L.H.M.A.

TEC/39.3619/10/ACD/fq

April 21th, 1981

20th PLENARY MEETING OF THE WORKING GROUP
"HOT CELLS AND REMOTE HANDLING"

at Karlsruhe

May, 1981

NUCLEAR STEREOMACROSCOPE

A.C. DEMILDT G.J. FOLENS[(x)]

(x) Research and Development
L.E.T. Vaartstraat 20, B9800 Deinze, Belgium
Docent at "Hoger Instituut De Nayer" 2800 Mechelen, Belgium.

TABLE OF CONTENTS

Abstract

Non-destructive examination of irradiated fuel pins requires detailed visual inspection and photographic documentation for photogrammetric measurements.

For those purposes a shielded stereomacroscope has been developed and constructed in such a way that it can be installed in an adequate orifice of the walls of a concrete - or lead-shielded hot cell.

1. Introduction

In order to evaluate the quality of cladding and fuel of different kinds of fuel pins, developed in view of nuclear power reactor use, reaching high burn-up values, the stereo visual observation and stereophoto documentation are necessary tools allowing further destructive examination and analysis. These permit to locate the areas where crud sampling has to be performed and where samples have to be marked for later cutting. The stereophotographic documentation permits to measure, by triangulation, the thickness of crud deposition and of cracks formed in the outer surface of the cladding during irradiation.

2. General description

The stereomacroscope is an optical instrument which permits the user to create both visual and photographic stereo images of strongly radioactive samples, such as fuel pins with high burn-up (70,000 MWd/t) and short cooling time (180 days). This macroscope, designed for a large hot cell with a wall thickness of 1 metre is gas-tight at the radioactive side. It fits in a step-shaped tube fixed in the hot cell wall (Fig. 1A). The hermetical seal (α- or gas-tightness) with respect to the hot cell atmosphere is assured by 2 barriers :

1. an inflatable rubber joint mounted around the opening of the step-shaped tube, at the inner wall of the hot cell ;
2. a large plastic ring around the macroscope at the front wall of the hot cell to fit a plastic bag when the instrument has to be discarded from the cell.

Three lead discs, mounted inside the optical device as gamma-ray shielding, protect the users against radiation during the observations.
The instrument has a fixed-focus distance of 144 mm below the mechanical axis of the macroscope. The zoom system providing for the change in magnification is electronically adjustable between 3.5 and 28 times.

All optical components (lenses and prisms) are made of stabilized glass in order to prevent fast darkening due to gamma radiation ; they guarantee an image of high resolution, substantially free of spherical and chromatic aberrations. Only the eyepieces, some prisms and the photographic parts consist of classical optical quality glass.

3. Physical and mechanical characteristics

The stereomacroscope is composed of a horizontal and a vertical section. The horizontal part, with a length of 1.4 m, consists of a stainless steel tube in which the different optical and mechanical parts with their holders and blocking parts are located.
The main parts are : the input window, the deflection mirror, the objective lens system, the relay systems with the electronic zoom and the lead protection (Fig. 1A). The mechanical parts are all made of a cast aluminium alloy, which is blackened by anodization. The input window and the deflection mirror are fixed in the head of the stereomacroscope, which is fixed to the horizontal tube with a fitting piece and sealed with an O-ring. The objective lens can be moved by an electric motor over a distance of 30 mm. The lenses of the zoom system are driven by two ball-bearing screwed spindles. The lens holders themselves are supported by high-class ball-bushings. The ball-bearing screwed spindles as well as the slide-bearing spindles are made of tempered steel. The complete zoom system is mounted in a rigid frame.
Three different discs of lead shielding with a total length of 250 mm are fitted into the horizontal section of the instrument.
A flange with a locking mechanism is located at the end of the horizontal tube. This mechanism allows the stereomacroscope to be fixed to the wall of the hot cell and to be moved horizontally over a distance of 10 mm.

The vertical part of the stereomacroscope is the external part at the operator side of the instrument. It consists of a housing made of cast aluminium alloy. This housing contains different deflection prisms and lenses mounted in their holders. Besides the optical components it contains the encoders, the motors for the zoom drive unit and the shutters of the stereophoto camera.

The eyepieces, the photo plate, the operating panel with the control switch knobs and the plug for the electronic processor are located outside the housing (Fig. 1B).
The eyepieces are mounted under an angle of 45°. Their interpupillary distance can be varied between 56 and 76 mm. They are adjustable between +5 and -5 dioptre.

