PROGRESS MADE IN SENSITIZED MATERIALS USED IN AERIAL PHOTOGRAPHY[1]

IN THE manufacture of sensitized materials for aerial photography certain standards must first be established so that the products will be correctly adapted to their use. The standards for aerial photography are fundamentally different from the standards for every other type of photography and therefore require films and papers whose characteristics are matched to fit the particular problem. In order to establish the proper standards it is necessary to consider the fundamental characteristics of all sensitized photographic materials which include their speed, contrast, color sensitivity, etc. These characteristics and the many variations of each of them would permit an infinite number of film combinations but, of all of these, there are certain particular combinations which most closely fit the requirements for aerial photography.

Considering all characteristics individually, in order that the correct combination of standards may be set up, it was first found that the speed characteristic was limited in practice by the minimum exposure which would give an acceptable negative; that is, acceptable in both the photographic and photogrammetric sense. The speed standard to be set up, therefore, was that the film should be as fast as possible.

The practical requirement relating to the contrast standard was that the gradation should be such as to permit the maximum tonal separation of objects and the standard was, therefore, that the film have a brilliant gradation to counterbalance the extremely low subject contrast of natural terrain as viewed from the air. This has been especially exemplified by the case where different kinds of soils have had to be identified by their photographic recording.

The color sensitivity of the film is also a factor for particular attention in setting a standard. Its basic practical requirement parallels that of the contrast of the film in that maximum tonal separation is required, and in order to fit this requirement, the film must have a high sensitivity to all of the colors of nature, particularly to the dark brownish earthy colors and to the greens. The required standard is, therefore, that the film have as high a panchromatic sensitivity as possible. In addition to giving maximum tonal separation of the earthy colors, high panchromatic sensitivity also gives an improved penetration of haze with filters and lower filter factors, permitting shorter exposures with them.

Another result of the combination of brilliant gradation with high color sensitivity to produce maximum tonal separation is that less filtering is required, in order to get a desired negative brilliance, than would otherwise be the case, since the brilliance is inherent with the film and does not have to be obtained by means of contrast filters. This, of course, does not mean that filters are wholly unnecessary since they are of recognized importance in penetrating haze, but it does mean that such a film is helping to accomplish what otherwise could be done only with heavier filters and the consequent sacrifice in speed.

There is one exception to this characteristic, for although a high panchromatic sensitivity is the most desirable for all average use, in the springtime when trees are just turning green, the use of an ortho film would be more desirable because of its better ability to record the green tones of nature. Some experimental work has been done in this country with such films although they have not as yet met with general acceptance despite the fact that ortho aerial films

[1] Paper delivered at the semi-annual meeting of the American Society of Photogrammetry in New York City on September 8, 1938, by Verne H. Reckmeyer, Research Laboratory, Agfa Ansco Corporation, Binghamton, N. Y.

can be made with speed, gradation, and other characteristics that are comparable to those of panchromatic films.

Films sensitive to the infra red are also used to obtain maximum detail and tonal separation and such films are particularly useful for recording detail in extremely distant objects. Their general use for mapping, however, has not been entirely satisfactory since, because of the inverted color recording of infra red film, their pictures cannot be matched with those of panchromatic negatives.

Of particular importance in photogrammetry is the standard for film shrinkage. The practical requirements have resolved themselves into, first of all, the requirement that dimensional variations due to differences in shrinkage of the film in different directions shall be the most important consideration and, secondly, that the total shrinkage shall be as low as possible. Shrinkage standards which have been arrived at for aerial mapping film by various government and commercial purchasing agencies usually require a maximum total shrinkage of less than 0.15%, with a directional variation which does not exceed 0.04%. For general aerial photography somewhat lower standards have been allowed.

The total shrinkage is most commonly determined by an accelerated aging test which is expected to show the maximum shrinkage that will occur over a period of years. Experience with this test has shown that the shrinkage actually occasioned by normal storage of films has never exceeded that shown by their accelerated aging test, at least, not within a period of several years. In a strict sense the accelerated aging test must be interpreted as an indication of the probable total shrinkage of the film.

