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Modified double grating shearing interferometer

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The grating interferometer developed by Ronchi [1] is one of the most popular configurations among various types of lateral shearing interferometers. Since it uses single shearing element it is very simple, stable and easy to align [2]. In its original form, however, the Ronchi test is characterized by some inconveniences. First, in order to obtain good contrast two-beam interference fringes the shear value must be at least one half of the pupil diameter. Otherwise, three or more diffracted orders interfere what results in the decrease of interference fringes contrast [1] due to the Talbot effect [3]. Second, reference fringes of arbitrary orientation and number cannot be introduced in the field. By displacing the grating along the optical axis only the fixed orientation fringes perpendicular to shear direction can be introduced.

The works of several authors, starting from early seventies, have greatly improved the Ronchi test performance. First comes the configuration using double frequency grating [4, 5], next is the configuration of double grating interferometer [6–8]. The latter system is slightly more complicated but due to the introduction of second identical diffraction grating it provides all the interferometric characteristics required. These are: the maximum contrast two-beam interference, continuous change of the shear starting from the zero value, and the possibility of setting arbitrary reference fringe pattern by changing the direction and magnitude of tilt between the two interfering beams. In the double grating systems [4–8] the grating frequency must be properly selected so that the diffraction angle be large enough to prevent overlap of the zero order beam and the first order beams, on which the interferometer is operating. This beam aperture-grating frequency matching warrants the two beam interference free from multiple-beam overlap effects at small shear amounts, no additional spatial filtering being required. However, it excludes the use of the off-shelf gratings found in the optical laboratory and used for other purposes; for example, in moire experiments.

This drawback is partially avoided in the single sideband Ronchi test configuration proposed recently [9], Fig. 1. Two identical diffraction gratings $G1$ and $G2$ are placed in the extrafocal positions of the beam under test. In the focus (source image) plane the spatial filter $SF1$ is introduced. It passes only two diffraction orders of the first grating $G1$, the directly transmitted and first order diffraction (single sideband) beam. Double beam illumination of the second identical grating $G2$ (the angle between illuminating beams is equal to the diffraction angle of $G2$) leads to spatial coincidence of double diffracted beams in each diffraction order direction behind $G2$. Therefore, in the -1 double diffraction order selected by the spatial filter $SF2$ (see Fig. 1), the two-beam interference $(0, -1)$ and $(+1, 0)$ is encountered. The numbers in parentheses designate the diffraction order number on the first and second gratings, respectively. By rotating the gratings $G1$ and $G2$ about the optical axis and changing the distances z_1 and z_2 of the gratings from the focal plane (spatial filter $SF1$) the amount of shear and number as well as orientation of fringes can be varied continuously within reasonable limits [9]. However, in order to be able to perform spatial filtering the diffraction orders separation must be large enough. This fact limits the minimum shear amount and the maximum value of tilt the latter parameter being dependent on the width of spatial filter $SF2$, as well

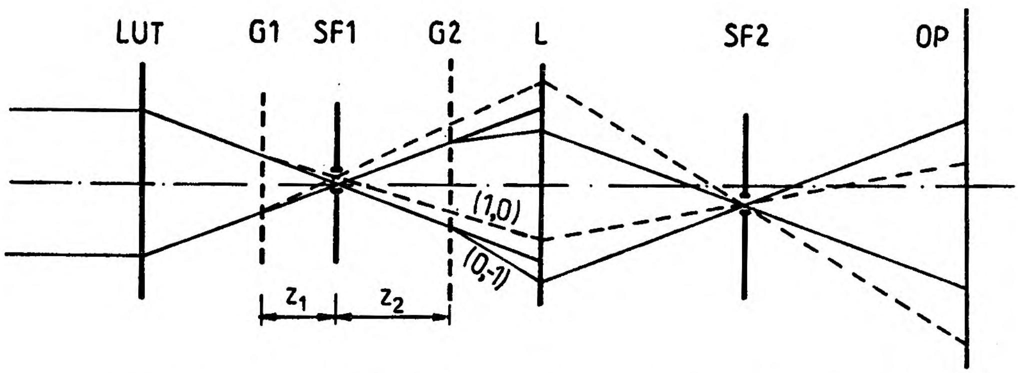

Fig. 1. Single sideband Ronchi test setup due to SCHWIDER [9]. *LUT* – lens under test, *G*1 and *G*2 – diffraction gratings, *SF*1 and *SF*2 – spatial filters, *L* – imaging lens, *OP* – observation plane