4. Optical characteristics

The function of the stereomacroscope is to do a stereoscopic visual inspection as well as to take stereophotos of fuel pins at a fixed distance (144 mm) below the mechanical axis of the instrument.
As it is well known, normal optical glass darkens when exposed to γ-radiation during a limited time lapse. Therefore it has been judged necessary to construct the different optical components of the instrument (window, lenses and prisms) using stabilized glasses. The addition of small amounts of CeO_2 (1.2%) to the molten glass bath during glass production results in a decrease of darkening effect due to gamma-ray exposure.

The optical instrument itself consists of two identical parallel channels, whose axes are mounted horizontally at 35 mm from each other. The optical lay-out of one of these channels is shown in Fig. 2. The large objective lens transmits the information from the object into both channels where a first stereo image is formed at position A. The position of the object (144 mm) and the distance between the two channels determine the stereo angle of the stereomacroscope which is about 6°. With a forward or backward displacement of the objective lens, one can focus on the fuel pin within a range of about 15 mm.

From positions A the image information of both channels is transferred to positions B with the aid of several relay systems in each channel. A zoom system added to one of these relay systems in each channel enables to change the magnification of the image (Figs 2 and 3).

The zoom system is built up by a positive (L_2) and a negative (L_1) lens. Their relative positions for some magnifications (3.5-7-14-28 X) are schematically represented in Fig. 2. The co-ordinated movement of these lenses is controlled electronically.

From positions B the image information is transferred via two beam splitters (BS) and two pair relay systems to positions C and D. Some prisms are added to this part of the system to correct the image orientation and to increase the initial distance between the two stereochannels up to the human inter-pupillary distance.

One can look at the images formed at positions C with the aid of the 7 X Ramsden eyepieces (OC). The field of view of this eyepieces is 30° and the true field of view of the stereomacroscope varies between 8.5° and 1° depending on the magnification chosen.

At position D the images of both channels are projected simultaneously on a 13 X 18 photo plate (PHOT) (Fig. 3). The magnification of the image upon the photo plate varies between 0.5 and 4 X while the field of view varies between 8.5 degrees and 1 degree. The difference in enlargement in both channels is not more than 2.5% for each enlargement and the deviation from parallelism is not more than 2 degrees. The resolution of the instrument is never less than 20 seconds of arc.

5. Electronic characteristics

The electronic processor (Fig. 4) controls the zoom system of the macroscope, the shutter time of the photographic system, the displacement of the objective lens and the display of the photo as well as the eyepiece magnification.

As mentioned in sections 3 and 4, the zoom effect of the stereomacroscope is obtained by changing the positions of two lens systems. These two longitudinal displacements are obtained by two ball-bearing screwed spindles. Two motors drive the two spindles which are mechanically coupled with an absolute digital encoder. The longitudinal positions are thus translated into a digital code.

The memory unit of the electronic control system is programmed with sixty positions for each of the two lens systems. These programmed positions, each at a well-determined address in the memory, can be selected through an up/down counter operated by a zoom min/max control switch (Fig. 1B). Having selected a certain address, which means a certain magnification, the memory content is compared to the actual encoder positions. Both motors are then driven in either one or the other direction until the memory content of the chosen address and the information of the encoders are equal. The motor speed is automatically controlled in order to prevent oscillations of the system. At each address of the memory, the values of the eyepiece magnification and the photo plate magnification are also stored. This information is displayed when the corresponding address is selected.

Conclusions

The instrument as it is constructed (Fig. 5) fits very well the scientific and technical needs as a stereomacroscope for studying highly radioactive samples, especially the cladding of irradiated fuel pins. Table 1 summarizes its major characteristics. From the practical point of view, it is a very versatile instrument as it can be used simultaneously as a stereoviewing and stereophotographic instrument. The "continuous" changeable enlargement factor, realized with the electronic steered zoom system, enables the experimenters to isolate very specifically the largest possible images of those parts of the object under study which seem to be of interest. The quality of the stereophotographic pictures can be judged in Fig. 6.

Acknowledgement

The authors are indebted to J. Van de Velde, A. Gys and C. Van Loon of S.C.K./C.E.N. at Mol and to M. Van den Berghe and S. Walravens of L.E.T. at Deinze for their valuable scientific and technical advice and support.