The accelerated test measures the irreversible shrinkage of the film which is the permanent shrinkage occurring with the passage of time. It is thought to be caused, at least in part, by the slow evaporation of solvents or volatile substances from the film base. There is also another type of shrinkage which may occur and which is reversible. It includes those dimensional changes which are caused by changes in the moisture content of the film. The moisture content of the film changes with the relative humidity of the surrounding atmosphere and under unfavorable conditions can result in much greater shrinkage than the 0.15% indicated by the accelerated test. Since this shrinkage, or elongation as the case may be, is reversible, a restoration of the film to its original humidity will cause the film to return to its original dimensions. While this dimensional change affects the total shrinkage to the greatest extent, it affects the differential shrinkage the least. This reversible shrinkage is minimized in special non-shrink film base, as is the total shrinkage, but cannot be completely eliminated. In practice, cold light enlargers and printers, utilizing mercury vapor or argon tubes, are used to prevent drying out the negative while printing and there is also an increasing trend towards air conditioned laboratories to minimize possible errors due to dimensional changes in both films and papers. All of the Agfa aerial films are supplied on a non-shrink base which meets with the above requirements for shrinkage, having a maximum of less than 0.12% total shrinkage and 0.03% dimensional variation.

The above standards are those of major importance for aerial photography to which, of course, must be added the additional requirements demanded of all films, such as latitude, fineness of grain, uniformity, good keeping quality, etc. A few additional special characteristics have become important from time to time and these have been automatically incorporated into the manufacture of the film as the need arose. Among them, for example, has been the anti-static treatment now applied to the film which minimizes difficulties with static at

