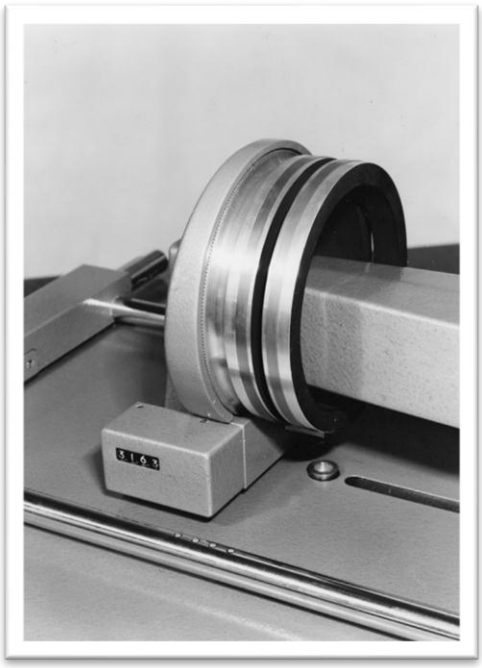
The Wooster Double Beam Microdensitometer

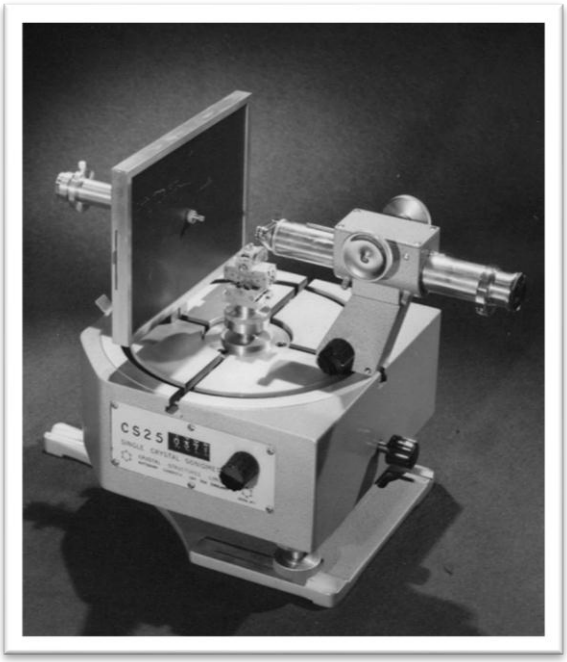
Designed to measure the darkness of spots and lines on films and plates in transmission, this instrument is capable of working up to optical density 4 with an accuracy of ± 1% of the density range of the optical wedge in use. Density up to D6 can be measured. The optical wedges can be easily interchanged. The motions of the 20cm diameter carriage which supports the sample under test are X, Y, and Polar. The built-in electro-sensitive chart recorder is driven at a rate accurately in ratio to the motion of the carriages allowing precise measurement of distances and angles. Remote control by computer can be provided.

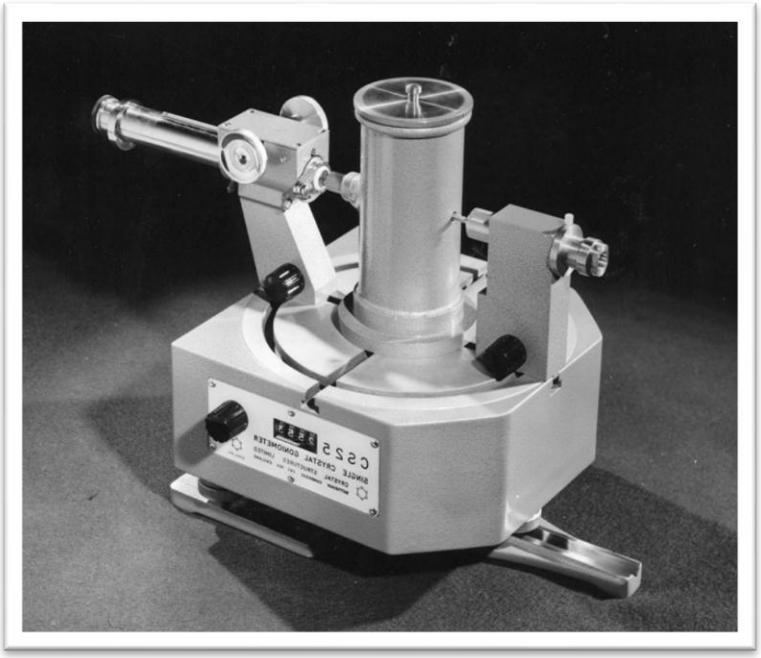


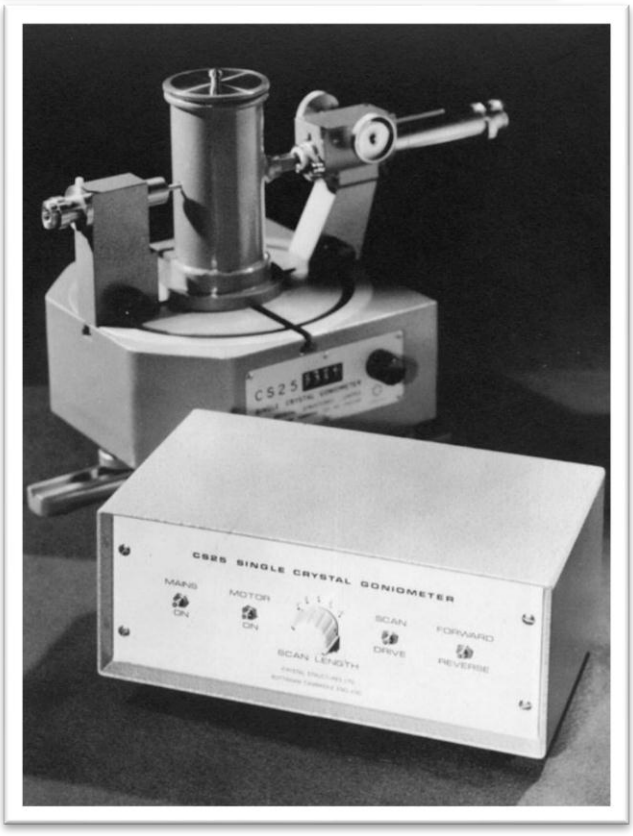
A **Vertical Drum Attachment** may be mounted in place of the carriages for films up to 40cm in length. The film is wrapped around the drum and clamped in place by two steel straps. The drum is driven round by a precise worm gear having the same pitch as the Y-axis lead-screw. This is also coupled in accurate ratio to the chart recorder. The X and Y coordinates are given on two odometer type counters reading to 0.1mm. Scanning over areas can be set up for integrated density measurements or production of contour maps of parts of the sample.

CS25 Universal Crystallographic Goniometer

This instrument comprises a substantial steel base with a range of attachments for examining crystals and powders using Laué, forward- and back-reflection cameras with flat film, cylindrical cameras for single crystal or powder studies. An optical telemicroscope is used with the goniometer head for setting single crystals on the axis and for studies using light from an optical collimator with a polariser and analyser. X-ray collimators of 0.5 and 1mm diameter and a mounted Geiger-Mueller counter with separate rate-meter are available. An oil-filled gearbox, driven by a stepping motor, provides rotation and oscillation of the vertical axis and the angle can be read out to ±0.05^{o} on an odometer type counter. Manual rotation and Z-axis adjustment of the main axis is also catered for.

