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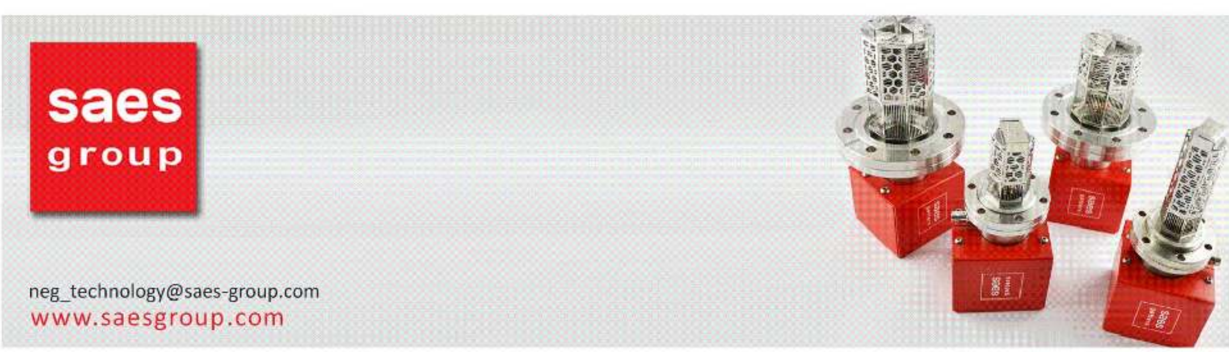

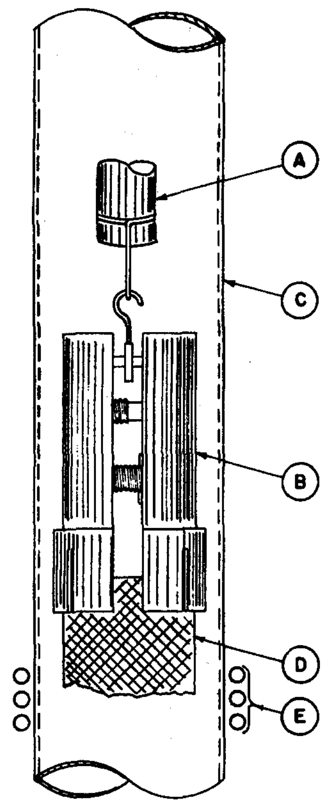

FIG. 2. Position drawing of chuck: (A) quartz support rod; (B) chuck; (C) quartz tube; (D) silicon rod; (E) induction coil.

type, class 2 fit. A $\frac{3}{8}$–16 thread was used in parts 2 and 3 while a $\frac{1}{4}$–20 and 10–24 were used in parts 4 and 5.

The material used to make the chuck must not be a source of contamination to the silicon. The chuck discussed in this paper was made of stainless steel because of its strength and machining properties. Other materials such as tungsten, tantalum and molybdenum are also acceptable.

Conical Two-Crystal Monochromator for Scattering, Diffraction, and Absorption Cross Section Work with Slow Neutrons

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THE flux density of slow neutrons of some specific energy value, as obtained from a pile, being less compared to that of characteristic target radiation from a sealed off x-ray tube, and also the Bragg reflection coefficient for neutrons being poor compared to that of x rays, the early investigators designed monochromators sacrificing resolution in order to gain intensity. This enabled them to carry on diffraction, scattering, and absorption experiments not exactly with strictly monochromatic beam, but with neutrons having the wavelength band of the order of 0.05 A in width, because: (1) the "rays" incident on the crystal are not absolutely parallel and (2) the crystal is not ideally perfect. The resolution of a crystal spectrometer is given by $\Delta E/E = 2\cot\theta\Delta\theta$, the angular divergence $\Delta\theta$ depending both on crystal imperfections and the angular spread of the incident neutron beam which can be obtained from the crystal rocking curve. By using a curved crystal there is a gain in intensity, and the angular spread of the incident neutron beam could be reduced by using convergent slit system (Soller), thereby gaining in resolution and also in intensity (because of the better background) as successfully utilized in the study of Raman lines in x rays.[1] Further improvements in resolution could be obtained by using a two-crystal spectrometer, but such an instrument requires much greater intensities not to be easily obtained from the existing high neutron flux reactors. Moreover, in working with very intense neutron beam the diffuse instrumental scattering introduces complication by raising the background level.

An energy uncertainty less than 9% could not be claimed in a recent report[2] on a two-crystal neutron spectrometer using 200 plane of a lead crystal with rocking curve width 37 ft and the integrated thermal neutron flux falling on the monochromator of the order of 10^7 neutrons/cm^2 sec. A universal double-crystal spectrometer has been reported[3] claiming high precision as a neutron monochromator for cross section measurements in the range 0.03 to 10 ev.

Recently, the author has built up the essential part of a two-crystal monochromator bending cylindrically and conically two excellent pieces of green mica from south India mica mines and used successfully in the case of x rays; the preliminary setting being done by the method of optical reflection, the bending of mica removes the macroscopic undulations of big flat pieces. The instrument after some modification could be conveniently used for cold, thermal, and slow (resonance) neutrons having significant crystal diffraction property. The investigators[4] in the field have used crystals of LiF, NaCl, Cu, Pb, mica, etc., for neutron monochromators; Shull and Wollan[5] showed that the metallic crystals like lead and copper gave greater intensities, as compared to halides, in Bragg reflection for slow neutrons. The intensity due to the second-order component is very poor. The author has been able to bend cylindrically (20 cm diam) and conically (5° semivertical angle and mean diameter 16 cm) pieces of NaCl crystals, the surface being the 200 cleavage plane of 0.1 cm thickness and 5×2 cm area while the crystals were immersed in a saturated solution of sodium chloride; the shape of the bent NaCl crystal could be retained without any permanent clamping device.

