Grid Processing of Large Photographic Plates

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1. Introduction

We have investigated a new method ("grid processing") for mechanical agitation during development of large, photographical plates. It appears to be superior to the classical tray-rocker, both in terms of efficiency and uniformity, and without any loss in resolution. We believe that this method may become important in astronomical photography, once it has been thoroughly tested and automated.

Development of large, photographic plates poses difficult technical problems, in particular concerning the uniformity over the plate surface. Various methods have been devised, but so far none have been able to match the "tray-rocker", which was introduced into astronomical photography by the late Wm. C. Miller. Following his advice, several tray-rockers were acquired in 1973 by the European Southern Observatory. They have since been in use for development of original Schmidt plates at the La Silla observatory and in the production of glass copies for the various sky atlasses which are being made at the ESO Sky Atlas Laboratory in Garching. Thousands of plates have been processed this way and much experience is now available about the optimum tuning of the rocking and rotation rates, the amount of developer, how to immerse the plate in the developer, etc. (West and Dumoulin, "Photographic Reproduction of Large Astronomical Plates" [ESO Sky Atlas Laboratory, 1974]; "Photographic Reproduction of Large Astronomical Glass Plates: Some Problems and Pitfalls [*AAS Photobulletin* **23,** 3, 1980]).

The many virtues of the tray-rocker method include reliability, handling ease and good reproducibility, i.e. the possibility of producing identical copies in large numbers which is of great importance in atlas work. However, there is at least one shortcoming: the plate centre is always (slightly) less developed than the edges because of variation in agitation, introduced by the wave geometry. This is problematic, especially since the photometric calibration wedges are placed near the edges. It should be noted, though, that this effect is less evident on Schmidt plates, where the plate edges are less exposed than the centre due to vignetting in the telescope – in fact the two effects partially compensate each other. Another problem is that the tray-rocker rotation and rocking rates must be kept rather slow in order to maintain an acceptable uniformity (and to avoid splashes). This reduces the efficiency.

We have performed many experiments with our tray-rockers over more than 10 years, but now believe that there exists no simple modification of the classical tray-rocker, which will significantly improve its performance.

2. The Grid Method

Looking for alternative methods, we were inspired by the KODAK Versamat 17 automatic developing machine, which is used at the ESO Sky Atlas Laboratory for processing of 40 × 40 cm atlas film copies. In this machine, the vertical motion of the film, combined with horizontal agitation (jets of developer) gives remarkably uniform results.

The grid method, which will be described here, does not appear to have been used much in the past. The only reference which we have been able to find, concerns machine development of cinema films, more than 40 years ago. In our set-up, a metallic grid moves rapidly back and forth in the developer, just above the emulsion.

All tests were made with 30 × 30 cm, 3 mm thick KODAK Process plates (resolution ~ 200 lines/mm), which are used for the production of the glass-based ESO/SRC Atlas of the Southern Sky. The plates were exposed uniformly by a point light source at 5 m distance and developed at 20°C in Kodak D76 developer.

The initial tests were made with a hand-held grid from a refrigerator, with the plate in vertical (as in the Versamat 17 machine) or horizontal position. Although the early results were similar in both positions, the latter was much more convenient for the operator and vertical tests were discontinued. The method immediately showed promise and a special tray with fitting plateholder (both 38 cm × 50 cm) and a corresponding grid (38 cm × 41.5 cm) was built (Figure 1). The grid bars are cylindrical with a diameter of 3 mm.

The most important parameters were now varied, e.g. the distance between the grid bars, the distance between emulsion and grid and the depth of developer over the emulsion.

