AIR CONDITIONING APPLIED TO PHOTOGRAMMETRY

John M. Noble
Julien P. Friez & Sons Division
Bendix Aviation Corporation

AIR conditioning was introduced over a quarter century ago by industry as the solution to continuous production, and some industries are completely dependent upon it. Comfort air conditioning is merely an outgrowth of the necessity of the factory.

Most materials, regardless of their composition, take up from or give off moisture to the surrounding air. This water is carried by solid materials in two characteristic forms. The first is free or capillary moisture, whcih is contained in the capillary space between the particles or fibers of the material. The second form is absorbed or hygroscopic moisture and is intimately associated with the physical nature of the material having a direct effect on such physical properties as size, strength, electrical conduction, heat conduction, etc. Removal of the capillary water has little or no effect upon the material except to reduce its weight, while removal of the hygroscopic water causes definite changes in physical properties and characteristics. This article, prepared in connection with the Friez Engineering Department, is concerned with the hydroscopic moisture of material as it affects certain phases of photogrammetry.

Paper Manufacture

Paper is a felted mass of minute vegetable fibers and is hygroscopic by virtue of its capillary structure. As paper absorbs moisture, the fibers swell causing a sheet of paper to become larger and wider; as it gives up moisture the paper contracts. The practice of purchasing paper by specification makes air conditioning of increasing importance to this industry.

Photogrammetric Problems

Intimately associated with the difficulties of paper manufacturing due to varying atmospheric conditions are the troubles of the photogrammetric industry. A change of 30% in relative humidity makes a 38″ sheet of one type of coated paper vary $\frac{1}{6}$″. Variations, particularly at certain times of the year, of from 6% relative humidity to 90% relative humidity over comparatively short periods of time are not at all unusual. Special papers are selected for photogrammetric applications and samples of each lot should undergo elaborate tests with particular reference to variations in proportions in all directions caused by variations in both humidity and temperature. Even so, these variations are still very costly and experience has shown that the proper control of humidity particularly is most advisable for uniform results and the elimination of endless annoying and expensive delays.

Most photogrammetric work is done at present on cellulose nitrate and cellulose acetate sheets. The variations in size of these materials with changes in relative humidity are much more uniform than is the case with paper, for which reason changes in size of the drawing sheet represent scale changes only and not distortions of the map. These materials have many advantages where transparency of the drawing is useful if precautions are taken to use them in fully air conditioned space.

Expansion or contraction of drawing paper on which an exact projection has been made is very detrimental in map work. If the change in size of the paper stock were uniform, corrections to compensate entirely for these changes

could be made. Unfortunately, the paper stock is characterized by irregular expansions or contractions which result in a distortion of the map scale. Scale changes of this kind cannot be compensated for in stereoscopic mapping methods and, as a consequence, errors are introduced into the map through no fault of the operator of the mapping process in use. However, these errors can be minimized by keeping the base map sheet under stable atmospheric conditions from the time the projection is drawn until the map is printed. Distortions are inevitable in maps after they leave the presses as they may be subjected then to the effect of extremely low and high relative humidity, depending on the region in which they are used. These changes, however, do not destroy the inherent accuracy of the map drawing and their effect can be reduced by printing the map on heavy paper of the best quality or by determining the distortion of the system of projection lines due to the atmospheric changes and applying an appropriate correction if this is necessary.

Humidifying alone will not solve the problem completely. Humidifiers are only capable of increasing the moisture content of the air when it is excessively low. Something must still be done to reduce the moisture content when it is excessively high. The solution is in controlled air conditioning.

The manner in which paper takes ink is seriously affected by the moisture content of that paper. Ink is taken into paper in two ways, one by absorption and the other by oxidation. On plain, dull, uncoated paper, ink dries by absorption, while on highly coated paper, ink dries by oxidation from the top down. If inks mixed to dry by absorption are applied to a sheet which contains excess moisture, the paper does not absorb or sense the ink as quickly as it should, thereby causing a very objectionable smearing of the ink lines even after an appreciable period of time.

