December 1933

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# THE TABULAR VIEW

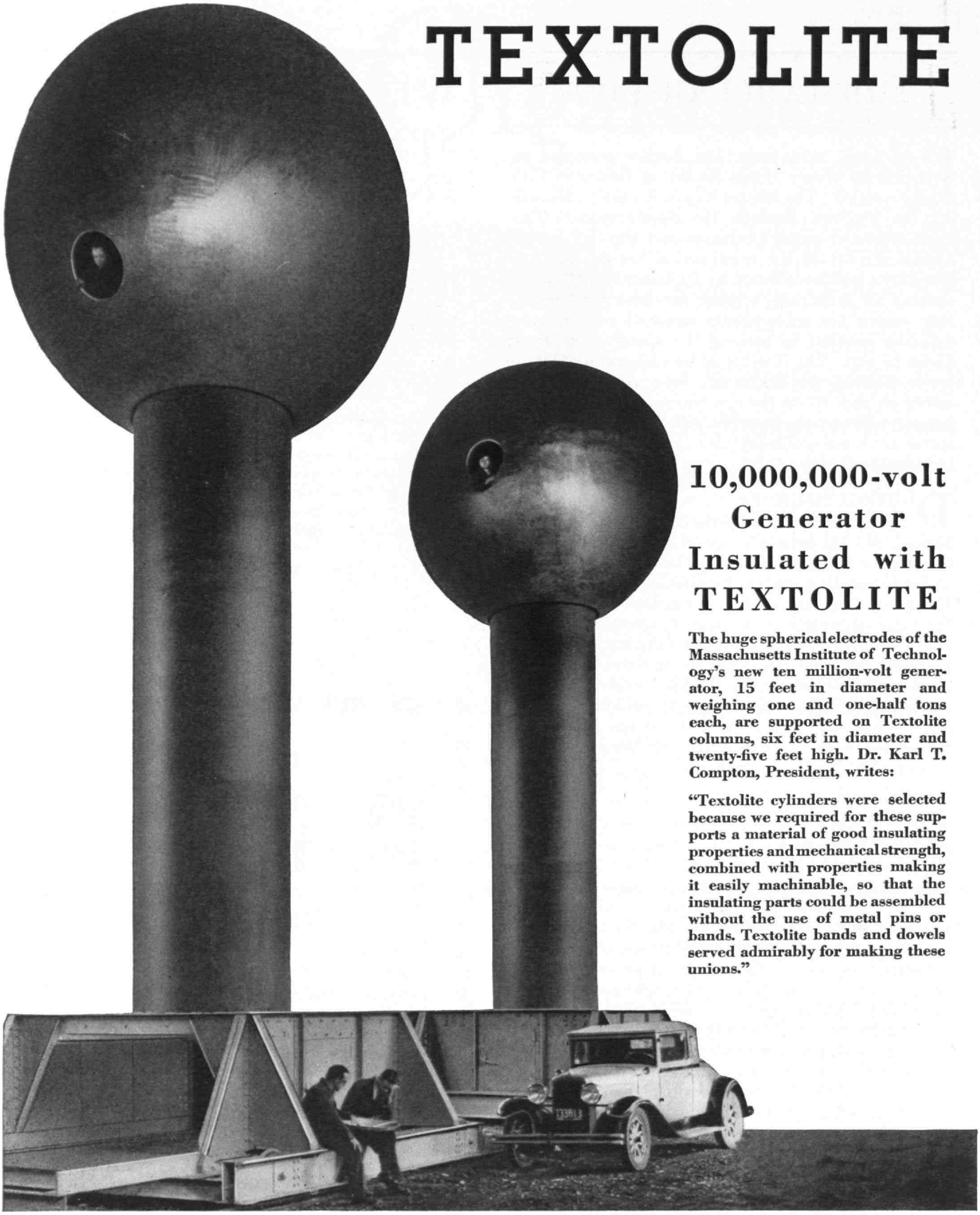
IN its April, 1932, issue, The Review presented an article by Henry Norris Russell of Princeton University entitled "The Master Key of Science — Revealing the Universe through the Spectroscope." This much-reprinted paper (it reappeared this fall in the Annual Report of the Smithsonian Institution) was based on a lecture delivered by Professor Russell at the opening of Technology's great Spectroscopy Laboratory, which has subsequently assumed such a commanding position in making the spectroscope more useful to man. The director of this laboratory is Professor George R. Harrison, who contributes the article on page 87 on the spectroscope's importance to industry. His article, together with Professor Russell's, serves as an admirable introduction to one of the great techniques of science.

