The Zeiss Light Section Microscope

by Fritz Schulze, Canada

Every so often you will find on eBay an unusual microscope on offer. The seller, not knowing what it is, describes it as “unusual rare microscope”. You may also find the same instrument again but this time correctly identified by a knowledgeable seller as a “Zeiss Light Section Microscope”. An innocent microscopist may wonder if this is a special microscope that cuts sections with light, or? What is it?

For an explanation, please, allow me to look back in Zeiss's history. In the postwar years from 1948 on in the newly established Zeiss factory in Oberkochen, West-Germany, the scientists and researchers were gung-ho in their effort to reestablish the company's leading role in optics. The speed of development of new instruments was simply astounding. The first products were eyeglasses and camera objectives (for Zeiss Ikon) as stipulated by the occupying forces for the permission to start production.

There followed in quick succession binoculars, microscopes (the Stand W), and instruments for ophthalmology. Simultaneously, engineers developed geodetical instruments (among them the famous self-levelling NI 2), aerial cameras and cartographic instruments (the Stereo-planigraph), astronomical telescopes and the planetarium. The operating microscope appeared in 1957, as did a range of analytical instruments from the Abbe-Refractometer to the spectrophotometer PMQ II. Industrial measuring instruments such as the Abbe-Comparator were the products of the Metrology Dept. which at the time also produced interferometers. It is obvious that with such an extensive manufacturing programme the development core of the young company was thinly spread. So it is not surprising that in the course of the next decades one after the other of these divisions were sold off or closed down outright due to inefficient production, technical progress (from analogue to digital, for example) or severe competition. The first ones were the department for geodetical instruments, for analytical instruments and metrology.

To come back to our mystery microscope, the LIGHT SECTION MICROSCOPE. It was part of the metrology production programme and developed in response to the industry's demand for instruments to determine the surface quality or roughness of machined workpieces. At the time there were three systems available for measuring surface roughness. One way to measure roughness is to scan the surface to be tested with a stylus much like a gramophone needle follows the groove. The “wavelength” and the amplitude of the stylus' movement is then transformed into an electric current and displayed on an instrument as a value of roughness. This system is, of course, unidirectional and does not give an overall impression of the surface. This problem does not exist with the pneumatic method. Here a ring-shaped sharp-edged nozzle is pressed against the surface (which by necessity has to be flat) and a certain air pressure applied. The rougher the surface, the more air escapes. The resulting drop in pressure is compared to a standard and so gives a value for the roughness.

Being an optical company, Zeiss approached the problem optically. The method employed was already described in principle in the 1930s by a Prof. Schwartz.. In the 1950s Zeiss designed a compact, easy to use **Light Section Microscope** based on Prof. Schwartz's idea.

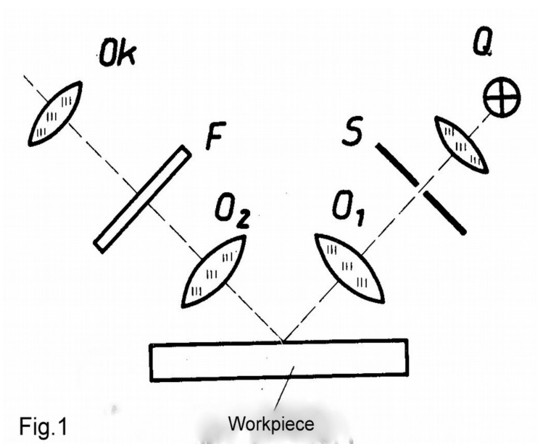

Fig.1

A sharply defined light band is projected at an angle of 45° onto the surface to be tested and observed at an angle of 90° (see Fig. 1)

Q = light source
S = slit
O_1 and O_2 = paired objectives
F = measuring scale
Ok = eyepiece.

