REFERENCES

[1] Drying, by W. R. Marshall, Jr. and S. J. Friedman, Perry's Chemical Engineers' Handbook, McGraw-Hill Book Co., Inc., New York, 3rd Edition, 1950. Indicated material supplied by W. R. Marshall, Jr. and S. J. Friedman, authors of the Section on Drying in the Third Edition of the Chemical Engineers' Handbook. Permission to use this material has been kindly granted to THE GUIDE by the Editor, John H. Perry, and by McGraw-Hill Book Company, publishers of the Chemical Engineers' Handbook.

[2] The Drying of Foods, by W. R. Marshall, Jr. (*Heating, Piping and Air Conditioning*, September to December, 1942, and November and December, 1943).

[3] Drying Materials in Trays, by C. B. Shepherd, C. Hadlock and R. C. Brewer (*Industrial and Engineering Chemistry*, April, 1938).

[4] Drying of Solids by Through-Circulation, by W. R. Marshall, Jr. and O. A. Hougen (*Transactions, American Institute of Chemical Engineers*, 1942).

[5] Heat, Mass and Momentum Transfer in the Flow of Gases through Granular Solids, by B. W. Gamson, G. Thodos and O. A. Hougen (*Transactions, American Institute of Chemical Engineers*, 1943).

[6] Mass Transfer in the Flow of Gases through Granular Solids Extended to Low Modified Reynolds Numbers, by C. R. Wilke and O. A. Hougen (*Transactions, American Institute of Chemical Engineers*, 1945).

[7] Limitations of Diffusion Equations in Drying, by O. A. Hougen, H. J. McCauley and W. R. Marshall (*Transactions, American Institute of Chemical Engineers*, 1940).

[8] What the Air Conditioning Engineer Should Know About Drying (*Heating and Ventilating*, December, 1942).

[9] Spray Drying, by Ben B. Fogler and Robert V. Kleinschmidt (*Industrial and Engineering Chemistry*, December, 1938).

[10] An Introduction to Convection Drying and Drying Calculations, by V. P. Victor (*Heating and Ventilating*, Vol. 41, Dec. 1944, p. 67).

BIBLIOGRAPHY

The Temperature of Evaporation, by W. H. Carrier (A.S.H.V.E. TRANSACTIONS, Vol. 24, 1918, p. 25).

Thermodynamic Properties of Moist Air, by John A. Goff and S. Gratch (A.S.H.V.E. TRANSACTIONS, Vol. 51, 1945, p. 125).

Factors Influencing the Performance of Rotary Dryers, by C. F. Prutton and C. O. Miller (*Transactions. American Institute of Chemical Engineers*, Part 1, February, 1942; Part 2, August, 1942).

Drying of Solids by Through Circulation, by W. R. Marshall and O. A. Hougen (*Transactions, American Institute of Chemical Engineers*, 1942).

Factors That Influence Dryer Performance, by A. Weisselberg (*Chemical and Metallurgical Engineering*, August, 1932).

Typical Dryer Calculations, by O. A. Hougen (*Chemical and Metallurgical Engineering*, January and March, 1940).

Symposium on Drying, Articles by W. K. Lewis, W. H. Carrier, A. E. Stacey, Jr., R. S. Fleming, R. G Metz, G. B. Ridley, C. O. Lavett, D. J. Van Marle (*Industrial and Engineering Chemistry*, May, 1921, pp. 427–460).

Studies in Rotary Drying, I and II, by S. J. Friedman and W. R. Marshall, Jr. (*Chemical Engineering Progress*, 1949).

Symposium on Drying (*Industrial and Engineering Chemistry*, 1938).

Principles of Drying Lumber and Humidity Diagram, by H. D. Tiemann (*Forest Service Bulletin*, 104, 1912).

The Drying of Solids, by T. K. Sherwood (*Bulletin, Massachusetts Institute of Technology*, Nos. 237, 247, and 258).

Radiant Energy Drying with Heat Lamps, by T. P. Brown (*Metal Industry*, Vol. 37, Dec. 1939, p. 607).

Drying by Sublimation, by E. W. Flosdorf (*Food Industry*, Vol. 17, Jan. 1945, p. 607).