DISTINGUISHED for his studies of internal secretions and as a biochemist, Dr. Allan Winter Rowe, '01, has been a frequent and welcomed contributor to these pages. He is Director of Research at the Evans Memorial of the Massachusetts Memorial Hospitals, President of the Association for Study of the Internal Secretions, a leader in amateur athletics, and a member of the Institute's Corporation. Among his recent contributions to The Review are: "Endocrine Therapy," "Athletics and Health," and "Causes of Misbehavior." His article on page 93 summarizes recent advances in our knowledge of the causes of physical abnormalities and describes research toward this end conducted at the Evans Memorial.

IN September Dr. Robert J. Van de Graaff, of Technology's Department of Physics, delivered by invitation two papers before the British Association for the Advancement of Science, one on the subject of the high-voltage generator, described on pages 90 ff., and another on high-voltage electrostatic engineering. In reporting on these two papers, the Manchester *Guardian* of September 14 said, "Mr. Van de Graaff, of the Massachusetts Institute of Technology, gave two excellent papers on his researches on electrostatic machinery for producing high voltages, and as a possible form of commercial dynamo. His work is of the highest technical interest and may provide new methods of atomic disintegration and even of producing electric power. Like many of the American scientists, and contrary to popular belief, he is most modest in the description of his admirable work."

As The Review goes to press, the giant generator at Round Hill is being swung into action against the citadel of the atom. Symbol of the boldness and ingenuity of the modern scientist, it is a milepost along the path of man's progress toward a better understanding of the nature of matter. ¶ The article on transatlantic air transport, which opens the *Trend of Affairs* (p. 97) was prepared by Daniel C. Sayre, '23, formerly Contributing Editor to The Review and some time Assistant Professor of Aeronautical Engineering at Technology.

# TEXTOLITE



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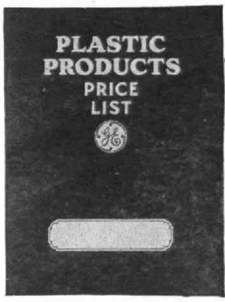


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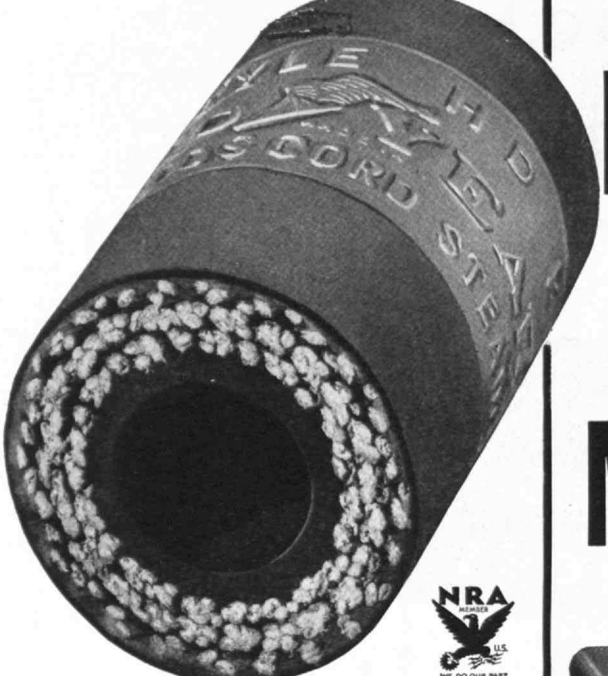


