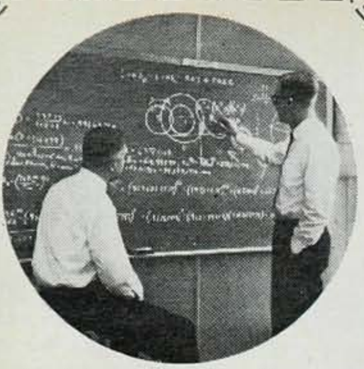

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muons, scintillation counters are to be placed at floor level, with several feet of iron between them and the spark chambers. This arrangement will subject the muons to the requirement that after their directions of arrival have been measured in the spark-chamber system, they must be sufficiently energetic to pass through the iron and be counted at the floor-level detectors. The thereby "hardened" muons will be less subject to scattering errors because of their higher energies. By changing the orientation and position of the detectors, the whole volume of the pyramid can be probed for unknown chambers.

After the equipment has demonstrated that it can detect the well-known "King's Chamber," and "Grand Gallery" in the Great Pyramid, it will be moved a few hundred yards into the only known chamber of the neighboring "Second Pyramid" at Giza. It will search the whole volume of that pyramid, and it should find a presently unknown chamber of "average size," if such a chamber exists.

The Pyramid Project is set up under the jurisdiction of a ten-man committee chaired by Yousef Kotb (Vice Rector for Research, Ein Shams University, Cairo). Day-to-day operations are handled by an executive committee of Fathy El Bedewi (head, Ein Shams physics department), Fakhry and Alvarez. Project financing is a joint undertaking of the US Atomic Energy Commission, the Smithsonian Institution, and the UAR government. Approximately \$250 000 is available for an eighteen-month period.

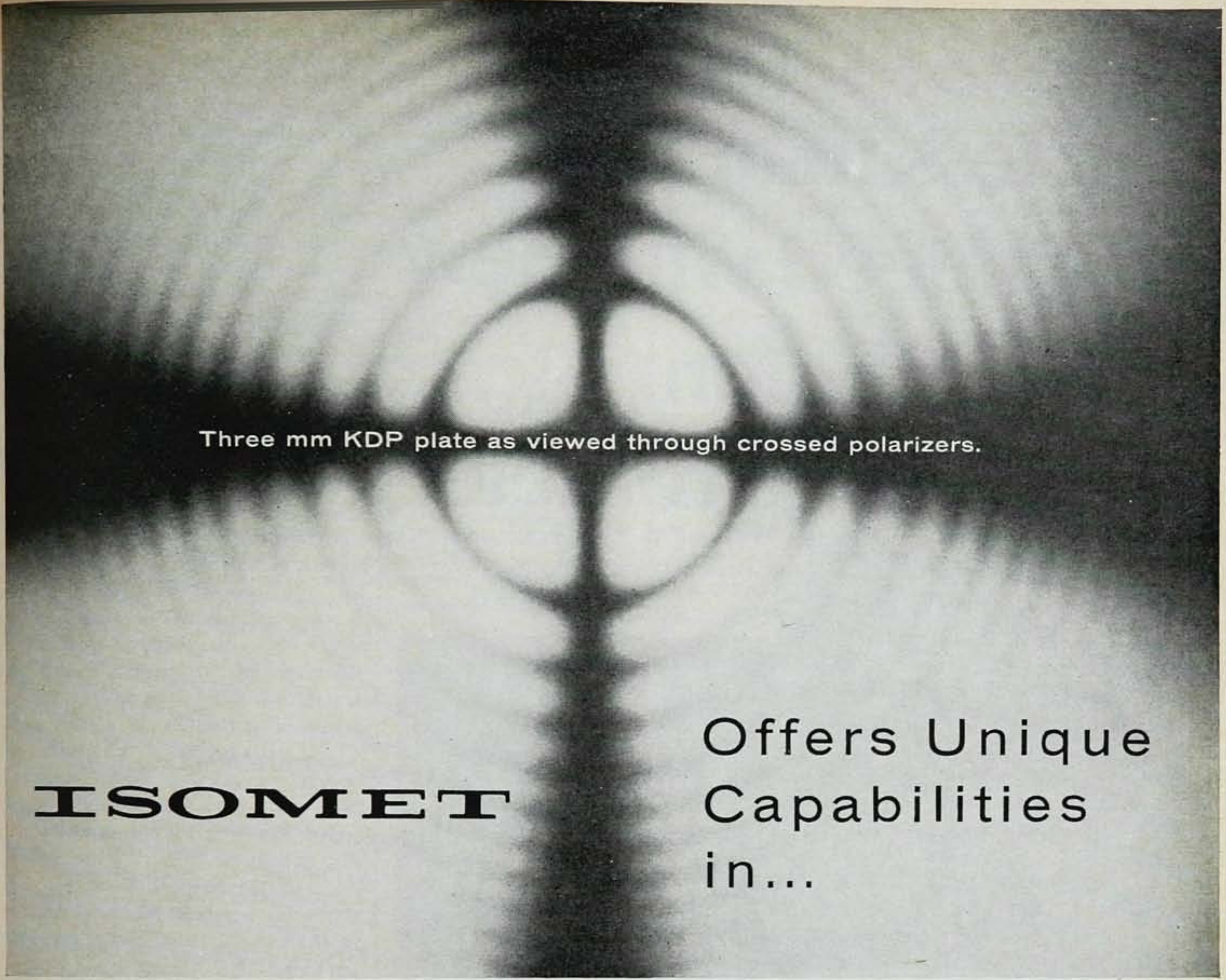
Spark chambers and their associated electronic equipment are now being tested at LRL, and it is hoped that they will be installed at Giza in January of 1967. Data analysis will be in the computing center at Ein Shams University. At a recent meeting of the executive committee in Berkeley, Jared Anderson of LRL was named head of the US scientific group that will help install the equipment in the pyramid. The seven-man UAR scientific team includes A. R. Fikry Hassan, who was until recently a member of the sonic spark chamber group at CERN.—GP

