ABSTRACT

of the thesis entitled
"EFFECT OF ULTRASONICS ON PHOTOGRAPHIC FILMS"

Ultrasonic waves are mechanical waves (frequency greater than 20KHz) unlike light waves which are electromagnetic in nature. When a moist photographic film is exposed to ultrasonic waves it gets blackened even in the absence of light. The mechanism by which ultrasonic waves blacken the photo-emulsion has remained controversial. Many theories have been suggested prominent among which are the direct action theory which attributes blackening to collision excitation energy due to incident ultrasonic waves and the secondary action theory which attributes blackening to luminiscence produced in certain liquids when intense ultrasonic waves propagate through them. The present work is an attempt to understand this mechanism. The details of this investigation are described in this thesis consisting of four chapters namely Introduction, Experimental, Results and Discussion.

The first chapter begins with a detailed up-to-date review of the experimental results on the blackening of photo-emulsions by ultrasonics in which the various theories on blackening and their contradictions are discussed. This is followed by a brief description of the nature of the photo-
emulsion, production of latent image in it ... and on the development of this image. Certain ultrasonic phenomena like the radiation pressure in front of a plane crystal and the phenomenon of ultrasonic cavitation have been briefly described. Sonoluminescence accompanying ultrasonic cavitation and the contradictions in its origin and in its intensity values in different liquids and at different temperatures are discussed. The problem and the various experiments that will be performed to solve it are stated at the end of the first chapter.

The experimental details are given in the second chapter. Ultrasonic waves were obtained using piezoelectric crystals of frequency 0.45, 1 and 3 MHz and magnetostrictive transducer of frequency 20 KHz. Experimental details to measure the wavelength and intensity of ultrasonics are described. The details of the construction of an RF oscillator of input power 100 watts and of frequency range 1 to 5 MHz and of an optical densitometer to measure the film blackening are described. The details of the assembly of the apparatus to obtain ultrasonographs using piezoelectric and magnetostrictive transducers are illustrated. The experimental arrangement to measure sonoluminescence intensity using a piezoelectric ceramic bowl of frequency 450 KHz and a photomultiplier tube is also illustrated. The experimental procedure to estimate the change in weight and volume of the film on absorbing water and the effect
of temperature and humidity on the blackening of the film is given in the end of the second chapter.

The details of the results obtained in this investigation are given in the third chapter. The densities of blackening of the ultrasonographs obtained by varying such parameters as, (i) distance and angular position of the film; (ii) intensity and frequency of the waves; (iii) moistening of the film in different liquids; (iv) speed of the film; (v) temperature; (vi) transmitting medium; (vii) presence of external light, etc. are recorded. Whereas in most of the previous investigations the films were immersed in dilute developer in the present work they have been immersed in distilled water. The density is found to increase with the increase in (i) intensity of the waves; (ii) time of exposure; (iii) pre-moistening of the film; (iv) sonoluminescence intensity; (v) temperature and is found to decrease with the increase in (i) angle between the normal to the film and the direction of the incident waves and (ii) speed of the film. These results have been compared with those of the previous workers. The intensity and wavelength of the ultrasonic waves have been measured. The relative values of the sonoluminescence intensity in water, xylene alcohol, carbon tetra chloride, nitrobenzene, glycerine etc. and in case of water at different temperatures are tabulated and compared with the results so far available. The sonolumi-
results on the variation of density of blackening of the photographic film exposed to ionising radiation at different temperatures and humidities are recorded. The density of blackening decreased with increase in humidity but it remained the same in the temperature range 3 to 47°C. The amount of water absorbed by the film and the corresponding change in its dimensions are also recorded.

On the basis of these results the possibility of blackening by different ultrasonic effects like mechanical, heating, hydrodynamic and cavitation are discussed in the beginning of the fourth chapter. The results, excepting those on variation of blackening with temperature and film-speed, suggest that the blackening is due to cavitational effects. The results on the blackening of the film are then examined along with those on the scoluminiscento intensity, water absorption by the film and sensitivity dependence on temperature and size of the silver halide grains. It is then found that the variation in the blackening with all the parameters including temperature and film speed can be explained on the basis that the blackening is due to cavitation. A mechanism of blackening of photographic films by ultrasonics is then suggested. Cavitation is favoured at the liquid film interface because of the air molecules entrapped (1) at the interface; (2) inside the porous gelatin and (3) between the silver halide grains and the absorption layer of gelatin. The cavitational effects like scoluminiscento act on the silver halide grains on the
surface and in the interior of the emulsion layer unlike ordinary light which act only on the front surface of the grains in the outermost layer. The hydrodynamic, thermal, mechanical and chemical effects of ultrasonics facilitate the image formation by cavitation effects. It is found that all the observed results on the variation of blackening of photo-emulsion by ultrasonics can be satisfactorily explained by this mechanism.