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Ion-Scattering Analyzer

STANFORD RESEARCH INSTITUTE has a new instrument capable of identifying and measuring minute quantities of the elements present in the surface of a material—the ion-scattering analyzer. This “proton bombardier” consists of a two-million volt generator, a twenty-foot vacuum tube, and two large electromagnets. It weighs about five tons, yet it can detect as little as 10^{-12} gram. The device bounces protons off the atoms composing the surface of a sample into a spectrometer that sorts them according to their rebound velocities (just as an optical spectrometer sorts light waves according to their wavelengths) and feeds them into a counting device. Since the velocity of the protons depends upon the weights of the atoms that deflect them, the various velocities coming from a bombarded surface indicate which elements are present. The relative numbers of protons reveal the proportional composition of the surface.

A van de Graaf type generator delivers the high voltage needed in the apparatus, and a vacuum tube runs down its center to a large electromagnet. The high voltages produced are insulated, by nitrogen under pressure, from the heavy steel tank that contains the generator, and an endless belt carries charges up to be accumulated on a high-voltage electrode at the top. Hydrogen gas, leaking slowly from a small tank inside the electrode, is ionized in an arc discharge. The resultant ions are accelerated downward through the vacuum tube by the successive voltages of a series of hollow electrodes spaced along the interior of the tube. Emerging from the accelerator, the stream of ions is focused into a beam which contains protons, as well as the multiple hydrogen ions produced in the hydrogen ionization. The ions are separated from the protons, and the proton beam enters the target chamber, striking the small target area on the surface of the sample, where most of the protons are absorbed.

Some of them come close enough to atomic nuclei to be bounced out again, losing energy to the atoms hit in inverse proportion to their atomic weights.

The protons that are allowed to pass through the spectrometer to the counting device are those with a definite, limited range of velocity. For maximum resolution of the various elements, the target area is narrowed down by regulating the entrance slits that shape the beam to a very small spot. The exit slit of the spectrometer is about the same size. Behind it is a thin layer of phosphorescent material on the end of a photomultiplier tube. Target chamber and tube are so arranged that a sharp “image” of the target area is focused on the phosphor, which emits light pulses when struck by protons. In contrast to an optical spectrometer, which scans over a focal plane, the magnetic spectrometer covers that part of the proton velocity range desired by varying the magnetic field in a series of “runs” to permit protons of different velocities to reach the counting circuit.

The number of protons that hit the target is kept the same for each of a series of runs by a current integrating circuit, and in each run a different fraction of the total is counted by the photomultiplier tube. Plotting the particular ratio setting used against the number of protons counted for each run gives a curve that looks like a series of steps, each of which corresponds to a different atomic mass in the sample, and the height of the step is proportional to the concentration.

The ion-scattering analyzer will be used initially to study surface modification of ferrous alloys, crystal boundary contamination of some nonferrous metals, and intermetallic diffusion, for the Ordnance Department of the Army. Stanford Research Institute also expects that many industrial applications will be found.

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