ICANS-XI International Collaboration on Advanced Neutron Sources
KEK, Tsukuba, October 22-26, 1990

Shutter System for the SINQ Neutron Guides

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ABSTRACT

Viewing the liquid D_2 cold moderator of the spallation source SINQ, a neutron guide system will be provided to achieve an efficient transport of subthermal neutrons to the instruments in the remote experimental hall. Four separate neutron guides are forseen, with an option for a fifth one to be installed in future. The concept of guide shielding and performance includes a set of shutters, situated at the outside of the main target shielding, with the dual purpose of shielding the radiation from the target and inner shielding in the closed position and guiding the neutron beam in the open position. This latter function imposes strict requirements on alignment accuracy and mechanical stability while the necessity of shielding high energy neutrons from the spallation target implies the use of bulky shielding. The technical concept elaborated to fulfill these requirements is presented.

I INTRODUCTION

One of the significant features of the SINQ spallation source is a large liquid D_2 cold source which, due to an optimum position near the flux maximum in the heavy water moderator, will provide a cold neutron flux which is comparable to most medium flux reactors /1, 2/. Initially four neutron guides with large cross-section (120 x 50 mm^2) are planned which start in the main shielding at a distance of 1.5 m from the source. Additionally an option has been retained in the design of the system, in particular the in-shielding part, to install a fifth guide at a later stage. Moreover promising results in the development of high quality multilayers at PSI /3/ and elsewhere make us confident that high divergence coatings will enable us to optimize the guide system for high transmission even at relatively short wavelengths. This requirement together with the desire to retain large cross-section beams leads to rather long line of sight lengths, which may to some extent be reduced by the use of channelled guides /4/, and necessitates the installation of beam shutters which are capable of stopping the small but problematic flux of high energy neutrons leaving the target. At SINQ two such shutters (each one serving two guides) will be situated at the outside of the main shielding, Fig. 1., in a heavily shielded enclosure. Because of the restricted space available, and the possibility of installing a fifth guide and shutter at a later date, the shutters operate by rotation about a horizontal axis perpendicular to the guide axis.

In addition to functioning as a high energy neutron beam stop the shutter system must fulfill certain other requirements:

- In the open position maximal transmission of neutrons must be assured so that the shutter comprises a section of guide which must be aligned to within the nominal tolerances (0.01 mm) of the subsequent system leaving a minimum gap between successive sections and taking into account thermal distortions.
- Due to the fragility of the glass guide section and the required alignment accuracy opening and closing of the shutter must be carried out in a controlled manner to prevent shocks. In the present design the closing/opening time is of the order of 3 minutes.
- The shutter must close automatically under conditions of power or compressed air failure or when access is attempted into radiation controlled areas of the guide system. For this latter purpose end position indicators are branched into a security system.
- The shutter will remain under vacuum to reduce neutron flux losses.

All the above requirements have been integrated into the detailed technical concept elaborated in the next section.

II TECHNICAL CONCEPT

2.1 Mechanical construction

As shown in Fig. 2 the main component of the shutter is a large drum, 1880 mm in diameter and 700 mm wide, weighing 16 tons which, for ease of construction, is made up in two parts which have been stepped to prevent gaps in the shielding. The material for the drum has been selected according to the requirement of minimum Co (< 0.01 %) and Cr (< 0.8 %) content, which may be guaranteed by suppliers, and depending on cost estimates will be either Steel St 37-2 or cast iron.

Two, 2 m long guide sections separated by an angle of 2 degrees will be pre-aligned in a boral jacketed, aluminium housing which is in turn mounted on three adjustable supports within the drum. The shutter housing is essentially in the form of a flat, hollow cylinder, 2080 mm in diameter, made up of 25 mm thick steel walls to which a 50 mm thick plate is welded on one side and a similar coverplate is mounted with vacuum flange on the other side. The shielding drum turns on two precision bearings mounted in the centres of these two plates.

Taking into account the desirability of reducing to a minimum the gaps between successive sections of guide, the simplest solution for introducing the guide sections immediately preceeding and following those in the drum is to align them directly in extensions mounted on the shutter housing as shown in Fig. 2. Furthermore the ends of these connecting guide sections and those of the sections mounted in the drum will be cut in the form of an arc centred on the axis of rotation of the drum. In this way the gap between successive reflecting sections can be reduced to 2 mm. The complete shutter is mounted by means of three adjustable supports onto a positioning trolley which runs on a rail system allowing the whole system to be rolled away from the main shielding prior to removal by means of the lifting rings mounted on top of the housing. The rails are mounted on a steel ground plate which is underlayed with cement for correct alignment and the positioning accuracy of the trolley in the forward position is guaranteed by a reference pin. The total weight of the shutter system is 20 tons.