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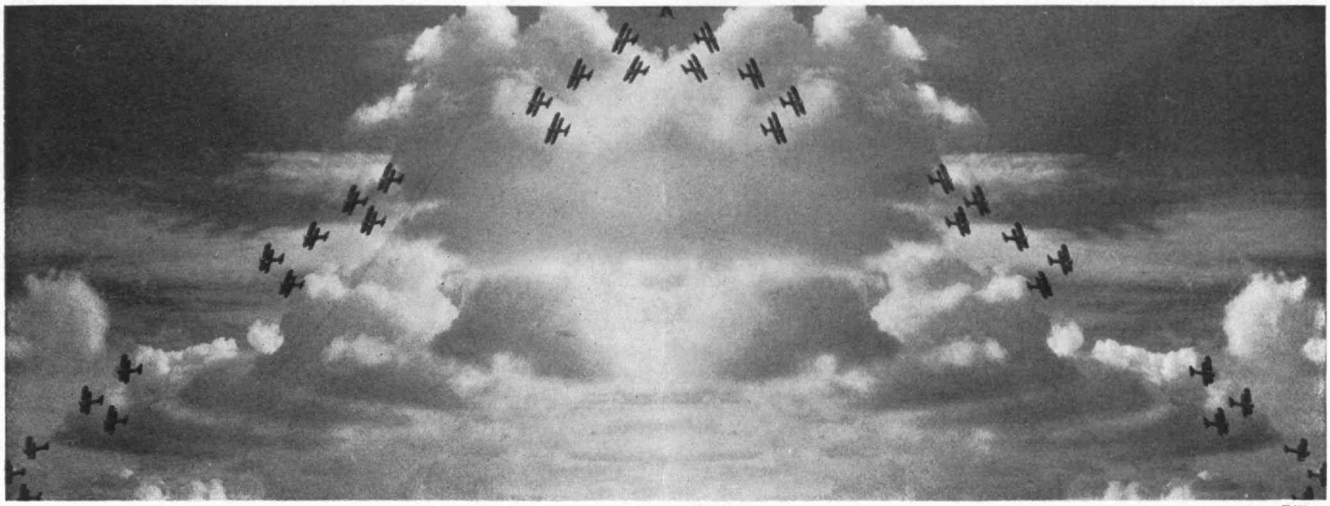

*Rittase*

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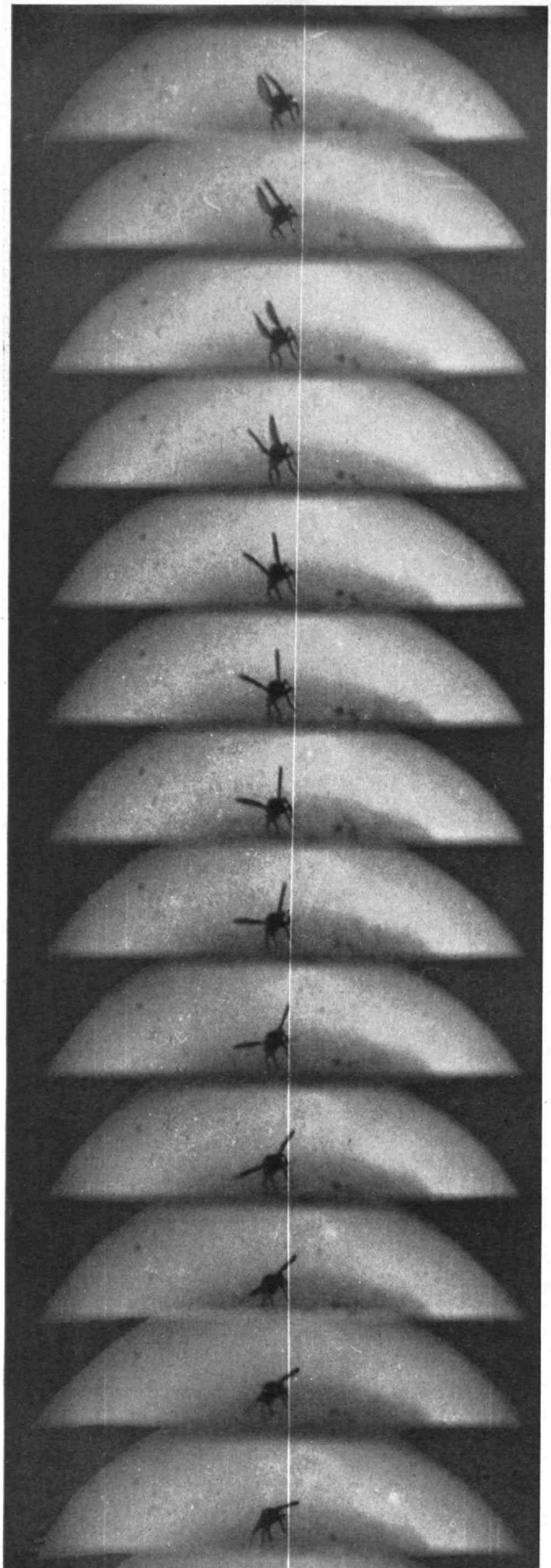