We found that it is very important that the individual bars are randomly spaced, otherwise patterns may develop. Our grid has 35 bars with a mean distance of 11 mm. A distance of about 1 mm between plate and grid is optimal and the grid must be flat to within ± 0.1 mm. If the plate-grid distance is too large, say 5 mm, the uniformity of development is lost and a wave pattern results. If the distance is too small, there is a risk of scratching the plate. The minimum depth of the developer is

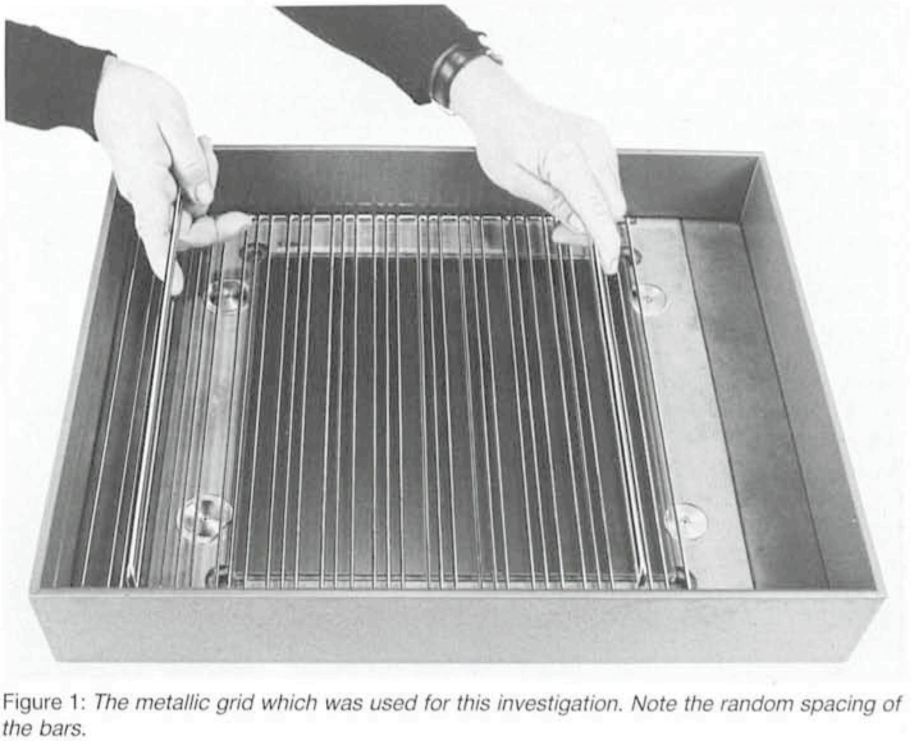

Figure 1: *The metallic grid which was used for this investigation. Note the random spacing of the bars.*

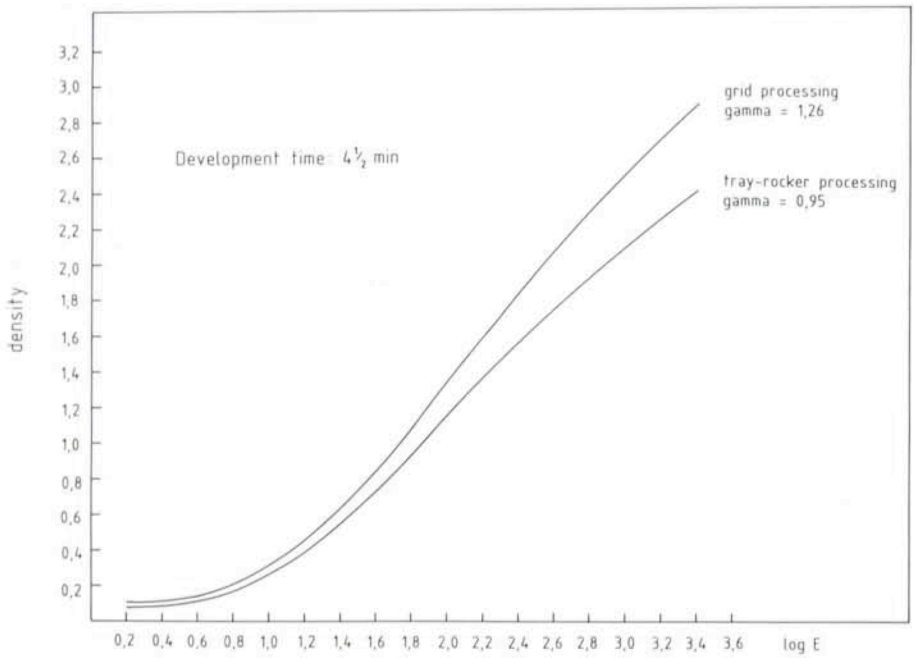

Figure 2: *Comparison of tray-rocker and grid development characteristic curves for KODAK Process plates.*

