acetates until he finds the type of photographic coverage to fill his requirements. The acetates are arranged chronologically by year, with the sheets showing latest coverage on top, and within year by type of photography (mapping, charting or reconnaissance). All acetates are in exact register with the others because the preprinted bisecting meridian (vertical registration line) and the pre-punched post holes have a fixed relationship.

Exact or individual exposures, including stereo pairs can be ordered because of the style of indexing employed in the Standard Indexing System. Mosaic or photo index; coverage information is located in the same binder, graphically indexed, but overprinted with a different format. If more detailed evaluation is desired prior to ordering prints or if reproduction is not absolutely necessary, the research analyst may view the photography by ordering the prints from the "view" file of the Aerial Print File. The "Print File Number" in the upper right-hand corner of the acetate overlay is the locator file number for the prints of that particular sortie camera position.

The US Air Force radar photography is being plotted and indexed in a manner somewhat similar to the visual aerial photography, by the use of specific symbols for various range setting and distances.

This type of photography is plotted on a transparent sheet keyed to a World Aeronautical Chart at a scale of 1:1,000,000. Due to the large areas covered by the radar scope, this photography is plotted in composite form with all pertinent information that is necessary for its use for military purposes.

A booklet covering this topic is available on request. Address the Commanding Officer, Office of Research and Liaison, Aeronautical Chart and Information Center, Washington 25, D. C. Ask for ACIC Technical Report no. 65, entitled Standard Indexing System for Aerial and Radar Photography.

PERFORMANCE CHARACTERISTICS OF "CRONAR" POLYESTER PHOTOGRAPHIC FILM BASE*

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ABSTRACT

The laboratory and field test performance of "Cronar" photographic film base are discussed and data presented on stability coefficients, flexibility, strength and optical properties of this new base. All of these data suggest that "Cronar" base will offer handling and performance advantages of especial benefit to the field of photogrammetry.

BECAUSE of the restricted time available for this presentation, it will be necessary to limit our coverage to actual performance characteristics of "Cronar" base when sensitized with du Pont "Photolith" lithographic film emulsion

As these data will indicate, this base is ideally suited to many photographic fields, but a description of all of these applications and the interesting story of "Cronar" base must be deferred until another time.

Our remarks must be prefaced with the statement that "Cronar" base is not commercially available, today, and the field experience being reported is based on the output of a pilot plant now producing continuous rolls of 11″ material. Small quantities of this pilot plant base have been made available for field trial. Quantities of "Cronar" base will not be available until sometime after the commercial plant unit now under construction starts operation in the middle of this year.

The commercialization of polyester films is the culmination of many years of du Pont research and development. "Mylar" polyester film is now in production by the Film Dept. of du Pont for non-photographic applications. Its chemical relative, "Cronar" polyester photographic film base, will be manufactured by the Photo

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REFRACTIVE INDEX OF UNSENSITIZED FILMS

"CRONAR" * BASE	1.64
HIGH ACETYL ACETATE BASE	1.48
VINYL BASE	1.54
POLYSTYRENE BASE	1.59
VARIOUS GLASS TYPES	1.52–1.65

*POLYESTER PHOTOGRAPHIC FILM BASE

FIG. 1

AVERAGE SPECIFIC GRAVITIES OF SEVERAL BASE TYPES

"CRONAR" * BASE	1.39
CELLULOSE DIACETATE OR HIGH ACETYL BASE	1.28
CELLULOSE NITRATE BASE	1.37
VINYL BASE	1.35

*POLYESTER PHOTOGRAPHIC FILM BASE.

FIG. 2

Products Dept. of du Pont for photographic applications.

Let's by-pass the chemistry of "Cronar" base by simply pointing out that it is a polymerization product of ethylene glycol and terephthalic acid. The resultant film contains neither solvents or plasticizers to leach out with age and create sensitometric and dimensional stability problems.

In considering "Cronar" base "Photolith" lithographic film in photogrammetric usage, the first factors to be noted are the extremely smooth and planar surfaces and the optical transparency of the base.

