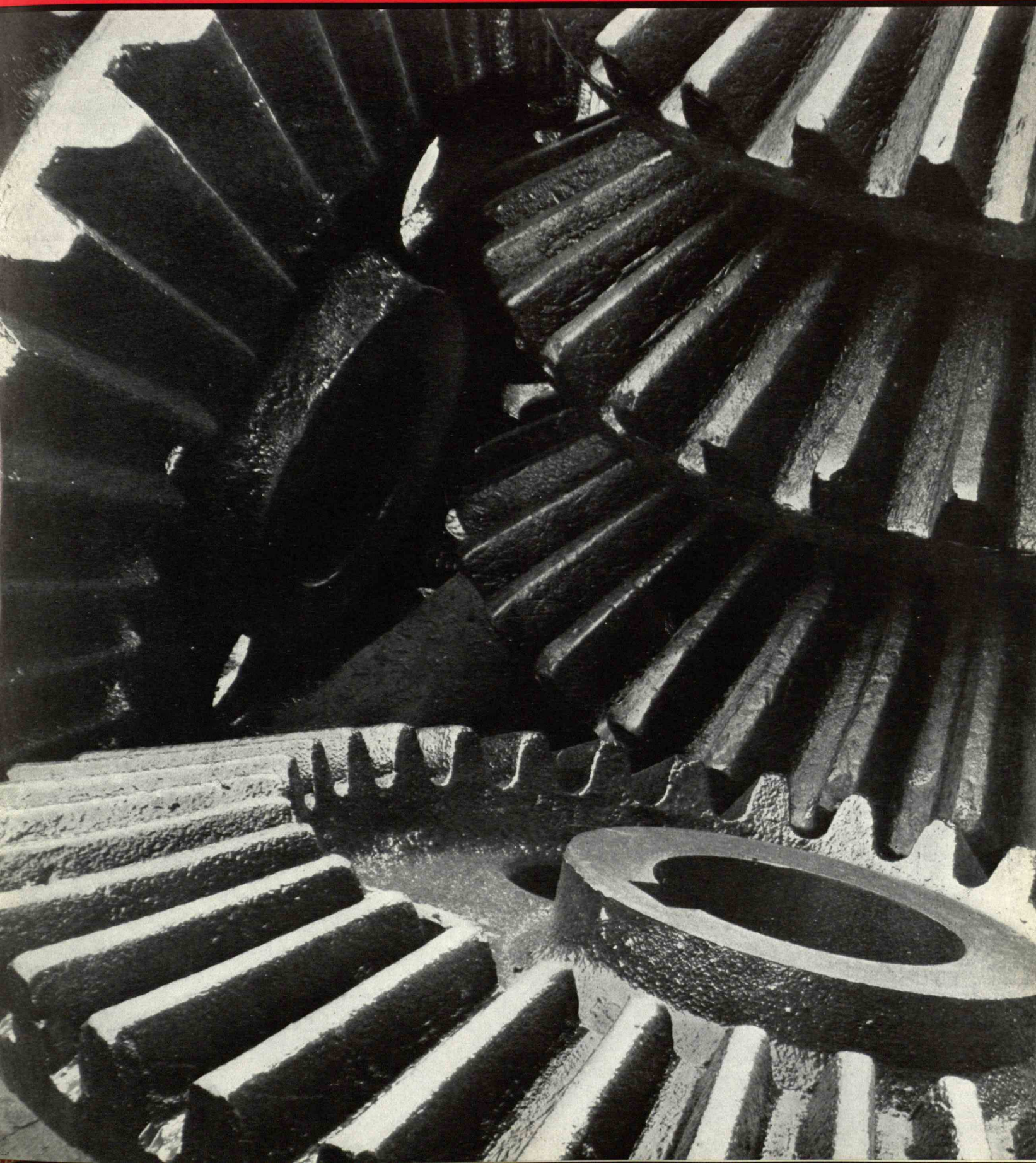
April 1932

TECHNOLOGY REVIEW



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THE TABULAR VIEW

HENRY NORRIS RUSSELL, author of the article on spectroscopy, page 279, is Director of the Princeton University Observatory and is a Research Associate at the Mount Wilson Observatory. He is internationally famous for his contributions to astrophysics and mathematical astronomy, and has received many scientific awards for his work. President Hibbard, several years ago, remarked that only three men had received Princeton's Doctor of Philosophy degree in physics with the designation of *summa cum laude* — President Compton, his brother, Arthur H., and Dr. Russell. The paper which we present by Dr. Russell is an abstract of a lecture delivered here at M.I.T. under the auspices of the American Institute of Physics during the joint convocation of the American Physical and Optical Societies in February. ¶ The illuminating discussion, beginning on page 282, of German engineering education and of the social position of the German engineer was prepared by two professors of the Technical University at Karlsruhe. DR. THEODOR REHBOCK is internationally known for his contribution to engineering. Among some of his engineering achievements was the designing of the great cantilever bridge across the River Weser. Following this, he traveled to all parts of the world and in coöperation with Fredrich Krupp he made the plans for the defense works at the mouth of the La Plata River and the Bay of Bahia Blanks in South America. He headed an expedition