Quarks on land and sea and in the air

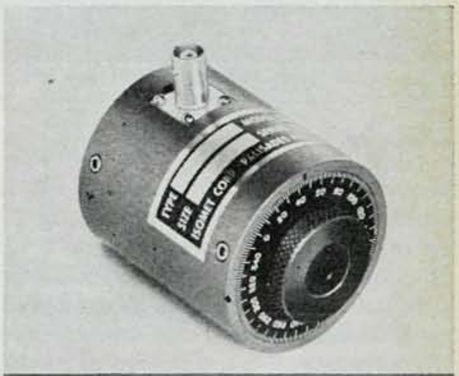
A search for quarks in meterorites, air, and sea water has been conducted by W. A. Chupka, J. P. Schiffer, and C. M. Stevens of Argonne National Laboratory [*Phys. Rev. Letters* **17**, 60 (1966)]. Previous quark hunts have been conducted by looking for fractionally charged particles in the products of high-energy collisions of particles from accelerators and cosmic rays. (In sum, these experiments set a probable lower bound of 5 BeV/c^2 on the quark mass.) The present work proceeds on the assumption that quarks are stable particles and looked for the chemical (or, more precisely, ionic) effects that quarks would produce if they entered into combination with ordinary chemical species or other particles.

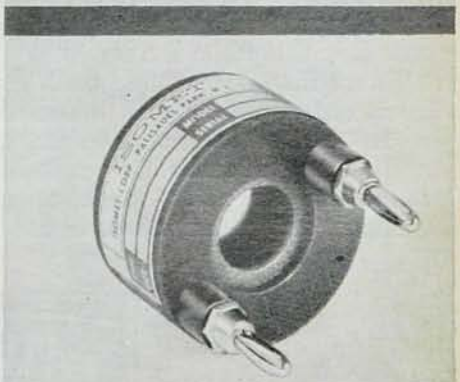
The important point is that fractional charges cannot be neutralized in ordinary substances. A negative quark (with charge $-e/3$) could be captured into a Bohr orbit in an atom, and the resulting system would be fractionally charged and remain so indefinitely. (For such a heavy particle the Bohr orbit would be inside the nucleus but the possibility of the negative quark annihilating or recombining into a nucleon would still be vanishingly small. Likewise, although such atoms could undergo beta decay, the products would still be fractionally charged.)

A number of things could happen to positive quarks (of which two varieties, $+e/3$ and $+2e/3$, are postulated). On capturing an electron, they would behave like oversize, very electropositive and reactive hydrogen atoms—chemically similar to alkali metals. For $+e/3$ quarks the ionization potential would be 1.51 eV and they would exist as hydrated ions and evaporate predominantly as positive ions (possibly associated with neutral molecules). The ionization potential for $+2e/3$ quarks would be 6.04 eV. These would also exist as hydrated ions in water solution but, under most conditions would evaporate, predominantly in tight association with electrons or with negative ions. Therefore, the $+1/3$ quark is best sought as a posi-