Fig. 2 gives a realistic impression of the effect of a light section. It is, of course obvious that the light beam so observed is considerably distorted. In order to compensate for this distortion the eyepiece micrometer scale is ingeniously turned 45° and thus gives the correctly measured height.

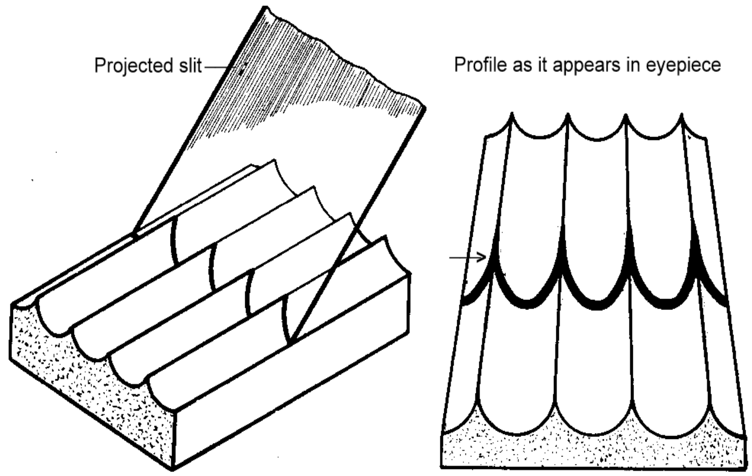

Fig.2

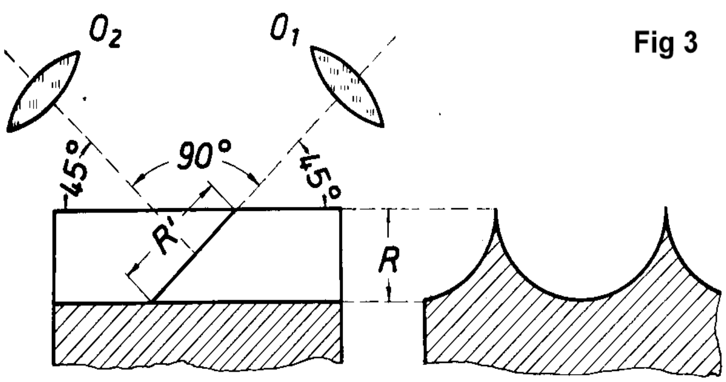

Fig 3

Fig. 3 explains the theory behind the measurement: the apparent depth R' is exaggerated by $\sqrt{2} \approx 1.42$.

$R'/R = 1.\sin 45° = \sqrt{2}$

The light section microscope (see Fig. 4) consists of a heavy base with a plane stage with T-grooves for attaching such accessories as a mechanical stage. A strong column with a helical groove carries the microscope body. The height can be adjusted by means of a ring nut. The actual microscope consists of two pairs of objectives resulting in a magnification of 200x and 400x in combination with the eyepiece. The objectives, the illuminating one of which is equipped with a diaphragm to increase the depth of field, are permanently adjusted to each other and arranged in a revolver for easy changing. There is also a fine focusing mechanism and a tube to attach a camera (see Fig. 5). The eyepiece with its metric millimeter scale gave the corrected readings as mentioned earlier, optionally, documentary photomicrographs could be evaluated leisurely later on.
A later edition (Fig. 5/1) had the microscope mounted at 90° to the column so that also long objects could be examined.