in South Africa which surveyed the possibilities of utilizing its water resources for irrigation. As Director of the Hydraulics Laboratory at Karlsruhe, he has been connected with many great hydraulic projects, pursuing his study of river control and river flow problems, and in the spring of 1929 he lectured at the Institute on his work in these fields. ¶ EMIL PROBST, aside from his work as Professor at Karlsruhe, has practiced as a consulting engineer in concrete and reinforced concrete construction. He is Editor of the magazine *Der Bauingenieur* (Civil Engineer). Dr. Probst is a member of the *Verein Deutscher Ingenieure*, the Society of American Military Engineers in Washington, and Honorary member of the American Academy of Arts and Sciences in Boston.

THE account of George Eastman's relations with M.I.T. on page 284 was prepared for The Review by Carl W. Ackerman, Director of the Columbia University School of Journalism. ¶ In commenting on the death of Mr. Eastman, President Compton said: "The Massachusetts Institute of Technology owes to Mr. Eastman not only the greatest portion of its present material resources, but also reinforcement of its purpose to be of service. First as the 'Mysterious Mr. Smith' and later as its recognized benefactor, this institution has honored Mr. Eastman and has been one of the instruments through which he served his fellow men. The Corporation, Alumni, Faculty and Students all mourn the passing of a great benefactor and a great man."

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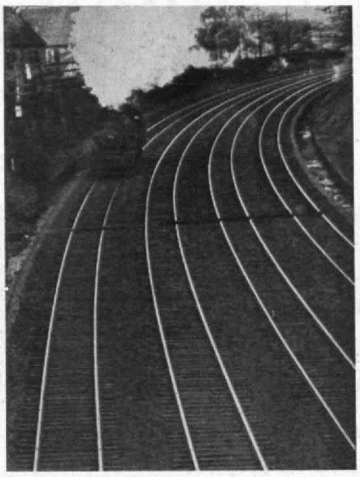