Table 1

Characteristics	Dimensions and qualifications
Total physical length of the instrument :	1800 mm
Mass (lead charged) :	170 kg
Length of optical paths :	
viewing :	1885 mm
photographic :	1897 mm
Optical glass :	gamma radiation stabilized glass
Magnification :	
through the ocular :	between 3.5 and 28 times
on the photo plate :	between 0.5 and 4 times
Light intensity needed :	minimum 1500 lux
Field of view :	from 1° to 8.5°
Interpupillary distance :	between 56 and 76 mm
Diopter setting :	between -5 and +5D
Deviation from parallelism :	less than 2°
Resolution of the instrument :	20 seconds of arc

FIGURE CAPTIONS

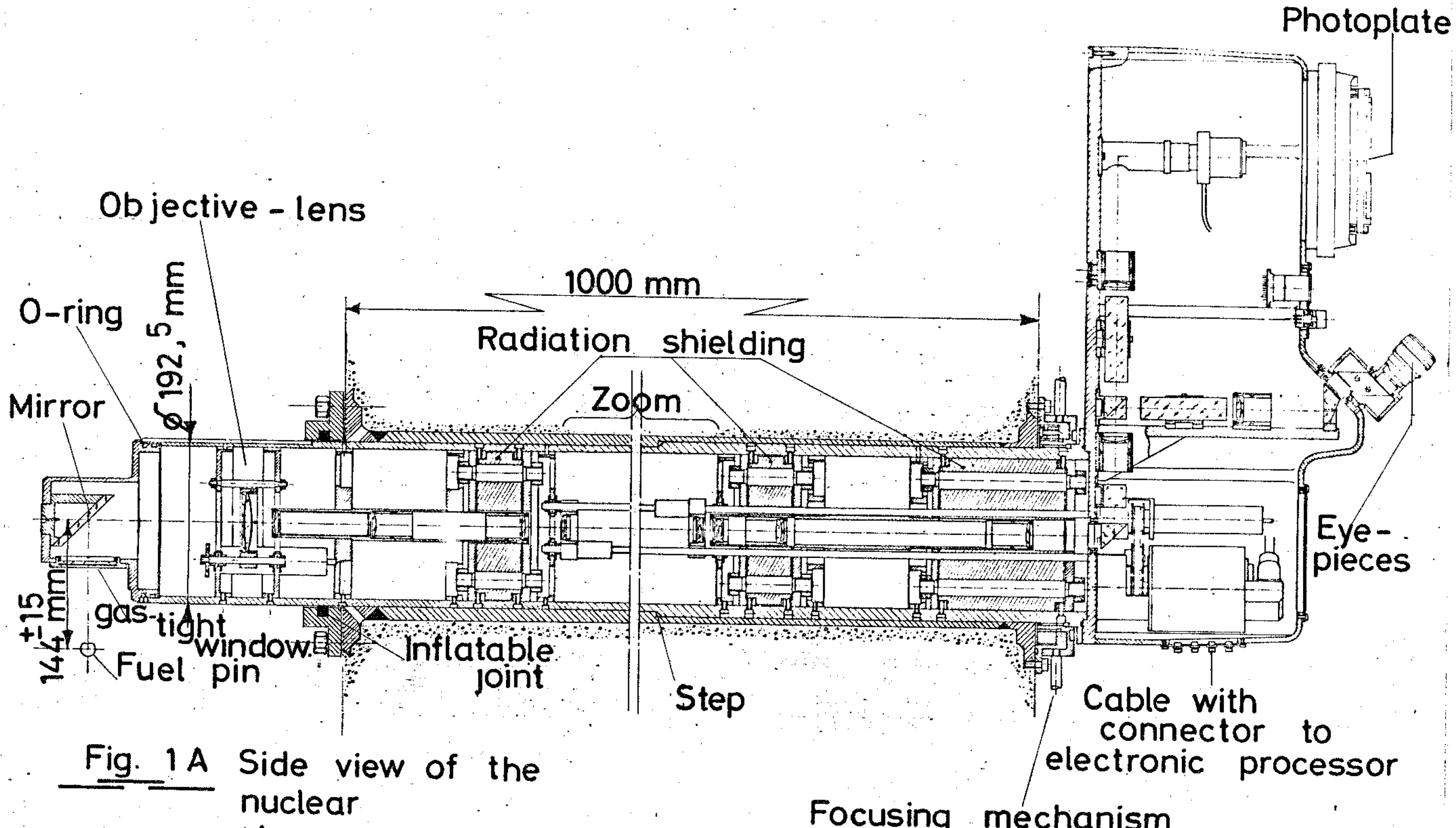


Fig. 1A Side view of the nuclear stereomacroscope.

