CHAPTER 1. INTRODUCTION

1-1. Purpose. The purpose of this manual is to present data accrued from experience and research that may be useful to Corps of Engineers hydraulic designers concerned with the design of control valves for navigation lock filling and emptying systems. Primarily, the objective is to consider the hydrodynamic forces that enter into the design of valves. However, the interrelationship of structural features, operational procedures, and hydraulic performance will be discussed when pertinent to an understanding of the problems involved. Consideration will be given only to valves used to control flow in relatively long culverts. Valves in tubes with a length less than about 5 diameters, such as might be installed in or around the lock service gates, present a somewhat different type of design problem than those installed in longer culverts;, and since they are rarely used in any but very low-lift modern locks, they will be omitted from the discussion. Service gates which in themselves either constitute the primary filling system or are used as auxiliary devices, such as vertical-lift gates, tainter gates, sector gates, bascule gates, etc., also will not be treated in this manual.

1-2. Applicability. The provisions of this manual are applicable to Corps of Engineers Divisions and Districts concerned with civil works design, construction, and operational maintenance.

1-3. References.

a. Picket-t, E. B., "Hydraulic Prototype Tests of Tainter Valve, McNary Lock, Columbia River, Washington," Technical Report No. 2-552, Jun 1960, U. S. Army Engineer Waterways Experiment Station, CE, P. O. Box 631, Vicksburg, Mississippi 39180.

b. U. S. Army Engineer Waterways Experiment Station, CE, "Vacuum Tank Tests of Model Tainter Valve for McNary Dam," Technical Memorandum No. 2-282, Jun 1949, Vicksburg, Miss.

c. U. S. Army Engineer Waterways Experiment Station, CE, "John Day Tests" (in preparation), Vicksburg, Miss.

d. Fidelman, S., "Filling and Emptying Systems for Walter F. George Lock, Chattahoochee River, Alabama-Georgia; Hydraulic Model Investigation," Hydraulic Laboratory Report No. 73, Sep 1961, U. S. Army Engineer District, St. Paul, St. Paul, Minn.; prepared by St. Anthony Falls Hydraulic Laboratory, 3625 22nd Avenue, Minneapolis, Minn. 55407.

e. Ables, J. H., Jr., "Intake Studies, Dardanelle Lock, Arkansas River, Arkansas; Hydraulic Model Investigation," Technical Report No. 2-573, Jul 1961, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

f. Ables, J. H., Jr., and Murphy, T. E., "Culvert Tainter Valves, New Lock-Nom. 19, Mississippi River; Hydraulic Model Investigation," Technical Report No. 2-537, Jun 1961, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

g. Ables, J. H., Jr., and Schmidtgall, T., "Filling and Emptying System, New Poe Lock, St. Marys River, Sault Ste. Marie, Michigan; Hydraulic Model Investigation," Technical Report No. 2-561, Apr 1961, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

h. Murphy, T. E. and Ables, J. H., Jr., "Lock Filling and Emptying System, Holt Lock and Dam, Warrior River, Alabama; Hydraulic Model Investigation," Technical Report No. 2-698, Nov 1965, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

i. U. S. Army Engineer District, Portland, "Navigation Lock for McNary Dam, Columbia River, Oregon and Washington; Hydraulic Model Investigation," Report No. 26-1, May 1955, Portland, Oreg.; prepared by North Pacific Division Hydraulic Laboratory, Bonneville, Oregon 97008.

j. Fidelman, S., "Filling and Emptying Systems for Barkley Lock, Cumberland River, Kentucky; Hydraulic Model Investigation," Hydraulic Laboratory Report No. 75, Jun 1963, U. S. Army Engineer District, St. Paul, St. Paul, Minn.; prepared by St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minn.

k. U. S. Army Engineer Waterways Experiment Station, CE, "Barkley Prototype Tests" (in preparation), Vicksburg, Miss.

l. Ables, J. H., Jr., and Boyd, M. B., "Filling and Emptying System, Cannelton Main Lock, Ohio River, and Generalized Tests for Sidewall Port Systems for 110- by 1200-ft Locks; Hydraulic Model Investigation," Technical Report No. 2-713, Feb 1966, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

m. American Society of Civil Engineers, "Manual on Lock Valves,"

Manuals of Engineering Practice No. 3, 1930, Committee on Lock Valves, Waterways Division, New York, N. Y.

n. Murphy, T. E., "Hydraulic Model Investigation of Lock Culvert Valves," Jan 1942, Special Engineering Division, Panama Canal Zone, Diablo Heights, Canal Zone.