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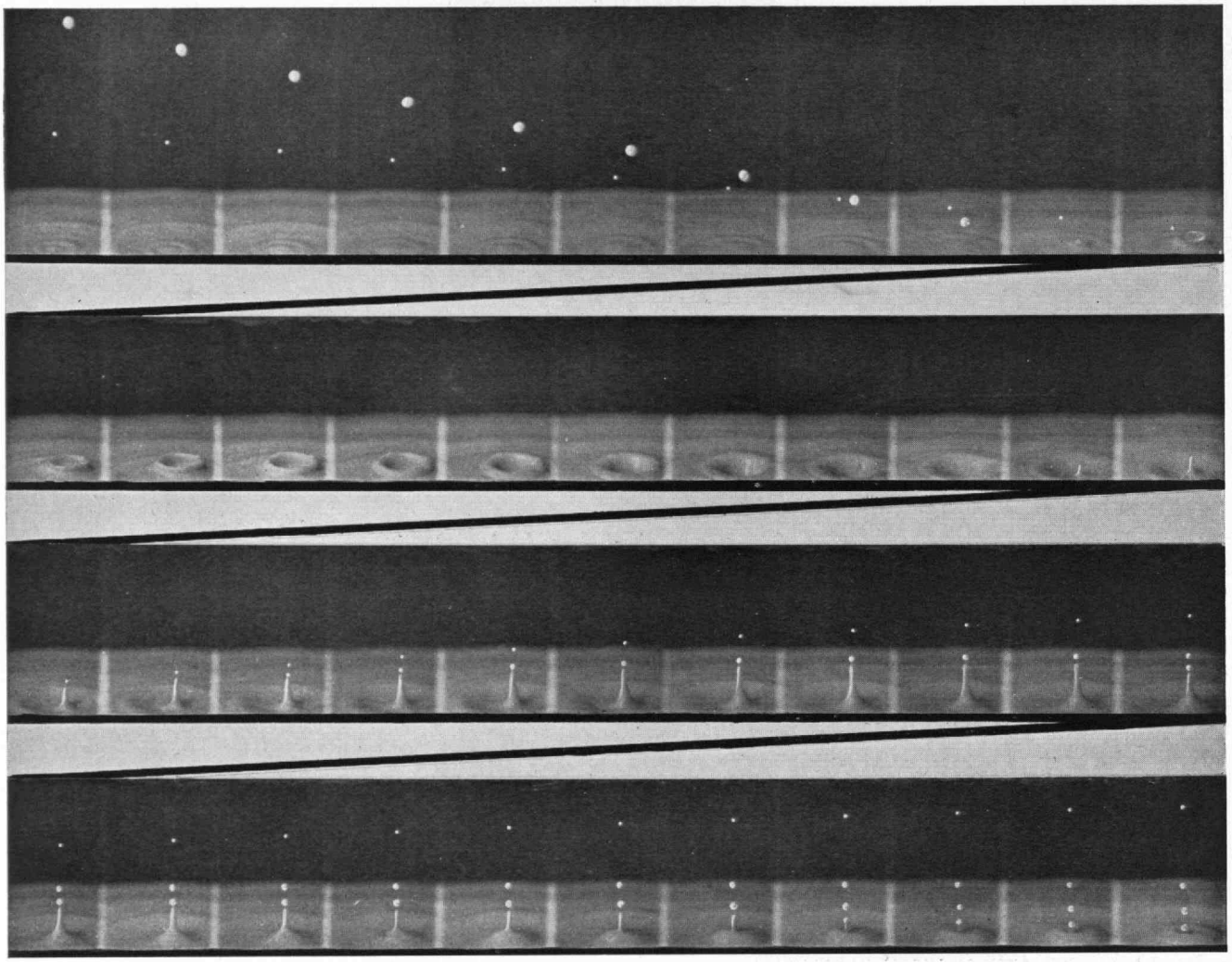
A FALLING DROP OF MILK

Caught in the Act by a New Method of High Speed Photography



ABOVE is shown, from left to right, row by row, 44 separate, successive pictures of a globule of milk dropping into a puddle of milk. When the drop strikes the surface of the puddle a crater is formed as shown in the second row down. There next occurs a conical growth in the center of a crater which resolved into small droplets bouncing upward as pictured in the bottom row. This phenomenon is not observable by the eye, since it takes place too rapidly.

These pictures which reveal it were taken at a speed of 480 exposures a second or nearly 30,000 a minute. Each row of 11 pictures represents a time interval of about 1/45 of a second, and the entire sequence shown above an interval approximately 1/10 of a second.

The camera which was used has no shutter nor any clawing mechanism. The film is simply run through it continuously without stopping for each picture as ordinary motion picture cameras do. The drop being photographed is illuminated by powerful stroboscopic or intermittent light which lasts about 1/100,000th of a second or less for each flash. The instantaneous intensity is sufficient to expose a photograph in this short time and the time of exposure is so short that there is no appreciable blur. In other words, the light is on and off so quickly that a photographic impression of the object is exposed upon the film as though both the object and the film were stationary.

The flashes of light are obtained by discharging condensers through mercury-arc lamps. The circuit is arranged so that the condensers are charged up between flashes. This method of high speed photography has been developed by Harold E. Edgerton, '27, of the Institute's Electrical Engineering Department with the assistance of Kenneth J. Germeshausen, '32.

While there are other methods of high-speed photography with even greater speed, they are complicated and expensive in contrast to the extreme simplicity and portability of this one. The stroboscopic method is finding a great variety of uses in industry, particularly for observing the operation of high-speed machinery, and in making motion studies.

THE
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THE MASTER KEY OF SCIENCE

Revealing the Universe through the Spectroscope

By Henry Norris Russell

THE great French philosopher of the last century, Auguste Comte, was an exceedingly well informed and versatile man, but it was he who once remarked: "There are some things of which the human race must forever remain in ignorance; for example, the chemical composition of the heavenly bodies." To Comte and the other intelligent men of his time, this problem seemed hopelessly insoluble; there was no way of attacking it.

