DEPARTMENT OF MINES AND TECHNICAL SURVEYS
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EXCITED X-RAYS IDENTIFY MINERALS AS ORE MOVES DOWN CONVEYOR BELT

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Excited X-rays identify minerals as ore moves down conveyor belt

Electrons from Beta radiation excite characteristic X-rays to reveal presence of minerals. High atomic number works best

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In mining three principal types of operations are performed: procuring and handling of materials; sorting of valuable material from waste products; and changing of the chemical form of the material.

When an ore is mined, the barren rock has to be separated from the desired mineral and this is generally done after crushing. Presorting the ore is desirable because waste material can be discarded before milling and crushing.

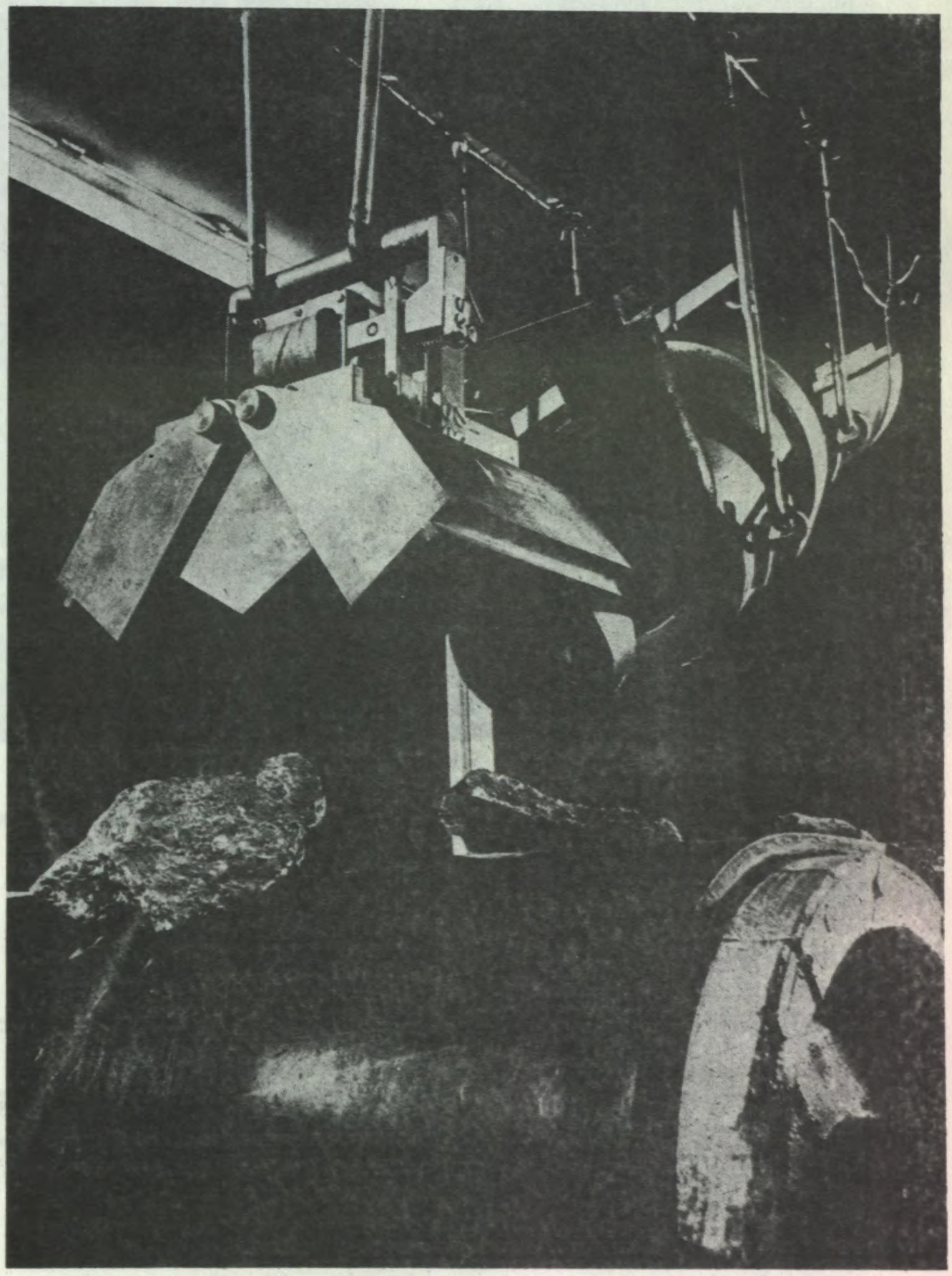
In the uranium mining industry, the presence of uranium ore can be detected through its natural radioactivity but there are few techniques which allow detection of non-radioactive elements. An electronic ore-sorting system using X-ray fluorescence has been developed at the Department of Mines and Technical Surveys, Ottawa, to allow the extension of sorting techniques to other minerals.