ELECTRO-OPTIC CRYSTALS





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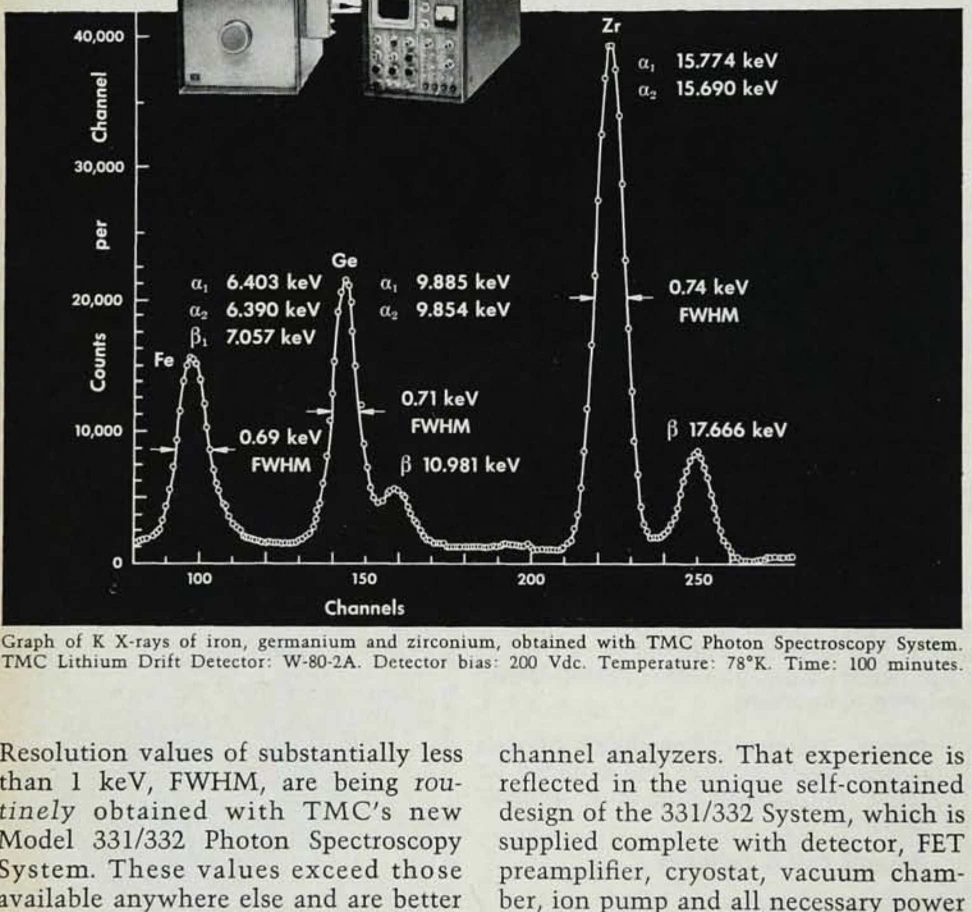

Graph of K X-rays of iron, germanium and zirconium, obtained with TMC Photon Spectroscopy System. TMC Lithium Drift Detector: W-80-2A. Detector bias: 200 Vdc. Temperature: 78°K. Time: 100 minutes.

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tive species; the +2/3 as a negative.

The authors remark with amusement that Robert A. Millikan, in his first report on measurement of electron charge on water droplets in a cloud chamber, noted that he had discarded one piece of data in which the charge on the drop was 30% lower than the final value of *e*. Similar discrepancies were not found in later runs of the famous oil-drop experiment by Millikan and others, but the present authors suggest that the refining techniques that the oil had gone through had eliminated any fractionally charged atoms (since their chemical properties would be different from those of ordinary atoms).

The experiments of Chupka, Schiffer and Stevens were done by allowing natural samples of meteorites, sea water or air to diffuse in the gaseous state through an electric field strong enough to extract fractionally charged atoms or molecules. With this method large quantities of material could be examined and molar concentrations as low as 10^{-30} could be detected. Any particles separated out by the field were collected on a small platinum filament that was placed at a positive potential to retain negatively charged particles and then heated for about 10 sec in air to about 600°C to drive off impurities. A larger, heated, negatively charged filament was placed so as to insure that quark-containing atoms that volatilize as positive ions would be collected, reevaporated and returned to the small filament. The small filament was then put into a device that accelerated any negative ions through 15 kV and onto the first dynode of an electron multiplier. Pulses from the multiplier were recorded on a multiscaler as a function of time.

Although some strange charged species were found, including negative ions of the form $FeCl_4^-$ and other iron tetrahalides, the result of the investigations is, according to the authors, "rather unsatisfactory. One cannot with any degree of certainty set limits on the existence of fractionally charged atoms. One can only state that under the circumstances in which reasonable assumptions might lead one to expect to see quarks, we have not seen fractionally charged atoms." □