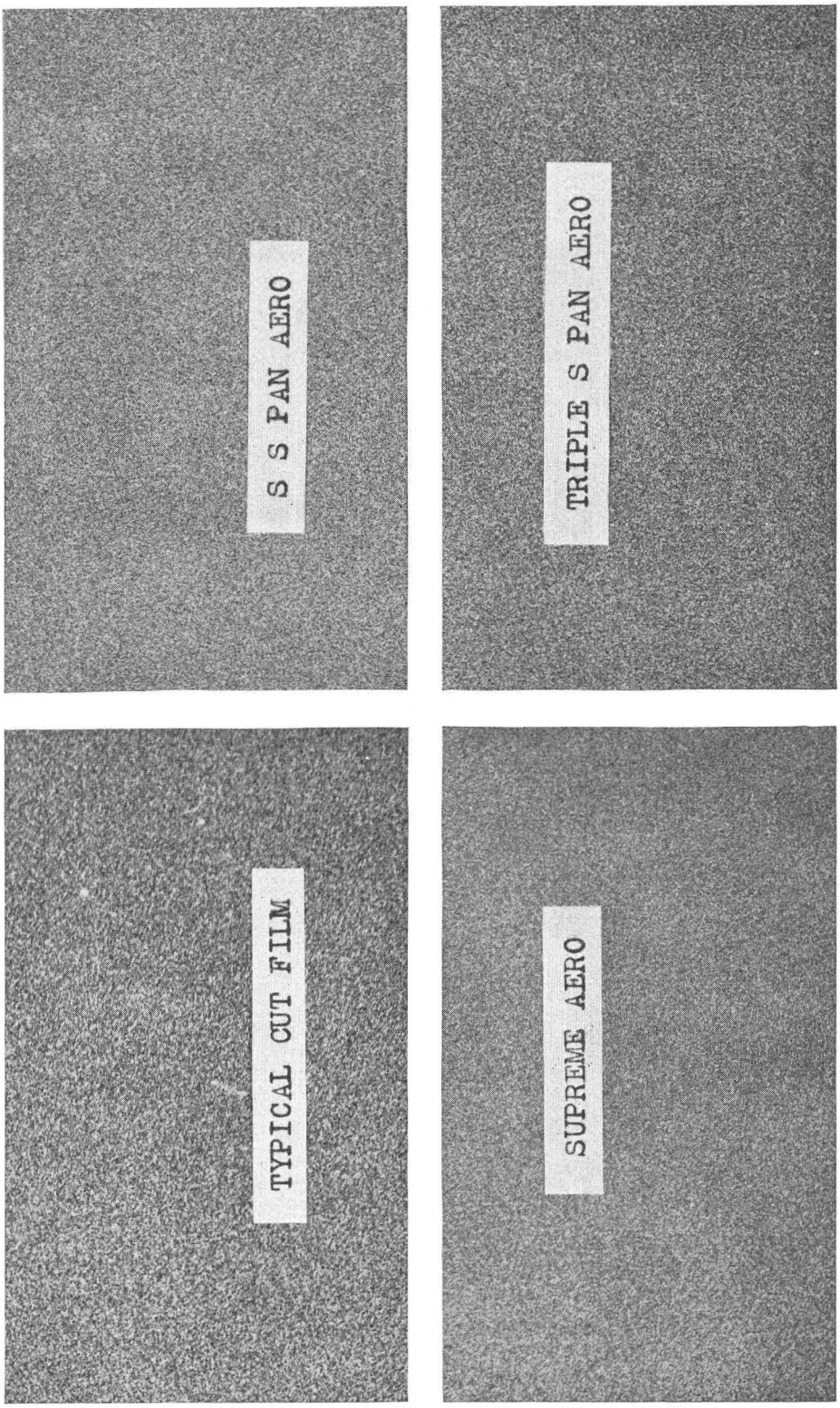


FIG. 1

high altitudes as well as reducing the curl of the negatives. Another is the use of a gray anti-halo base to preserve the details of fine grained films.

Based upon these standards, the first Agfa Ansco S. S. Pan Aero film was developed some five years ago. The resulting film was especially regarded for its high speed, improved tonal separation, latitude, fineness of grain, keeping quality, etc. Since then no major changes have been made in this film, nor has there been found any reason to deviate from those original standards. A few minor improvements have been made possible including occasional increases in speed which have amounted to approximately doubling the sensitivity of the film.

A year ago a special fine grain aero film, having a maximum resolution of detail, was experimented with and introduced. It was known as Supreme Aero film and was outstanding in that markedly finer grain (see Fig. 1) and improved recording of detail were obtained. The film was manufactured with a gray anti-

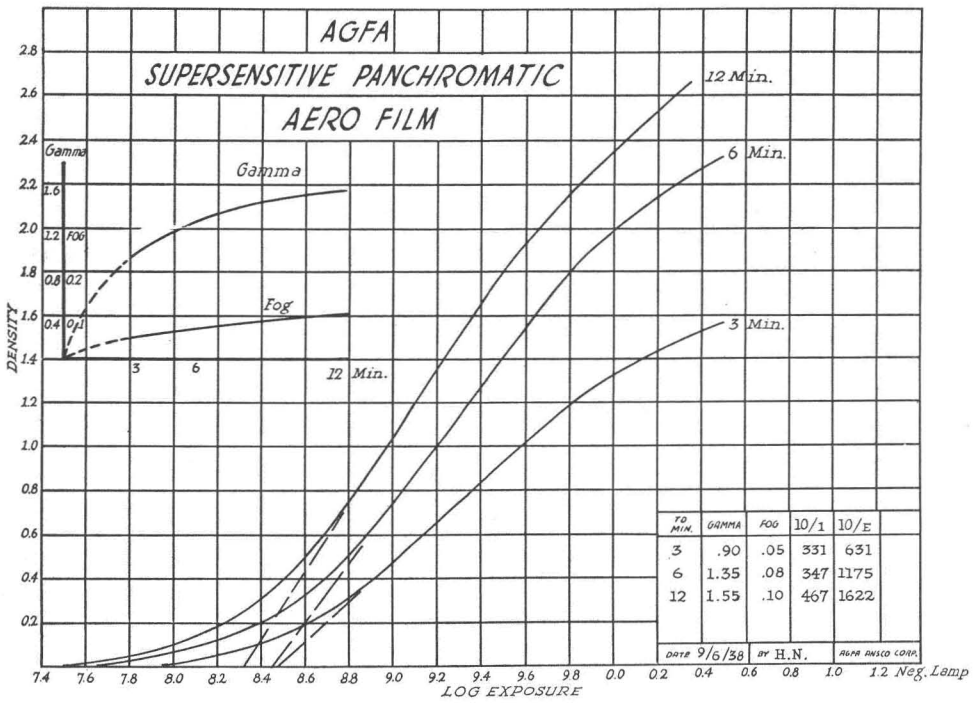
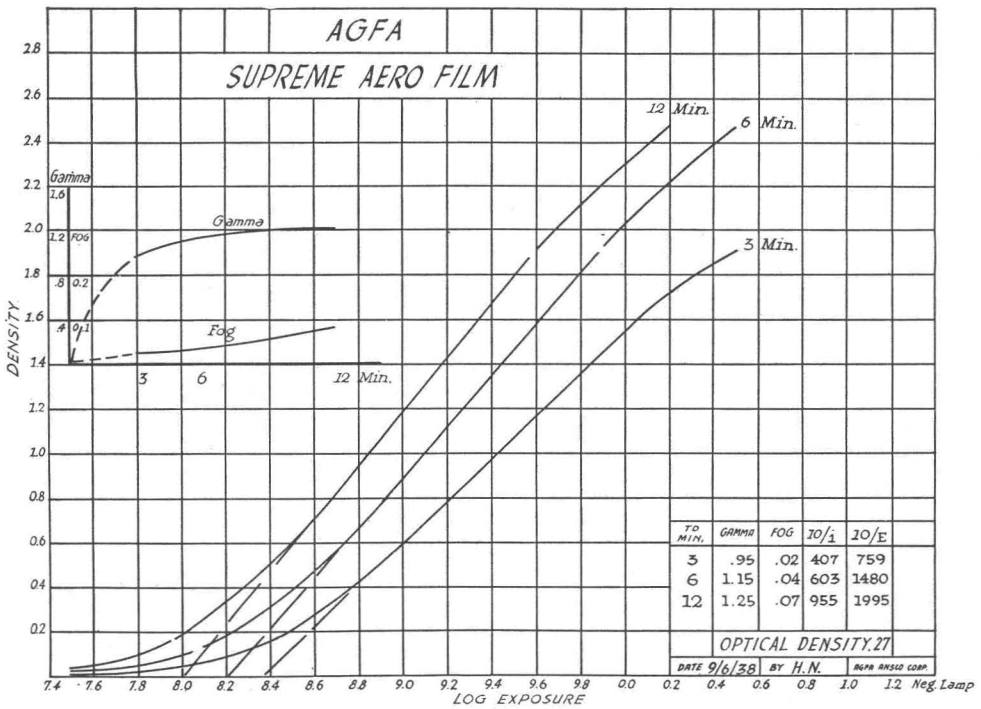