1-4. Typical Filling and Emptying System. The most common type of filling and emptying system used in modern locks has a longitudinal culvert in each lock wall extending from the upper pool to the lower pool, with a streamlined intake at the upstream end and a diffusion device at the downstream end. Flow is distributed from the longitudinal culverts in and out of the lock chamber by short ports or secondary culverts in the floor of the lock chamber. Two valves are required in each longitudinal culvert, one between the intake and the lock chamber manifold to release flow in the filling operation, and the other between the chamber manifold and the discharge diffuser to empty the lock chamber.

1-5. Types of Lock Valves.

a. In 1930 the America; Society of Civil Engineers published a manual on lock culvert valves which described valves at 12 projects, "all of reasonably recent construction." At these 12 projects, seven types of valves were used, namely stoney gate, cylindrical, wagon body, butterfly, spool, slide gate, and tainter. However, since about 1930, tainter valves (an adaptation of the tainter gate developed by Jeremiah B. Tainter and patented by him in 1885 for control of flows over spillway crests) have been used almost exclusively in hydraulic systems of major locks in North America. Among the first locks in which tainter valves were used are Lock No. 2 on the Mississippi River, completed in 1930, and the Welland Ship Canal Locks in Canada, completed in 1933. The valves in these and several other installations were oriented in the manner of the conventional tainter gate, that is, with the trunnions downstream of the skin plate causing the convex surface of the skin plate to face the flow and seal along the upstream end of the valve well. When the Pickwick Lock on the Tennessee River was being designed for a lift of 65 ft, model tests showed that during the opening period the pressure gradient immediately downstream of the valve skin plate dropped below the top of the culvert; this caused large volumes of air to be drawn down the valve well and into the culvert. The air formed large pockets in the model culvert which restricted the flow until sufficient pressure was developed to expel the air through the ports or into the downstream bulkhead recess. Air expelled through the ports erupted at the water surface in the lock chamber with considerable violence, causing disturbances that would be hazardous to small craft.

b. By reversing the tainter valves, that is, placing the trunnions upstream of the skin plate with the convex surface of the skin plate facing downstream and sealing against the downstream end of the valve well, air was prevented from entering the culvert at the valve recess. A typical reverse tainter valve installation is shown in figure l-l. Valves of this general type have been used on all major locks constructed by the Corps of Engineers in recent years.

c. Since data collected in the past 40 years have been concerned with reverse tainter valves, this type of valve will be used in examples in this manual. The reverse tainter valve certainly has proved very satisfactory, it probably will be desirable at most new projects, and its continued use is advocated. However, the designer should consider other types of valves. For instance, if submergence is such that air definitely will not be drawn down the valve well and into the culvert, the use of a tainter valve in the normal position may prove desirable. With the valve in the normal position, loads and load variations on the valve hoist caused by flowing water will be negligible.[n] Structural-design of the trunnion anchorages probably would be simplified. Further, depending upon whether the position of the valve in the lock wall is upstream or downstream from the lock gate, use of the normal position for the tainter valve may prevent large differentials between the water in the valve well and the lock chamber or lower pool. Also, vertical-lift gates which are used extensively in outlet conduits should be suitable as lock culvert valves. The vertical-lift valve would not require the large recess that is necessary with a tainter valve. With one spare gate at an installation, maintenance could be performed without taking the culvert out of service as is necessary with the tainter valve. However, the vertical-lift valve's rollers, wheels, or sliding surfaces might require considerably more servicing than do the elements of the tainter valve. If a vertical-lift valve is considered, certain of the procedures given in this manual could be used in design; but it is suggested that model tests be conducted to develop an optimum bottom shape for the gate and to determine valve hoist loads.