Of course this statement sounds ridiculous to us now. It became ridiculous because man's dream came true of a master key that would unlock many doors, one after another, and so open up many new realms of knowledge.

That master key was the spectroscope. No sooner was it discovered than the composition of the heavenly bodies, previously unknowable, became an open book. With its use, many of the familiar chemical elements were identified in the sun, and not long after, in the stars. Later work has extended the number of elements identified in the sun to sixty, and spectroscopic study has shown that the atmosphere of Mars contains oxygen and water vapor, while that of Venus shows no signs of them.

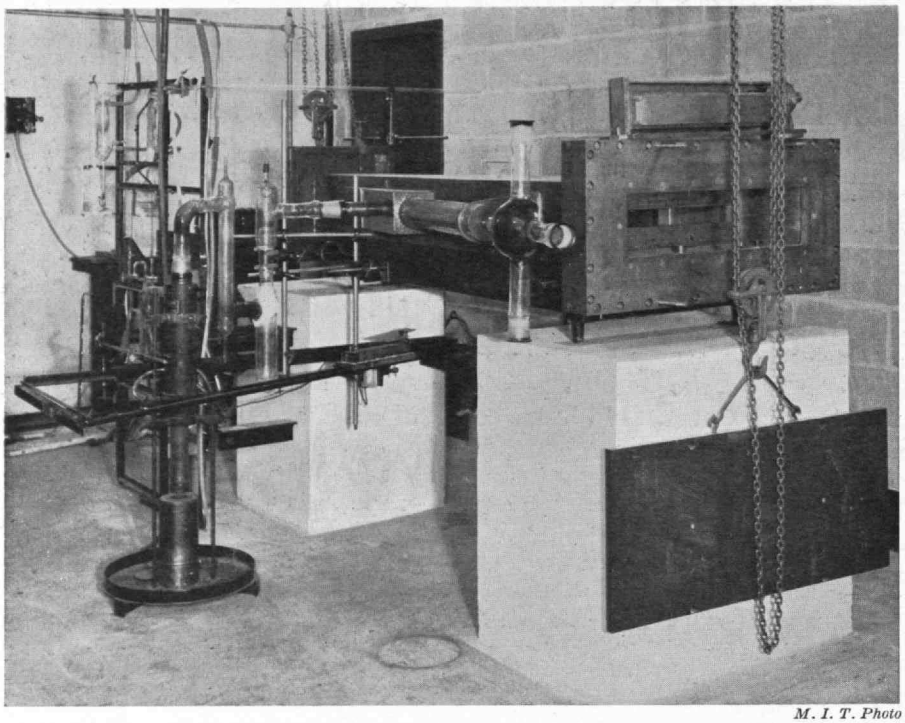
All the stronger lines in the spectra of the sun and stars and a host of the weaker ones have been identified. It has been demonstrated that the same atoms are present on earth that are also present in the remotest nebulae, in the relatively cold tail of a comet, and in the intensely heated surface of a white star. By showing these things, the spectroscope has given the most impressive of all proofs of the unity of nature.

This achievement has been described in poetry, as it should be, by Edmund Clarence Stedman, in one of his more philosophical poems "Corda Concordia." The stanza in which this is done is such good science, as well as such good poetry, that I would like to quote it:

> "White orbs like angels pass
> Before the triple glass,
> That men may scan the record of each flame, —
> Of spectral line and line
> The legendry divine, —
> Finding their mould the same, and aye the same,
> The atoms that we knew before
> Of which ourselves are made, — dust, and no more."

It is more than two hundred years since Newton, passing his beam of light in a darkened room through a prism, saw the rainbow-colored streak of light upon the wall as the rays of different color were refracted in different amount by the prism, and so was led to realize the composite nature of white light. Unfortunately, Newton took his light through a small round hole and he took it from the large round sun; consequently, even if the sun had been all one color, the image that he would have had thrown on the wall would have been like the image that he got when it came through a pinhole in the window shade. If only he had had the wit to set up a narrow slit so that the image would have been sharp and not round, the master key might have been discovered.