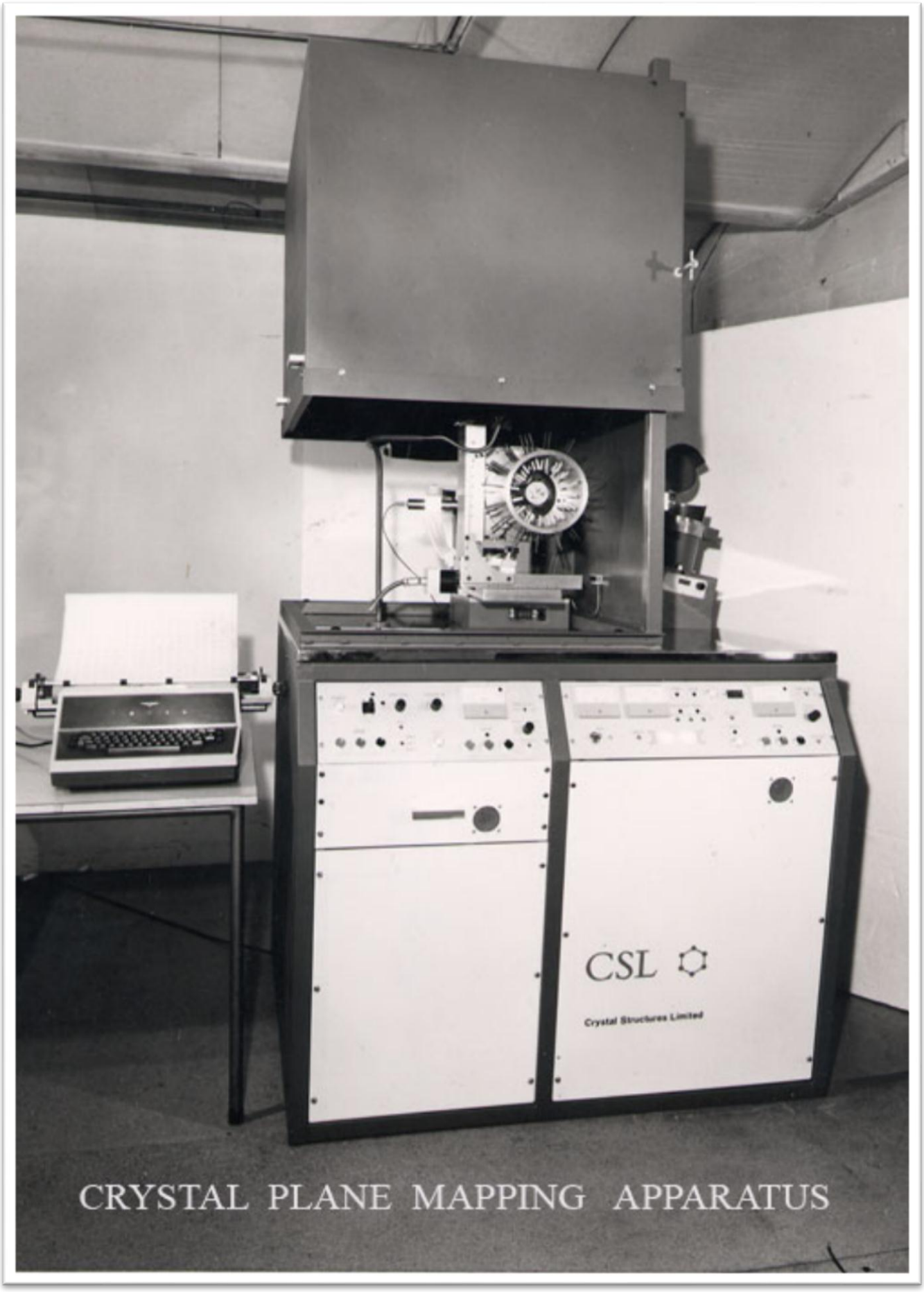






CS26/CS27 Single Crystal Orientation Apparatus

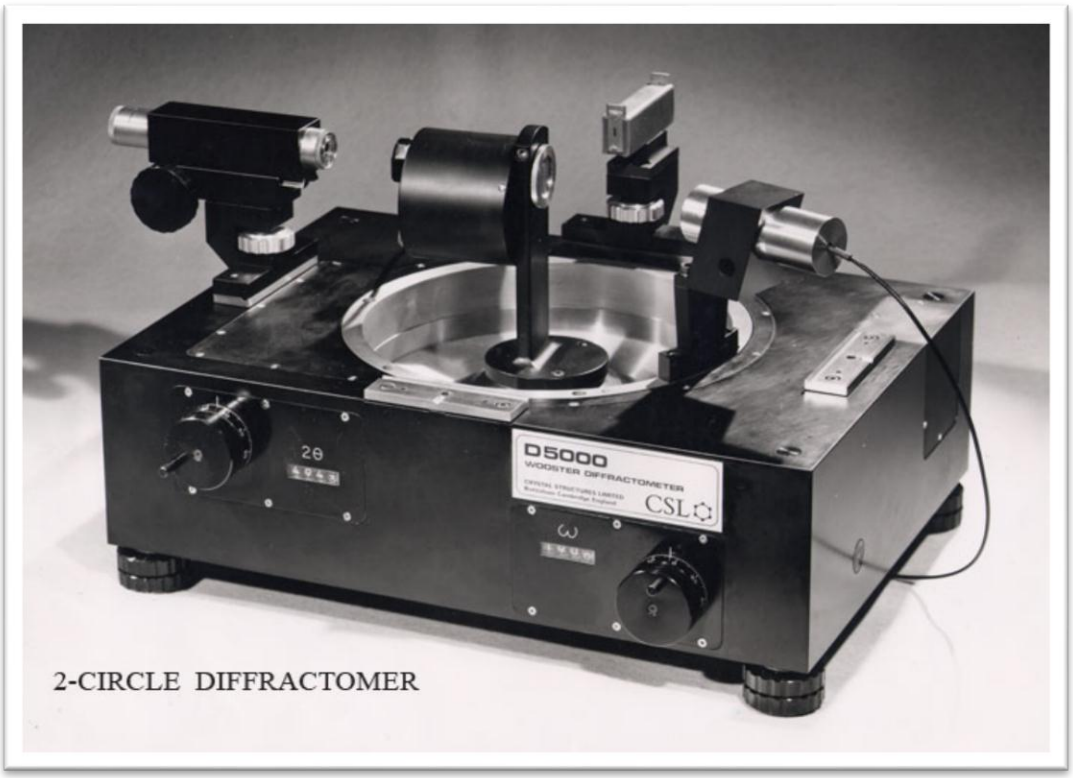
Self-contained X-ray generators operating at up to 30kV, 20mA with closed circuit water cooling, providing X-ray beams to two goniometers which can be arranged with an optional range of crystal/wafer supports. Vacuum chucks are used to retain delicate wafers and a vacuum pen is also available. The CS26 is designed for use with silicon and other semiconductor materials requiring a precision of ± 0.1°. The CS27 is provided with an angular measuring system with a precision of ±0.1 min. of arc. Complete X-ray safety is ensured by screens and mechanical interlocks making the apparatus suitable for use by un-classified operators.



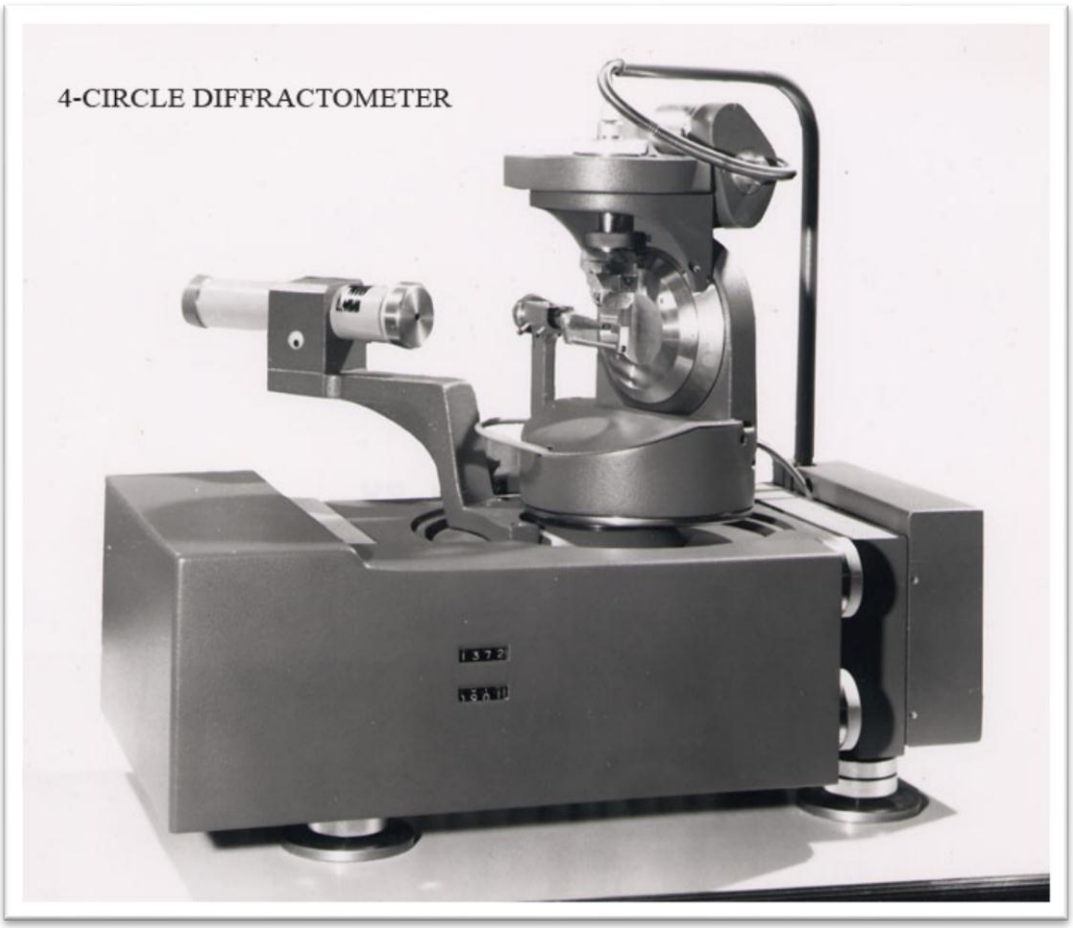
For recording the misorientations of parts of the end face of a nearly single crystal bar.