2.2 Drive system

Closing the shutter involves turning the shielding drum by 90 degrees thus bringing the guides into the vertical position. This is achieved by means of a large oil filled hydraulic cylinder operating on a rack and spur gear mounted on the side of the shutter housing.

Although compressed air is readily available at PSI, the tendency for vibration in a compressed air drive system makes it unsuitable for the precison and control required in the present application. Thus we have chosen to use a hydraulic medium transformer (compressed air/oil) which guarantees a slow and controlled rotation in both directions. The rotation speed can be adjusted by means of a throttle valve as indicated in Fig. 3.

The end positions are defined by contact of a cam on the shutter housing cover plate which comprises a shock absorber ensuring a gradual decrease of the rotation speed as the end positions are approached. In addition the accurate rotation of the drum is aided by a guide bearing mounted on the housing and running in a channel on the outer edge of the drum. This channel is so positioned to provide the necessary asymmetry in the drum which causes it to close automatically under loss of power or compressed air.

2.3 Adjustment of the guide elements.

The guides in the aluminium housing will be pre-aligned by the manufacturer before introduction into the drum. The horizontal alignment is guaranteed by the wedge shaped form of the housing itself while the vertical adjustment is achieved by means of the three adjustable supports and facilitated by the provision of reference surfaces and pins on the outside of the shutter housing. In a similar way the connecting guide sections in the extension mountings may be adjusted to match the prealigned sections in the drum. Finally the entire shutter may be aligned with respect to the rest of the guide system by means of the three large adjustable supports on the positioning trolley.

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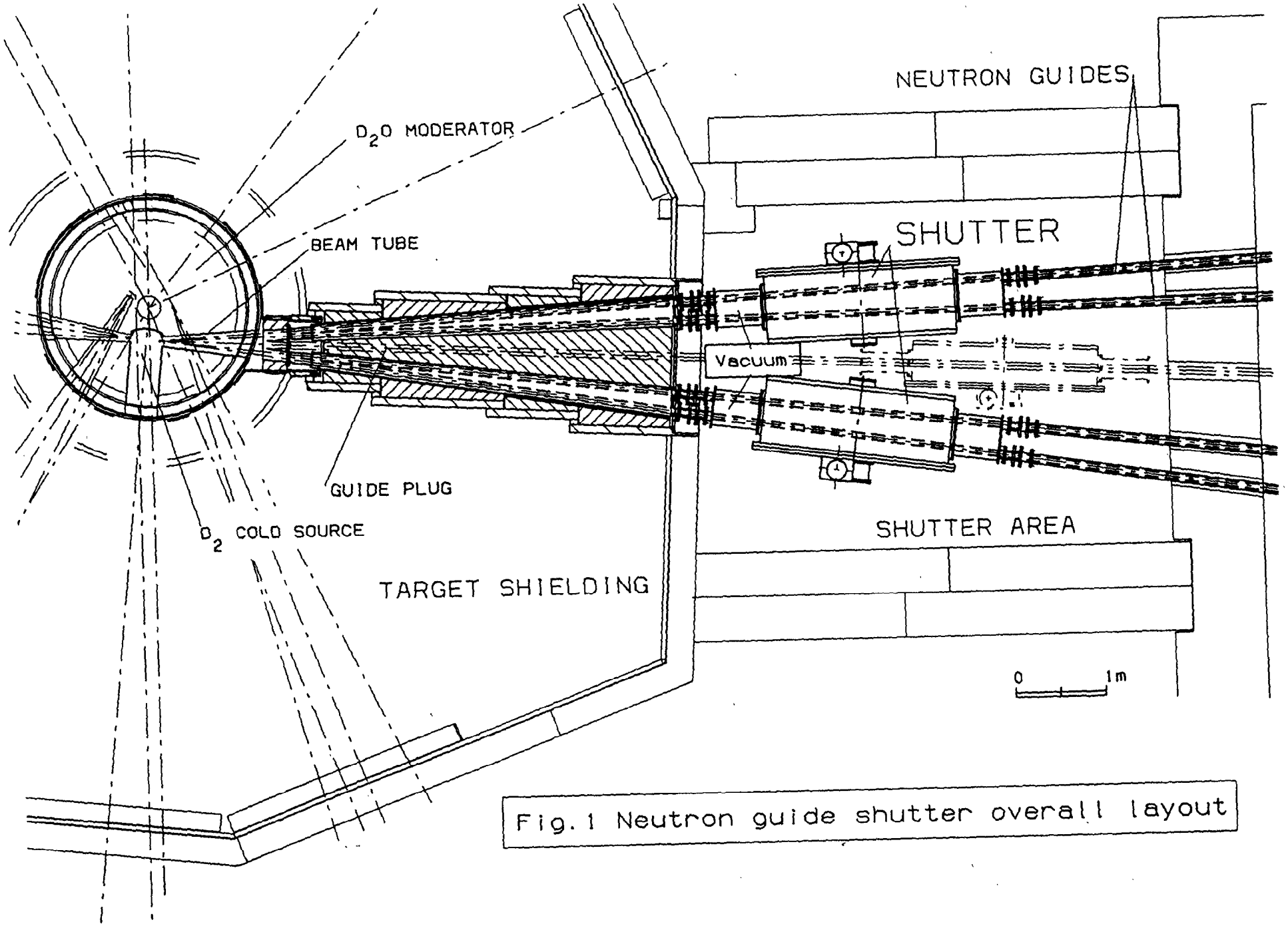

