Elkins College; *Treasurer,* Professor C. G. Brouzas, West Virginia University; *Editor,* Professor A. M. Reese, West Virginia University.

Following the business session tours were made to some of the industrial plants of the region.

The West Virginia Junior Academy of Science held its meeting one week earlier at Charleston. The meeting was reported to be very successful. The 1937 meeting of the academy will be held on April 30 and May 1 at Marshall College, Huntington. The Junior Academy will hold its meeting at the same time and place.

M. L. VEST,
Secretary

THE NEW HAMPSHIRE ACADEMY OF SCIENCE

THE eighteenth annual meeting of the New Hampshire Academy of Science was held on May 29 and 30 at Shirley Hill House, Goffstown. The Friday evening session was devoted to papers by members and to a series of electrical demonstrations.

A symposium on "Conservation of New Hampshire's Natural Resources" was held on Saturday morning, under the chairmanship of Professor Karl W. Woodward. Representatives of the White Mountain National Forest, the Society for the Protection of New Hampshire Forests, Soil Conservation Service, Division of Chemistry and Sanitation of the State Board of Health, the State Water Resources Board and Fish and Game interests presented prepared papers, which were followed by vigorous discussion.

At the Saturday afternoon session, following the business meeting, the presidential address, "Popularizing Science," was given by Mr. Albert L. Clough, president of the Manchester Institute of Arts and Sciences. The remainder of the scientific papers on the program were then read.

At the business meeting it was announced that the American Association for the Advancement of Science grants had been recommended by the council to Professor Charles F. Brooks, of the Blue Hill Observatory, for analysis of certain meteorological data from the Mt. Washington Observatory, and to Mr. Richard P. Goldthwait, of Harvard University, for studies on the geology of Mt. Washington. The academy also voted Mr. Goldthwait a further grant from the academy funds to aid his work.

The following officers were elected for 1936–37: *President,* Professor George M. Robertson, Dartmouth College; *Vice-president,* Professor Karl W. Woodward, University of New Hampshire; *Secretary-Treasurer,* Professor George W. White, University of New Hampshire; *Member of the Executive Council,* Mr. Albert L. Clough, Manchester Institute of Arts and Sciences; *Councillor to the American Association for the Advancement of Science,* Professor Walter C. O'Kane, University of New Hampshire.

GEORGE W. WHITE,
Secretary

REPORTS

MICROWAVE RADIO CIRCUIT OF THE RADIO CORPORATION OF AMERICA

THE first demonstration of the Radio Corporation of America's ultra-short wave radio circuit connecting New York and Philadelphia was given on June 11. The two institutions which were first to recognize the importance of the electric telegraph of Samuel F. B. Morse a century ago celebrated this new advance in communications by exchanging greetings. In 1836 Professor Morse gave the first demonstration of his new instrument to his colleagues at New York University. He gave the next demonstration outside New York City before the membership of the Franklin Institute in Philadelphia. On June 11 Chancellor Harry Woodburn Chase, of New York University, and Vice-president W. Chattin Wetherill, of the Franklin Institute, Philadelphia, exchanged pictures and greetings by radio facsimile. Models of the first Morse apparatus were connected to the circuit and operated simultaneously with the facsimile equipment.

Chancellor Chase radioed:

It is eminently fitting that New York University, which cradled the theory and practice of electrical communications, and the Franklin Institute, the learned society which was the first outside of New York to appreciate their significance, should to-day join in recognizing this new and important centennial milestone in the translation of intelligence. I am happy to have this opportunity to send heartiest greetings to you and your organization over one of the channels of the new, ultra-high radio frequency circuit for facsimile transmission. This development is but another evidence of the great achievements which scientific effort is daily producing for the service of mankind.

Vice-president Wetherill responded:

The Franklin Institute is particularly gratified to acknowledge the greetings of New York University on this the first public demonstration of the new ultra-high frequency radio circuit. Since 1824 the Franklin Institute has devoted itself to the promotion of science and the mechanic arts. It is, therefore, especially appropriate for us to join with New York University in appreciation of this new and important development.

A century ago, the Committee on Science and the Arts of the Franklin Institute in reporting on its examination of the electro magnetic telegraph invented by Professor Samuel F. B. Morse stated in part: ''The committee beg to state their high gratification with the exhibition of Professor Morse's telegraph, and their hope that means may be given to him to subject it to the test of an actual experiment made between stations at a considerable distance from each other.''