2-Circle and 4-Circle Diffractometers

Invented by one of the founders of CSL in 1936 diffractometers have become, throughout the world, the most used apparatus for identification or detailed analysis of crystalline powders. A 2-circle diffractomer with scintillation detector, pulse height analyser and ratemeter/counter provides the essentials. Extensive data bases for comparative purposes are available. The 4-circle diffractometer is the most powerful tool available for the determination of the structure of single crystals.

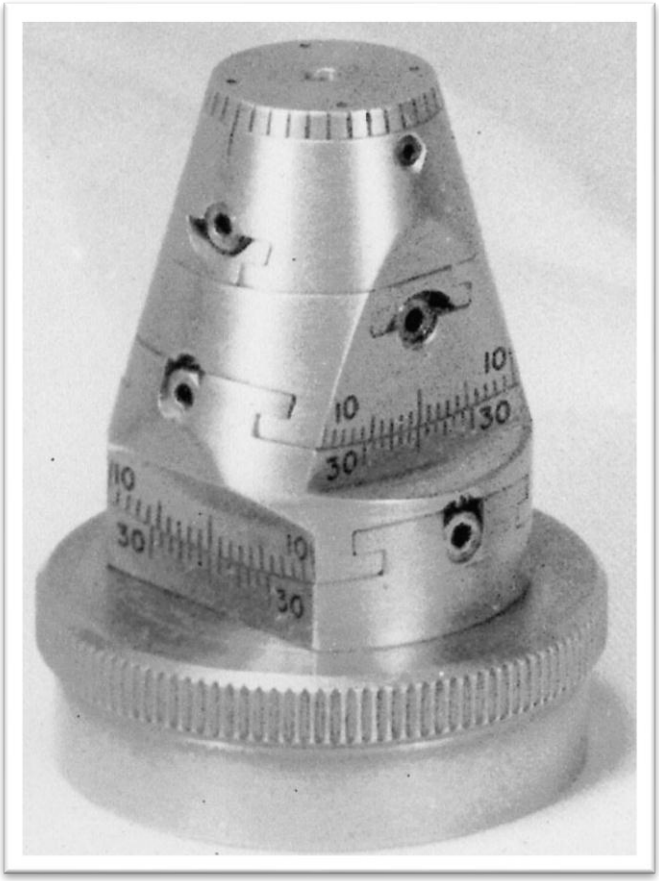


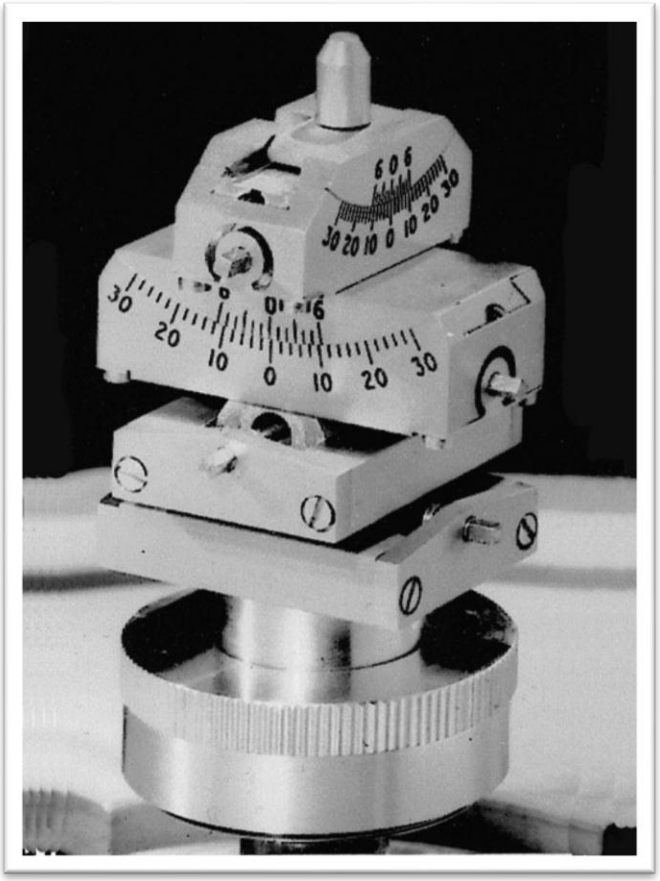
2-CIRCLE DIFFRACTOMER



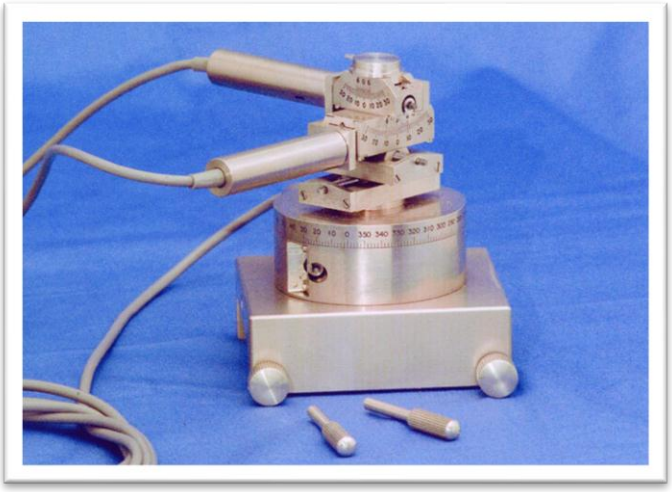
Goniometer Heads

Goniometer heads are used to mount crystals on the axes of optical or X-ray goniometers, diffractometers or crystal cutting machines, to facilitate centring on the main axis and to align any particular direction in the crystal with the axis. Two types are used: Eucentric, where two slides support the crystal mount and are arranged on two arcs which are centred on the crystal. This arrangement offers the benefit that the crystal stays on the axis when the angles are changed. The more common arrangement has the arcs nearer the crystal than the slides. This allows the arcs and slides to be operated by motors for remote control, and increases the angular adjustment that can be accommodated within a given cone angle, as drawn from the crystal's centre.





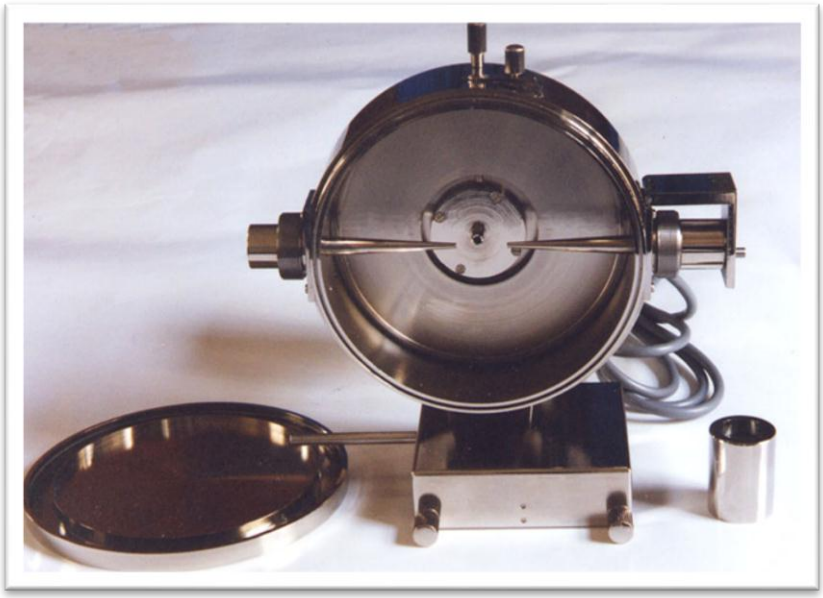
MOTORISED FIVE-AXIS GONIMETER HEAD



CS10 Powder Camera

A Debye-Scherrer type camera allowing recording of the powder diagram through 360^{o}.

The beam trap is provided with a fluorescent lead-glass window to confirm correct alignment with the X-ray beam. A convenient film punch and cutter is available to shape 35mm wide film to fit the camera.



CS20 X-ray Generator for Student Use

A console with high voltage and insulated current supplies (35kV, 20mA) for the X-ray tube, controls and front panel displays of the HT and mA supplies, closed circuit water cooling system, two timers to control the exposure at each window, mounting of the CS25 Universal Goniometer control box and a table-top fitted with tube-shield, CS10 Powder Camera, CS25 Universal Goniometer and two safety screening enclosures. These comprise two concentric, slightly more than half cylinders, which can be rotated about their vertical axes. In the working position two holes allow the X-ray beam to reach the apparatus within the enclosure. In all other positions of the cylindrical shields, the beam is cut off making it impossible for

the operator to be exposed to any significant radiation. The X-ray goniometer or powder camera can be accessed from three sides.