This system operates on ore sizes from 2 to 10 inches. Rejection of waste material before much effort has been spent in processing means that for a given grinding capacity and reagent quantity, a greater output of final product can be obtained.

How it works

This system detects the mineral by exciting characteristic X-rays of the element present, with beta radiation (electrons) from a strontium - 90 source. These electrons interact with the ore in a variety of ways; they may be elastically or inelastically scattered, they may cause Bremsstrahlung, or they may excite X-rays characteristic of the elements present in the sample (Fig. 1).

The composite spectrum is collimated by collimator A (Fig. 2) and passes through permanent magnet M. This deflects any charged particles (electrons) in the beam. The electromagnetic radiation passes through col-



Solenoids on top of strontium 90 source holder close doors automatically to protect operators if primary power fails. Castle cuts radiation to safe level limator B into the proportional counter, and the resulting X-ray spectrum is analyzed using a single-channel analyzer. When X-rays of an energy corresponding to the desired element are detected, they are amassed in a conventional counting system. If this total exceeds a certain preset value, the piece is routed for further processing. If the characteristic X-rays of the element searched for are not found, the rock is rotated and another face is scanned. Three such passes are made, and if at the end of these passes the desired element has not been detected, the rock is rejected as waste.

Fail-safe castle protects workers

Radiation used for this system comes from a 200-millicurie (7.4 x 10^9 disintegration per second) strontium-90 source. This radioactivity is dangerous, and extensive precautions have been taken to ensure that the radioactivity is confined, especially in emergency situations. The strontium-90 source consists of a ceramic-like material, strontium titanate, which is embedded in a silver matrix. This was supplied by the Radiochemical Centre of Amersham, England.

The source is retained behind a screen secured in the lead castle. Two doors of the castle, held open by bars, close automatically under gravity when the bars are raised by 2 solenoids on top of the castle. The bars then drop down and lock the doors shut.

Fig. 3 is a circuit diagram of the control unit for this castle. The solenoid driver is a fail-safe system. In the event of a power failure or the failure of the fused fire link in the power line, a relay shorts the capacitors across the solenoids, thus closing the doors. The voltage applied to the solenoids is a pulse of amplitude twice their normal operating voltage to generate an extremely high mechanical impulse. This system has worked reliably in many tests. The radiation close to the castle with the doors closed is 1/100 of the tolerance dose, and is barely detectable using conventional monitors at a distance of 3 ft from the castle.

Detection system

The detection system uses a proportional counter, (which has the advantage of a relatively good resolution at low energies), a single-channel pulse-height analyzer and a count-rate meter. The single-channel analyzer is set to accept the appropriate X-ray energy. When the input counting rate in the energy window exceeds a preset value, the trip meter actuates a solenoid valve, which transfers the material for further processing. As long as the counting rate does not ex-