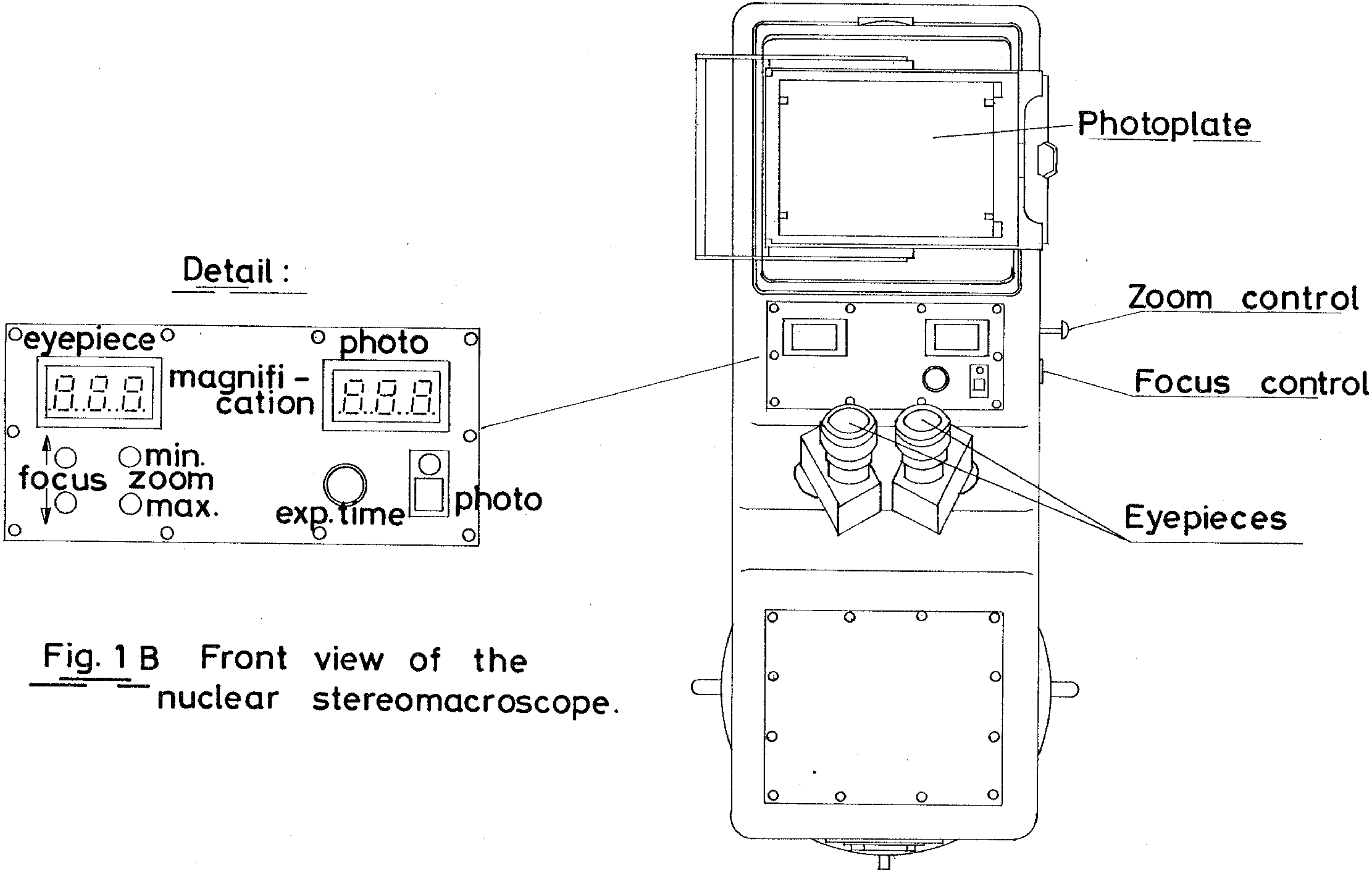


Fig. 1 B Front view of the nuclear stereomacroscope.

