

## RESTORATION METHODS<sup>1</sup>

RESTORATION of documents and records by the process of sealing them between thin sheets of plastic foil is being more and more recognized and used in archival establishments throughout the United States as the accepted method of treating such material, and there has come into being a considerable body of information on the subject, much of it quite technical in character. The purpose of this paper is to recapitulate these findings and to add information from studies of my own, not heretofore printed, on processes for arresting deterioration before it reaches an advanced stage.

It has been recognized by chemists for a number of years that acidity in paper is the chief cause of brittleness found in many documents. This acidity arises from chemical changes within the paper itself as well as from conditions of storage. It is possible to measure the degree of this acidity by laboratory tests and to rate it according to a standardized scheme technically known as pH values. These are expressed as logarithms ranging from 1 to 7, a low pH representing a high acid content. Samples of badly deteriorated papers which I have tested have been found to be very acid, with a pH as low as 3.1, and similar findings have been reported by the National Bureau of Standards and the U. S. Department of Agriculture.

Acidity, if allowed to remain, not only continues the destruction of the paper but contaminates and weakens any cellulosic material used to strengthen it. Obviously some non-injurious method of neutralizing the acid seems to be called for, but early experiments along these lines were discouraging because the acid condition had a tendency to recur. However, the discovery of the fact, through tests conducted by various U. S. agencies as well as by Messrs. Torrey and Sutermeister of the S. D. Warren Company, that certain old papers probably manufactured in a limestone region seemed to owe their remarkable preservation to the presence of calcium carbonate in them pointed the way to a method of neutralization which prevented acid recurrence.

As developed in my laboratory, this process consists of passing the document to be treated through two solutions, allowing it to remain for about twenty minutes in each. The first is a solution of 0.15 per cent calcium hydroxide which effectively neutralizes the

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acid, and the second is a solution of approximately 0.20 per cent calcium bicarbonate which carbonates the excess hydroxide and precipitates calcium carbonate into the fibers of the paper. The precipitated calcium carbonate not only has a stabilizing effect upon the cellulose fiber, but also acts as a buffer against the absorption of any acid at a later time. Tests conducted by Messrs. Shaw and O'Leary of the National Bureau of Standards indicate that calcium carbonate used as a filler exerts a beneficial effect upon the stability of papers made of rag, sulfite, and soda pulp. Mr. A. R. R. Westman of the Ontario Research Foundation has concurred in these findings in his study of the use of alkali earth metal carbonates in making a non-tarnishing paper for wrapping metals.

Documents should be treated for acidity before restoration by any method is attempted, and the restoration process itself should be free of any factors that would tend to renew this condition. The two principal methods of restoration employed at the present time, silking and lamination with cellulose acetate foil, are described below in this light.

The silking process consists of using a starch paste to attach to each side of the document a coarsely woven piece of silk cloth. This greatly increases the document's physical strength for a few years, but many archivists have reported that the silk usually deteriorates within eighteen to twenty-five years to such an extent that the document must be again restored. Documents thus treated are still susceptible to attack by micro-organisms and insects, the acidity of the paper is increased by the alum in the paste, and the deterioration of the silk will adversely affect the paper.

Lamination with cellulose acetate foil was originally advocated by the National Bureau of Standards which found through tests that this material makes a suitable protective covering since it possesses many satisfactory qualities. It is relatively permanent and strong and is resistant to bacteria, fungi, insects, and the passage of gases. Its transparency permits the passage of ultra-violet and infra-red rays and is no bar to photography. Further, it is relatively inexpensive. The suggestion of the bureau that adhesion could be obtained by heating and pressing the thermoplastic foil into the pores of the paper by a steam heated hydraulic press was first adopted by the National Archives, which has nothing but favorable reports on the process after some years use.

One of the best comparisons between silking and lamination that has been made was done by Dr. S. N. Sen, keeper of the records of the government of India, who with the archaeological chemist of India concluded, after examining all available evidence, that the lamination process was a superior method worthy of adoption. His findings likewise stressed the fact which had been before stressed by the National Bureau of Standards that cellulose acetate is a far different product than cellulose nitrate which is unstable and injurious to paper. This is worth stressing because there is still a tendency to confuse the two.

A laminator which is less costly to install than the steam heated hydraulic press has been developed in my shop. It consists of two electrically heated thermostatically controlled metal plates which pre-heat the material to be laminated. Compression is applied by passing the material from a heating unit between two revolving calender rolls which have a pressure range from 300 to 2,000 pounds per square inch. A complete cycle of heating and pressing requires only about thirty-five seconds. Major advantages of this process, for which patents have been granted, consist of the facts that no artificial cooling is required and that pressure by rollers eliminates the entrapment of air between the document and the foil.

A further modification of the process by the use of a sheet of high grade tissue on the outside of the cellulose acetate foil has been found to produce a much stronger product than that laminated with foil alone. With this addition, the folding endurance for newspaper is increased about twelve times and tearing resistance about four times. Binding margins are likewise easily formed by this method.

The superior results obtained by laminating paper after treatment for acid have been demonstrated in my own laboratory by testing samples of eighteenth century deteriorated papers before and after treatment by various processes. Among a group of these, some were silked, some laminated without treatment for acid, and others laminated after acid neutralization. Upon subjection to accelerated aging tests by baking for seventy-two hours at 100 degrees centigrade, it was found that the silked papers had lost 52 per cent of their folding endurance, those laminated but not treated for acid had lost 31 per cent while those laminated with the acid neutralized had lost but 5 per cent and had no increase in acidity.

A complete program for restoration embodying acid neutraliza-

tion and lamination with high grade tissue and foil is being used with my type of equipment at the Archives Commission, Dover, Delaware; the Hall of Records, Annapolis, Maryland; the Department of Archives and History, Atlanta, Georgia; and in my own shop which does considerable work for the state of Virginia. So far as I have been able to determine, satisfactory results have been obtained in all cases.

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