in the world. Now the art and science of transmutation are dispersed throughout all countries; they are cultivated in America most of all, largely because Americans invented the two very ingenious devices which are used to produce the very high voltages demanded for transmutation. It was, however, an Italian who first taught the world to use the most variously efficient of all the agents of transmutation, the agent which we call "the slow neutron."

I could tell the same sort of story for almost every achievement in physics, and the lesson would always be the same. Progress in science depends on the spirit of the brilliant man; and in this case above all, the spirit bloweth where it listeth, heedless of national boundaries and heedless of racial groups. There has never been a city which was the capital of physics as Vienna for a century was the capital of music. There has never been a nation which was preeminent in physics as France so many years was preeminent in painting. Metaphorically speaking, if you walk through the galleries of physics you do not find the masterpieces labelled "French School" or "Dutch School" or "Italian School." There is just one school of physics, and from its inception it has been the school of all civilized nations.

Those of my listeners who heard the prior programs of this series are probably expecting something more. You may be waiting now to hear me tell of some great scheme or schemes of formal international cooperation, set up and going on for the benefit of physics. But those who speak for other sciences, astronomy for instance, can give you more striking examples than I can. I might indeed mention the laboratories built and the equipment given by the Rockefeller Foundation for physicists in certain European lands—laboratories now, by tragic irony of fate, ruined by civil war or taken over by the Nazis. It is allowable to hope that soon they may again be serving their intended purpose, and that the example of great donations by private wealth across frontiers may survive to be followed by future generations.

More significant as yet has been the living aid interchanged by the nations—I mean, the students who have gone from their homelands to some other country, not to sit at the feet of a famous master (as the saying used to be) but to stand beside him and work with him upon some problem of his own selection. Few of the leaders of physics have worked entirely by themselves. Normally, the brilliant physicist requires aid, and the skilled intelligent aid of men who are almost his peers, to follow out the ramifications of his thought and to perform the experiments suggested by his ideas. Mostly his fellow-countrymen supply the aid, but not by any means always. Many a Canadian and many an Australian has brought his stone or stones to the edifice reared by a British physicist; many an American has done the like for a German in the days before the other war and in the days of the Weimar republic; many a Chinese and many a Japanese has done it for an American. The graduate schools of many a university were microcosms of a non-embattled world, little groups composed of many strangers working together in a comity and with a mutual understanding such as we all should like to see realized in the world at large. We ought to try to increase their number after this war, and do away with certain formal restrictions which impeded them from arising in certain parts of the world. Yet if there had never been any such group, or if there were never to be any such group again—even in that deplorable and highly unlikely case, science would still be international. It would be inevitably international, so long as the books and the journals were allowed to cross the frontiers. Every physicist sooner or later, and glad or sorry as he may be, finds collaborators springing up all over the world. They are taught by his experiments and by his calculations, and he is taught by theirs. It could not be otherwise. Ideas flow about the world like the life-blood in an organism. If from any part of an organism the flow of blood is withheld, that part decays. The same is true of the organism of science and of thought. If any one doubts this, let him look upon the demonstration which for the past ten years has been presented by the enemy.

OBITUARY

FRANK SCHLESINGER
1871–1943

THE death of Frank Schlesinger deprives American astronomy of its most distinguished authority upon precise astrometric measurement.

Born in New York, the son of Joseph and Mary Wagner Schlesinger, he received the degree of B.S. from the College of the City of New York at the age of nineteen. After five years' experience as a surveyor in his native city he studied for the doctorate at Columbia (Ph.D., 1898).

In the following year he began his astronomical career at the International Latitude Observatory at Ukiah, California, which he established, and operated for four years, as observer-in-charge. The visual observations demanded the highest attainable precision and care, and half of them had to be made in the morning hours. It was a severe introduction to astro-

metric work; but his enthusiasm for this somewhat austere type of investigation was life-long.

