theater programs.

In addition to handling television, telephone, and radio services, the new system will provide an increased capacity for transmission of "digital" information used in teletypewriter and data transmission. The system will have extremely fast switching equipment for bringing in alternate equipment or channels in case of component failures or atmospheric disturbances.

Citing the "TH" system as an example of the impact of solid-state physics on telecommunications, Dr. Kelly in his keynote address)declared that the "fundamental approach" was bringing about the new era in electronics.

The "TH" system is designed to operate in the 5,925-6,425-mc microwave band. It provides a total of eight 10-mc broadband channels in each direction, plus two narrow-band 0.5 mc channels for order wire and alarm facilities. Six of these eight bands may be in use at any particular time, the other two being held in reserve as protective channels to be switched into service automatically if needed.

Each broad-band channel can provide a number of services: 1,860 voice channels with 4-kc spacing; a black-and-white or color television signal plus 420 voice channels; or a broad-band television signal such as might be required to transmit a color television picture of theater-screen size. Various other services such as teletypewriter, facsimile, and data transmission can also be readily accommodated.

An r-f output of 5 watts, frequency modulated, is radiated at each transmitter. This output is provided by a newly designed traveling wave tube which has a gain of 30 db. The traveling wave tube is driven by a frequency converter, which boosts the i-f of 74.1 mc to the final transmitted frequency. Conversion is accomplished by a newly developed gold-bonded diode which can provide gain, if desired, but is operated at a low bias to give a uniform impedance over the i-f range and so gives neither gain nor loss. This is the first use in a system of a diode modulator without inherent loss.

Isolation between forward and reflected signals at various points in the system is provided by microwave ferrite isolators, each of which has an insertion loss of 0.25 db or less in the forward direction, and at least 27 db in the reverse direction.

A microwave ferrite switch is employed to switch rapidly and automatically between regular and standby critical equipment in case of equipment failure. Switching time is less than one millisecond.

The horn reflector antennas and round waveguide now being installed in relay towers can be used simultaneously for the new "TH" system at 6,000 mc, the present transcontinental *TD-2* at 4,000 mc, and the new short haul *TJ* system at 11,000 mc. Special filters are employed to separate the various signals.

Adjacent channel signals are alternately horizontally and vertically polarized to provide isolation between channels of 20 db more than would otherwise be available. This permits adjacent channels to be placed much closer together, and aids greatly in increasing the utilization of the available frequency spectrum.

Silicon power rectifiers are employed in the power supplies, thus contributing greatly to reliability. Because of the high efficiency of these rectifiers, power consumption and heat dissipation are both appreciably reduced.

Activities of Other Organizations

National Committee for Utilities Radio—The NCUR in answering the Federal Communications Commission (FCC) on several Dockets, with reference to Docket No. 11991 opposed an amendment which specified that the use of any frequency may be restricted as to hours of operation. It was urged that all channels in the 152–162 mc band be continued available to the Power Radio Service. Docket No. 11990 which is an amendment to establish a new Local Government Service seems feasible, but needs further study, it was stated by the NCUR representative. The comment on Docket No. 11997 was to the effect that, at the present rate of increase, a more realistically equitable allocation of bands be made. NCUR has an Operating Practices Manual and a Technical and Policy Guide Manual available which cover various points of interest to the membership with regard to their relationship to FCC rules and regulations. NCUR will continue to oppose any proposed changes which restrict or endanger the use of radio by the electric, gas, water, and steam utilities.

Joint Military–Industry Symposium—Guided missile reliability is the topic of the annual meeting sponsored by the Office of the Assistant Secretary of Defense for Engineering and the Chief of the Bureau of Aeronautics, Navy Department, from November 5 through 7.

The 1957 Guided Missile Reliability Symposium will be held at the Naval Air Missile Test Center at Point Mugu, Calif. Papers on component problems, mathematical treatment, plant techniques, and testing techniques will be presented which are not classified, or have been cleared through the proper authorities. Preprints will be available.

Standardization Seminar—A 5-day seminar on industrial standardization is to be conducted by Dr. John Gaillard, management counsel, at the St. Francis Hotel, San Francisco, Calif., from November 18 through 22.

EIA (former RETMA)—The Membership and Scope Committee has been appointed by the President W. R. G. Baker according to the formula previously adopted. The members for the fiscal year 1957-58 are: H. J. Hoffman (chairman), L. F. Muter, R. S. Alexander, S. R. Curtis, D. W. Gunn, W. J. Morlock, A. D. Plamondon, Jr. (ex officio), J. D. Secrest.

American Nuclear Society—At its 3rd Annual Meeting, the ANS elected its 1957-58 officers as follows: L. J. Haworth, president; T. G. LeClair, vice-president; M. A. Schultz, treasurer; J. G. Beckerley, editor; seven new Directors at Large elected consisted of J. C. Bugher, Karl Cohen, W. K. Davis, M. C. Leverett, W. B. Lewis, J. R. Menke, Sidney Siegel, and Clarke Williams; and W. W. Grigorieff, executive secretary, who continued in office.

American Standards Association—Eight American Standards on electronic components have been approved by the ASA. Seven were developed by the EIA (C83.9—C83.15) and submitted to the ASA for approval. The specifications cover tolerances, performance and test requirements for waveguides, capacitors, cable connectors, rheostat, coaxial cables, and dimensions for panels used to mount electronic equipment. The Institute of Radio Engineers developed the standard on pulse quantities (C16-28). As the national co-ordinating body and clearinghouse for engineering, industrial, and consumer standards, the ASA is a federation of 118 associations, societies, and organizations as well as 2,300 companies. The individual standards are available at varying nominal cost from the ASA, 70 E. 45 St., New York, N. Y.

National Science Foundation Grant to MIT—Translation of three Russian-language electronics journals into English will be made possible by $70,000 grant