about 7 mm, corresponding to 1.8 liter per plate, but we found that the efficiency increases if more developer is poured in, at least up to a total of 2.3 liter, i.e. a depth of 10 mm.

The motion of the grid above the plate is not very crucial, as long as the operator tries to make it random. A convenient, optimum cycle period (back and forth) is about 1 second. The maximum, lateral distance from motion reversal to reversal is about 90 mm. The motion is therefore rather violent. Clearly, a most important result is the need to "randomize" the grid and its motion in order to avoid standing waves and thereby non-uniform development.

3. Results

All tests for which the results are shown here, were made at the optimum settings, as outlined above. The only variable parameter was the development time. In all cases, control plates were developed with an optimally tuned tray-rocker (40 × 40 cm tray, 7 mm developer depth above plate = 2.3 l in total, 1.5 rotation/min, 18 rocks/min). It should be noted that the normal development time for atlas plates is 4.5 min. Figure 2 compares the characteristic curves of the two methods at development time 4.5 min. The grid method is clearly the more efficient. Figure 3 shows the achieved mean density as a function of development time. Again, the grid method is more efficient, although the difference becomes somewhat smaller with increasing time.

In order to investigate the uniformity, the plates were divided into 16 × 16 = 256 squares and the ANSI Diffuse density was measured with a GRETAG densitometer in the middle of each square (2 mm circular aperture). Figure 4 compares the measured, central density profiles (heavy line). The mean densities are indicated with thin, horizontal lines. For the grid method, the measurements were perpendicular to the direction of the grid motion. The tray-rocker edge effect is clearly seen. The apparent deterioration of the grid method with time, cf. the 12 min. profile, may be partly due to operator fatigue resulting in less-than-optimal motion of the grid.

The mean densities and r.m.s. values, based on 256 measurements on each plate, are given in Table 1. Figure 5 compares the uniformity of two plates, developed in the tray-rocker and by the grid method, respectively. Repeated operations proved that the grid developing method is extremely well reproducible.

We find that the grid-method is superior to the tray-rocker, both in terms of efficiency and uniformity, without any loss of resolution. These findings are of great interest for the atlas work at the ESO Sky Atlas Laboratory. With increased efficiency, the processing time necessary to reach a desired density and gamma, decreases and more plates can be handled in the same time. With greater uniformity, the sensitometry (calibration) on copies of original atlas plates will be more accurate, especially because the calibration wedges normally are situated near the plate edges. The method also offers great promise for very large plates, e.g. 50 × 50 cm, and has a potential for use in the graphics