Portable Radiation Monitor

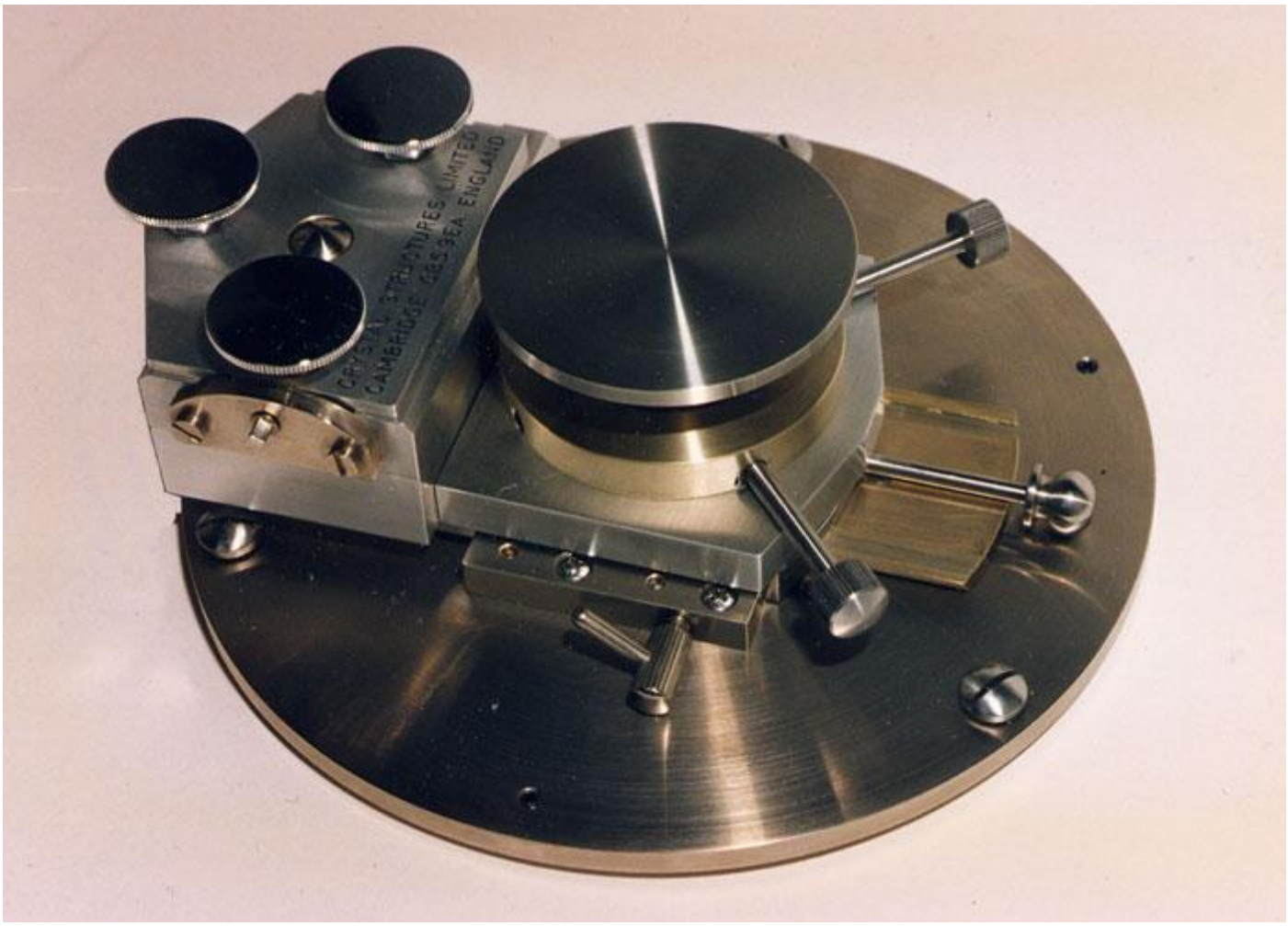
The CS15 a rechargeable, battery operated, Geiger counter has a moving- coil meter with a calibrated dial and a separately mounted GM tube. The On-Off switch allows a battery check in the third position. A built-in circuit allows recharging from the mains. A loud speaker makes clicks as the counter tube pulses.

Pocket GM Monitor

The smaller pocket monitor with a calibrated dial has the GM tube built in and uses a long life PP3 battery. An LED and speaker display/monitor the pulses. It is ideal for checking the safety of an environment.

Lanham Microscope Stage

Using a microscope fitted with colour filters to vary the colour of light being reflected from the polished surface of a speck on a rock sample, a graph of reflectance against wavelength can be produced. By comparison with a file of pre-recorded graphs, the identity of the rock can be determined. A speck as small as 5µ diameter can be measured. To standardise the reading at each wavelength it is necessary to compare the reflecting power of the rock against a polished silicon standard. This microscope stage provides mountings for the rock sample and the silicon standard so that they can be adjusted to be level and coplanar. An accurate slide allows rapid interchange between the two, with precise return to the given measuring positions. Rock samples from the Moon were examined using this apparatus.

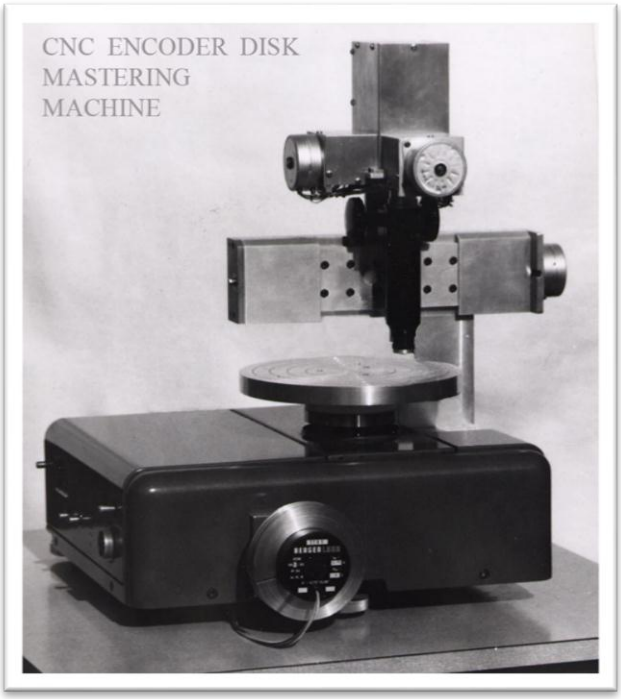


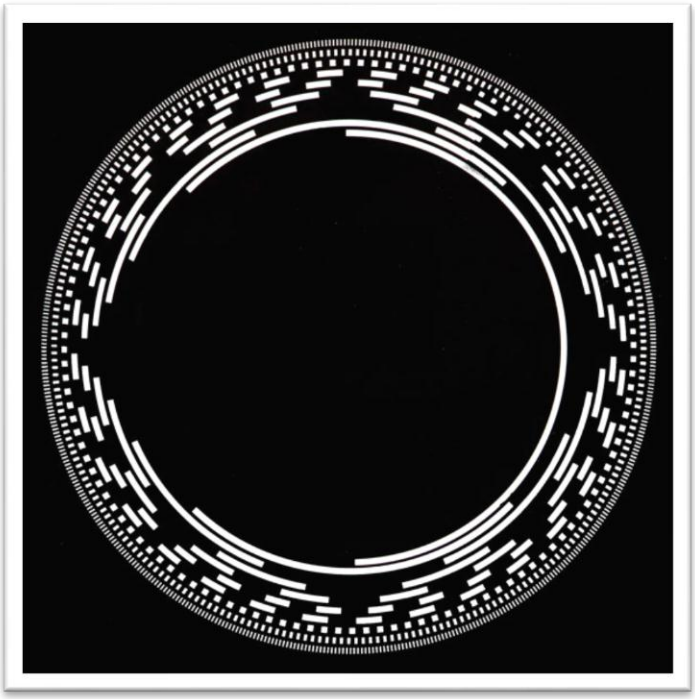
Encoders

Various **Linear and Rotary Encoders** have been produced including **Incremental Encoders** with up to 1024 lines, 10-bit Absolute Single Turn, Multi-turn, absolute encoders, resolving to 200 parts per turn, can be provided with encoded lay-shafts geared 10:1 to each other, to count any number of turns. A **heavy duty linear** one, designed for use with very powerful hydraulic jacks on building sites, uses a nylon coated stainless steel pull-cord, allowing measurement of 600mm with an accuracy better than ±0.5mm. It is constructed with a substantial stainless steel case and was specified to withstand a fall of 2m on to

concrete. A portable battery operated readout box is available for on-site confirmation of correct functioning.