FIG. 2

halo layer incorporated in the base immediately under the emulsion. This anti-halo layer was similar to that which the motion picture industry has used for years on 35 mm. negative films. The film was also unique in that it had a single coated emulsion, permitting more rapid drying after development than would be the case with double coated films. Recent improvements in S. S. Pan Aero film, increasing its emulsion speed to equal the original speed advantage obtained with Supreme Aero film, and its present availability on gray anti-halo base have now, however, resulted in its largely replacing Supreme Aero film as being the best general purpose aerial film.

The most recently introduced film in the aerial mapping field has been Triple

S Pan Aero film. It has the same emulsion as Superpan Press which has already won recognition in newspaper work and other high speed photography. Now, available on aero film stock, it offers the same speed advantage in that it can be exposed with about two lens stops less exposure than S. S. Pan Aero film (about one stop less than present productions). It is remarkable that this emulsion speed has been produced with practically no alteration of the color sensitivity or gradation characteristics found in S. S. Pan Aero film. This introduction of a higher speed film has opened up possibilities for an entirely new technique in aerial photography. Such possibilities are the use of wide angle lenses, working at small apertures, and at high shutter speeds, with correspondingly greater



TO MIN.	GAMMA	FOG	10/1	10/E
3	.95	.02	407	759
6	1.15	.04	603	1480
12	1.25	.07	955	1995

FIG. 2

plane speeds. Night photography has also been made more possible, as has been daylight photography under less favorable light conditions, particularly with filters, than has been heretofore possible.

Sensitometric curves for this film in comparison with the other aerial films are shown in Fig. 2. An exceptional feature of Triple S Pan Aero film should be noted there, in that with increasing development there is a greater threshold development than with the other films. This property, which is peculiar to the new high speed films, strongly tends to prevent excessive contrast by overdevelopment, and also provides some reserve speed if the pictures are definitely known to be underexposed. Development of Triple S Pan Aero film should be in total darkness and slightly more than normal time should be allowed for complete fixation. The grain has not been coarsened with this phenomenal increase in speed (see Fig. 1).

