PRACTICE IN HIGH-HEAD HYDRAULIC PLANTS.

In a paper read at the June convention in San Francisco of the National Electric Light Association, Mr. J. P. Jollyman, of the Pacific Gas and Electric Company, gives the following interesting notes on high-head practice, chiefly as exemplified by Pacific Coast plants.

Pipe-lines.—By reason of the high pressures carried and their length, pipe-lines for high-head plants, and particularly for plants having 1,000-ft. head or over, are a problem of importance. Cast-iron pipe with bell and spigot joints has been used in a few installations in the past on heads as high as 700 ft. Pipe-lines of this kind are not very satisfactory since the cast iron is not well adapted to withstand shock from a sudden change in water pressure nor the stresses set up by changes in temperature. The joints cannot of themselves withstand the tendency to pull apart, hence the pipe must be held in alignment by being covered with earth or be supported on a continuous line of concrete piers. While it may be the best material for high-pressure fire systems the conditions on a steep hillside are so different from those in a city street that cast iron is no longer considered a suitable material for high-head pipe-lines, and it has been abandoned in favor of other materials.

Present practice favors the use of steel with either riveted or welded joints. The use of riveted pipe in California is, in a way, a development of the practice which was followed by the hydraulic miners. One of the most noteworthy examples of early practice in the use of riveted pipe is the syphon crossing the west branch of the Feather River near Cherokee, which has a maximum head of 887 ft. and a diameter of 30 in. This pipe was installed in 1870 and is still in fair condition. Riveted pipe is reliable since hidden flaws in the plates are rare and the strength of the joints can be determined with accuracy. It is so flexible that bends up to about 9° can be made at any round-about joint and small changes or corrections made at every field joint. Pipe of this type has been cold-rolled and cold-punched up to 1¼ in. thickness and down to 52 in. diameter. Thicker riveted pipe has been made but the holes in this have been drilled and the process of manufacture is more like that of boilers than of typical riveted pipe.

The disadvantages of riveted pipe are the excess weight in the cross-section due to the efficiency of the riveted joints being 87% or less, and the higher coefficient of friction due largely to the protruding rivet heads. Pipe with welded longitudinal seams and with either riveted or flanged round-about joints has the advantages of minimum weight and low friction losses and is being used for high-head work. In general, welded pipe has not proved quite as reliable as riveted pipe, but the process of welding has been rapidly improved and the new welded lines are satisfactory.

It will generally be found that a material saving in weight can be made by tapering the diameter of a high-head pipe-line in such a way that the total head lost in friction will be the amount considered permissible, rather than by selecting a uniform diameter which will give the same total friction-head. This is particularly true where the profile is such that the slope increases as the head increases. In a recent riveted line whose profile had this characteristic, the diameter was tapered from 72 in. at the upper end to 52 in. at the lower end where the head was 1,375 ft. One of the latest welded lines has been tapered from 42-in. diameter to 36.8-in. equivalent diameter, the 42-in. pipe being divided into two 26-in. pipes.

The problem of anchoring a pipe on steep slopes is important. The weight of the pipe and the stresses set up by changes in temperature have to be considered. The lines must be rigidly anchored at the power house and should be anchored to concrete piers at sharp bends. Expansion stresses in a straight line held rigidly at each end are about 195 lb. per sq. in. for each degree Fahrenheit change in temperature. Experience indicates that horizontal and vertical bends in a long pipe are of great advantage in absorbing the changes in length due to these stresses. Slip-joints have been used at various points along the pipes, but they are a cause of serious trouble in that the pipe tends to blow apart at the joint. The present tendency is to avoid long runs of straight pipe and to use slip-joints only at points near the upper end of the pipe.

Gate-Valves.—Special fittings such as Y-pieces or gate-valves are generally required at the power house on nearly all high-head lines. The practice of connecting all pipe-lines to a common header-pipe and taking all the connections from the header to the water-wheels has been abandoned for the simpler plan of feeding a certain number of wheels from one pipe and reaching these wheels through Y-pieces. These Y-pieces are usually of cast steel heavily ribbed to strengthen the sections that are not circular.

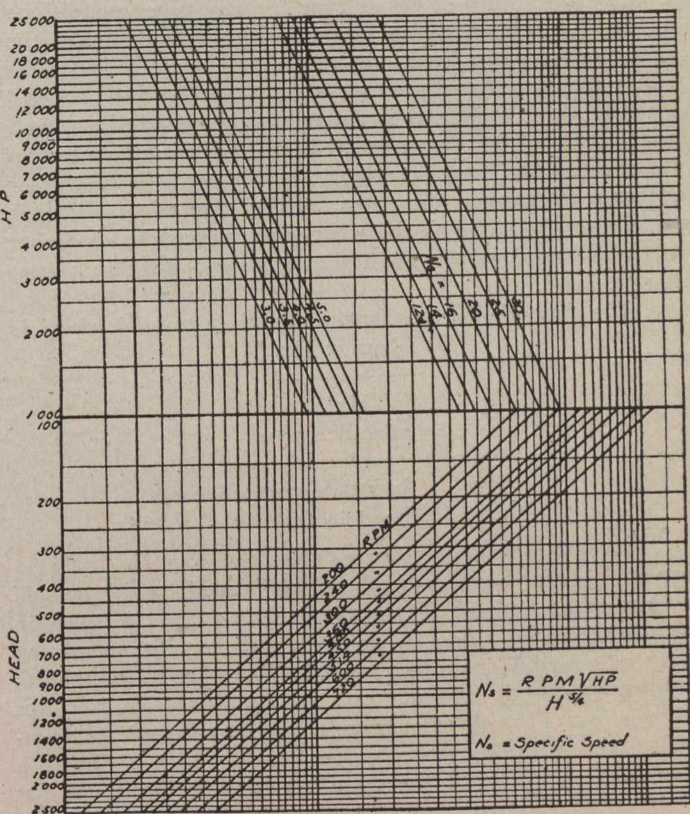

Fig. 1.—Chart for Computing Specific Speed.

Gate-valves are an item of great importance. The disc of a 36-in. valve under 1,000-ft. head must withstand a pressure of 440,000 lb. when closed. Present practice favors a gate with a single disc and with an operating-gear of sufficient power to move the disc under full-head. With so powerful an operating-mechanism any form of wedge-disc is objectionable, since the stresses in the body of the gate may be greatly increased by the wedging of the disc; besides, the great pressures against the disc due to the water alone will be sufficient to prevent leakage.

The Johnson or needle-valve form of gate seems to be well adapted to high-head requirements particularly where