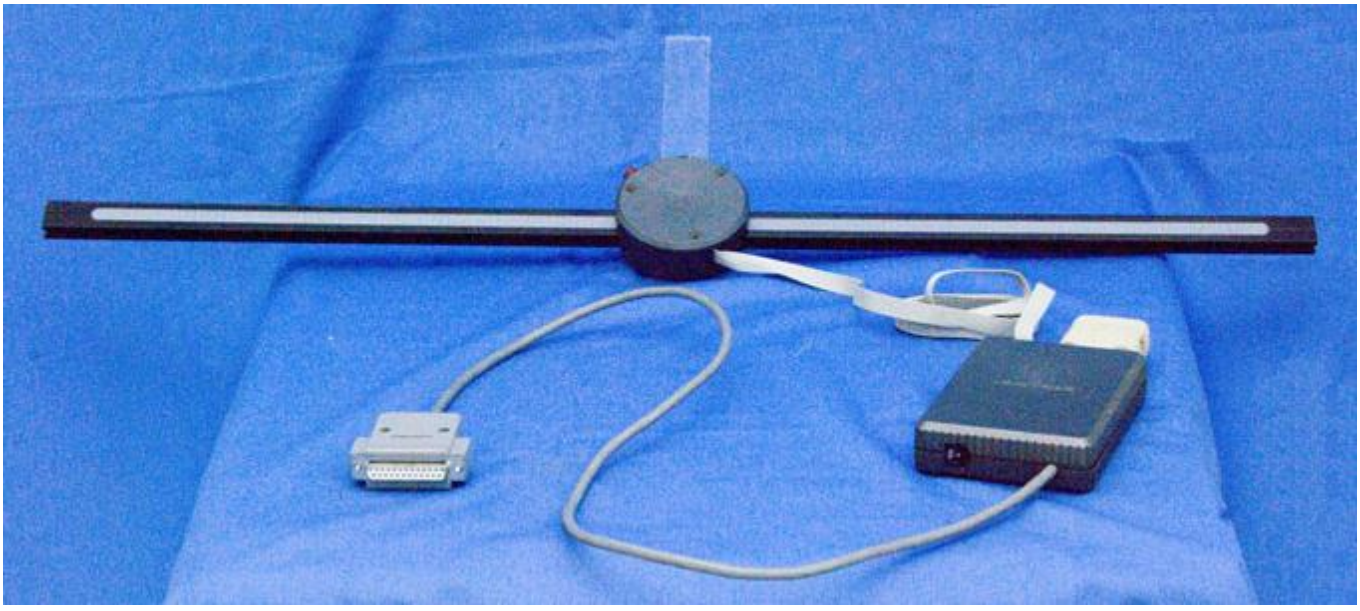
A CNC Disk Mastering Apparatus can resolve to 0 .001º and is available to generate patterns for incremental or multi-channel absolute encoders.





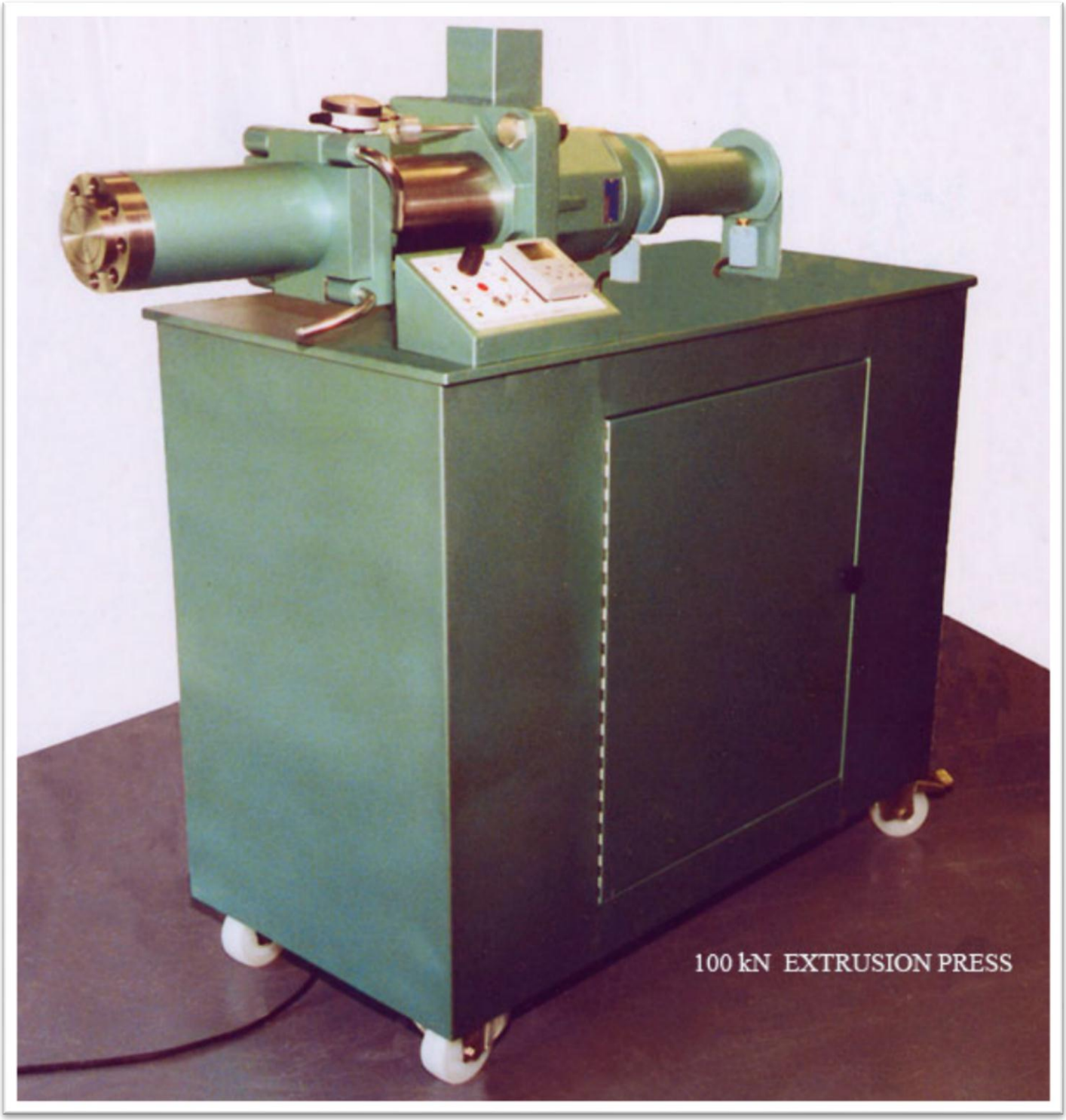
SEIZTIMER - Electronic Scale Reader

Petro-geologists were scanning the North Sea with hydrophones trailing a boat, fitted with a gas banger. The output of the hydrophones was recorded on 30m long charts. They drew lines on these charts as they interpreted them and then needed to rapidly scan across the chart at 50 cm intervals and transfer the coordinates of their lines to a computer. We made a bar with a black and silver, 1mm pitch grating and a reading head with four led-phototransistor pairs, which scanned the grating to generate two differential signals with a 90º phase shift. These signals were put through a circuit to count the transitions, four per mm, which were counted, serialised and sent through the RS232 serial input of the computer. The computer could then generate contour maps of the seabed, to pin point likely sites for drilling.



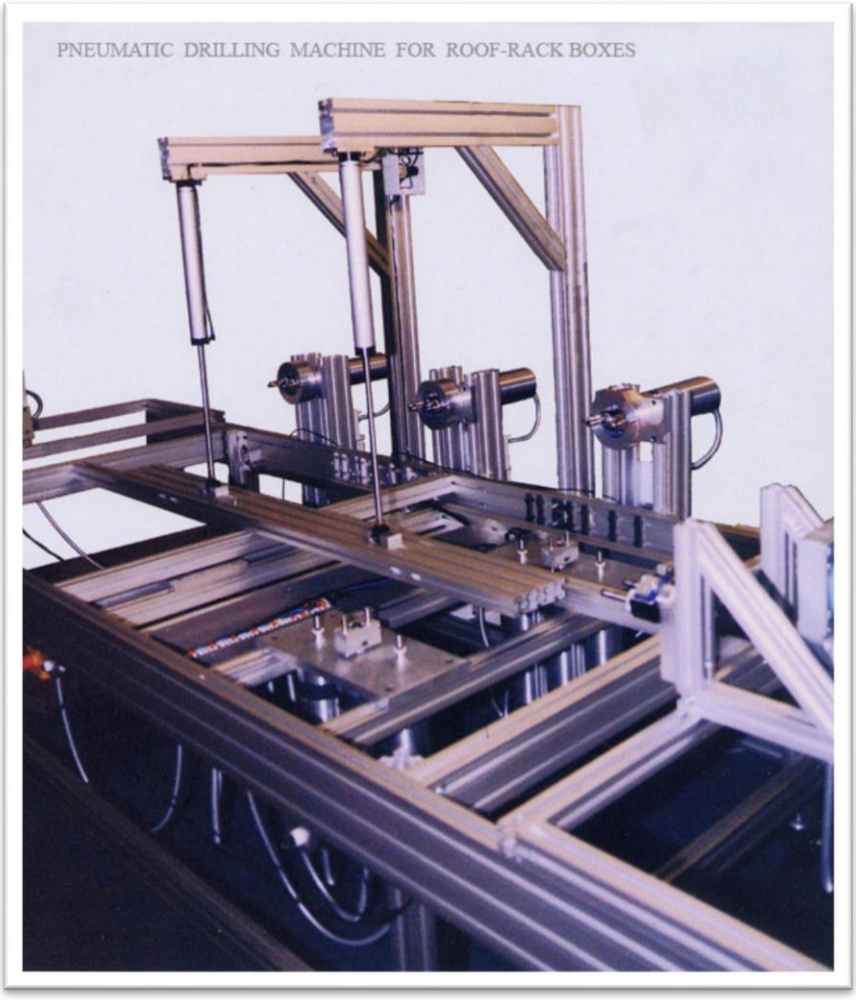
Batch Extrusion Press

A horizontally mounted piston and cylinder is driven by a screw jack capable of exerting a force of ten tonnes on the piston. The cylinder can be made of steel or stainless steel. A variable speed motor, driven by an inverter controls the rate of extrusion. Optionally, the actual force being applied to the piston can be monitored by a dial gauge and the cylinder can be arranged with heaters or may be refrigerated. Conveyor belts to receive the extrudite can also be provided.



