distance along the axis of the field, and M is the magnetic moment induced in the ferromagnetic cyclinder by the field H. If M is roughly proportional to μH, where μ is the permeability of the cylinder, then $F \propto \mu H dH/dX$. Consequently, it is possible to adjust H and dH/dX so that F varies very slowly with height. This has been done by proper shaping of the field of the solenoid and by supporting the ferromagnetic cylinder well below the solenoid. Also in some experiments an additional solenoid with a constant current was used to support a portion of the weight of the suspended body.

When the apparatus is properly adjusted, the suspended body shows no motion, as viewed through a microscope focused on scratches on the suspended cylinder except when a vertical force is applied to the suspended cylinder. Consequently, the elevation of the suspended cylinder in the field of view of the microscope is a measure of the applied force. However, it is preferable in practice to measure the change in the current or voltage in the circuit as a function of the vertical force on the suspended cylinder. With a suspended steel cylinder 10 mils in diameter and 50 mils long, changes in force on the cylinder of the order of 10^{-9} gram weight could be observed. The balance was calibrated by suspending the cylinder in a glass chamber which could be evacuated and then determining the change in buoyancy of the air on the suspended body when the air pressure around the body was varied.

The above magnetic suspension balance may be used in almost any experiment where small changes in mass or force are to be determined. It is especially suited to experiments where the weighing must be carried out in an evacuated or enclosed chamber, under a transparent liquid, etc., where no mechanical connections to the outside are possible. Also the same apparatus may be used to support and weigh over a wide range of masses or forces.

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Preparation of Transplutonium Isotopes by Neutron Irradiation

A. Ghiorso, R. A. James,* L. O. Morgan,† and G. T. Seaborg
Radiation Laboratory and Department of Chemistry, University of California, Berkeley, California
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THE first production of isotopes of the transplutonium elements americium (atomic number 95) and curium (atomic number 96) was reported[1] by the present authors in a preliminary way in 1945 and more recently[2] in a more complete fashion. In these communications it was pointed out that a number of americium isotopes can be formed in cyclotron bombardments with various charged particles, and in particular that the ~500-yr. Am^{241} can be produced with approximately 40-Mev helium ions according to the reactions $U^{238}(\alpha,n)Pu^{241}\xrightarrow{\beta^-\ (10\ \text{yr.})}Am^{241}$. It was also reported that a number of curium isotopes can be formed by cyclotron bombardments with charged particles and in particular that the ~150-day Cm^{242} can be prepared by the 40-Mev helium ion bombardment of Pu^{239} according to the reaction $Pu^{239}(\alpha,n)Cm^{242}$. In addition it was stated that Cm^{242} can be formed by neutron irradiation of Am^{241} according to the reactions $Am^{241}(n,\gamma)Am^{242}\xrightarrow{\beta^-}Cm^{242}$ where Am^{242} exists in two isomeric states with half-lives for beta-emission given as 17 hr. and some 10^2 to 10^3 yr.

The purpose of the present note is to point out that the isotope Am^{241} can also be formed by neutron irradiation, according to the following reactions $Pu^{239}(n,\gamma)Pu^{240}(n,\gamma)Pu^{241}\xrightarrow{\beta^-\ (10\ \text{yr.})}Am^{241}$. This method of production was first observed by the authors late in 1944, and the use of the chain reacting piles as a source of neutrons makes it the best for the production of weighable amounts of Am^{241}. (The first evidence for the reaction $Pu^{239}(n,\gamma)Pu^{240}$ was that of Chamberlain, Farwell, and Segrè.[3]) In fact, the intense irradiation of large quantities of plutonium leads to the production of *milligram amounts* of Am^{241}. The cross section of Am^{241} for the n,γ-reaction is such that it is possible with long irradiations at high neutron fluxes to transmute a substantial fraction of it to Cm^{242}.