Fig. 1 Neutron guide shutter overall layout

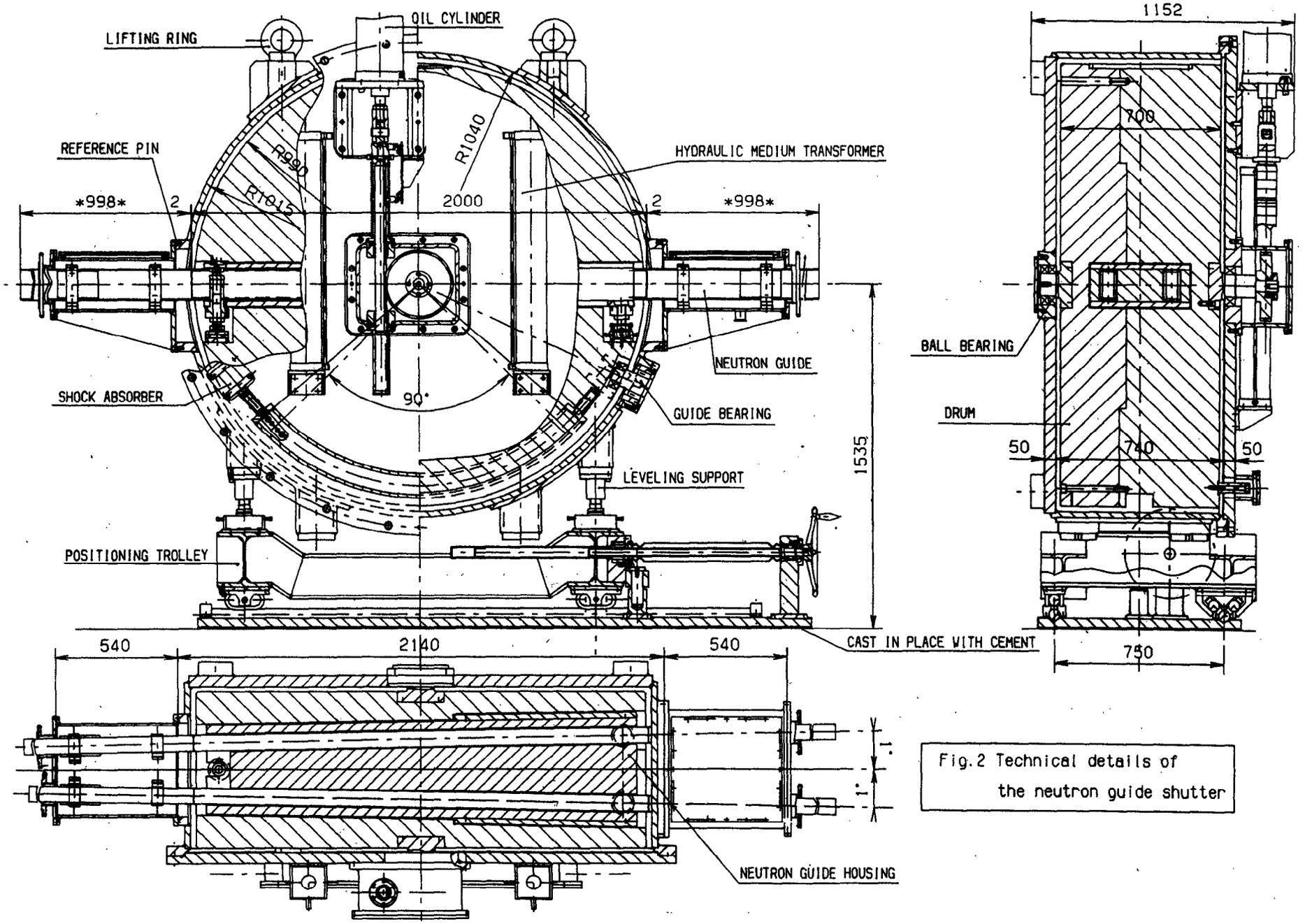

Fig.2 Technical details of the neutron guide shutter

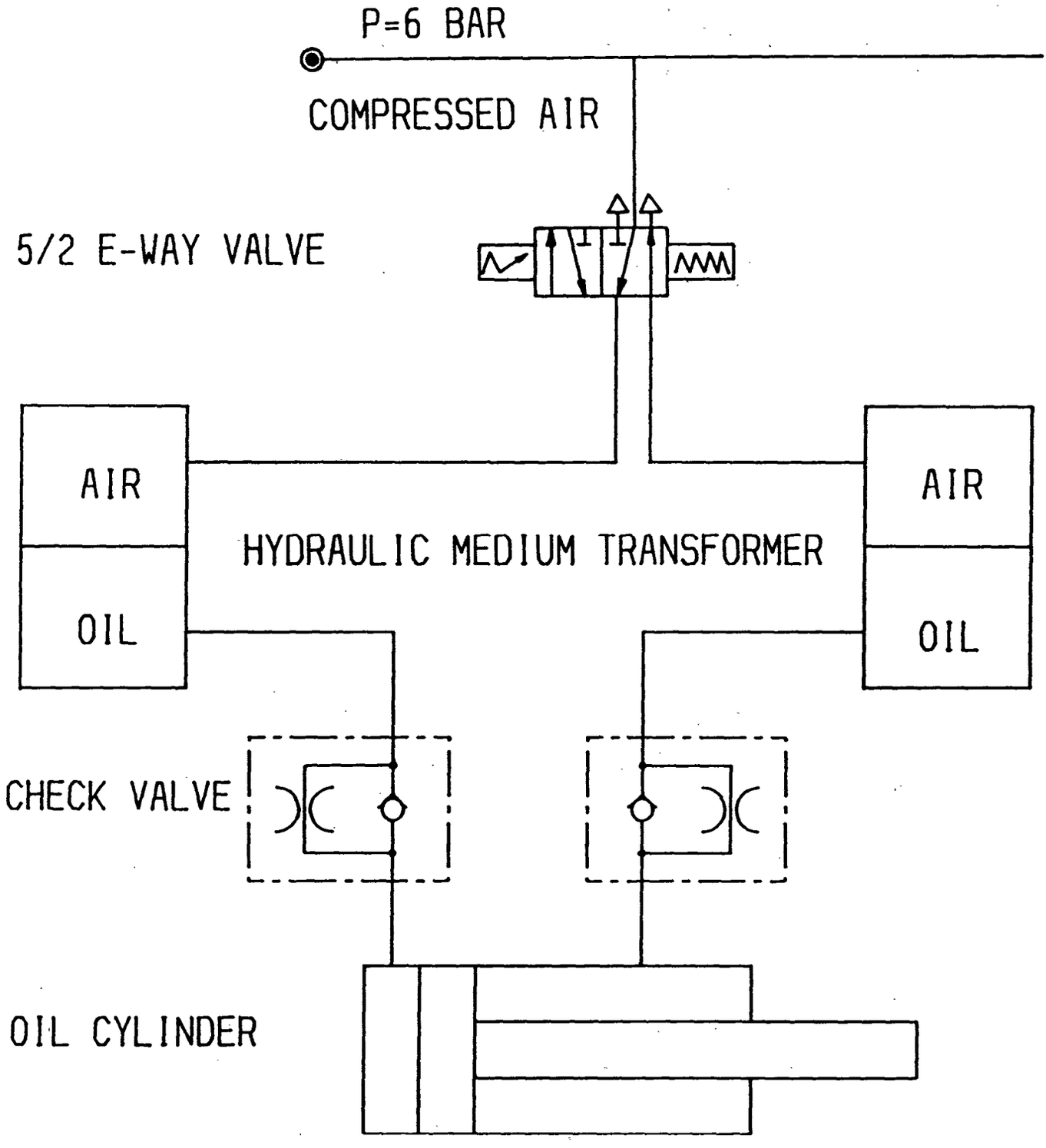

Fig.3 Schematic of the shutter drive system

Q(I.M.Thorson): Are the shutters certainly necessary? For what? What is their cost?

A(W.Wagner): The shutters may not be absolutely necessary , but they certainly are helpful. They allow modifications at the neutron guides, e.g. at the instrumental position, with the target in operation, and fast and easy access to the neutron guide shielding bunker after the target is shut down. The estimated cost is about 800 kFr.