The sensitization of VR-P Russian photoplates for recording pulsed holograms

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ABSTRACT

A simple and effective method to increase the sensitivity of VR-P Russian holographic photoplates used for recording pulsed holograms by Nd laser is presented. The method is based on strengthening the latent image directly after recording the hologram by a long exposure to weak incoherent light (effect of latensification). We describe the conditions for latensification and experimental results. The recommendation for optimum drying of the holograms are given. Processing the VR-P photoplates according to the method presented leads to a sensitivity very similar to that seen with the well-known Agfa Gevaert 8E56 plates.

1. INTRODUCTION

In accordance with the failure of the reciprocity law[1], the sensitivity of holographic photoplates is significantly reduced at very short exposures.This directly influences the recording of pulsed holograms by Nd lasers which have a pulse duration of around 20 nsec. Consequently it becomes necessary to increase the energy of the pulse or to use non-optimum development with an associated increase of the noise in the reconstructed image of the hologram. To eliminate this undesirable phenomenon it is possible to use an effect known in photography as latensification[1,2]. This effect consists of strengthening the latent image directly after recording the hologram by a long exposure to weak incoherent light. This leads to an increase of size of the centres of the latent image up to sizes characteristic of a normal exposure. It is remarkable that the influence of such weak light on a non-exposed photoplate does not result in the occurrence of any appreciable density after development.

2. EXPERIMENTAL SECTION

For a quantitative estimation of the effect of latensification test transmission holograms were recorded. The energy of the pulse from the Nd laser was 1 Joule. A sheet of a white paper 15*20 cm with some text served as the object. For the purposes of latensification a photographic light source with a frosted lamp of 40 W with and without green filter was used. The distance between this light source and the hologram was 80 cm. The photochemical processing sequence that we used is given below:

Development in VR-P developer	2 min
Washing	5 min
Fixation	5 min
Washing	5 min
Bleaching	up to full transparency
Washing	10 min
Drying in 50%, 80%, 100% ethanol	2 min

For the reduction of noise in the reconstructed image the proprietary VR-P developer was modified. The amount of sodium sulphite in it was reduced from 140 g down to 50 g. The recipes of the modified developer and bleach are given below:

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VR-P Developer	
Metol	6 g
Sodium sulphite	50 g
Hyroquinone	20 g
Potassium metaborate	112 g
Potassium hydroxide	17,42 g
Water	1 l

Bleach	
Ferric nitrate	150 g
Potassium bromide	30 g
Water	1 l

Before use dilute 1:3

After fixation the holograms were cut into two parts. One part, after washing and drying, was used for the measurement of density, the other part for the subsequent bleaching and visual estimation of the quality of the reconstructed image.

The optimum time of latensification was found as follows. A photoplate was cut into some small pieces. All the pieces except one were placed at a given distance from the light source and were illuminated for different times. The non-illuminated piece is necessary for an estimation of the haze of the photoplate. Then all pieces were developed in one bath and fixed. The optimum time of latensification was determined as the time required for the density of an exposed photoplate to just exceed the density of the haze of the control plate. Fig. 1 shows the dependence of density on the time of latensification. The horizontal line indicates the density of the haze of the photoplate. The optimum time of latensification is 2 min for the light source with filter (Fig. 1a) and 10 sec for the light source without filter (Fig. 1b).

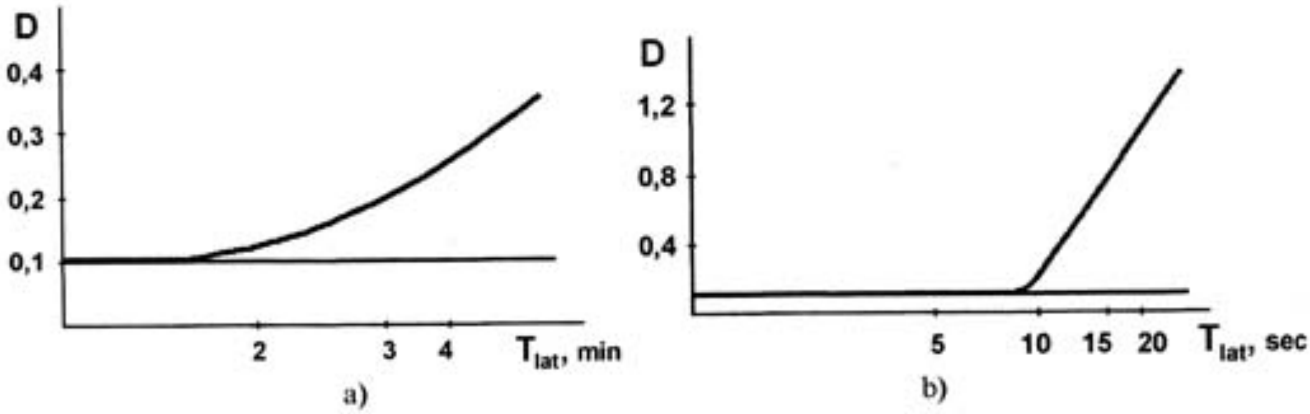

Fig 1. Dependence of density of the photoplate on the time of latensification for the light source with filter (a) and without filter (b).

Fig. 2 shows the dependence of density of the recorded holograms on the time of latensification. The horizontal line represents the density of the recorded hologram without latensification. This diagram shows that the optimum latensification gives an increase in the opacity of the recorded hologram of more than ten times ($\Delta D \geq 1$). In this sense it is possible to speak about a ten times increase in the sensitivity of the VR-P photoplate.