# The Flight of the Fly

*Aerial maneuvers, obligingly performed by a house fly* (Musca domestica), *before the lens of a super-fast camera. These pictures were taken at the record rate of 6,000 per second with exposures of approximately one-millionth of a second. Of all the high-speed photographs presented in these pages, these are the fastest. For other interesting examples of stroboscopic photography at M. I. T.* *see pages 104 and 105*

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*Photographed by*
*Harold E. Edgerton, '27, and Kenneth J. Germeshausen, '32*

THE
TECHNOLOGY
REVIEW

Vol. 36, No. 3 December, 1933

# Hard-Headed Rainbow Chasers

## *The Spectroscope Opens New Fields in Science and Industry*

BY GEORGE R. HARRISON

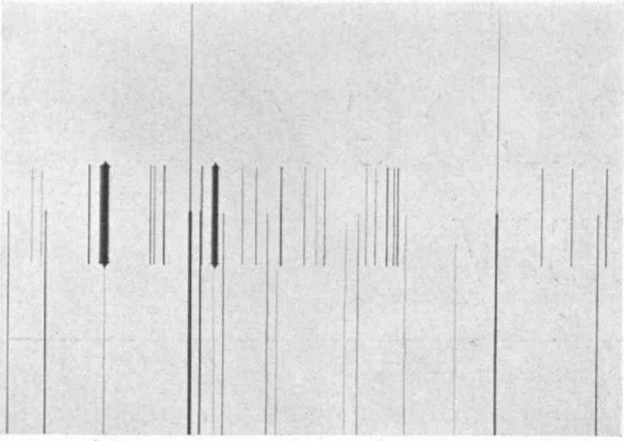
ASTRONOMERS, chemists, biologists, engineers, textile manufacturers, physicists — more than a hundred individuals gathered in the George Eastman Research Laboratories of M. I. T. one day last summer with a common purpose. They were holding a spectroscopy conference, arranged by the Physics Department as one of the associated functions of its spectroscopy laboratory. Every day, for the greater part of a week, they were to meet to discuss what the spectroscope has done and can do to aid science and industry. The chief object of all at the moment was to find out how man's controlled rainbow producer could help solve their problems. It was, in effect, a group of hard-headed rainbow chasers.

The spectrum was first observed by man many centuries ago; even the most conservative estimate puts the date as far back as 4004 B.C. Its purposeful production, however, did not occur until 1666, when the great Sir Isaac cut a hole in his landlady's window screen, and, inserting a prism in the beam of sunlight which fell through it, flashed glittering colors on the wall. For many years thereafter nothing much was done about the spectrum, and it was not until 75 years ago that the first real spectroscope was constructed to give a foretaste of the wonders to come by lending its powers to the discovery of new chemical elements.

During the last few years the cycle of development which began at that time has culminated in recognition of the spectroscope as by far the most powerful tool now available to science. Its functions of super-microscope, super-telescope, super-thermometer, -clock, -yardstick, -balance, are becoming so well known now as to be taken for granted by scientists. The progressive industrialist has begun to wonder whether there may not be something in this for him, and he who does not take the trouble to investigate may shortly expect to receive a jolt from the balance sheets of his competitors.

A watch manufacturer finds that a rival has introduced a marvelous new mainspring. This must be duplicated or improved on at any cost, but the first problem is to find what substances have produced its excellence of temper and elasticity. With much trouble and expense he obtains several dozen of the springs, and puts the problem up to his analytical chemist. What shall the chemist look for? He makes some guesses and dissolves a number of the precious springs to carry through the regular wet analyses for carbon, nickel, tungsten, copper, and as many more elements as his patience will allow and his boss pay for. But there are 90 known chemical elements, of which at least 75 might conceivably be of value in improving the qualities of a watch spring if introduced in the proper quantity. His problem is not solved until every one of these has been searched for, since there might be any number of important components. Even then he may never ferret the secret out, since we now know that as little as one part of a metal in 100,000 parts of an alloy may play an important part in changing its crystalline structure and hence its physical properties.

But let us take pity on the chemist before he gives up all hope, and suppose that his employer is sufficiently up-to-date to furnish him with a small spectroscope, or



*A small section of the spectrum of iridium as photographed with one of the large M. I. T. spectrographs to detect impurities in a small sample. The long lines are from the iridium atoms and from the impurities, while the shorter lines along the middle of the picture were produced by putting on the spectrum of iron for comparison, the known wavelengths of the iron lines being used as standards to determine the wavelength scale. The original spectrogram of which this picture is a part was over 40 feet long*

better, with a spectrograph which will record the spectrum photographically. Now all the chemist need do is take two of his springs, place them in holders so that he can strike an electric arc between them, let the flash of light which results pass through his spectrograph, and develop the resulting photograph of the spectrum. The whole procedure is completed in five minutes, and though all that can be seen in the picture is a series of short, unevenly spaced, parallel lines, the whole story lies there unfolded for him who can read.