Color registration in the printing industry definitely requires proper humidity control at all times if satisfactory results are to be obtained at reasonable cost. If a change in relative humidity of as little as 5% takes place, the normal paper on which the color printing is made, on a sheet 25″×38″, will stretch as much as 3/32″ in only 20 minutes. Similar variations take place while working on photogrammetric applications.

It must not be forgotten that improper storage conditions are a serious handicap in this industry. Although paper manufacturers encase paper of a definite moisture content in the average print shop, the paper in waterproof containers will wave or curl when opened. No standard of uniform relative humidity has been adopted by paper mills. Similar conditions under proper control are required for paper storage rooms before being placed on the work tables in the drafting rooms.

Another reason for maintaining a controlled atmosphere where paper products are stored is the matter of preservation. It is well known that many of our records are being made on paper which contains much chemical pulp. Only a few documents are being preserved on pure rag paper. Paper which if properly stored might last for centuries may be ruined in a week by improper atmospheric conditions. Moisture is less a governing factor in paper storage than the presence of acid fumes which rapidly destroy the very substance of the paper itself. Libraries, record rooms, etc., where original drawings may be stored which are situated near railway stations, blast furnaces, or sources of sulphur laden gases, should be supplied with properly washed and conditioned air.

Dust Elimination

Dust must definitely be eliminated in practically all phases of the photogrammetric industry. This subject has been touched upon by Mr. Pendleton

in his article entitled "Topographic Mapping with the Multiplex Aeroprojector" in the April-May-June, 1938 issue of PHOTOGRAMMETRIC ENGINEERING. At that time Mr. Pendleton pointed out that the continual sliding of the lightweight drawing table over the sheet in the multiplex process rubbed into the paper surface great quantities of grit and dust (when the air in the space concerned is not properly conditioned), and consequently penciled drawings soon become very unattractive and difficult to read. Mr. Pendleton also pointed out that unless provision is taken to maintain the cleanliness of the room in which the work is done it might be necessary to roughly ink such sheets to make them sufficiently legible for photography. He further pointed out that it is important that this costly and unnecessary operation be avoided. The specific recommendation has been made that Multiplex Aeroprojector equipment always be operated in air conditioned spce.

INSTRUMENTS

The success or failure of an air conditioning system often depends upon the adequacy of the controls.

Automatic control which responds to changes instantaneously saves kilowatt hours in electrical operation, decreases the number of man hours needed to operate a system, reduces losses from spoiled materials, and improves the quality of the product. The possible savings will more than offset the cost of adequate instrumentation. Accurate indicating and recording instruments produce an unbiased record.

Regardless of what system is used, control refers chiefly to temperatures which are maintained by thermostats and humidities which are maintained by humidistats.

A thermostat is a primary control consisting of an element sensitive to temperature changes which is used to control the source of heat supply or removal. A humidistat contains an element which responds directly to atmospheric humidity by a change of dimension, thereby actuating the devices to regulate the moisture content of an area. In 90% of the humidity controls used today, the sensitive element is specially processed human hair which responds directly to moisture changes. All electric control instruments are basically switches automatically actuated and used to complete and break electrical circuits and, in turn, start and stop the valves, dampers, etc., of the system.

Indicating and recording equipment is especially important to be included in the equipment for photogrammetric applications. The records thus obtained not only prove the proper functioning of the air conditioning equipment, but they serve as a permanent record of the conditions being maintained (both humidity and temperature) during the entire time any work is being carried out. Therefore, any variations or discrepancies which are not otherwise easily traced might often be located by careful study of the air conditions maintained during the time these sheets were being worked upon in the drafting room. Permanent records of these conditions during the original working period make possible also future use of these same materials at the original scale by merely placing them back under those same atmospheric conditions for a sufficient length of time for them to become thoroughly acclimatized. Thus, part of the work can be easily carried out in one part of the country under one condition and these sheets can be transferred to another part of the country, undergoing very great changes in transit, and then be returned to their normal conditions by an examination of the record of air conditions originally maintained. Obviously a uniform system of control and recording in all installations becomes highly desirable.