The existence of a few groups which are much larger than the average and which carry only a small fraction of the conduction current, suggests that the carriers composing these groups are quite different from most of the carriers, and that they are electrons rather than ions. This opinion is supported by recent work of von Hippel[5] which indicates that electrical breakdown, which may be regarded as a later stage in the development of the phenomenon we have observed, is primarily an electronic phenomenon.

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[5] v. Hippel, Zeits. f. Physik **67,** 707; **68,** 309 (1931).

The Isotopic Constitution of Zinc

The constitution of zinc has been determined by a new method of analysis. The mass numbers of the isotopes of zinc are 64, 66, 68, 67, and 70 in order of relative abundance. No evidence has been secured for the existence of Zn^{65} or Zn^{69} although from Aston's[1] measurements Zn^{65} and Zn^{69} are respectively 6.5 and 2 times more abundant than Zn^{70}. This new analysis indicates that *the ions of mass numbers 65 and 69 measured by Aston were hydrides of* Zn^{64} *and* Zn^{68}. Fig. 1 is a positive contact

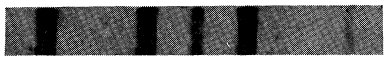


Fig. 1.

print of the mass-spectrum of zinc. Zn^{70} is clearly visible on the original plate. Fig. 2 is a densitometer record of the mass spectrum of zinc.

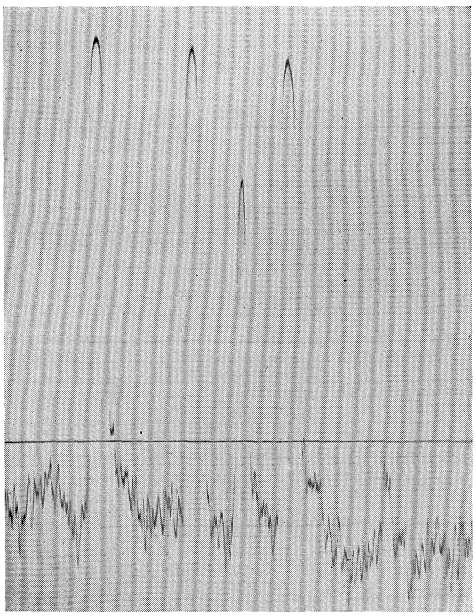
The apparatus used for this analysis of the isotopes of zinc may be most simply described as a combination of a source of ions, a "velocity filter" or selector, and a focussing chamber and camera. Ions of all energies up to the maximum potential applied across the discharge tube enter the first slit, (0.005 cm wide), of the velocity selector. In this region the ions are subjected to the combined action of crossed electric and magnetic fields. All ions passing through the second slit of the velocity selector have the same velocity, $v=X/H$, within narrow limits. The ions which emerge from the second slit are immediately introduced into a uniform magnetic field, and arrive normally incident to the surface of a photographic plate 180° from the second slit. The radius of curvature of the ions is proportional to the mass of the ions and a linear mass scale is secured.

The present analysis of zinc was undertaken as the available evidence indicated that the ions of mass 65 and 69 as measured by Aston were not isotopes of zinc. Dempster[2] determined the isotopes of zinc by means of his method of analysis. The ions were produced by electron impact of zinc vapor essentially free from hydrogen. Isotopes of proton numbers 64, 66, 68, and 70 were found with indications of an isotope at 67 *but no evidence for an isotope of mass 69.* Aston[3] has suggested in commenting on his analysis of germanium that "the possibility of hydrides cannot be ruled out". The germanium ions were produced from a volatile compound containing hydrogen in abundance which was released under the dissociative action of the discharge. Zinc methyl was used in the discharge tube to produce zinc ions and again large quantities of hydrogen must have been present under conditions favorable to the formation of hydrides. Barton[4] has called attention to the possibility of error in the analysis of germanium due to hydrides and has suggested less directly that Aston's analysis of zinc might be in error.