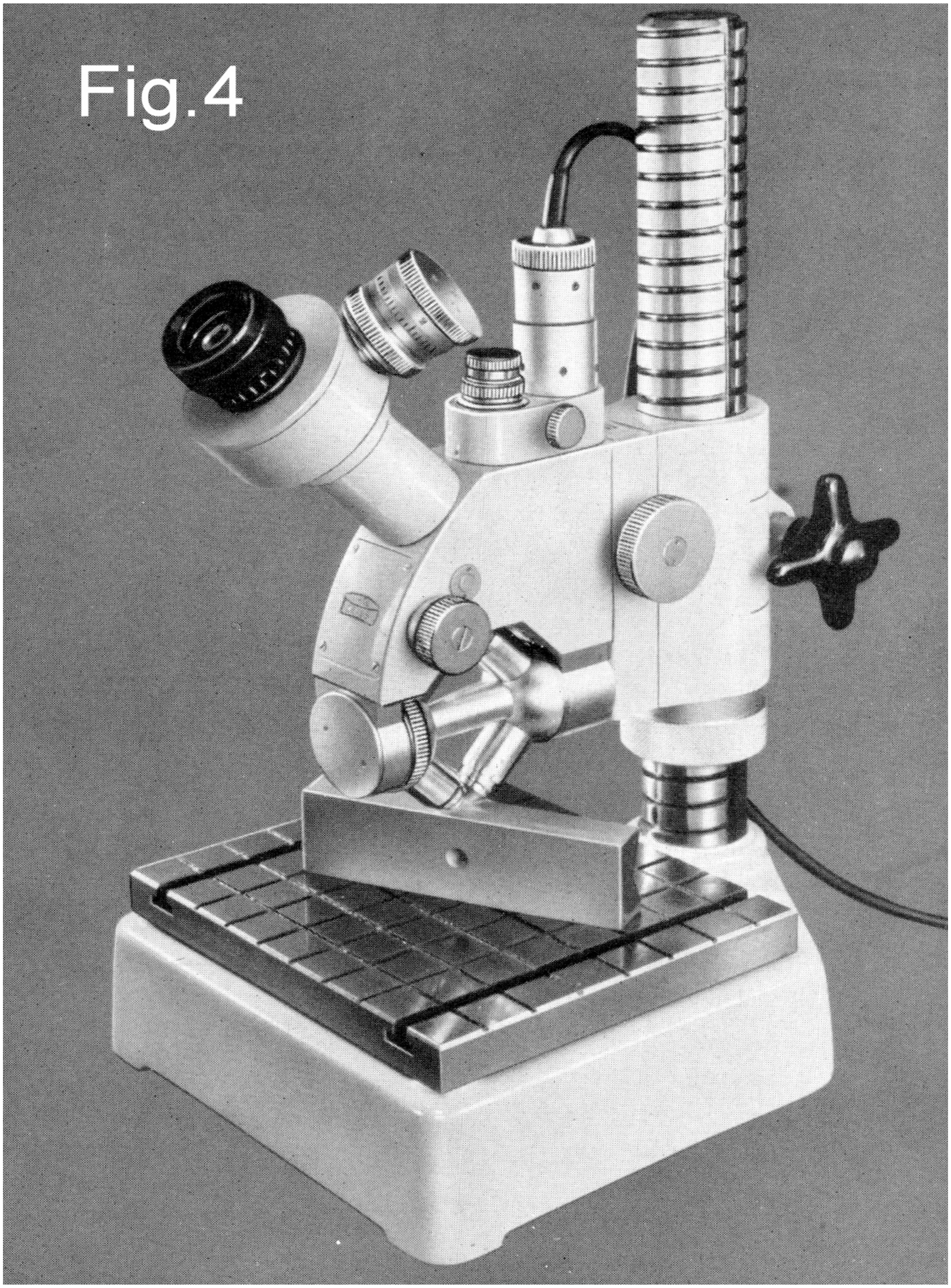

Fig.4

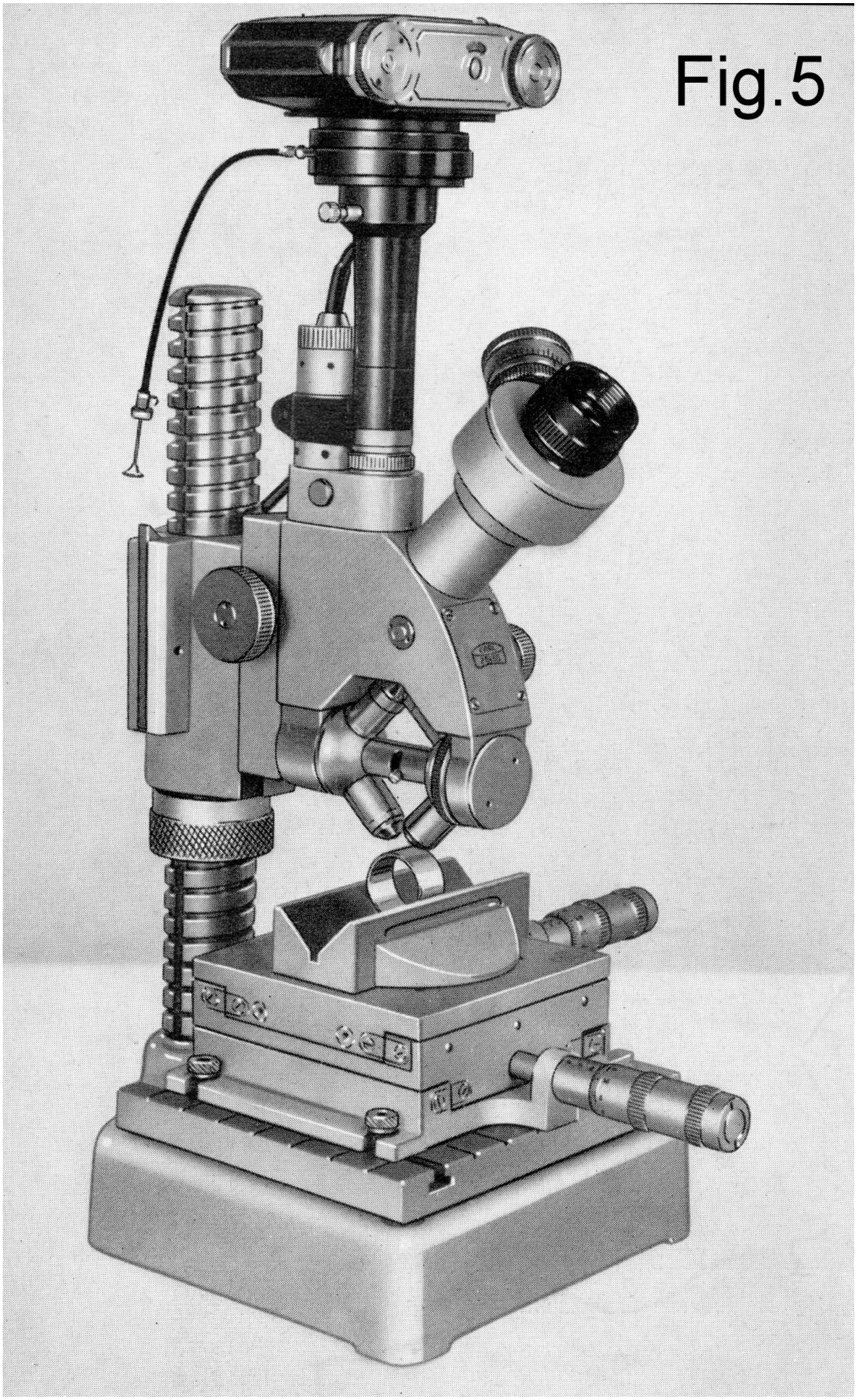

Fig.5

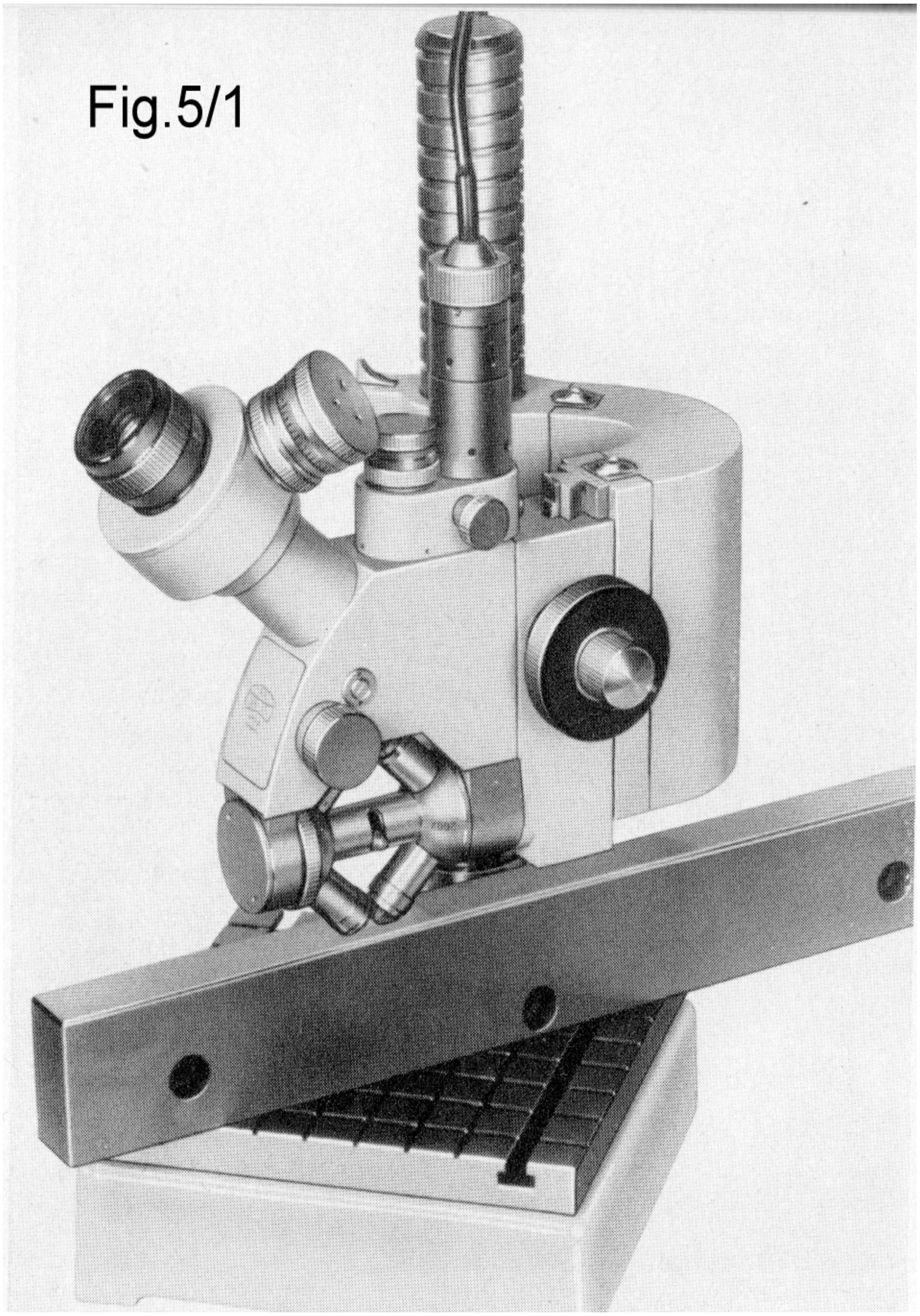

Fig. 5/1

This “improved” version (1961) has a versatile elaborate suspension: it can be assembled as shown in order to accommodate long work pieces or, as in Fig. 5, the original way by rearranging the curved elbow piece (on the right). Furthermore, this version is equipped with a coaxial coarse and fine focusing control.

The measuring range of the light section microscope is 3-100µm and 1-4µm for the 200x and 400x objectives resp. (1µm = 0.001mm), the field of view 1.4 and 0.7mm resp. It finds its application in testing machined surfaces, measuring the roughness of papers or painted surfaces, the thickness of lacquer layers or of anodized aluminum (Eloxal). In the latter cases the refractive index of the layer has to be considered.