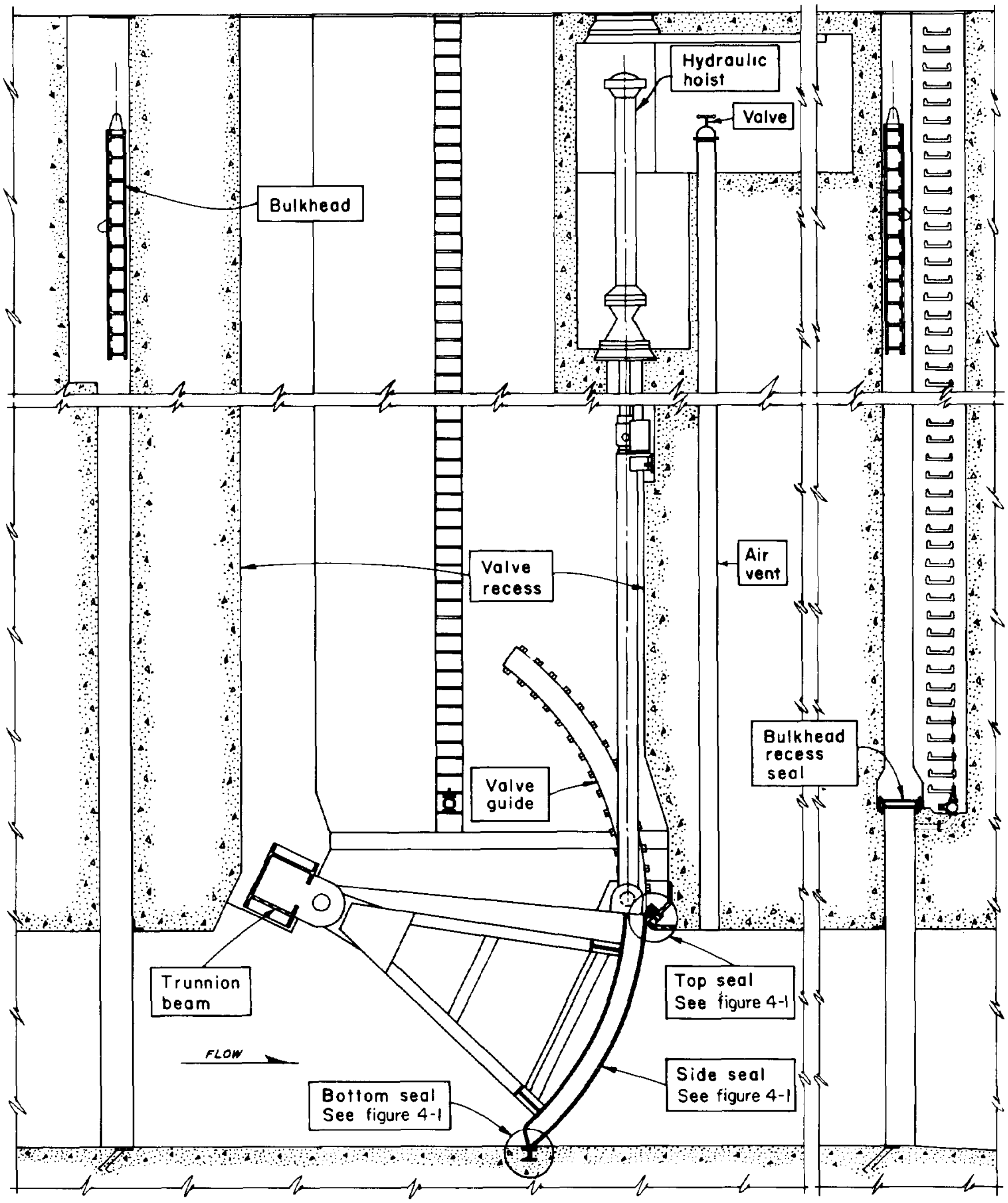

Figure 1-1. Typical reverse tainter valve installation