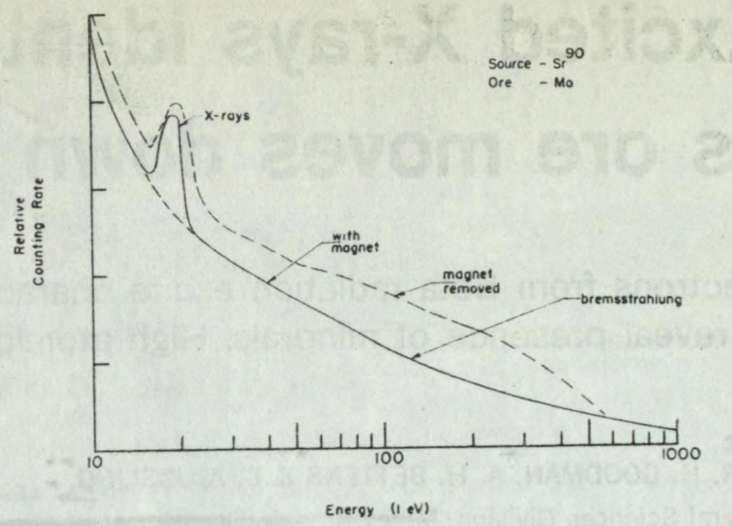


Fig. 1. Pulse height spectrum of molybdenum ore excited by Sr^{90} beta rays

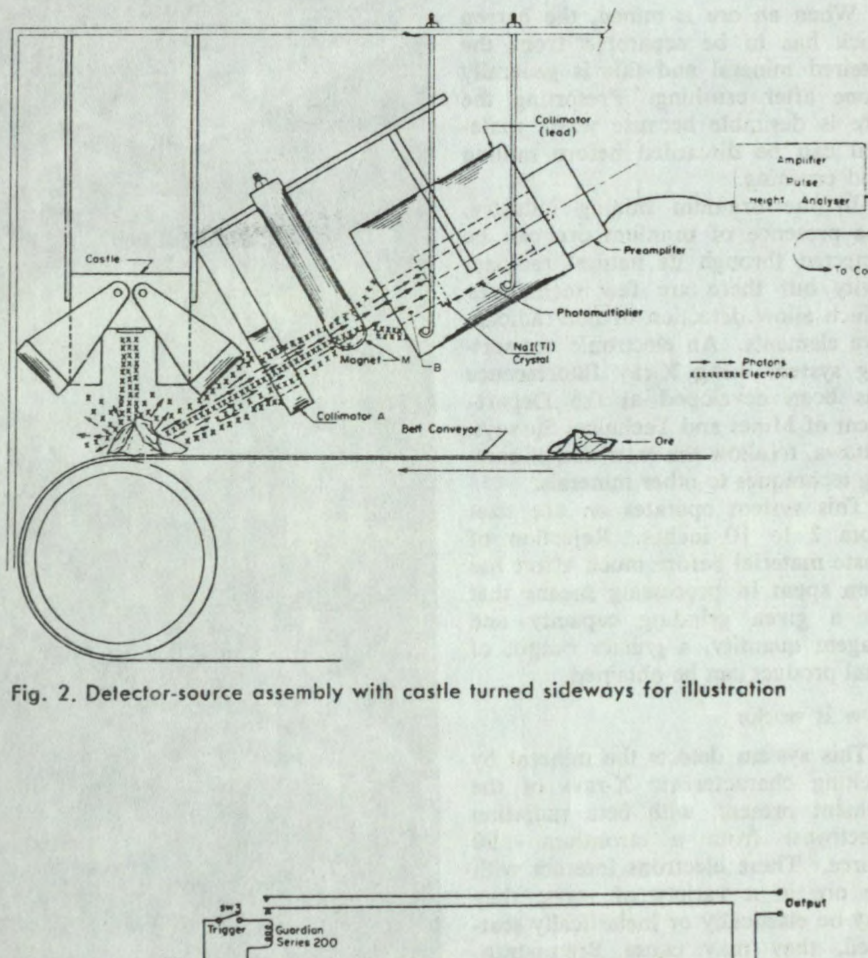


Fig. 2. Detector-source assembly with castle turned sideways for illustration

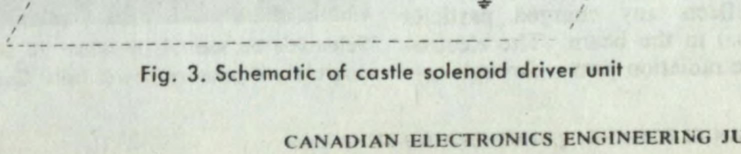
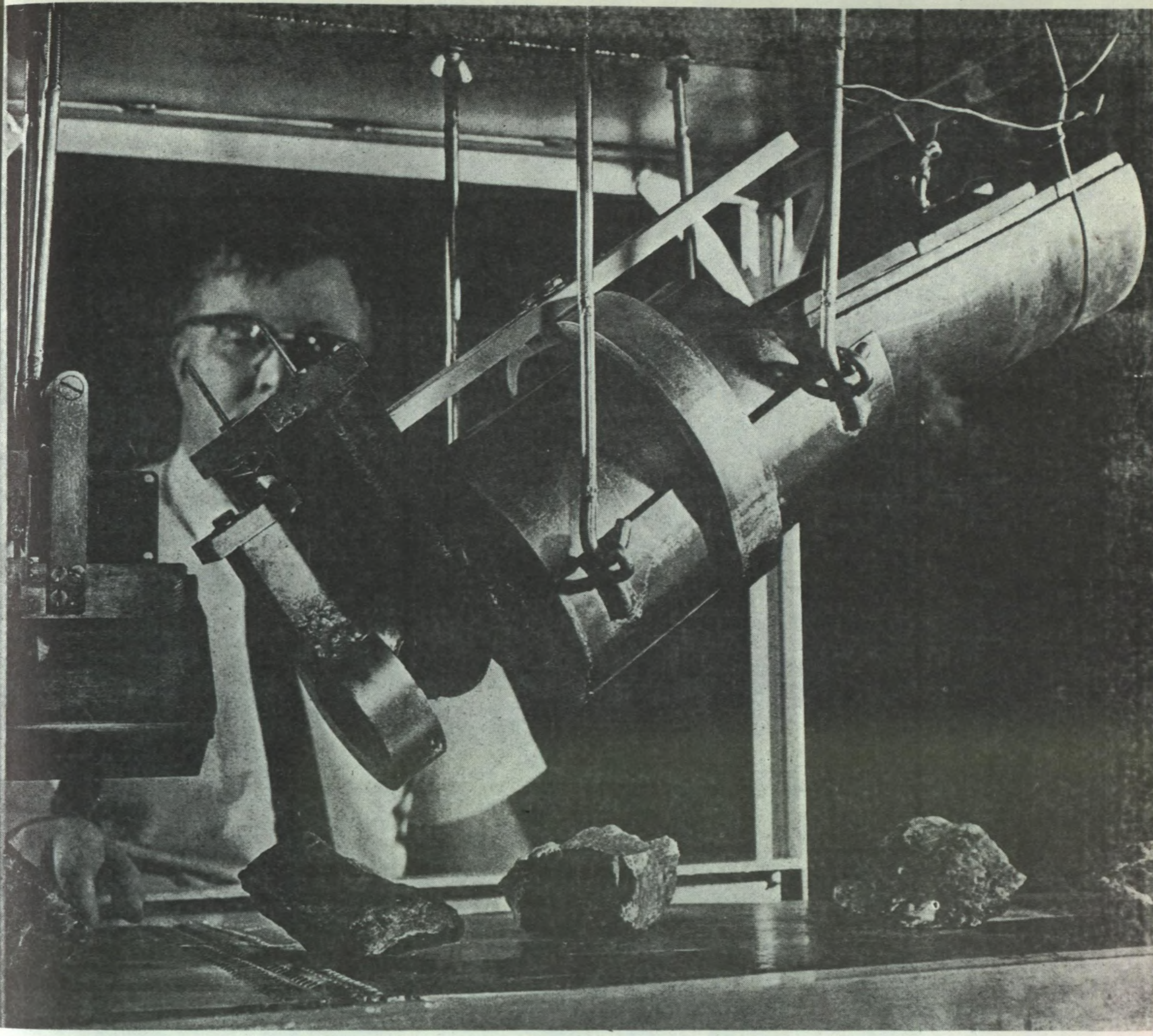


Fig. 3. Schematic of castle solenoid driver unit



ceed this predetermined level the material is rejected. A lower level trip point is used to ring an alarm if the castle closes.

When to use an ore sorter

For this system to have economic advantage, the material to be sorted must possess certain characteristics. The desired mineral should occur in localized quantities interspersed in the rock. The pieces of ore to be sorted should have a high surface concentration of the desired mineral, since the X-rays do not penetrate more than a few millimetres below the surface. This type of ore sorter, therefore, is not useful for a disseminated ore. There is a practical range of concentration of ore where this system becomes useful since, for a high-grade ore, it is more economical to process the entire output of the mining operation. The usefulness of this sorter has been demonstrated for ores of arsenic, selenium, molybdenum, niobium, caesium, tungsten and lead. Ores containing elements of atomic number less than 36 cannot be detected easily. This lower limit is set because of the absorption of the characteristic X-rays by the air between the sample and the detector. Detection becomes easier as the atomic number increases.

Speed of operation of the system is such that each piece requires at least 1/10th of a second to pass under the detector. To increase the capacity of this system a number of sorters may be operated in parallel.

Detector (right) and source (left) assembly for electronic ore sorter. Equipment works best with ores containing elements of high atomic number