UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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MIXING LOSS AT SUDDEN ENLARGEMENTS AND A NEW ENERGY DISSIPATOR

By

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Translated

By

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Denver, Colorado
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Branch of Design and Construction
Engineering and Geological Control
and Research Division
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Subject: Mixing loss at sudden enlargements and a new energy dissipator. - Mischverluste bei plotzlichen erweitungen und ein neuer energievernichter, by G. de Tomasi. Translated from Wasserkraft und Wasserwirtschaft, Volume 33, 1938, page 163.

The dissipation of the kinetic energy of fluid flow offers no particular difficulties so long as one has the choice of the space in which the dissipation is to take place, and no detrimental influences on machine parts are to be anticipated in practice. Energy dissipators used for outlets of pipe lines or pressure regulators of hydraulic turbines have been in use only for short periods of time, so that there is little chance that the material of construction will be worn away rapidly. On the other hand, the primary aim is to construct satisfactory arrangements of compact structures.

Energy dissipators for municipal water-supply systems have to satisfy not only the above condition, but they must also be built for long periods of operation, and loss of water, contamination, and too much mixing of water and air are not to be tolerated.

Contamination of the water can take place easily if metallic surfaces are attacked by cavitation.

In general, the following fundamental principles, supported by the collected experience in this field, can be stated thus:

1. The most simple and practical way to dissipate the energy of fluid flow consists always in converting a high-velocity jet into a low-velocity flow. The superfluous kinetic energy is converted into heat by friction (mixing loss).

2. The principal defect inherent in the most ordinary energy dissipators originates from the entrainment of air by the discharging jet (spontaneous or otherwise) or from negative pressures which are conductive to cavitation.

The principle stated in (1) can be achieved by discharging the high-velocity jet directly into a pipe whose cross-sectional area is of large enough dimensions so that the average outflow velocity is smaller than that of the entering jet. This pipe should be long enough to confine within itself the extremely turbulent region of flow and within which the superfluous kinetic energy is dissipated by mixing.

In order to avoid the undesirable phenomena in (2), it is necessary that the larger pipe (or the energy-dissipating chamber) be completely closed at the valve (or gate), so that the discharging jet can entrain no air. At the same time, provision must be made to prevent negative pressures from occurring in the interior of the energy dissipator as well as in the region of the outlet works, so that cavitation can be avoided. For example, such a provision can consist of an end piece attached vertically to the energy dissipator. Care must be exercised that the flow in this is from below to above. In this way, a positive pressure is maintained in the chamber of the energy dissipator, which will prevent the appearance of cavitation.

The chief data for designing an energy dissipator on the basis of the above principles can be derived theoretically by applying the principle of impulse and momentum to the section at the valve and the section in the chamber of the energy dissipator which lies directly downstream from the region in which the mixing takes place.

The length of the chamber of the energy dissipator can be fixed with advantage at the outset (with recourse to supplementary model tests), taking into consideration the calculations of Tollmien[2] on the spreading of a jet in a medium of the same fluid. The expanding jet is bounded by a truncated cone whose smaller base corresponds to the initial cross section of the jet, and the angle at the tip of the cone is invariably eight degrees.

Naturally, the theoretically computed length based on the above consideration must be increased as a precautionary measure in order to avoid a backflow or instability in performance.

Figure 1 shows an energy dissipator designed on the basis of the above principles, which is intended for the dissipation of 13,000 metric horsepower under a head of 250 meters. Model tests up to a head of 60 meters have verified the ideas used in the design (figure 2).

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[1] The theoretical computation is from an article appearing in L'Energia Elettrica, August 1937, page 618.

[2] W. Tollmien - Gottingen, Zeitscrift fur angewandte Mathematik und Mechanik, 1926, volume 6, No. 6, page 468.

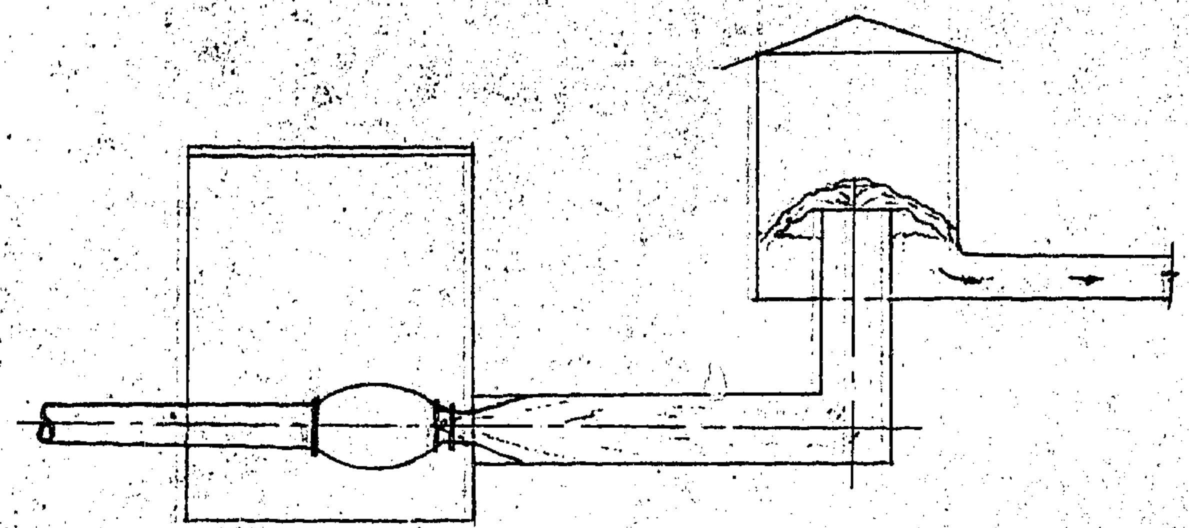

FIGURE 1

Note that cone-shaped jet has an 8° at vertex. Horizontal pipe is necessarily increased in length above the theoretical as a factor of safety.

Figure 2 shows a vertical section of expanding pipe used in model tests. Can see little connection between figure 2 and figure 1.

Figure 2 not included