Inaccessible surfaces such as the inside of bearings can be examined by employing a replica method: a thin lacquer is painted on the clean surface and subsequently lifted off with a hardening plasticine-like substance. The replica can then be measured in the usual way with sufficient accuracy. The light profile is, of course, also unidirectional. Depending on the surface, measurements at various orientations would have to be made.

Here are some examples:

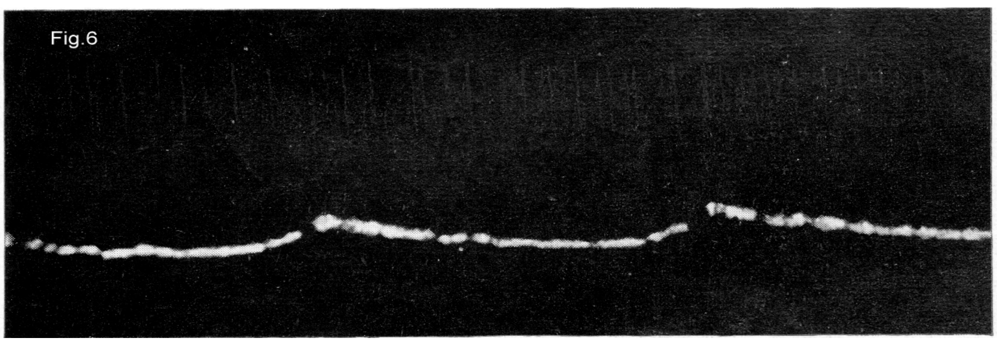

Fig.6 Turned brass surface, roughness 20µm

Fig.7 Stereo (printing block) depth of etching: 59µm

In the 1960s the American banks started to use magnetic ink on their cheques for quick electronic sorting. They actually recommended their printing suppliers to use the Zeiss Light Section Microscope to check on the quality of their paper and the thickness of the printed ink in order to comply with the specification. Another unusual application of the light section principle in quality control.

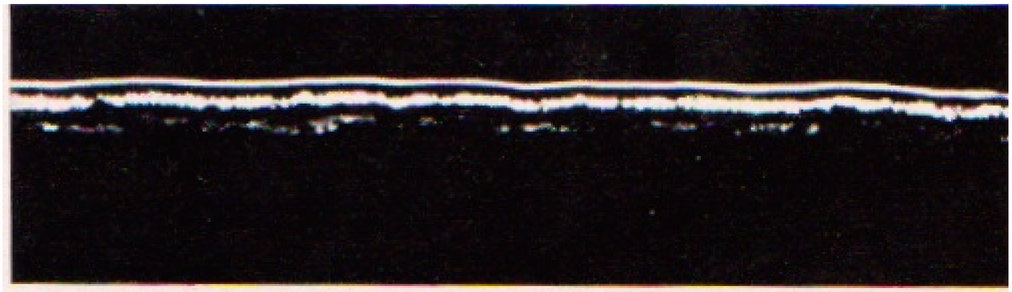

Fig. 8 A transparent lacquer on a machined metal surface: the thin upper band of the lacquer shows its smoothing effect on the metal surface (lower thicker band)

Fig.9 Cross-section of a wallpaper

Since the Zeiss Light Section Microscope has been discontinued, I assume other methods of surface roughness measurement have been developed to fill the gap. I wonder, though, if a Light Section Microscope offered on eBay will find a buyer who will use it for the intended purpose.

References: This article is based on publications in the Zeiss Werkzeitschrift Nrs 24/1957 and 32/1959 by Werner Illig.

Fritz Schulze, email - glenelly AT sympatico DOT ca
Vineland,ON, Canada

Published in the December 2022 edition of *Micscape* magazine.

www.micscape.org