Since that distant day, scientific research and a public appreciation of its contribution to human progress have made possible this epoch-making event in which we are participating to-day.

We send to you and your colleagues our kindest personal regards.

In a statement to guests present at the New York end of the radio circuit, David Sarnoff, president of the Radio Corporation of America, said:

Radio communication is to-day placing in useful public service a region of the radio spectrum which only yesterday was virtually unexplored and scientifically unconquered territory. Having developed a technique of operation for the three-meter band of radio wave-lengths, we find in that region a medium of transmission unlike anything that we have ever known.

The most significant feature of the new communications development is that it marks the attainment of a radio circuit so efficient that we are challenged to take full advantage of it. This is very important, for radio communication has, from its beginning, struggled to provide even better connecting radio channels between transmitter and receiver. Now we find that the ultra-short-wave portion of the radio spectrum gives us a medium of almost unbelievable possibilities. We can not only send messages in facsimile as fast as present equipment will allow, but we can send two pictures simultaneously, and on the same radio wave we can also add two automatic typewriter channels and a telegraph channel. Of course, this means that we do all those things in both directions at the same time.

The possibilities of multiple transmission are still not exhausted. Perhaps this single illustration will give some idea of the traffic-handling possibilities of the circuit. If we were concerned only with communication on a word basis, we could, with increased power and filter systems, operate enough automatic typewriters to carry a total of twelve thousand words per minute in both directions between New York and Philadelphia.

Such flexibility, in being able to accommodate so many separate services simultaneously offers important commercial advantages. But we intend to continue this development further with the object of creating new devices for higher speeds of transmission on the individual channel. There would be little point in our using the new system merely to add another hundred or two automatic typewriter channels between these two cities when adequate wire facilities for such services already exist. We can not be content merely to duplicate present practice at this stage of radio's development. Now that we have the circuit, we shall turn again to the laboratory to find out how best to make use of it. Of course radio wants its share of telegraphic traffic, but it looks also at the much bulkier mail bags.

According to a statement from the Radio Corporation, the equipment developed for the new circuit is regarded in engineering circles as a great advance. The automatic repeater stations, which catch the micro-waves flying in both directions and fling them on to their destinations at New York and Philadelphia, are located at New Brunswick, New Jersey, and Arney's Mount, near Trenton, New Jersey. Since the range of three-meter radio waves is virtually limited to line-of-sight, the points of reception and transmission for each of the stations were selected to provide the most distant optical horizon. In New York and Philadelphia, therefore, the antennas are located atop tall office buildings, whereas the intermediate points of New Brunswick and Arney's Mount were chosen for their favorable terrain.

Each of the repeater stations employs two different transmitting wave-lengths, or one for each direction. The two terminal stations each use one sending wave, making a total of six wave-lengths, or frequencies, for the complete circuit. If it should be desired to extend the circuit beyond either terminal point, those six microwaves could be used over and over again in the same sequence. Thus, two waves of the same length would be generated at points about one hundred miles apart, and would not interfere with each other, because of the line-of-sight limitation to their range.

A feature of the new circuit is the method by which the unattended relay stations may be turned on or off from either one of the terminal stations by radio. The receivers at each of the four stations are always alive and ready to catch impulses from their assigned transmitters. When it is desired to make the circuit ready for traffic, New York or Philadelphia starts up its transmitter and sends a certain musical note which the receiving circuits are pre-set to "recognize." At the unattended receiver at New Brunswick the tone passes through electrical filters somewhat like a key passed through the tumblers of a lock. Electrical circuits "accept" the tone and relays are actuated, turning on the power for the "south" transmitter, which, when in operation, passes the tone on by radio to the Arney's Mount station. There the operation is repeated.

When the tone signal reaches the Philadelphia station, the transmitter at that city is also automatically turned on, and the tone starts on its return journey, back to New York. Operators in New York know that when the tone comes back to them from the "north" transmitter at New Brunswick the entire circuit is in full operation and ready for traffic. The constant presence of the tone keeps the relays closed, and the circuit in an operating condition. When the tone is withdrawn from the circuit, relays click in the same succession over the round trip to Philadelphia, and one by one the transmitters are automatically turned off. Philadelphia has the same control over the circuit as New York.