The diagram of the newly designed two-crystal monochromator is shown in Fig. 1 for a typical Bragg angle

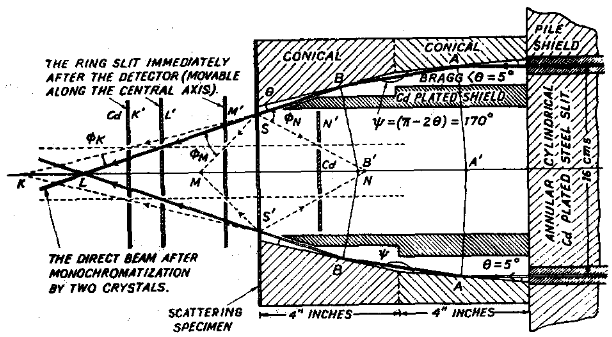

FIG. 1. Conical two-crystal monochromator for slow neutrons.

$\theta=5°$. In the case of 200 plane of NaCl crystal the energy of the neutron beam will be approximately 0.34 ev, corresponding to the wavelength 0.49 A. Two hollow cones are made out of the same material (aluminum), the cone A in a typical case, having the semivertical angle $\theta=5°$ and cone B the semivertical angle $3\theta=15°$, in order to satisfy the condition of the two-crystal method of monochromatization. The two cones A and B meet at an angle $\psi=\pi-2\theta=170°$ in the particular case as shown in Fig. 1. An annular cylindrical slit is introduced into the pile shield material, penetrating up to the region of high flux, the diameter of the cylinder being about 16 cm and the width of the annular ring about 0.1 cm, so that the total area available to the incident neutron beam is about 5 cm^2. The two cones A and B and the cylindrical annular slit in the pile shield are fixed in position so as to be coaxial. The incident annular beam of neutrons of 1 mm width strikes the crystal face at A at $\theta=5°$; the normals to the crystal face at A meet at the central axis of the cone at A'. After the Bragg reflection at A the neutron beam meets the second conical crystal at B in a circle at $\theta=5°$, and the normals at B meet at B' on the central axis. After two Bragg reflections the final emergent beam converges to the point L, meeting the central axis at an angle 4θ. The effective width of the crystals at A and B irradiated by the neutron beam is 1.15 cm, being cscθ times the incident beam width, viz., 0.1 cm.

The scattering sample SS' meets the monoenergetic neutron beam in a circular ring of width equal to $\csc(\frac{1}{2}\pi_2-4\theta)$ times the width of the incident beam. The area of the scattering specimen in a typical case is about 3 cm^2, depending on the distance between A and B and the placing of the specimen SS'. The movement of the detector $B^{10}F_3$ counter weighing about 100 lb and covered on the front with a cadmium sheet having a hollow ring slit as shown in Fig. 1 could be made, mounting the detector on the horizontal surface of a stout bench so that the center of the hollow ring slit in the cadmium plate lies precisely on the central axis of the instrument. Four typical positions K, L, M, and N are shown in Fig. 1, where scattering angles ϕ_K, ϕ_M, and ϕ_N are indicated in the figure. The direct beam converges to the point L, for which $\phi_L=0$. The finite width of the hollow ring slit and of the scattering specimen introduce known angular widths $\Delta\phi$ different for different scattering angles ϕ.

Taking different sets of conical crystal holders AB, the Bragg angle θ could be varied discretely from $\theta=1°$ to $\theta=5°$, and in extreme cases from $\theta=30'$ to $\theta=10°$, covering a wide range of neutron energies using crystals of NaCl (200) plane and mica (cleavage plane, $d=9.928$ A). In the case of mica the Bragg angle $\theta=8°\ 18'$ for 0.01 ev neutron and $50'$ for 1.0 ev neutron, and for NaCl (200) plane, $\theta=3°$ for 1 ev neutron and $55'$ for 10 ev neutron. The randomly oriented crystals of the specimen SS' should give rise to Debye-Scherrer rings and on the central axis of the instrument spots should appear corresponding to different d values of the scattering specimen. Recently, with an annular conical x-ray beam and the sample in the ring form, the author observed diffraction spots on a fluorescent screen, the spots appearing at the central axis of the cone. The intensity of the directly transmitted beam converging to the point L through different samples of known volume at SS' should give the total absorption cross section for the particular neutron beam and the particular specimen.

Attempts could be made to use single crystal of copper (111) similarly bent and the preliminary adjustment could be made optically. The strain produced in the crystals due to the bending could be decreased by increasing the diameter of the instrument. If the diameter of the cylindrical slit is doubled from 16 cm, as shown in the figure, to 32 cm, the bending of the crystals becomes much easier and to have the same incident neutron flux the width of the annular ring could be halved.

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Automatic Shadowing Device for Electron Microscopy

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An automatic shadow-caster is described which depends upon the conductivity of the evaporated material to cause the heating current to the evaporating filament, or