Electro-pneumatic Self Feeding Drills

A combination of a three phase motor directly driving a single or double drill chuck with pneumatic feed and pneumatic single pulse start signal. Ideal for stroke up to 25mm and drills up to 7mm diameter. An example of their use is provided by the pneumatically controlled roof-rack-box drilling machine shown below.



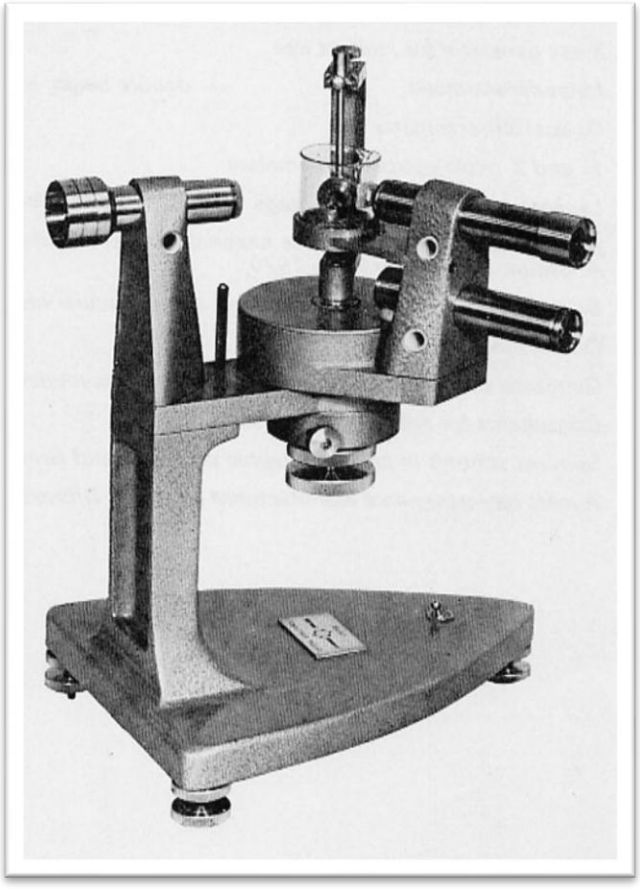
Crystal Physics Experimental Teaching Apparatus

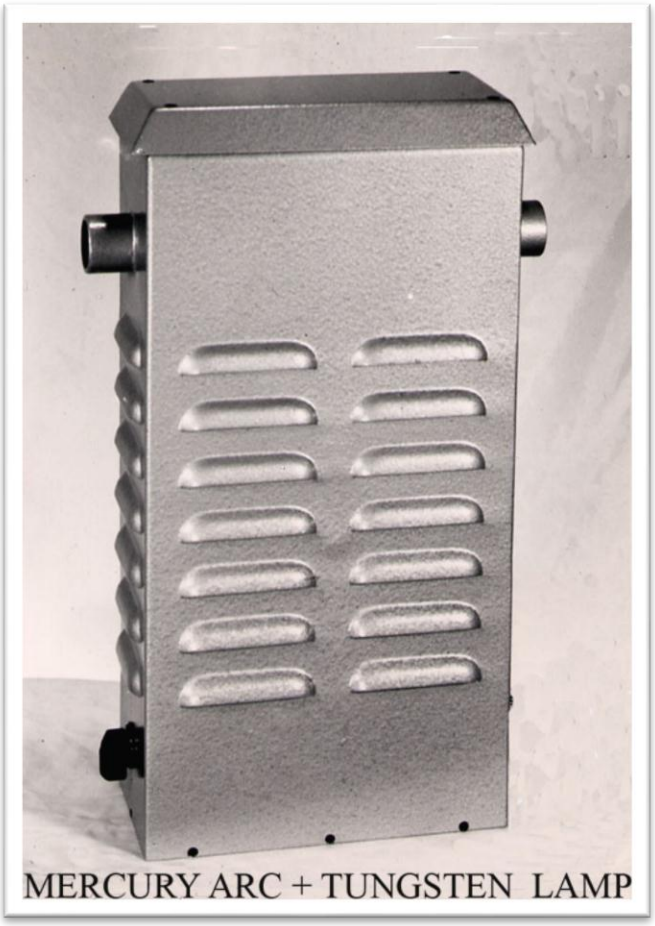
A range of experiments is available to illustrate the mechanical, optical, magnetic, thermal, piezo-electric and Hall effect properties,of single crystal materials, including:

KOHLRAUSCH REFRACTOMETER
with GONIOMETER HEAD

Single Circle Goniometer and Kohlrausch Refractometer has a fixed collimator and is used with a light box having tungsten and mercury-arc lamps for white and monochromatic light. There is provision for mounting coloured and polarising filters. The vertical axis is fitted with a glass scale, viewed by a microscope with a vernier graticule in the eyepiece, giving readings to 1 minute of arc. The crystal can be mounted on a standard goniometer head and is viewable through the telemicroscope. The goniometer head may be replaced with by a C-shaped frame, designed to hold a vertical rod, on which the crystal plate under investigation is mounted. This plate can be turned in its own plane. A beaker with an optically flat window is mounted from the telescope bracket, and allows immersion in a high refractive-index liquid.

A vertical circle with a vernier reading to 6 minutes of arc can be attached to the main spindle to convert it into a two axis goniometer.

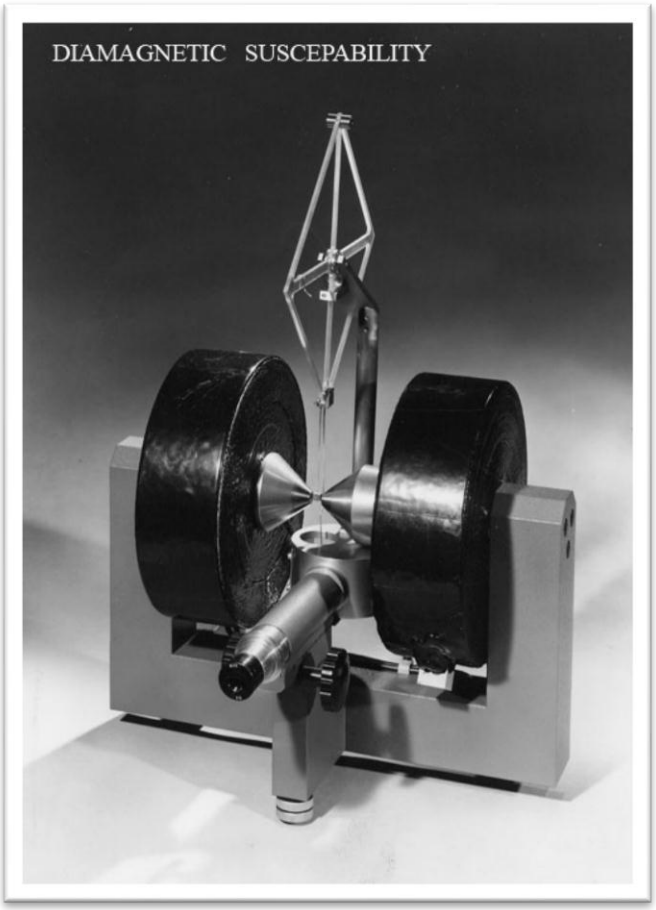




MERCURY ARC + TUNGSTEN LAMP

Magnetic Susceptability of Calcite varies with the direction through the crystal. The crystal is suspended on a torsion wire and its frequency of oscillation in a permanent magnetic field can be compared about its two principal axes.