Illustration (Figure 1) lists the refractive indices of various base types, and it is expected that the very high index of "Cronar" base may well contribute to improved resolving power under critical use conditions, but we have no actual data to present. Perhaps you will be able to tell us whether this characteristic is of any special value in your fields of usage.

The specific gravity data provided in Figure 2 permits calculation of film roll weight in critical applications like aerial films. In making such comparisons it must be remembered that the thinner "Cronar" base (.004") will provide longer roll lengths for equal roll weight.

The next characteristic that is apparent in handling "Cronar" base is its flexibility and strength, and Figure 3 details the laboratory findings that demonstrate the outstanding superiority of "Cronar" base over any currently available film base types.

In plant practice, these film characteristics mean that "Cronar" negatives will not be accidentially torn nor will they crack or break when handled or dropped. In addition, the anchorage of the emulsion to the base is extremely secure, so that there is no danger of defacing or ruining negatives when tapes or taped overlays are removed from a completed job.

One field practice must be changed when using "Cronar" base; the technique of scoring the base and cracking the base along the desired line. You just cannot do this with "Cronar" base—you must make a clean cut with a razor blade or scissors, since even repeated folding will not break off a scored edge of film. There are a few field situations where this strength may be a minor nuisance, but the vast majority of our contacts have considered the durability of the film to be a prime asset.

The outstanding attribute of "Cronar" base is its dimensional stability, and we are considering both humidity and thermal factors in making this statement. In

PHYSICAL CHARACTERISTICS OF SENSITIZED LITHOGRAPHIC TYPE FILMS

	THICKNESS IN INCHES	AV. TEAR STRENGTH (1) (LOAD IN GRAMS)	AV. YIELD OR BREAK (2) LOAD P. PER SQ. IN (WHICHEVER IS LOWER)	FOLD ENDURANCE OR FLEX LIFE (3) 20% RH	50% RH	70% RH
"CRONAR"* BASE	.0042"	225	13,500	20,000+	20,000+	20,000+
TRIACETATE	.0058"	40	9,000	—	15	—
VINYL	.0196"	72	8,900	10	10	50
POLYSTYRENE	.0055	21	11,300	80	90	100

(1) DETERMINED BY ASTM METHOD D689-42T
(2) DETERMINED BY ASTM METHOD D882-49T
(3) DETERMINED BY ASTM METHOD D643-41T

*POLYESTER PHOTOGRAPHIC FILM BASE.

FIG. 3

EFFECT OF BASE THICKNESS ON HUMIDITY STABILITY WITH CONSTANT EMULSION COATING WEIGHT

"CRONAR" * BASE THICKNESS	HUMIDITY COEFFICIENT
.0025"	3.3×10^{-5}
.003"	2.5×10^{-5}
.004"	2.0×10^{-5}
.007"	1.4×10^{-5}

*POLYESTER PHOTOGRAPHIC FILM BASE.

FIG. 4

our following discussion, we treat these two variables independently for ease of interpretation, but in usual shop practice both factors are at work and must be considered simultaneously.

Before giving specific humidity stability data on lithographic type films, let us consider one modifying factor. The humidity stability of a given base is directly related to the amount of gelatin coated on its surfaces, so that the heavier the gelatin coating weight, the greater the base size change caused by a given relative humidity change. Conversely, if we put the same coating weight on different thicknesses of the same base material, the thicker films will have greater resistance to the humidity distortion of the gelatin, or greater stability.

As an example of this relationship, Figure 4 shows the humidity stability results of an experimental emulsion coated on several different "Cronar" base thicknesses. The stability advantages of the heaviest .007" base are obvious.

In Figure 5 we list the humidity stability performances of several commercially available lithographic film types when tested under our laboratory conditions.

You will note that we have not attempted to define precise values for each base type because of sample to sample variations as well as test variations, but the average performance of our .004" "Cronar" base "Photolith" Film is comparable to other currently available stable base films.

The thermal stability of "Cronar" base is outstandingly good and covers a range well beyond usual shop conditions.

The thermal coefficients given in Figure 6 were derived for unsensitized base but should be applicable in usual practice where "Cronar" base will be much less heat sensitive than vinyl or polystyrene bases.