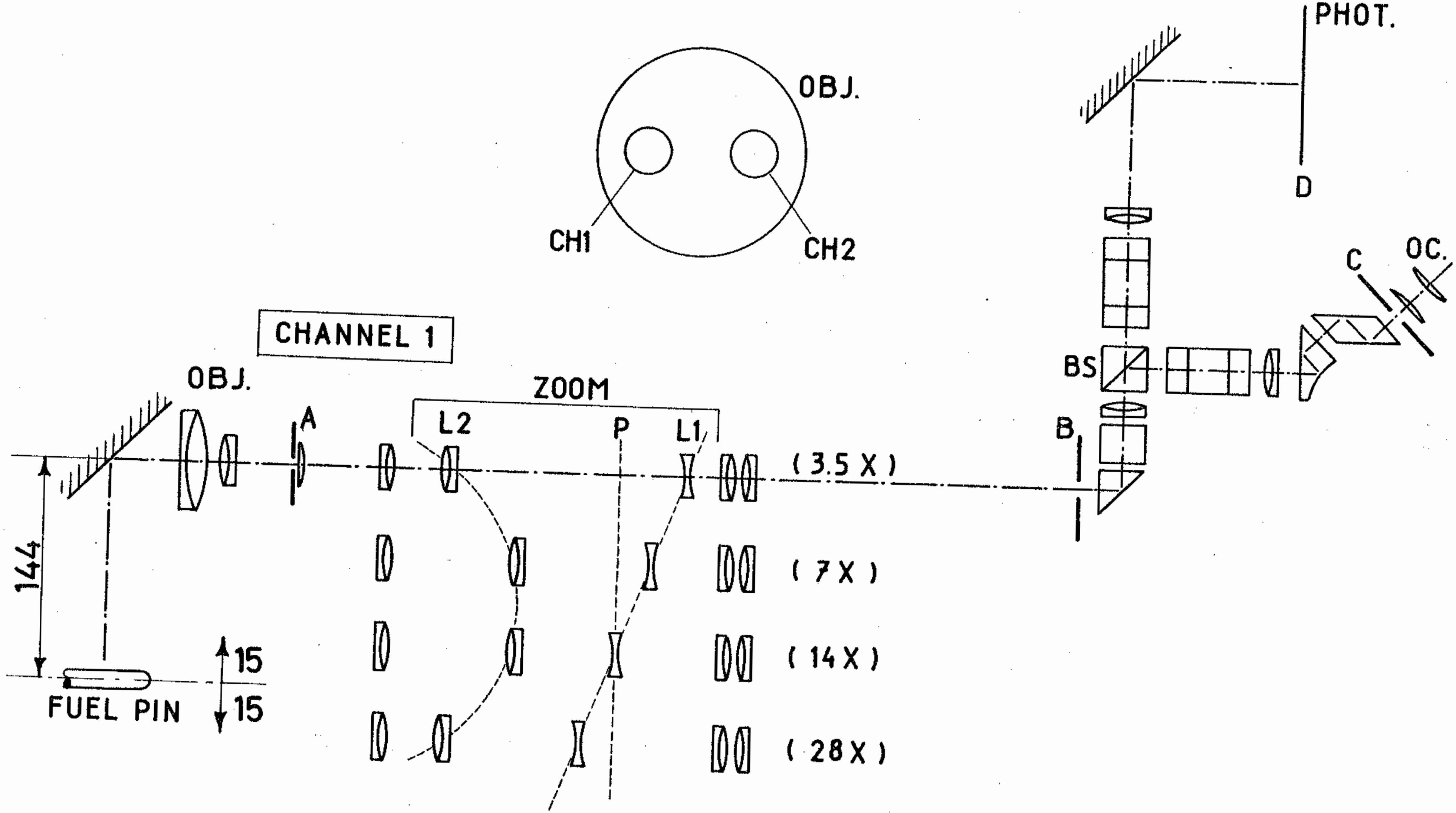


Fig. 2. Optical lay-out

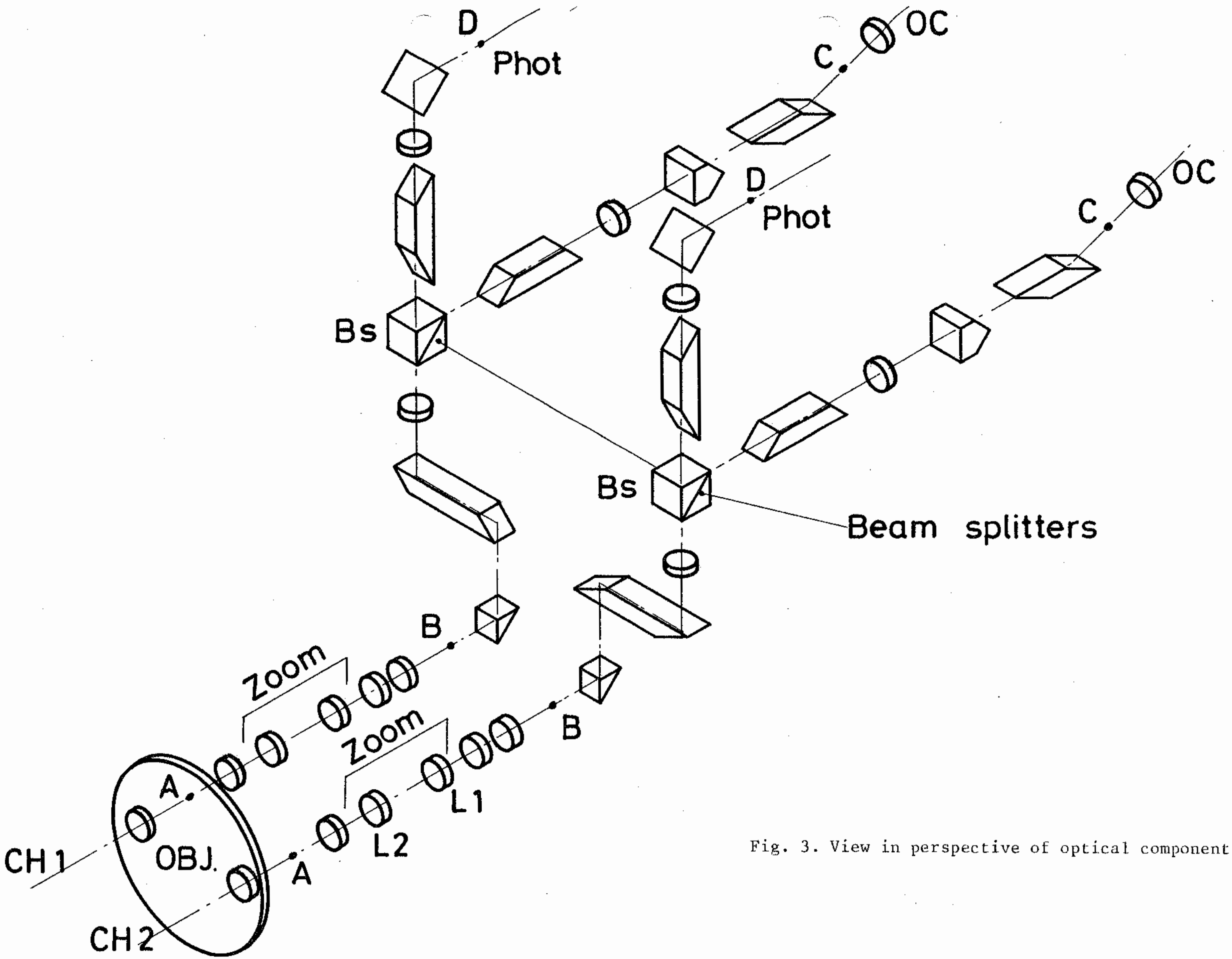