Direct Copy is a special film of such unusual characteristics that it should

also be mentioned. The film is not intended for use in a camera, but is for making duplicate negatives. When exposed and developed, a negative copy results if printed from a negative original, thus permitting copies to be made without the necessity of going through an intermediate positive stage. The film is exposed in a manner similar to making a contact print, except that about three times the exposure of Convira Medium is required. Development may be in any good negative developer and is carried out by inspection with a yellow or orange safelight to the desired density. No special manipulation or solutions are required, the only difference from ordinary contact materials being that one must accustom oneself to the fact that overexposure produces a lighter than a darker

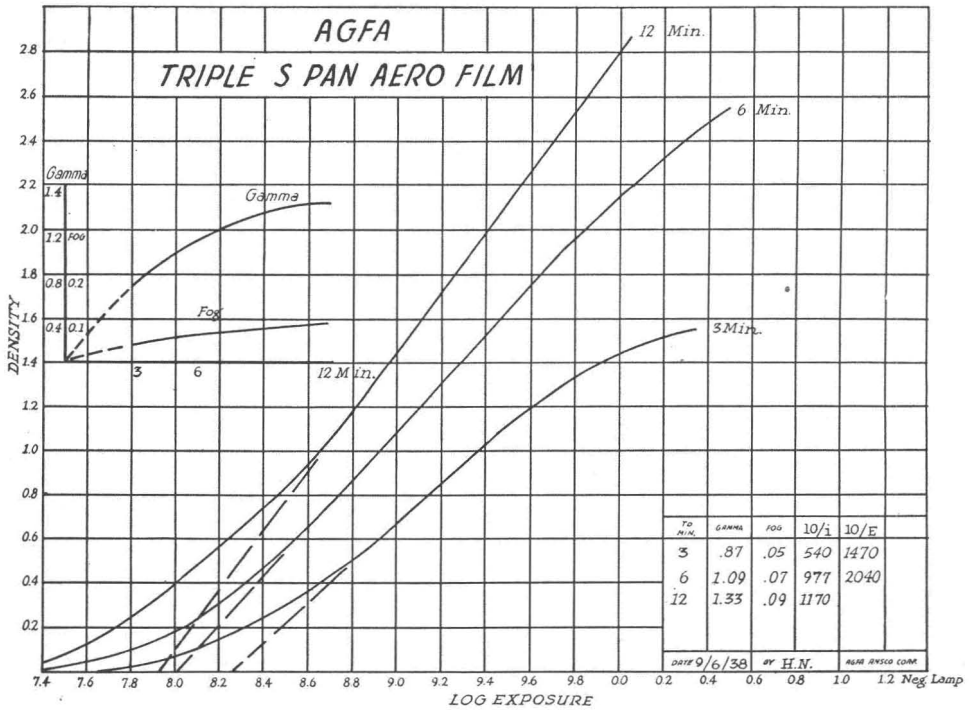


FIG. 2

negative, and that underexposure produces a darker negative which is contrary to the usual scheme of things (Fig. 3). Direct Copy film has proved to be of special value in duplicating negatives which are undesirably thin. Their contrast can be improved somewhat and a duplicate made in which original extremely light densities will be stepped up so as to print more solidly.

The latest addition to the list of aerial mapping products is Brovira Mapping Special Paper. This is the result of a three-year investigation to obtain a paper raw stock which would be the most practical for aerial photographs. It combines the already well established Brovira emulsion (Fig. 4) with the new raw stock which embodies advanced principles of manufacture and which reduces the shrinkage factor to far below that found with any ordinary photographic paper. The stock does not differ materially in appearance from ordinary double weight paper but has about one-half the total shrinkage and one-fifth or less of the dimensional variation. It has been approved by several government