In summarizing over-all laboratory stability data, "Cronar" base is equivalent to available stable bases for humidity amplitude, and is substantially superior for thermal amplitude. Actual shop experience has confirmed these laboratory findings.

In addition, "Cronar" base, because of its optical clarity, will be able to do many jobs now requiring glass plates, thus eliminating the handling dangers, breakage losses and storage problems created by glass plate usage.

"Cronar" base is not as stable as glass or template metal when the ultimate in dimensional stability is required; and when choosing between film or glass, critical users will have to balance the many

HUMIDITY COEFFICIENTS OF VARIOUS SENSITIZED LITHOGRAPHIC FILMS

BASE TYPE	HUMIDITY COEFFICIENT
.004" "CRONAR" * BASE "PHOTOLITH"	$1.0-2.0 \times 10^{-5}$
.0055" DIACETATE BASE	$8.0-10.0 \times 10^{-5}$
.0055" SENSITIZED HIGH ACETYL ACETATE	$5.0-7.0 \times 10^{-5}$
.0055" SENSITIZED POLYSTYRENE	$1.0-2.0 \times 10^{-5}$
.010" SENSITIZED VINYL	$1.0-2.0 \times 10^{-5}$

(COEFFICIENT IS LENGTH CHANGE IN INCHES PER INCH LENGTH PER 1% R.H. CHANGE)
VALUES DERIVED OVER THE HUMIDITY RANGE 20%–70% AT 70° F.

*POLYESTER PHOTOGRAPHIC FILM BASE

FIG. 5

THERMAL COEFFICIENTS OF VARIOUS UNSENSITIZED FILMS

BASE TYPE	THERMAL COEFFICIENT
"CRONAR" * BASE	2.0×10^{-5}
DIACETATE BASE	3.4×10^{-5}
HIGH ACETYL ACETATE BASE	2.3×10^{-5}
VINYL BASE	3.8×10^{-5}
POLYSTYRENE BASE	3.5×10^{-5}
GLASS	0.5×10^{-5}
ALUMINUM	1.4×10^{-5}

(COEFFICIENT IS LENGTH CHANGE IN INCHES PER INCH LENGTH PER 1° F. CHANGE.)

*POLYESTER PHOTOGRAPHIC FILM BASE.

FIG. 6

handling virtues of "Cronar" base against the marginal loss of dimensional accuracy encountered under specific use conditions.

In those cases where "stable" base films are used in extremely critical applications, it is mandatory that humidity and temperature conditions be controlled, and the degree of control necessary for a given application can be calculated from the humidity and thermal coefficients described in the preceeding illustrations.

The long term aging characteristics of "Cronar" base are excellent, since the base is chemically inert and contains neither solvent nor plasticizers to be lost gradually as it ages. Normal storage studies in the laboratory have given no indication of base change or deterioration, and 40 day accelerated storage tests have caused no significant changes in base properties. We have roll and cut sheet samples of our earliest production trials which are now 4-5 years old, and none of these samples show any evidence of base or emulsion degradation.

As a final performance factor, "Cronar" base is listed as slow-burning or safety base under the Underwriters Lab. Reexamination Service, with its fire hazard being slightly less than that of common newsprint in equivalent form and quantity. "Cronar" base also complies with ASA Standard Definition of Safety Photo Film Z-38.3.1-1948. "Cronar" base is thus similar to conventional safety films such as cellulose acetate.

In summary, the optical clarity, strength, flexibility and dimensional stability of "Cronar" base seem to be of especial value in lithographic and photogrammetric applications, so it is our plan to make .004″ "Cronar" base "Photolith" available as our standard litho product very early in our plant production program. It is probably that a heavier .007″ base "Photolith" will be supplied later for usage where sheet rigidity and maximum stability are required. The handling characteristics of a very thin .0025″ "Cronar" base "Photolith" are being investigated in gravure and other applications where thinness as such is of paramount interest (when coupled with excellent strength and good dimensional stability).

Guidance from Societies such as yours is welcomed as we try to develop the "Cronar" base products best suited to the requirements of your field.