MAGNETIC SUSCEPTABILITY of CALCITE

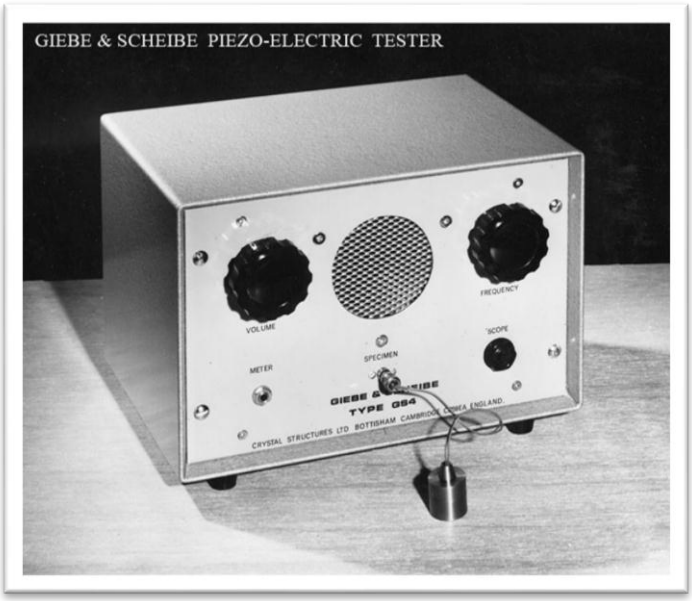


Diamagnetic Anisotropy in Calcite can be demonstrated by measuring the force exerted on a crystal in two directions at right angles, when suspended in a non-uniform field. The apparatus comprises a powerful electromagnet with tapered pole-pieces and a sensitive balance arm, with a rider weight, which enables the repulsive forces to be measured and compared. A microscope is used to set the balance arm to a standard position relative to the magnet.

The **Hall Effect** in Bismuth can be demonstrated by a piece of bismuth crystal with five attached electrodes and a strong, uniform field provided by an electromagnet. An adjustable current is passed from one end to the other and the voltage appearing across the crystal is measured by the included millivoltmeter. The field strength is measured by a search coil and ballistic galvanometer.

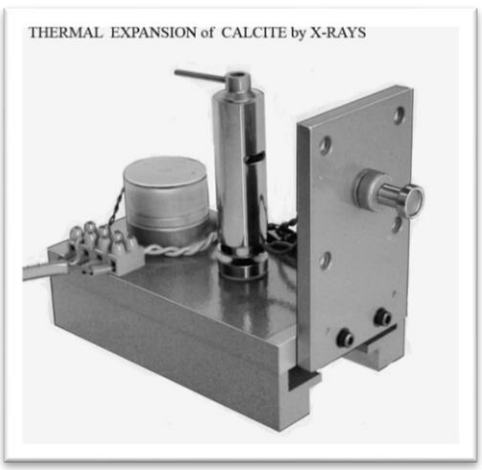
The **Static Piezoelectric Effect** can be measured in different directions through quartz blocks. An electrometer circuit gives a direct reading on the panel meter when a 1kg load is applied to the block.

The **Giebe & Scheibe** apparatus is used to detect whether crystal grains are piezoelectric or not. When crystal grains are placed between metal plates, included in an oscillator circuit and a varying radio frequency signal is applied, they will go in and out of resonance.

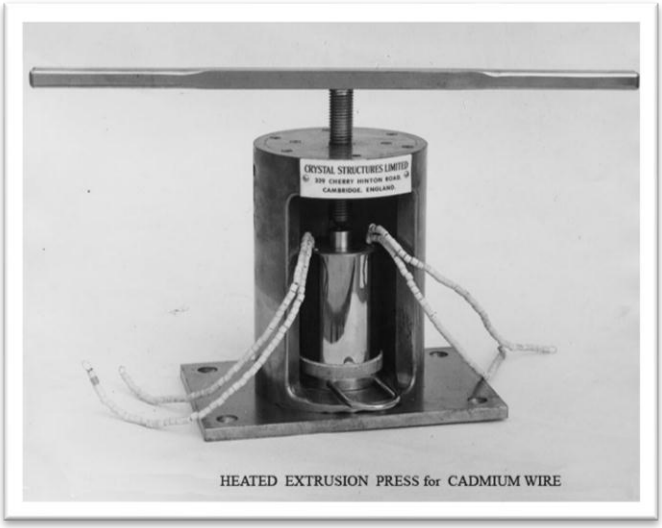


Energy is drawn from, and returned to, the driving circuit. This energy is detected and causes crackles or a hum to be audible through the loudspeaker.

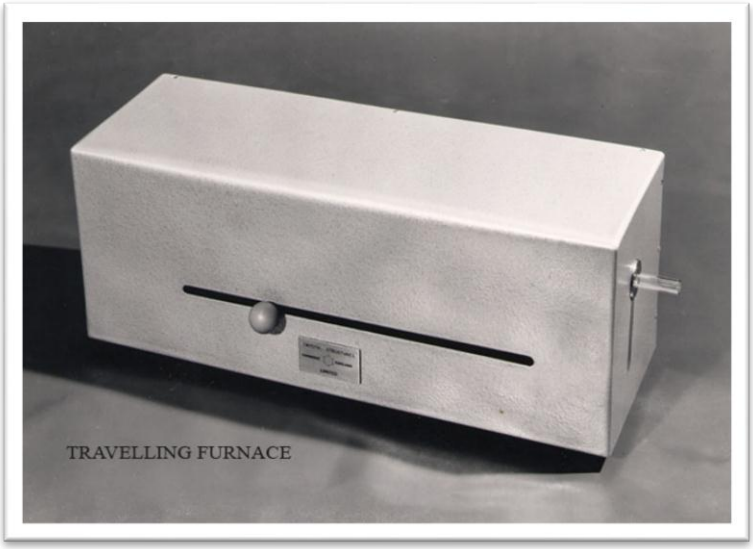
The **Thermal Conductivity** of Quartz can be sensitively measured using the Forbes Bar method. Two blocks of quartz, cut along different axes, are cemented between metal blocks having the same cross sectional dimensions and are fitted with thermocouples. Mounted in an insulated box provided with a heater and water cooling, theprincipal conductivities can be determined.



The **Thermal Expansion Coefficient** of Calcite can be measured by X-rays using the back-refection Laué technique . The crystal is mounted in a heatable chamber so that the lattice spacing can be determined at different temperatures.

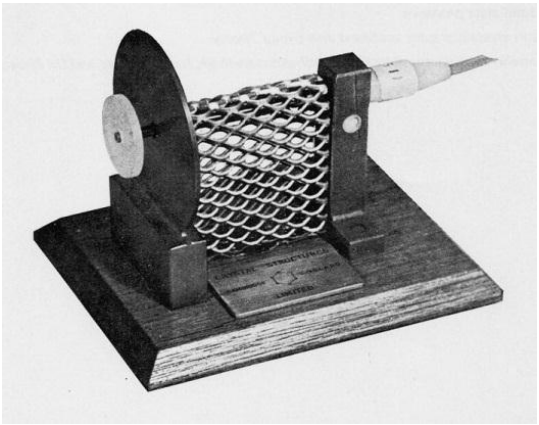


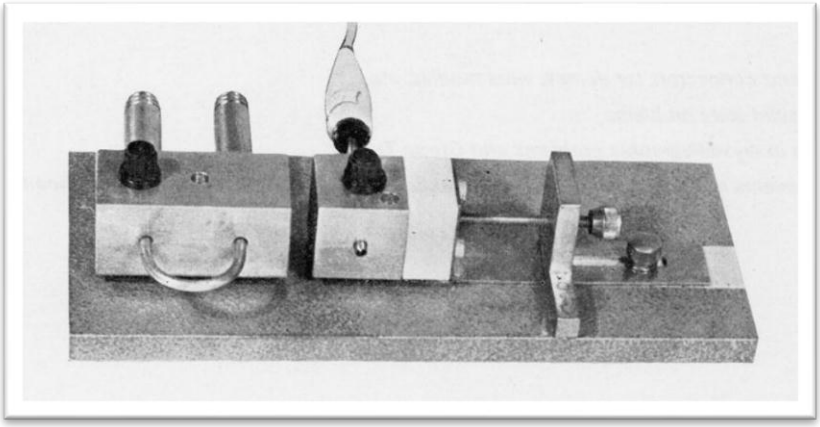
With the **Heated Extrusion Press** Cadmium Wire can be extruded and then placed in a borosilicate glass tube in the **Travelling Furnace**. By zone refining, single crystals of cadmium form in the wire.



Mounting the wire in the **Extensiometer**, the very strange stress-strain relationship displayed by cadmium single crystals can be studied. The wire crackles as the lattice planes slide over each other and produce a flat ribbon where this has occurred.

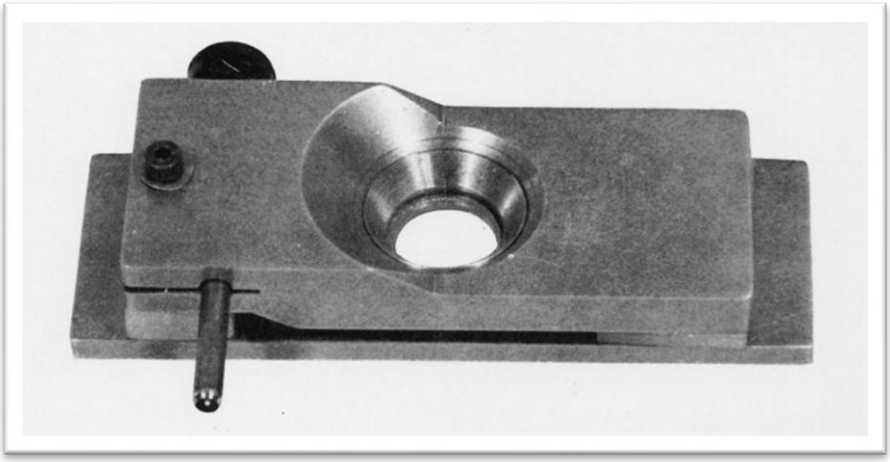
For determining **Isothermal Boundaries on a Crystal** the apparatus consists of an electrically heated rod mounted so as to project through a metal plate which acts as a radiation shield. Crystal plates of quartz and gypsum are drilled with holes of such a size that they can just fit on to the end of the rod. The crystal plates are coated with a layer of molten elaidic acid (M.P. 37^{o}C). When the crystal has cooled down to room temperature the plate is threaded on to the rod. The acid melts from the centre outwards and when the visible boundary between molten and solid wax has reached about halfway across the plate it is removed from the rod and allowed to cool. The elliptical, circular or other shape of the boundary corresponding to the 37^{o}C isothermal surface can be measured with a scale or travelling microscope. From these measurements the ratio of the principal conductivities associated with the directions in the plane of the plate can be found.