The fact that the elements americium and curium, as represented by their isotopes Am^{241} and Cm^{242}, can be prepared in substantial quantity in this manner by pile neutron irradiations makes it possible to investigate rather completely the chemical properties of these elements by use of weighable amounts. The existence of these reactions makes it quite likely that even higher mass isotopes can be prepared by n,γ-reactions, and in fact further work at this laboratory, to be published soon, indicates that this is indeed the case.

This work was performed at the wartime Metallurgical Laboratory, University of Chicago, Chicago, Illinois (now the Argonne National Laboratory) under the auspices of the Manhattan District, and at the Radiation Laboratory and Department of Chemistry, University of California, Berkeley, under the auspices of the Manhattan District and the AEC.

* Now at the Department of Chemistry, University of California at Los Angeles.
† Now at the Department of Chemistry, University of Texas, Austin, Texas.

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The Elastic and Photoelastic Constants of Fused Quartz

K. Vedam
Department of Physics, Indian Institute of Science, Bangalore, India
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EVEN though numerous investigations have been carried out on the various physical properties of fused quartz, the only known work on its photoelastic properties is that of Heymans and Williams,[1] who have determined the value of $(p-q)$ from bending experiments on a bar of fused silica, p and q being Neumann's strain-optical constants. In the present investigation the absolute values of p and q have been determined, and the results obtained are given below. The details of the method adopted will be published elsewhere.[2] The specimen studied was obtained from the Thermal Syndicate Ltd., England, and was in the form of a rectangular block of dimensions $2.7\times1.6\times0.85$ cm.

The elastic constants of fused quartz were determined by Hiedemann's method;[3] i.e., by observing the diffraction patterns produced by standing ultrasonic waves in the medium itself. Mueller[4] has shown that this method, with slight modifications, can be used to determine the value of p/q for isotropic substances. Using incident light polarized at 45° to the sound wave front, the light diffracted by the longitudinal waves is viewed through an analyzer. Then the analyzer is rotated through an angle θ, from the initial crossed position, to get the extinction of the first-order longitudinal pattern. By plotting the angle θ against the sound amplitude and extrapolating, it is possible to obtain "θ_{max}" corresponding to zero amplitude, which is given by the relation [Eq. (25) of reference 4]

$$\tan(\theta_{max}+45°)=p/q.$$

By this method the value of p/q for fused quartz was determined by the author and was found to be 2.85.

The value of $(p-q)$ was also determined by the well-known compression method[5] using a lever arrangement and a Fuess-Babinet compensator. The value of $(p-q)$ obtained by the author is equal to 0.135. This is about 50 percent too large, as compared with the value obtained by Heymans and Williams. However, repeated measurements have yielded consistently the same result within the limits of experimental error. As the original paper of Heymans and Williams dealing with this measurement was not available to the author, it is not possible to explain this discrepancy between the results. It is possible that the discrepancy may be due to the different natures of the specimens used.

The values of the Pockels' elasto-optic and piezo-optic constants of fused quartz calculated from the measured values of p/q, $(p-q)$, and the elastic constants are listed in Table I. All of the measurements were carried out using λ5893A.

TABLE I. Constants of fused quartz.

Density = 2.213 g/cc, $n_D = 1.4585$		
Young's modulus = 7.445×10^{11} dynes/cm²		
Modulus of rigidity = 3.195×10^{11} dynes/cm²		
$p = 0.208$	$p_{11} = 0.100$	$q_{11} = 0.078\times10^{-13}$
$q = 0.073$	$p_{12} = 0.285$	$q_{12} = 2.98\times10^{-13}$
(a pressure of 1 dyne/cm² is taken as the unit of stress)		

It is seen on comparison with the corresponding values for the various silicate glasses,[2] that the values of p/q and $(p-q)$ are maximum for the vitreous silica. The addition of metallic oxides has the effect of reducing the value of $(p-q)$ and thus the birefringence produced by any fixed stress.

In conclusion the author wishes to express his indebtedness to Professor R. S. Krishnan for his kind interest and guidance during the progress of the above work.