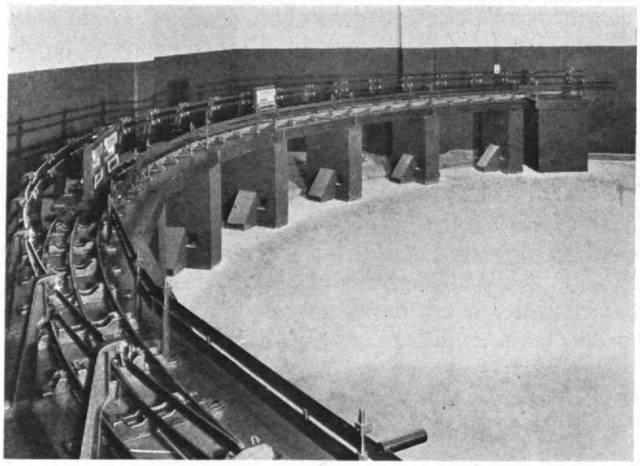
Every atom can be made to emit light if treated with sufficient roughness, as in an electric arc or spark, and the radiation which it sends out brands it much more definitely than fingerprint ever branded criminal. As one knows that he is listening to broadcasting station WZZZ when he turns the radio dial to 422 meters and hears a noise, because only WZZZ uses that wavelength, so one knows that he is looking at light from sodium atoms when he sees the familiar yellow light of the sodium flame, because sodium atoms always broadcast on the yellow wavelength 0.5896 micro-meters. The spectroscope forms a line at each point in the spectrum corresponding to a wavelength which is present in the light entering it, so from the pattern of lines observed, the varieties of atom from which the light originates can be deduced.

All our up-to-date spectroscopic chemist need do is to look at the spectrum photograph, consult a table giving the wavelengths emitted by the various atoms, and proceed to pick out the groups of lines whose wavelengths together identify the elementary substances present in the watch spring. It is the work of a few moments to identify iron, copper, chromium, tungsten, nickel — all common in watch springs of one kind or another. But he notices another set of lines which the book says are due to beryllium. Now who would have thought that beryllium would improve a watch spring? A quick further check shows that nothing else of importance is present, since no spectrum lines remain unaccounted for, and the problem is solved. Every part of this qualitative analysis was made with a single picture obtained by using only one pair of springs, and the results are complete, definite, and accurate.

The sensitivity of the spectroscope in detecting minute quantities of matter present in a mixture is phenomenal. While the limiting trace which can be determined varies with the atom involved, certain elements like sodium and lead have an uncanny faculty of making themselves known to the instrument. A teaspoonful of table-salt needs more than two thousand bathtubs full of water in which to hide successfully. Nor is it necessary to have a large quantity of material to analyze; indeed a complete analysis can often be made with less than a milligram of material, detection of all metals occurring to the extent of one per cent or more being practically certain. Non-metals such as sulphur and carbon show less tendency to make their presence known under ordinary conditions, but even these can be stimulated by application of third degree methods in a vacuum spark.

Not only does the spectroscope furnish a powerful means of qualitative atomic analysis, but it can also be used for quantitative measurements. Here the technic is more complicated and the advantage of the method is not so overwhelming, but it is definitely superior to chemical wet methods when the quantity of material available for analysis is small, when the substance being determined occurs in minute quantities, and when speed and ease of manipulation are more important than the highest quantitative accuracy.

A few years ago the analytical chemists of a certain company manufacturing sheet zinc could find no difference in the constitution of zinc which cracked on rolling and that which did not. The spectroscope was invoked and revealed minute traces of impurities which were later proved responsible. It was found that as little as 0.001% of bismuth, tin, or antimony has a great effect on the rolling properties of zinc. It may not be necessary to remove such traces of impurity when found, for in many cases other impurities can be added to neutralize their effects.



*A portion of the camera used with one of the M. I. T. diffraction-grating spectrographs. Photographic plates are clamped along the two rails held by the uprights, to photograph the spectrum. This instrument is over 20 times as powerful as those needed for most industrial work*