In 1903 he went to the Yerkes Observatory, where he spent two years in the photographic determination of stellar parallaxes, under the auspices of the Carnegie Institution. The precautions which were necessary to avoid systematic errors had been discussed theoretically by Kapteyn. Schlesinger's practical applications of these principles and his own ingenious inventions made his methods a standard which has been followed, with little change, in the thousands of determinations of trigonometric parallax made at many observatories ever since.

His most important personal contributions were the rotating sector, by which the image of a bright star is equalized with those of faint comparison stars, and the method of dependences, which greatly simplifies the reductions.

In 1905 he was appointed director of the Allegheny Observatory, and inaugurated an extensive program of observations for parallax with the 30-inch photographic refractor, and also researches on radial velocities and spectroscopic binaries.

The results of both were ably discussed. One example of his acumen may suffice. In all long series of observed stellar parallaxes, a few will come out negative—a geometrically impossible result, due to accumulation of observational errors. Most observers are irresistibly tempted to re-observe these stars, and the new series almost always give more reasonable values.

Schlesinger pointed out that this amounts to selecting for correction the cases in which the observational errors happen to combine in one direction, while ignoring those in which they had the opposite effect, so that the general mean of all the results would be systematically vitiated, and therefore resolutely avoided the practice.

He was called in 1920 to be director of the Yale University Observatory, where he remained for twenty-one years. Here he found an astrometric tradition which he continued, with increased equipment.

An observing station was established at Johannesburg, at which the parallaxes of hundreds of Southern stars were determined, and an extensive program of photographic observation of star-places inaugurated at New Haven. With the aid of specially designed lenses, the measurable area on a single plate was increased from about $5° \times 5°$ to $12° \times 15°$—with great saving in the number of specially observed reference stars required for a given zone of the heavens.

The reduction of these large plates demanded the inclusion of terms negligible on small ones; but Schlesinger's ingenuity reduced the total work of computation to a remarkably small total per star. His introductions to the volumes of the Yale Zone Catalogues afford by far the best text-book for the student of the subject.

Almost his last work was a general catalogue of stellar parallaxes, in which the results of all observers, after careful study of their accidental and systematic errors, are combined—a task demanding exceptional judgment.

In all this work he showed the same characteristics —unremitting industry; thorough knowledge of the problems to be investigated, the instruments for observation and the physical and mathematical principles involved in the reductions; remarkable ingenuity in devising improvements in both; a deep love of accuracy, which never tolerated defects; and a well-proportioned sense of scientific economics, which resulted in a remarkable volume of excellent work from the available equipment.

His work brought him many honors. He was a member of the American Philosophical Society, the American Academy of Arts and Sciences and the National Academy of Sciences; a foreign associate of the Royal Astronomical Society and the Royal Society of Science of Upsala; a correspondent of the French Academy of Sciences and the Bureau des Longitudes. He was president of the American Astronomical Society (1919–1922) and of the International Astronomical Union (1932–1935). He received the degree of Sc.D. from Pittsburgh in 1920 and Cambridge in 1925, the Valz Medal of the French Academy, the Gold Medal of the Royal Astronomical Society, the Bruce Medal of the Astronomical Society of the Pacific and many other distinctions.

Those who knew him will think most of all of the qualities which do not appear in this formal account—his cordial hospitality, his unfailing kindness and good humor and his invariable high ideals. He was the moving spirit of the "Neighbors"—the group of astronomers who, without any formal organization, derived great profit, as well as pleasure, from their meetings at New Haven.

His advice—by which the writer profited often—was valuable not only because of his full grasp of the scientific bearing of a situation, but even more for his sympathetic comprehension of the human problems involved and the high-minded lucidity of his appraisal of its ethical implications. He will be sorely missed by many friends.

He retired from his position at Yale in 1941. Failing strength had led to a gradual curtailment of his activities, which he accepted with quiet and cheerful philosophy during two years of retirement. Then his health failed, and the end came on July 10.