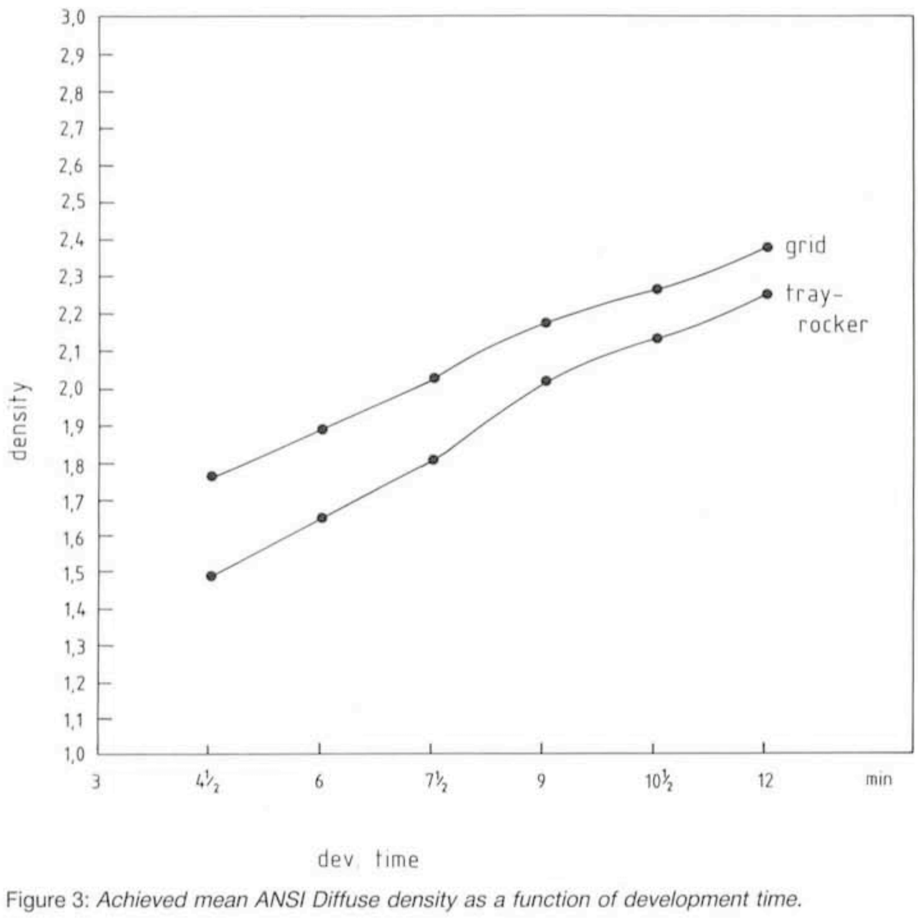

Figure 3: *Achieved mean ANSI Diffuse density as a function of development time.*