Fig. 3. View in perspective of optical components

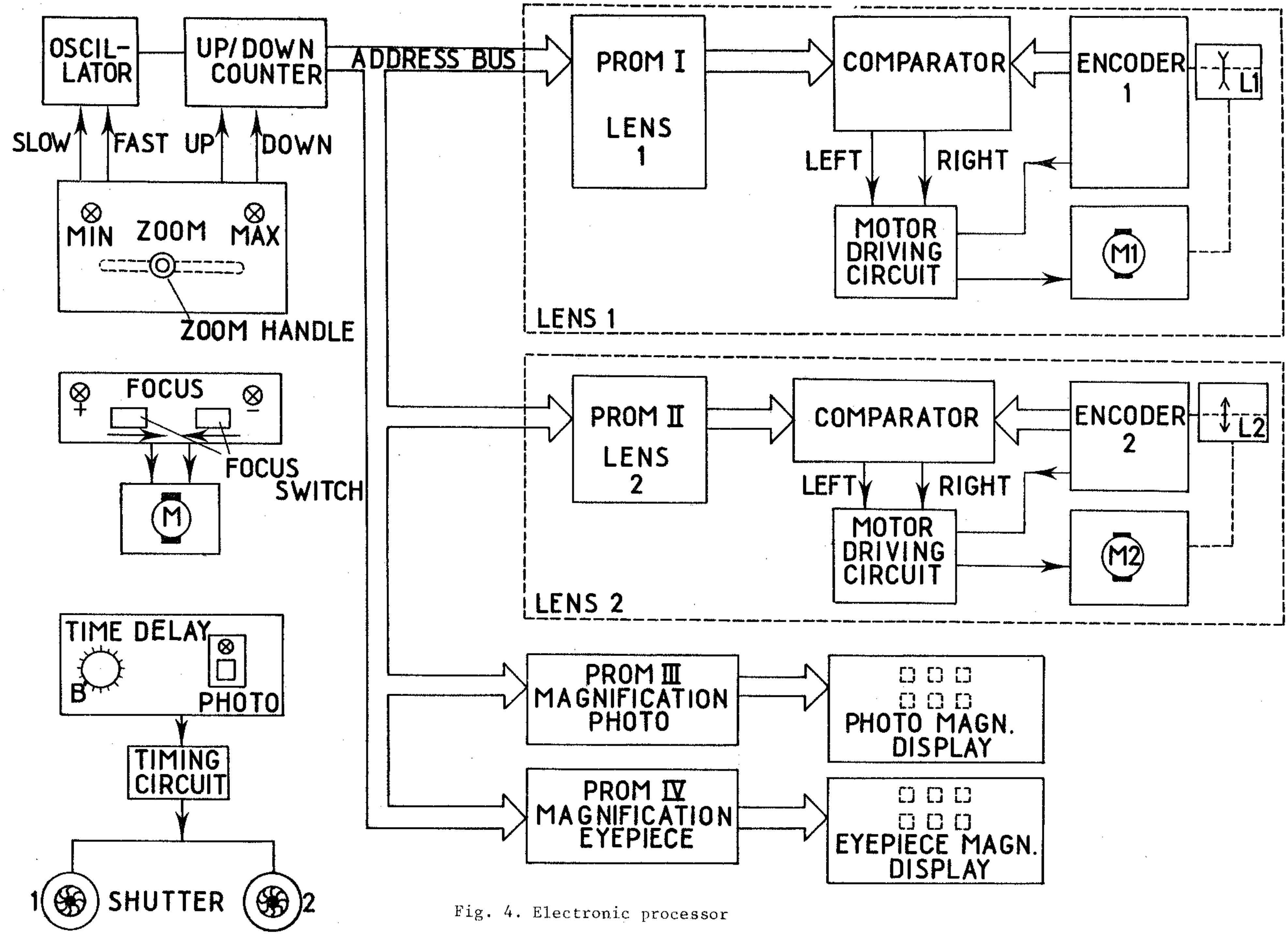