He was twice married, in 1900 to Eva Hirsch, of Ukiah, who died in 1928, and in 1929 to Mrs. Philip

W. Wilcox, of New York. His widow and one son by his first marriage survive him.

HENRY NORRIS RUSSELL
PRINCETON UNIVERSITY

ARTHUR WILLIS GOODSPEED
(1860–1943)

ON June 6, 1943, Arthur Willis Goodspeed, a pioneer in the study of x-rays, died at Concord, N. H., a few miles from the small town of Hopkinton where he had been born eighty-three years before. A descendant of early New England settlers, the son of Obed and Helen (Morse) Goodspeed, he passed his early years in Boston. Graduating from the Boston Latin School, he entered Harvard College. Here he came under the influence of John Trowbridge and Benjamin Peirce, who encouraged him to pursue the study of the physical sciences in which he had shown marked aptitude even as a boy. In 1884 he graduated from Harvard, winning high honors in physics and mathematics.

Immediately after graduation he was offered a position as assistant in physics at the University of Pennsylvania. As this provided an opportunity for advanced study, he accepted it, and this decision determined the scene of his life-work. He enrolled in the newly established graduate school of that university, and in 1889 received the degree of Ph.D., being, incidentally, the first recipient of a degree from that school.

At this time the chair of physics was held by George F. Barker, a scientist of international reputation. Goodspeed's association with this brilliant lecturer gave him invaluable experience and inspiration. He continued under Barker through the grades of instructor and assistant professor, succeeding him when he retired in 1900, and continuing as director of the laboratory until he himself reached the age limit in 1931. Thus, his teaching service of nearly half a century was wholly spent at this one institution.

The period of his service was one of rapid growth of the university and of the department of physics. He saw in his time its staff and its activities increase ten-fold. Much of the success of the many adjustments made necessary by this expansion was due to the administrative skill, ready decision and quiet tact which he exhibited.

As a lecturer he carried on the tradition of his predecessor in sparing no pains to devise ingenious and striking experiments with which to emphasize the essential aspects of his subject. Even after the pressure of administrative duties compelled him to give up much of his formal teaching he would frequently, in presenting new developments in physics, devote great care to illustrate them with clever and interesting demonstrations.

He was early attracted by the scientific aspects of photography—an interest which he retained throughout his life and which perhaps dated from the time when, as a young instructor, he witnessed and assisted at the famous experiments of Muybridge on animal locomotion. What wonder, then, that the report of Röntgen's discovery in 1896 strongly drew his attention and that he became one of the earliest investigators of the new rays? He at once recognized their importance from the medical point of view and, in collaboration with many physicians of the city, carried on numerous investigations on osseous malformations, the location of foreign bodies and similar topics. In this work he developed an experimental technique that was at that time unexcelled. Indeed, some of his plates taken then compare favorably with those of the present day.

His studies of the physical and therapeutic properties of the rays also were begun at this period and carried on for some years. He later investigated the properties of the secondary x-radiation. His work in the field of radiology was recognized by his election in 1902 as president of the American Röntgen Ray Society.

The increase of his official duties put a check to these investigations, though they were never wholly discontinued. The administration of the laboratory and service as chairman of important faculty committees demanded much of his attention. For some years he served on the board of managers of the Franklin Institute. In 1901 he was elected secretary of the American Philosophical Society. His faithful and efficient service in performing the duties of that responsible office will be remembered by many of its members. When he resigned the position in 1935 he was appointed editor of the society's publications and continued as such until a year before his death.

Goodspeed was married in 1896 to Annie H. Bailey, of Hyde Park, Mass. Their children were Frederick, who lost his life in a parachute accident in 1928, Willis and Helen (Mrs. John R. Skeen). In 1913 he married Ethel W. Mitchell, of Staunton, Va. Their son, Arthur, is at present Lieutenant in the armed services of the United States.

Though his professional life was passed in Philadelphia, Goodspeed always retained an affectionate attachment to his New England home. He usually spent his summers at Hopkinton and took part in many of its civic activities. And when his work was finished he returned to his native town to enjoy quietly the close of his life, which was to be so soon terminated.

Goodspeed always retained his sturdy New England characteristics. His thrift and skill in management served him well in the administration for many years of a department which never received adequate finan-