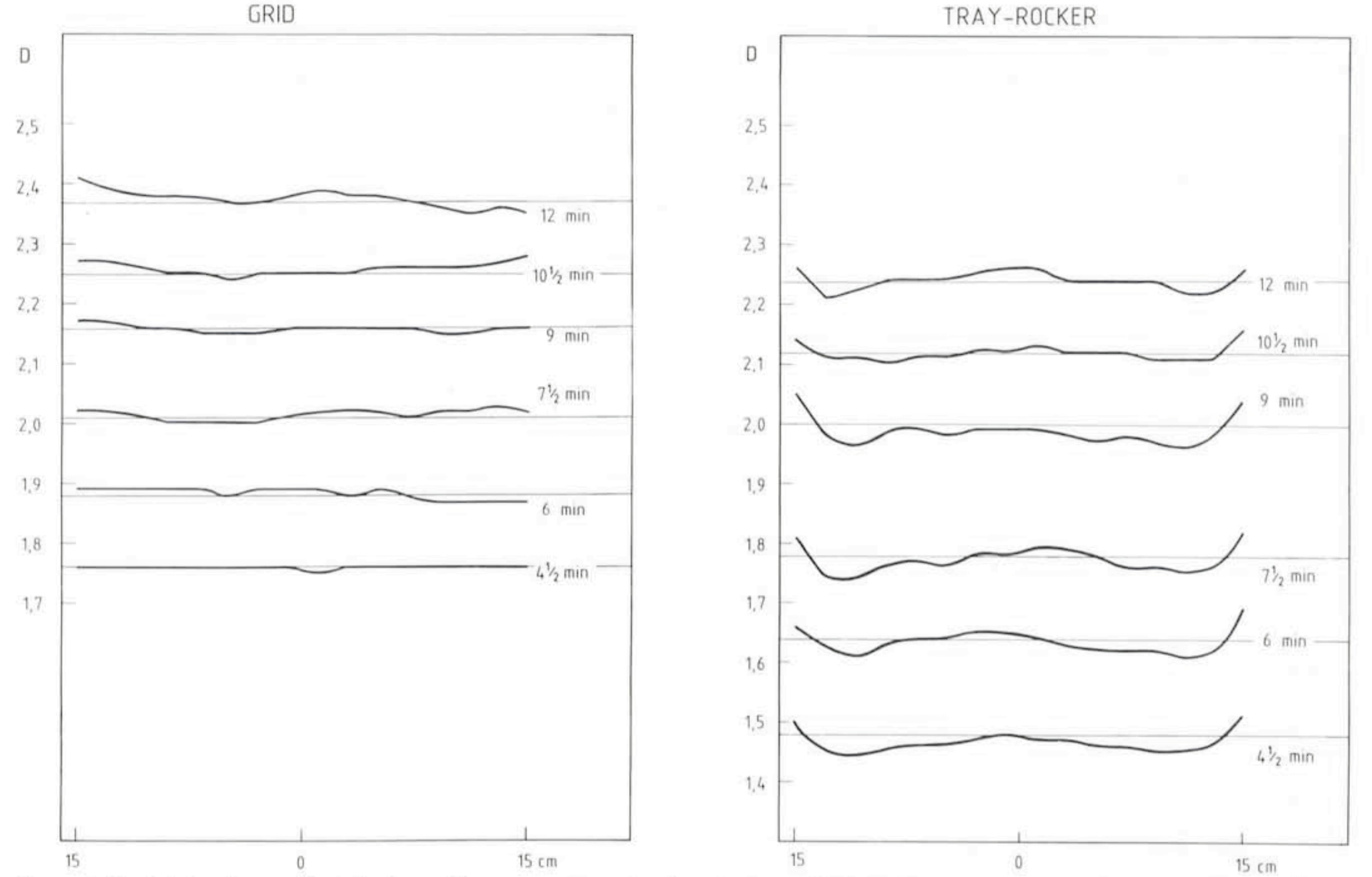

Figure 4: *Central density profiles. The heavy lines are measured values (for the grid in the direction of motion). The thin lines indicate the achieved, mean density.*