The new circuit is described by officials of the Radio Corporation of America as an example of the value of coordinated research and engineering in many special phases of radio. There being no precedent for building apparatus for commercial operation on three meters, the equipment developed is new. Antennas, because of their curious form, are characterized as "Christmas trees" and "turnstiles." Certain parts of the receivers look like small steam engines and the transmitters might be taken for hot-water boilers. These odd shapes result from the application of the principle of "resonant lines" to both transmitters and receivers. That principle, developed by the Radio Corporation of America for this use, eliminates crystal control and provides economical and efficient means of maintaining radio equipment in steady tune at extremely short wave-lengths.

The heart of the receiver is the "shoe button" or "acorn" tube, so-called because of its minute dimensions, and in the transmitters there are new power tubes specially designed for microwave service. These special tubes, along with the antenna, transmitter, receiver, facsimile and terminal control apparatus, were all developed in a group of Radio Corporation of America laboratories, each specializing in a separate phase of the work.

SPECIAL ARTICLES

THE SIZE OF ANTIBODIES

RECENT work has demonstrated that at least some of the antibodies in the blood of immunized animals are proteins or are intimately associated with proteins. Thus arises the question of the relation between these bodies and proteins found in the blood sera of normal animals. The ultracentrifugal analysis initiated by Svedberg[1] offers a way of investigating this problem. To make such an analysis a small quantity of solution is centrifuged at very high rotational speeds. In the intense gravitational fields thus produced big solute molecules will be thrown down just as are precipitates in an ordinary centrifuge. The rate at which the different molecular species are sedimenting can be recorded by photographing through the solution. This rate of sedimentation is commonly expressed as a sedimentation constant s. Though not directly a measure of weight, since it also depends on such factors as the molecular shape, s increases with the molecular weight.

Mutzenbecher[2] and later McFarlane,[3] both working in Svedberg's laboratory, have subjected many sera to this analysis. The normal sera of several kinds of animals show an albumen with a sedimentation constant $s = ca\ 4 \times 10^{-13}$ cm sec^{-1} dynes^{-1}, a principal globulin with $s = ca\ 7 \times 10^{-13}$ and small amounts of heavier globulins. Equilibrium studies have proved that this albumen has a molecular weight of ca 69,000 and that the globulin with $s = 7 \times 10^{-13}$ has a probable weight of ca 138,000.

We have applied the same method of analysis to several concentrated antibody preparations to see how the sedimentation constants of their proteins compare with those of normal sera. The apparatus used, which is a development of the air-driven turbine,[4] is described in a forthcoming number of the *Journal of Experimental Medicine*.

Among the most thoroughly studied antibodies are those in antipneumococcic horse serum. The work of Felton[5] and others has made possible commercial preparations containing these antibodies in concentrated form. We have made ultracentrifugal analyses of the ultra-violet absorbing material in such concentrates[6] of Types, I, II and VIII antibodies. Recent ultrafiltration experiments[7] on old but untreated Type I antipneumococcic horse serum have shown that its antibodies have a particle size between 54mμ and 140mμ. This means either that these antibodies have exceptionally large molecular weights or that as the serum aged they became or attached themselves to larger colloidal particles. All antibody concentrates have accordingly been examined to find out whether they contained appreciable quantities of such large molecules.

The chief component capable of absorbing light of wave-lengths λ2400–λ2700 in each Felton antibody preparation has a sedimentation constant of ca 15×10^{-13}. Besides the principal globulin with $s = 7 \times 10^{-13}$, normal horse serum[8] contains a small amount of another globulin with $s = ca\ 19 \times 10^{-13}$ and

[1] T. Svedberg, *Naturwiss.*, 22: 225, 1934, for bibliography.

[2] P. Mutzenbecher, *Biochem. Zeits.*, 235: 425, 1931; 266: 226, 250, 259, 1933.

[3] A. P. McFarlane, *Biochem. Jour.*, 29: 407, 660, 1175, 1209, 1935.

[4] J. W. Beams and E. G. Pickels, *Rev. Sci. Instruments*, 6: 299, 1935.

[5] L. D. Felton, SCIENCE, 79: 277, 1934; *Jour. Immunol.*, 27: 379, 1934; etc.

[6] All ultracentrifuged preparations have been manufactured by the Lederle Laboratories, Inc.

[7] W. J. Elford, P. Grabar and W. Fischer, *Biochem. Jour.*, 30: 92, 1936.

[8] P. Mutzenbecher, *op. cit.*