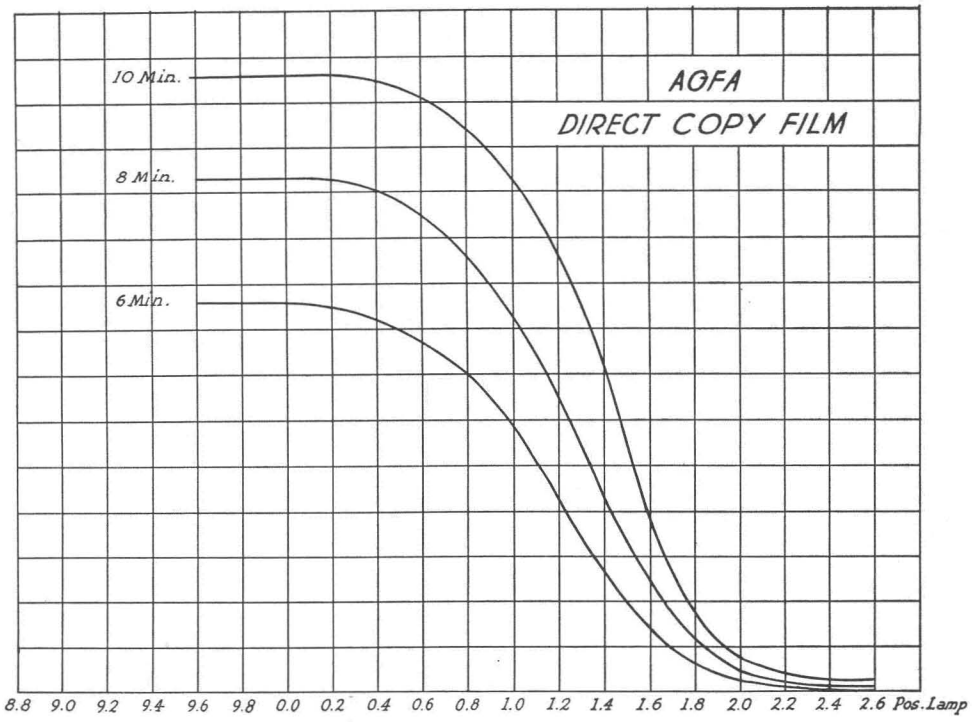

10 Min.
8 Min.
6 Min.
AGFA
DIRECT COPY FILM
8.8 9.0 9.2 9.4 9.6 9.8 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 Pos. Lamp

FIG. 3

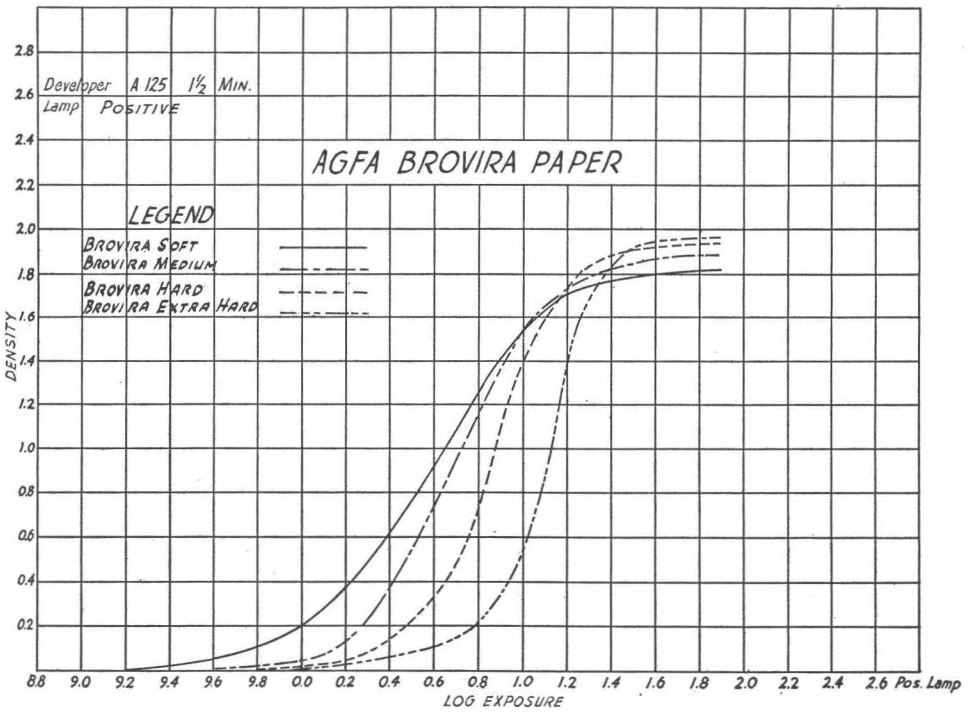

Developper A 125 1½ MIN.
Lamp POSITIVE
AGFA BROVIRA PAPER
LEGEND
BROVIRA SOFT
BROVIRA MEDIUM
BROVIRA HARD
BROVIRA EXTRA HARD
DENSITY
2.8 2.6 2.4 2.2 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2
8.8 9.0 9.2 9.4 9.6 9.8 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 Pos. Lamp
LOG EXPOSURE

FIG. 4

bureaus, meeting with both their shrinkage and photographic requirements.