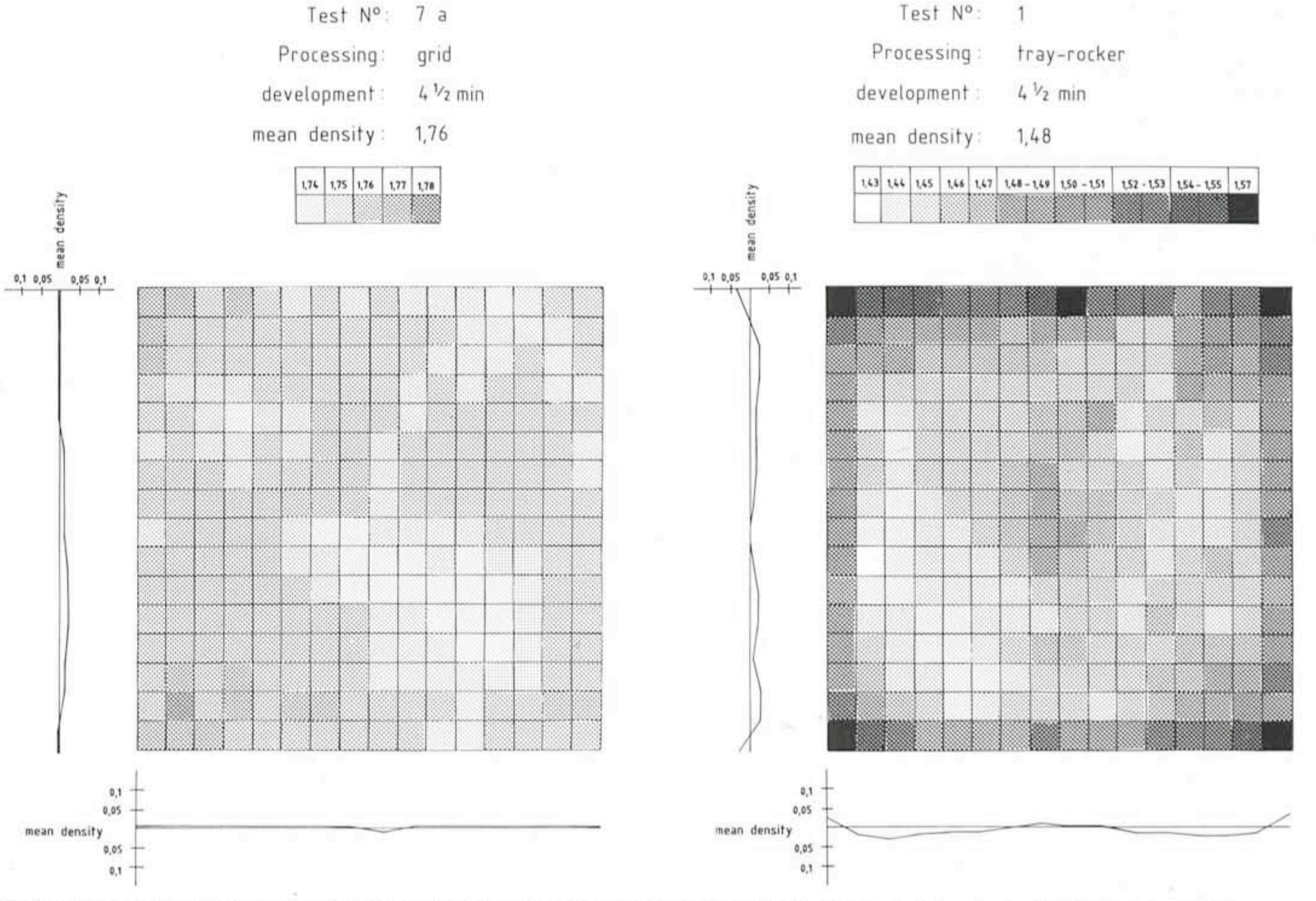

Figure 5: *Comparison of the uniformity achieved by the tray-rocker and the grid methods. The central density profiles in the two directions are shown.*

industry, especially in those areas where extreme uniformity is desirable (stamp matrices, etc.).

4. An Automatic Grid Developing Machine

It is obviously desirable to investigate whether these results are also valid for astronomical emulsions (IIa, IIIa, IV, etc.). For this purpose, and in order to improve the stability of the test conditions, an automatic grid developing machine has been built at the CERN mechanical workshop in Geneva, Switzerland (Figure 6). In this machine, the grid agitation is ensured by a motor. There are two motions, one that moves the grid rapidly back and forth and another that more slowly shifts the center of the first motion. In this way, it is avoided that the extreme positions of the grid are always in the same place. The speed can be changed, but since the two motions are produced by the same motor, they are not entirely independent. The initial tests showed that some wave patterns still remain; apparently the human operator is better than the machine in this respect! However, when the plate is moved manually and randomly, during the automatic grid motion, excellent results have been obtained, both in terms of efficiency and uniformity (Table 1).

Table 1: Mean densities and r.m.s. values

Dev. time	Tray rocker		Grid (manual)		Grid (machine)	
(min)	Mean D	r.m.s.	Mean D	r.m.s.	Mean D	r.m.s
4.5	1.475	0.037	1.756	0.008	1.970	0.010
			1.746	0.010		
			1.718	0.011		
6.0	1.644	0.030	1.878	0.011		
7.5	1.784	0.032	2.009	0.012		
9.0	1.996	0.033	2.156	0.011		
10.5	2.123	0.049	2.250	0.016		
12.0	2.235	0.030	2.369	0.018		

The mean ANSI Diffuse density and the r.m.s. values are calculated from measurements in 256 points. Data are given for three plates which were developed 4.5 min. with the grid method, in order to demonstrate the reproducibility.