Evaporative Drying System, by F. H. Slade (*Food Manufacturing*, Vol. 18, March, 1943, p. 70).

High Frequency Methods in Gluing and Drying Wood, by I. R. Berkness (*Wood Products*, Vol. 45, 1940, p. 12).

Development of the Unit Operations of Chemical Engineering: Drying, by T. K. Sherwood (*Chemical & Metallurgical Engineering*, Vol. 42, p. 214).

The Spray Dryer—Its Possibilities in Industry, by D. W. Biocheno (*Food Manufacturing*, Vol. 19, June, 1944, p. 195).

Mechanism and Rate of Drying by Near-infra-red Radiation, by L. E. Stout, K. J. Caplan and W. G Baird (*Transactions American Institute of Chemical Engineers*, Vol. 41, 1945, p. 283).

Some Engineering Problems of the New Vegetable Dehydration Industry, by W. B. Van Arsdel (A.S.H.V.E. TRANSACTIONS, Vol. 49, 1943, p. 49).

Electronic Dehydration of Foods, by V. W. Sherman (*Electronics*, Vol. 17, 1944, p. 94).

Air Conditioning and Engineering, American Blower Co., 1935.

Drying in Industrial Plants, J. O. Ross Company.

Elements of Chemical Engineering, by Badger and McCabe (McGraw-Hill Co., 1931).

Fan Engineering, Buffalo Forge Co.

Die Trockentechnik, by M. Hirsch (Julius Springer, Berlin, 1932).

Drying (*Kent's Mechanical Engineers Handbook*).

Drying, by W. H. Carrier (*Mark's Mechanical Engineers Handbook*).

Kiln Drying of Lumber, by A. Koehler and R. Thelen, New York, 1926.

Kiln Drying of Lumber, by H. D. Tiemann (Lippincott, 1920).

CHAPTER 48

TRANSPORTATION AIR CONDITIONING

Railway Passenger Car Air Conditioning; Streetcar and Trolley Coach Heating and Ventilating; Passenger Bus Air Conditioning; Automobile Air Conditioning; Aircraft Air Conditioning; Ship Air Conditioning, Heating and Ventilating, Refrigeration Systems, Air Condition Space Treatment, Systems and Controls

THE principles of air conditioning applying to stores, restaurants, hospitals, theaters, and homes are applicable to railway passenger cars, passenger buses, automobiles, streetcars, trolley coaches, airplanes and ships. However, equipment used for mobile applications differs from that used for stationary purposes in that it must meet additional requirements. Equipment must be compact, accessible for quick inspection and servicing, light-weight and unaffected by vibration and impact. Freedom from vibration which could be transmitted to supporting vehicle and thus to passengers, is essential.

RAILWAY PASSENGER CAR AIR CONDITIONING

The railway passenger car represents a very difficult air conditioning problem. Space is strictly limited so that all equipment and ducts must be reduced to minimum size. Electric power supply and water supply also are limited. All equipment must withstand severe vibration and shock, and must be very reliable since servicing points are frequently far apart.

During the heating season it is necessary to heat conventional cars with steam from the locomotive at pressures that may vary from 250 psig to only 5 or 10 psig on the last car in long trains. Passengers in window seats must sit only a few inches from cold outside walls and windows, and must also be very close to standing radiation installed along sides of cars. Sudden changes in load may be caused by changes in sun, wind, or train movement. Even in coldest weather, outside doors must be opened frequently.

During the cooling season, the problem is further complicated by a high concentrated internal load due to the passengers. Also, air distribution problems are increased by low ceilings and short air throws.

Heating

The heating of passenger cars is accomplished by using a split system consisting of an overhead air circulating system with heating and cooling coils, and standing radiation (floor heat) along car sides. The floor heaters, which usually consist of finned tubing, may be made more efficient by using covers designed to increase gravity air circulation, and to direct the warm air from finned heating surface along cold outside walls and car windows. In some new cars, wall convector panels are used and extend the full length of the car, with air intakes along the floor and outlets at window sill height and at window head height in dead-light panels. The heated panel protects passengers from cold outside walls, and the chimney effect of the panel duct increases air flow and improves heating surface efficiency.

Steam may be used directly in finned tubing, or steam may be used to heat a liquid (usually a mixture of water and diethylene glycol) which is