The shrinkage data for Brovira Mapping Special are shown in Tables 1, 2, and 3. These tables show that the paper has a dimensional variation that is less than 0.10%, which is the present acceptable standard. Table 2 shows the effect of handling the paper at high or low humidities, indicating that although the total shrinkage changes to some extent with the humidity, the dimensional variation, which is the more important, changes but very little. Table 3 indicates the change in dimensions after storage for different periods of time. In addition to this data a word of caution should be given in regard to humidity conditions where paper is used. Best results will always be obtained if the paper is stored and exposed under conditions of average humidity, that is, about 50%. This is

TABLE I

SHRINKAGE OF BROVIRA MAPPING SPECIAL PAPER

	Lengthwise	*Crosswise*	*Difference*
Processing only	0.35%	0.27%	0.08%
24 hours. Oven 120° F.	0.45%	0.40%	0.05%

Relative Humidity 50%

TABLE II

SHRINKAGE OF BROVIRA MAPPING SPECIAL PAPER

	Lengthwise	*Crosswise*	*Difference*
72% R. H.	0.32%	0.22%	0.10%
50% R. H.	0.35%	0.27%	0.08%
30% R. H.	0.40%	0.35%	0.05%

TABLE III

SHRINKAGE OF BROVIRA MAPPING SPECIAL PAPER

	Lengthwise	*Crosswise*	*Difference*
Sample 1–14 months old	0.30%	0.35%	0.05%
Sample 2–14 months old	0.31%	0.29%	0.02%
Sample 3– 3 months old	0.40%	0.36%	0.04%
Sample 4– 3 months old	0.42%	0.38%	0.04%

because of the fact that if, in the case the finished print is at some later date stored in an atmosphere of extremely high or low humidity and measurements are then taken from it under this condition, the dimensions will be changed relatively less than would be the case if the original exposure were not made under conditions of average humidity. This precaution is true for all papers except those which are aluminum laminated.

Mapping Special is supplied in three contrasts, Soft, Medium, and Hard, which are handled and developed in exactly the same manner as Brovira.The stock, however, is somewhat more limber, yet of a very fine texture, and it does not crack as easily as regular papers. It also drys in somewhat less time than ordinary paper, probably because of its firmer weave. The surface is smooth, having a very slight sheen, which is well adapted to taking pencil or ink markings. Since the price of the paper is no more than that of regular Brovira, it is economically more practical than aluminum laminated or other types of low shrink papers which must be sold at an increased price.

In conclusion, it has been our desire to express the thought that the manufacturer designs and continuously works to improve these products with definite consideration for their practical requirements, and thereby builds into them the highest possible measure of quality, so that the user can be assured that he is obtaining a material which is most satisfactory for the purpose that it is intended.

SPECIAL NOTICE

The University of Oklahoma plans to hold a Short Course on "Aerial Photographic Mapping and Geological Exploration" in Norman, Oklahoma on Friday and Saturday, February 17 and 18, 1939.

The course will emphasize the various geological uses of aerial photographs, both vertical and oblique. To this end, papers on "geological interpretation" have been scheduled as follows:

"Geological Interpretation by the Oil Geologist"

1. Dr. Donald C. Barton, Geologist and Geophysicist,
   Humble Oil Company, Houston, Texas.
2. Dr. Frank Evans, Geologist,
   Shell Oil Corporation, Houston, Texas.
3. Mr. Louis Desjardines, Geologist,
   Tulsa, Oklahoma.

"The Use of Aerial Photographs in Geological Teaching"

1. Professor Frank A. Melton, University of Oklahoma.

An important part of the course will be papers on the subjects of administration and planning of aerial mapping programs, new developments in mapping equipment, base map assembly, the construction of contour maps by stereoscopic methods from aerial photographs, etc.

The list of speakers in the field of aerial surveying and mapping has not been definitely determined, although an effort is being made to secure the following:

Mr. Marshall S. Wright, U. S. Department of Agriculture
Dr. I. C. Gardner, National Bureau of Standards
Mr. E. S. Massie, Jr., U. S. Forest Service
Mr. T. P. Pendleton, T. V. A., Chattanooga, Tennessee

A large attendance of geologists, engineers, conservationists and others is expected.