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A Square-Wave Modulation Method for Microwave Spectra

T. R. HARTZ AND A. VAN DER ZIEL
University of British Columbia, Vancouver, Canada
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THE double modulation method employed in microwave spectroscopy by Gordy and Kessler,[1] Watts and Williams[2] and others, usually consists in applying a radiofrequency modulation voltage to the reflector of a klystron in addition to the low frequency saw-tooth voltage. The modulated microwave output power is allowed to pass through a wave guide section containing the absorbing gas and is then fed to a receiver tuned at the frequency used for modulation. We have replaced the radiofrequency sine wave with a 50 kc square wave voltage, applied this along with the low frequency saw-tooth voltage to the klystron repeller, and proceeded as usual. The square-wave voltages used are of the order of 10 volts, but higher values may be used quite satisfactorily.

Several disdvantages of the old system of double modulation are apparent. The absorption line observed on the cathode-ray oscilloscope has a differentiated line shape, making for a possible error in the location of the center of the line. Perhaps more serious is the fact that there is considerable distortion in the observed pattern for large modulation voltages, such as would be required for increased sensitivity. Our method of detection gives immediately the true line shape when viewed on the oscilloscope. Due to the large square-wave signal there is also better sensitivity with very little distortion. However, each absorption line appears double; that is, a signal is obtained when the tops of the square-wave sweep over an absorption and another when the bottoms sweep over the same line. These appear on the screen as two lines, separated by an amount depending on the magnitude of the square-wave voltage. The use of lock-in detection inverts one of these lines with respect to the other, so that there is never any possibility of confusion.

We subsequently introduced a feature which removes one of these lines entirely. Instead of applying the square-wave and the saw-tooth modulations separately to the klystron repeller, the square-wave modulation is applied with a saw-tooth envelope. In this way only one absorption line is obtained from our detector since the bottoms of the square-wave remain fixed at the same level and hence contribute no signal.

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Stars and Showers at Balloon Altitudes*

A. M. THORNDIKE AND A. W. WOTRING
Brookhaven National Laboratory, Upton, Long Island, New York
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EVENTS have been observed in a cloud chamber flown to approximately 95,000 ft. from Camp Ripley, Minnesota (magnetic latitude 55°N).[1] It contained four plates; the top plate was 3.5 g/cm² of carbon, followed by 7.2 g/cm² of lead, 14.4 g/cm² of lead, and 14.4 g/cm² of lead.[2] About 1 g/cm² of material of low atomic weight was present above the cloud chamber in addition to about 14 g/cm² of the atmosphere.

The term "star" will be used to denote an event in which two or more heavily ionizing tracks appear to diverge from a common point, while "shower" will be used to denote one in which three or more lightly ionizing tracks do so. Tracks estimated to have a density of ionization one to three times minimum are classed as "light," those of four times minimum or more as "heavy." At high altitudes events with both light and heavy tracks are common. The term "shower-star" will be used when both two or more heavy tracks and three or more light tracks are present.

Events observed in 313 random expansions at altitude are given in Table I. Of a total of 66 events nine are shower-stars with three or more lightly ionizing particles. In eight of the nine shower-stars the lightly ionizing particles are fairly well collimated in a downward direction. Our results are consistent with the assumption[3] that the majority of lightly ionizing tracks from shower-stars are mesons. Of a total of 38 lightly ionizing prongs from shower-stars there are 11 which apparently stop in the next plate, 10 that penetrate without visible secondaries, one which appears to produce a small shower, and 16 whose behavior is uncertain, mainly because of leaving the illuminated region. Protons would have greater penetration and electrons greater multiplication than is observed. If the particles are mainly mesons, the results are understandable, since a meson ionizing one to three times minimum has a minimum range of 2 g/cm² of lead and some could well stop in the plates. Kaplon, Peters, and Bradt have interpreted multi-

TABLE I. Frequency of multiple events with various numbers of light and heavy tracks.

Number of heavy tracks	0	1	2	3–4	5–6
Number of light tracks			(Stars)		
0–2	—	—	4	6	2
	(Showers)			(Shower-Stars)	
3–4	18	1	3	3	1
5–9	15	6	0	1	1
10–19	3	0	0	0	0
20–30	2	0	0	0	0