For the present analysis, the ions of zinc were secured by ionization of metallic zinc vapor from a new type of source which may prove to have a wide range of application. A zinc cathode was used in the discharge tube and for some spectra metallic zinc was also deposited by evaporation from a tungsten filament onto the walls of a cylindrical discharge tube. When a discharge is run in neon or argon, a copious supply of metallic ions is secured. This method of producing ions was discovered quite accidentally when it was noticed in examining the abundance of Ne^{21} that an intense line of mass 27 always appeared on these plates when an aluminium cathode was used. The origin of the metallic

[1] F. W. Aston, Nature **122,** 345 (1928); Proc. Roy. Soc. **A130,** 303 (1931).
[2] A.J. Dempster, Phys. Rev. **20,** 635 (1922).
[3] F. W. Aston, Nature **122,** 167 (1928).
[4] H. A. Barton, Phys. Rev. **35,** 412 (1930).

vapor has not been located precisely; the cathode becomes very hot and considerable metallic vapor is continually given off by evaporation and sputtering. Although the intensity of the ion beam is increased by allowing the walls of the discharge tubes to heat up to 200° by electron bombardment and the recombination of ions and electrons on the walls, good ion intensity can be secured with the discharge tube cool and no metal on the walls. It appears therefore that the cathode surface supplies most of the metallic vapor. So far this type of source has been used successfully for



64 66 67 68 70

Fig. 2.

Al, Zn and Cd. It is peculiarly adapted for examining elements which form hydrides as the great affinity of ionized neon and argon for hydrogen tends to clean up any hydrogen present in the discharge tube. A "well" (filled with Se) in an aluminium cathode was a successful source of vapor for this element. The vapor pressures of Cd and Se are too great to allow the use of cathodes of these materials as the discharge tube walls become conducting too rapidly to permit a series of exposures.

A critical examination of Aston's results obtained since 1927 shows that in regard to the existence of specific isotopes only the analysis of germanium is questionable. Similarly, Aston's measurements of the relative abundance of isotopes are not in question insofar as they might be affected by the presence of hydrides except for Zn and Ge. "Consistent photometry of '*a*' group of lines on all of a very large number of plates"[5] is not a sufficient criterion to prove that hydrides are not present among those lines.

Assuming that all the isotopes of zinc form hydrides in the same ratio as Zn^{64} to $Zn^{64}H$ and no multiple hydrides are formed, the value obtained for the atomic weight of zinc from Aston's data and with the present results in view is $65.32_7 \pm 0.02$ on the chemical scale after deducting 2.2 parts in ten thousand[6] to transfer from the physical mass scale.

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February 10, 1932.

[5] F. W. Aston, Proc. Roy. Soc. **130,** 305 (1931).

[6] R. T. Birge and D. H. Menzel, Phys. Rev. **37,** 1669 (1931).

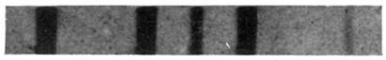
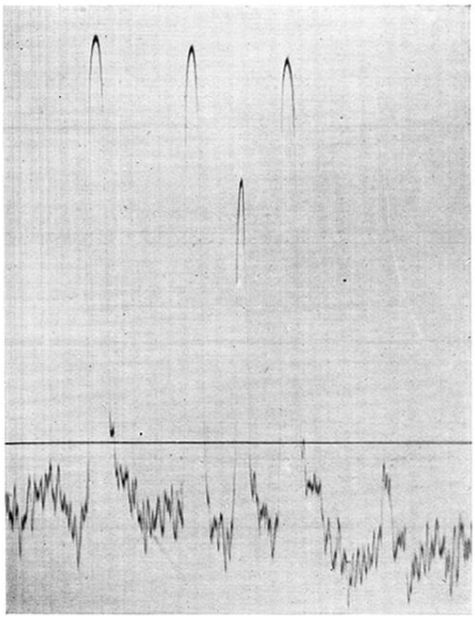


Fig. 1.



64 66 67 68 70

Fig. 2.