A visual estimation of the quality of the reconstructed image of the bleached holograms shows a significant increase in the brightness of the image after latensification of the hologram. The type of source used for latensification does not affect the quality of the holograms. A comparison with holograms which have been produced on the Agfa 8E56 material shows them to be of identical brightness and noise level.

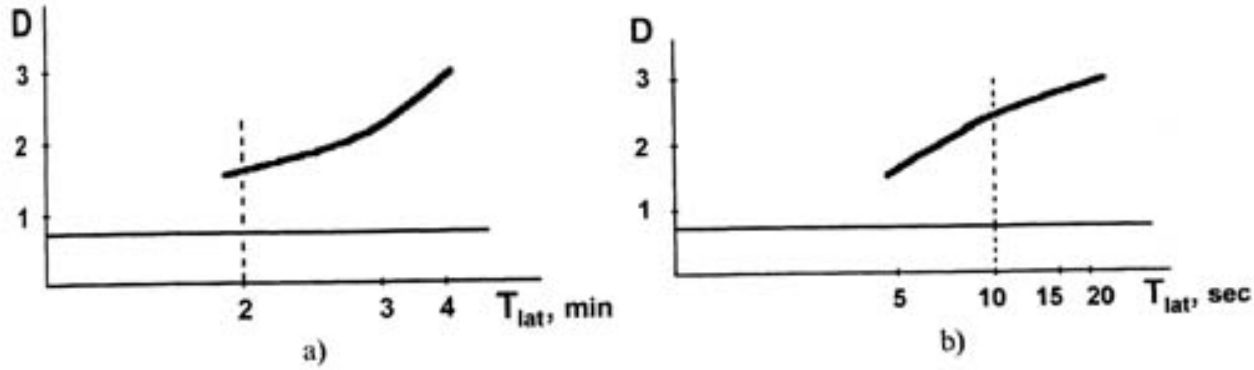

Fig. 2. Dependence of density of the recorder holograms on the time of latensification for the light source with filter (a) and without filter (b).

3. OPTIMISATION OF THE DRYING OF THE HOLOGRAMS

Careful drying after photochemical processing plays an important role in the final visual quality of the hologram. For Russian photoplates we have used drying by ethanol. The plate is consecutively dipped in baths containing 50% , 80% and 100% ethanol for 1-2 mins and constantly agitated. However this process by itself does not give stable results.

The analysis of the drying process shows that only complete and homogeneous removal of the water from the surface of the emulsion layer guarantees a high quality of the final hologram. The presence of water inside of the emulsion layer does not influence the uniformity of the hologram. However a thin layer of surface water is separated with large effort from the surface and frequently remains even after processing in 100% ethanol. Consequently coloured stripes and spots appear on the hologram. To remove the surface water it is necessary to change the method of drying as follows.

In all the ethanol baths the holograms are lifted from time to time as shown in Fig. 3 and are kept in this position for 10-15 sec. Between raisings of the hologram it is necessary to rock one time the bath to mix the solution of ethanol. When the water flows down from the surface of the hologram near to the part immersed in the solution of ethanol a knots becomes visible. When all the water has flowed down this knots disappears. This serves as a sign of the end of dehydration in the given ethanol bath and the necessity to proceed to the next ethanol bath, where the procedure repeats. In last 100% ethanol bath the surface of water vanishes completely. This drying method can be used for any holographic photoplate or film.

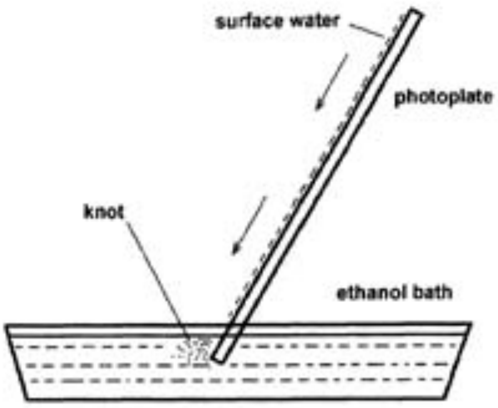

Fig. 3. Remove the surface water on photoplate in ethanol baths.

As was remarked in ref.[3], the processing of holograms in spirit baths occurs in a thin surface layer of the dry gelatin. It is as though a "crust" prevents the exit of water. The water begins to leave the emulsion layer only after the hologram is taken out of the last ethanol bath and the spirit has evaporated from its surface. If isopropyl alcohol is used for drying silver-halide holograms it is only necessary to use two baths containing 50% and 80% spirit solutions. In 100% isopropyl part of the water is linked into the emulsion layer and does not leave even on complete drying. As a result, a strong (more 100 mcm) shift of colour in the image to longwave occurs. This is exhibited clearly for DCG holograms (photoplate type PFG-04) where use of a bath of 100% isopropyl is obligatory for good final brightness of the image. The mechanism of this linkage of water into the gelatin is not understood.

The formation in the 100% ethanol bath of a dry and rather firm surface emulsion layer allows one to easily remove (with the help of a brush) any impurities which have adhered to the plate in the previous solutions. The most convenient time for such cleaning is as the hologram is raised above the ethanol for the last time.

4. ACKNOWLEDGMENTS

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