Just after the first half of the Nineteenth Century was over, Kirchoff and Bunsen made that simple but fundamental mechanical change. Really this master key was



M. I. T. Photo

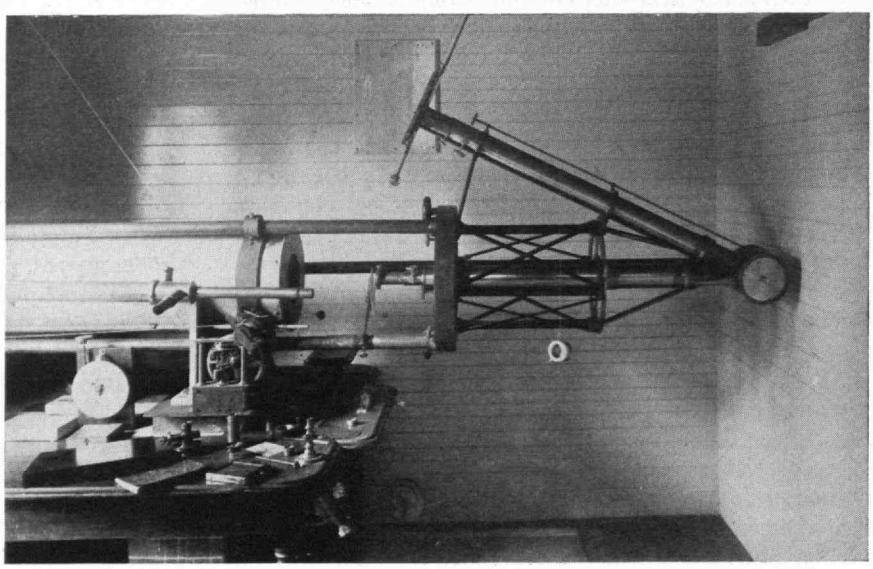
A vacuum spectrograph used for studies in the extreme ultraviolet region of light. It was developed from a design of President Karl T. Compton, of M. I. T., with the assistance of Dr. Joseph C. Boyce, a Research Associate in the Department of Physics. It is in the Spectroscopic Laboratory at M. I. T., a "Science Wonderland," which "represents the heaviest artillery yet concentrated by Science for assaulting the citadel of the atom"

found in a narrow slit — simply in letting your light into this prismatic instrument through a slit so narrow that you obtained a sharply defined image. As soon as that was done, as soon as they took the light through a narrow slit into their prism, with an eyepiece to look at it and a couple of other lenses to make the light go in parallel rays through the prism — the new doors were opened and the new worlds free to conquer.

The next necessary advancement was the development of a more delicate method of spectrum analysis. This came with Rowland, the great Johns Hopkins physicist in the Nineties. He developed an engine for ruling diffraction gratings, the device that is used for breaking light up into its components. The best of Rowland's gratings are the joy, the envy, and the despair of the investigators today — the joy of the man who has one, the envy of his colleagues, and the despair of the man who tries to make one as good. Rowland devoted years to the study of the solar spectrum and reported and recorded in it the position of 20,000 lines, each one carrying its own story of some substance in the sun. When Rowland was through his work, thirty-six of the chemical elements had been identified in the sun. Since that day, of course, a number more have been added because plates have been developed which are sensitive to the red end of the spectrum, and Rowland had no such plates available. Partly for that reason, and partly because some substances are now available of which Rowland could not get specimens, sixty chemical elements have now been identified in the sun — most of them with certainty.

In the stars, we cannot observe such immense detail as we can in the sun, although the big spectroscopes that are now being attached to the great refractors such as the Mt. Wilson 100″ telescope give us an amazing amount of information, and dozens of different chemical elements have been definitely identified in the stars.

The minute shift in the position of the lines due to motions of approach or recession has enabled us to detect and measure the rotation of the sun and the planets, to prove that Saturn's rings are not solid, but composed of myriads of tiny satellites, and to get one of the most accurate determinations of the sun's distance. Applied to the stars, it has determined the sun's motion among them, the distances of hundreds of individual stars, and the average for thousands more; has revealed hundreds of double stars too close to be resolved by the telescope, and determined the masses and even the diameters of some of them; and has disclosed those amazingly rapid motions of the remote nebulae — some as high as 15,000 miles a second — which point the way to new conceptions of the nature, the past and the future of the material universe. Spectroscopic tests have shown that the nebulae are of two kinds, one consisting of masses of luminous gas; the others, giving light



The spectroheliograph invented by George Ellery Hale, '90