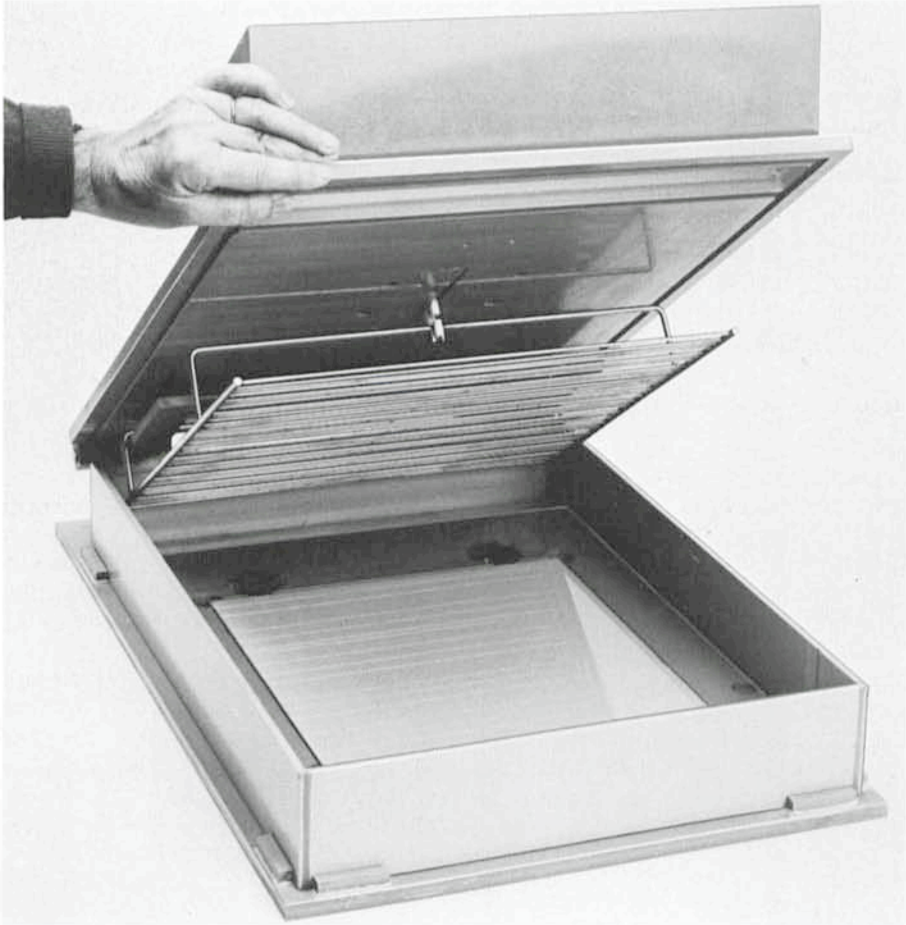

Figure 6: *Automatic grid developing machine. The motor is contained in the lid.*

Mechanical modifications are therefore now being made in order to "decouple" entirely the first two motions and to add a third, that is a slow motion of the plateholder and the plate. As soon as it is ready, we intend to test the new machine with plates from the ESO 1 m Schmidt telescope. If the present results are confirmed, the tray-rocker will be replaced with the grid machine. The greater efficiency and uniformity will clearly be of importance for achieving the best possible use of the Schmidt telescope.

VLT Documentation

Since the last issue of the *Messenger*, the following documentation about the ESO Very Large Telescope project has become available.

A **VLT Slide Set** has been produced in a very limited edition and reflects the status of the project by November 1986. It is provisional and future editions will be updated as more details of the project become defined. The set consists of 20 slides and may be obtained by sending DM 35,– (the equivalent of the cost price plus postage) to the address below.

The **Proceedings** of the Second Workshop on ESO's Very Large Telescope, which was held in Venice, 29 September – 2 October 1986, have now been edited by S. D'Odorico and J.-P. Swings. The 448 page volume comprises more than 35 papers and records the important discussions that took place at the meeting. It is available at a price of DM 40.– (including surface mail postage), from:

ESO Information and Photographic Service
Karl-Schwarzschild-Strasse 2
D-8046 Garching bei München
Federal Republic of Germany

In addition, the VLT Brochure is available free of charge (only one copy per order) in four different languages: English, French, German and Italian. A small number of the technical VLT Reports, announced in *Messenger* 45 (September 1986), are also available.