Fig. 4. Electronic processor

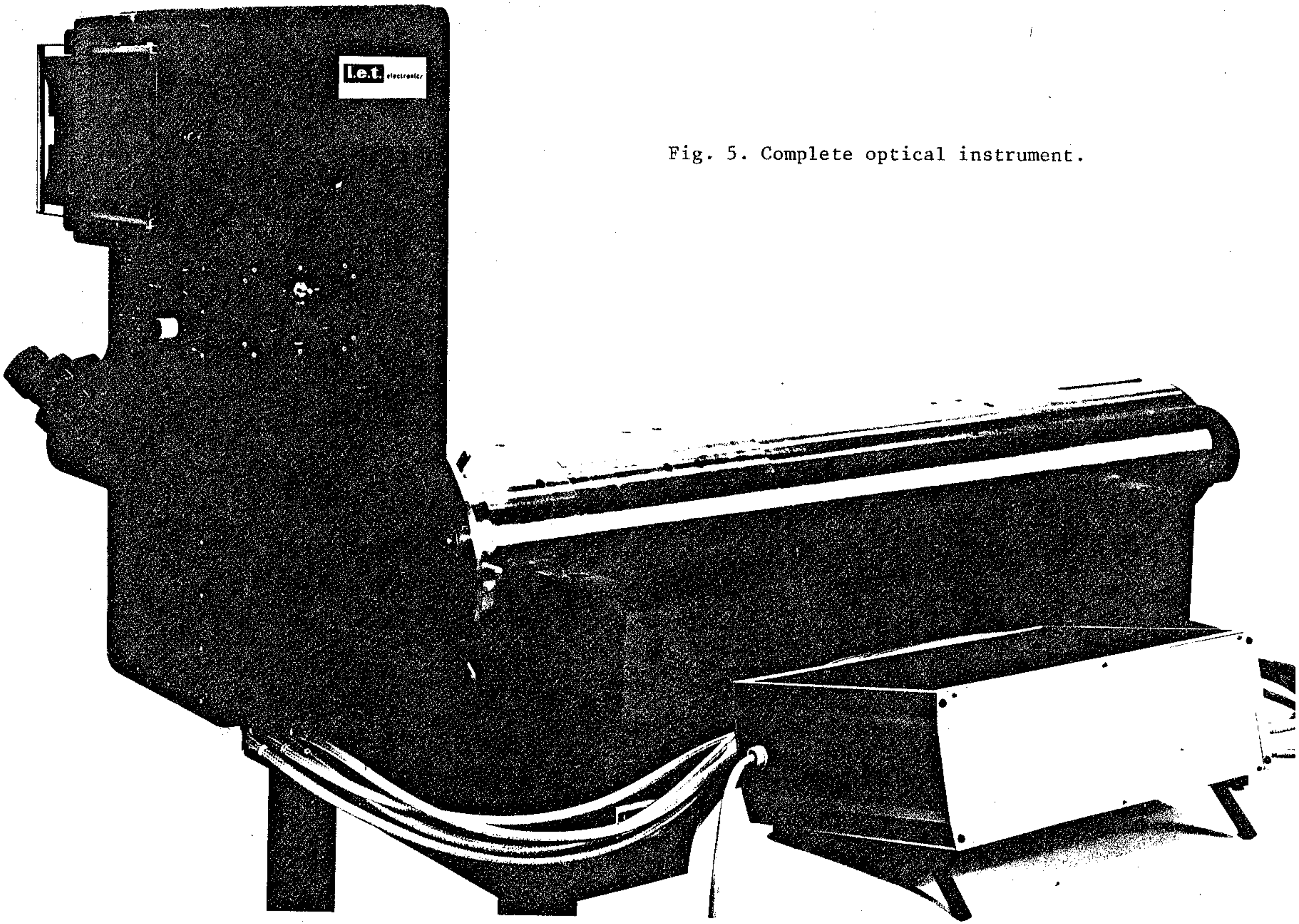
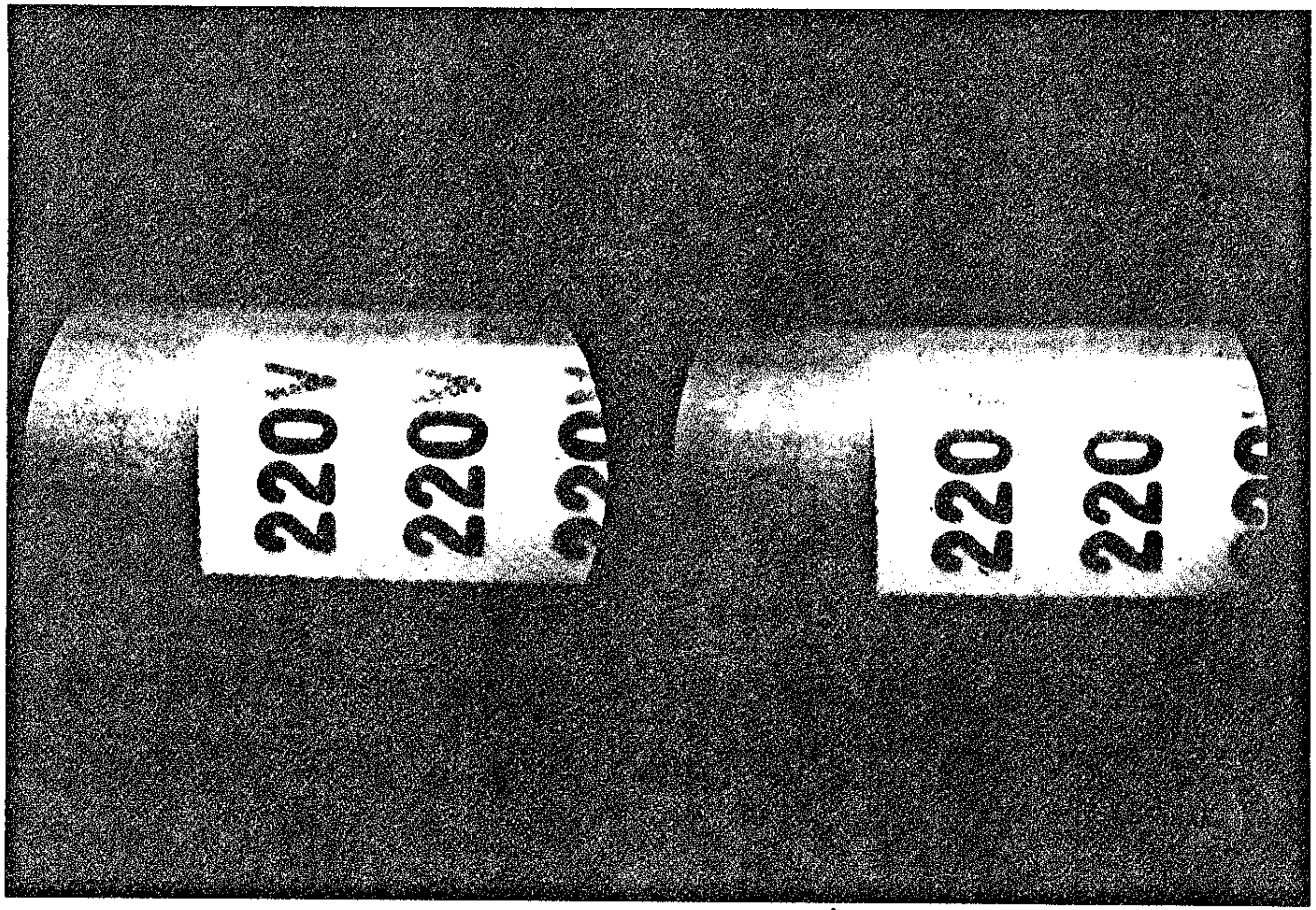


Fig. 5. Complete optical instrument.



Fig; 6.Stereo view of fuel pin sample.