The aim of this communication is to draw attention to the fact that in the case of using cosine [9] and Ronchi square wave type diffraction gratings the spatial filter $SF1$ (Fig. 1) is not necessary. The explanation is straightforward. The second spatial filter $SF2$, set in one of the first double diffraction orders, admits only two diffracted eams. This is due to harmonic content of the cosine (diffraction orders -1, 0, $+1$) and the square wave Roncki type (odd harmonics only) gratings. For example, in the case of -1 double diffraction order shown in Fig. 1, these beams are $(0, -1)$ and $(+1, 0)$ irrespectively of the presence of $SF1$. There exists no other combination of the numbers of double diffraction orders focusing at the lateral position of $SF2$ shown in Feig. 1.

The above described feature is quite important from the experimental point of view. Cosine and Ronchi type diffraction gratings are the most widely used in practice. The elimination of spatial filter $SF1$ significantly simplifies the optical arrangement and permits the axial and rotational movements of the first grating $G1$ without the necessity of adjusting the width of the filter $SF1$. The possibility of simultaneous "symmetrical" adjustment of gratings $G1$ and $G2$ with respect to the beam focus and vertical plane is the most useful in experimental practice; for example, it enables the change of shear without introducing tilt ($z_1 = z_2$). The problem of the lack of space to insert the filter $SF1$ in the optical system when gratings have to be located near the focus of tested beam is eliminated, as well.

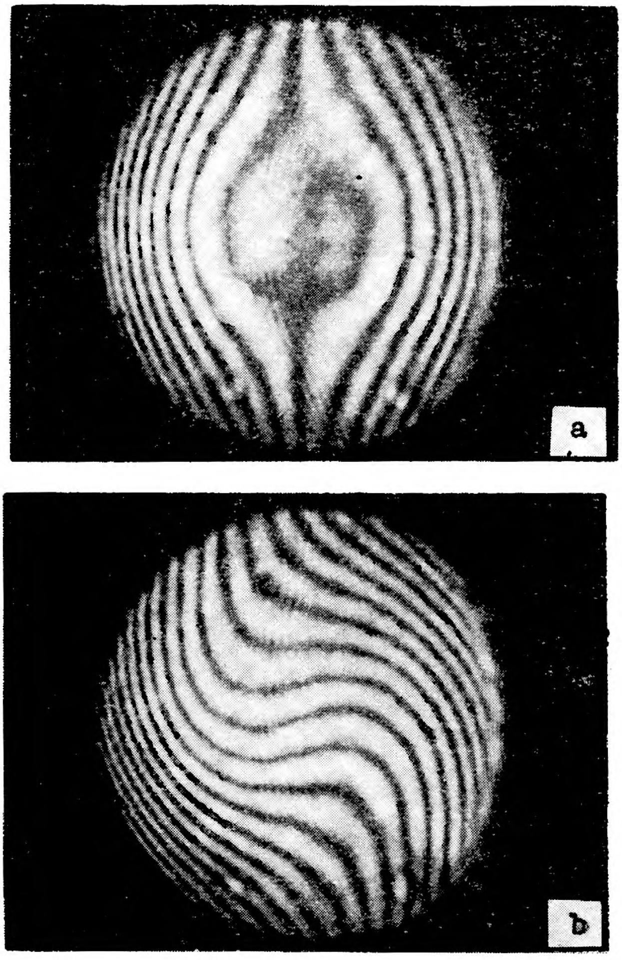

Fig. 2. Shearing interference patterns of a lens obtained in optical system of Fig. 1 without using the spatial filter $SF1$. (a) grating lines mutually parallel, (b) grating lines mutually inclined

Various experiments have been performed in the optical arrangement of Fig. 1, using two identical square wave Ronchi rulings. The same results have been obtained in the configurations with and without the spatial filter SF 1. Because of the identity of interference patterns only the exemplary photographs obtained without using $SF1$ are presented in Fig. 2.

The simplification proposed can be extended to the case of using two crossed gratings *G*1 and *G*2 in order to obtain the shear interferograms in two orthogonal directions.

The name ***single sideband Ronchi test*** introduced by Schwider [9] cannot be used any longer for the optical system shown in Fig. 1 without the spatial filter *SF*1. For example, the name of Ronchi test with double grating and spatial filtering, seems to be appropriate.

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