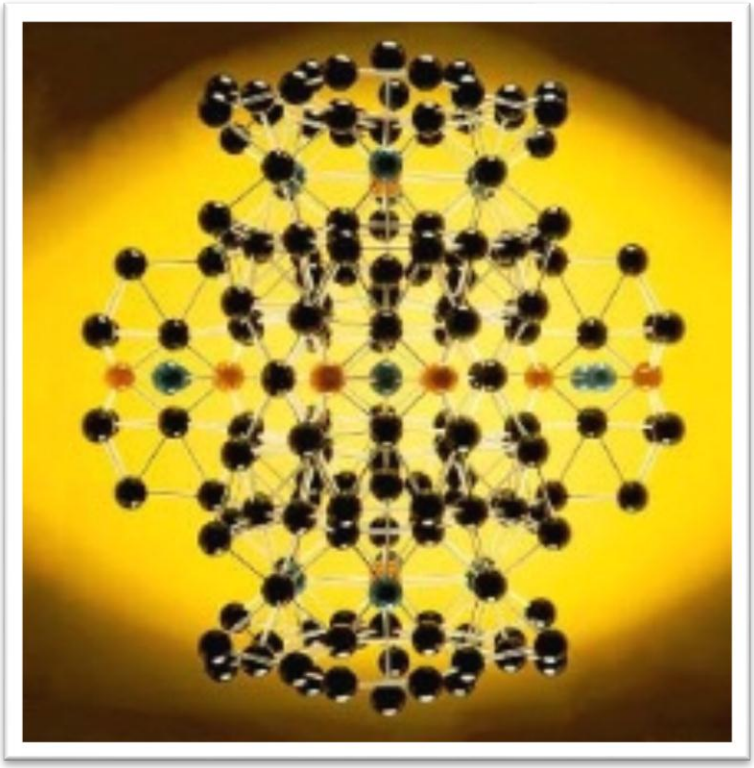


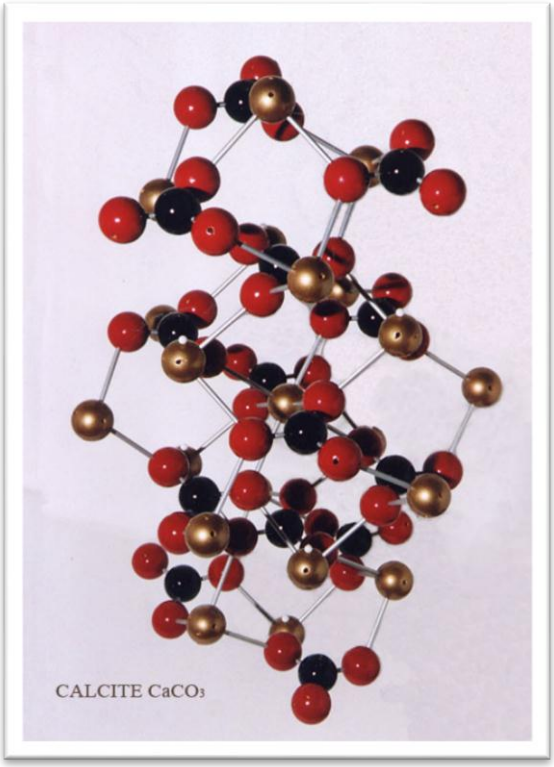
The **Thermoelectric Power** of a crystal can be determined using this apparatus which consists of two brass blocks, one heated and the other cooled. The crystal plate under test is clamped between them. A mercury-in-glass thermometer is used to measure the temperature of the blocks. Terminals are provided for connection to a potentiometer measuring the voltage between them.

Observation of a **Temperature Induced Phase Change** under a polarising microscope. Barium titanite is an example of a crystal which is tetragonal at room temperature but becomes cubic at 120°C. If a flake is viewed on a petrographic microscope in polarised light at room temperature, coloured fringes are generally visible. When the temperature is raised the colours disappear as the material becomes isotropic.



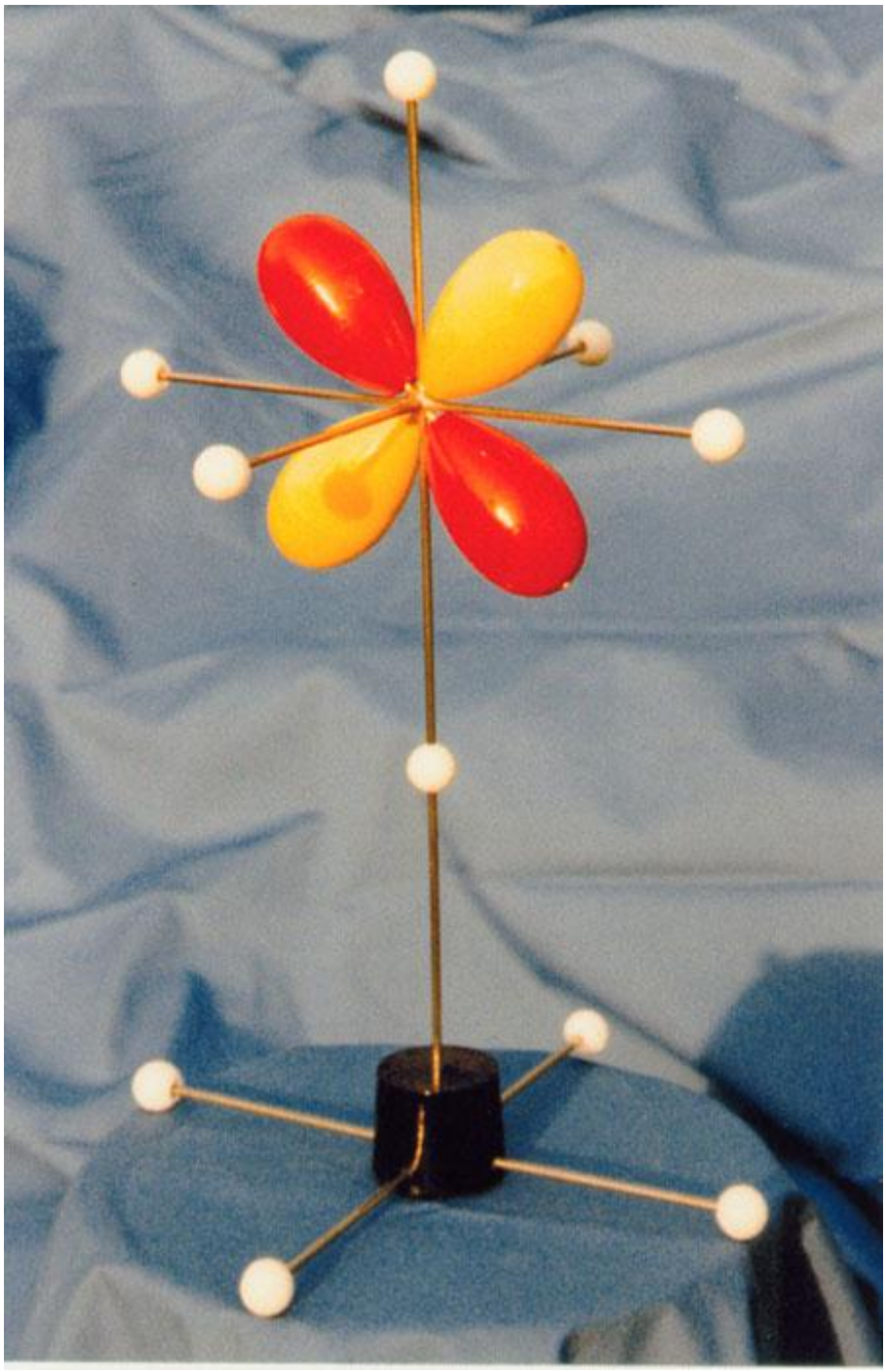
Crystal Structure Models of Neodymium Iron Boron and Calcite





Two examples of over 650 models that CSL has created

Orbital Model as an example of hollow plastic shapes we made the dies for and injection moulded in polystyrene.



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