AMERICAN CONSULTING ENGINEERS COUNCIL'S

HEAVY MOVABLE STRUCTURES
MOVABLE BRIDGES AFFILIATE

3RD BIENNIAL SYMPOSIUM

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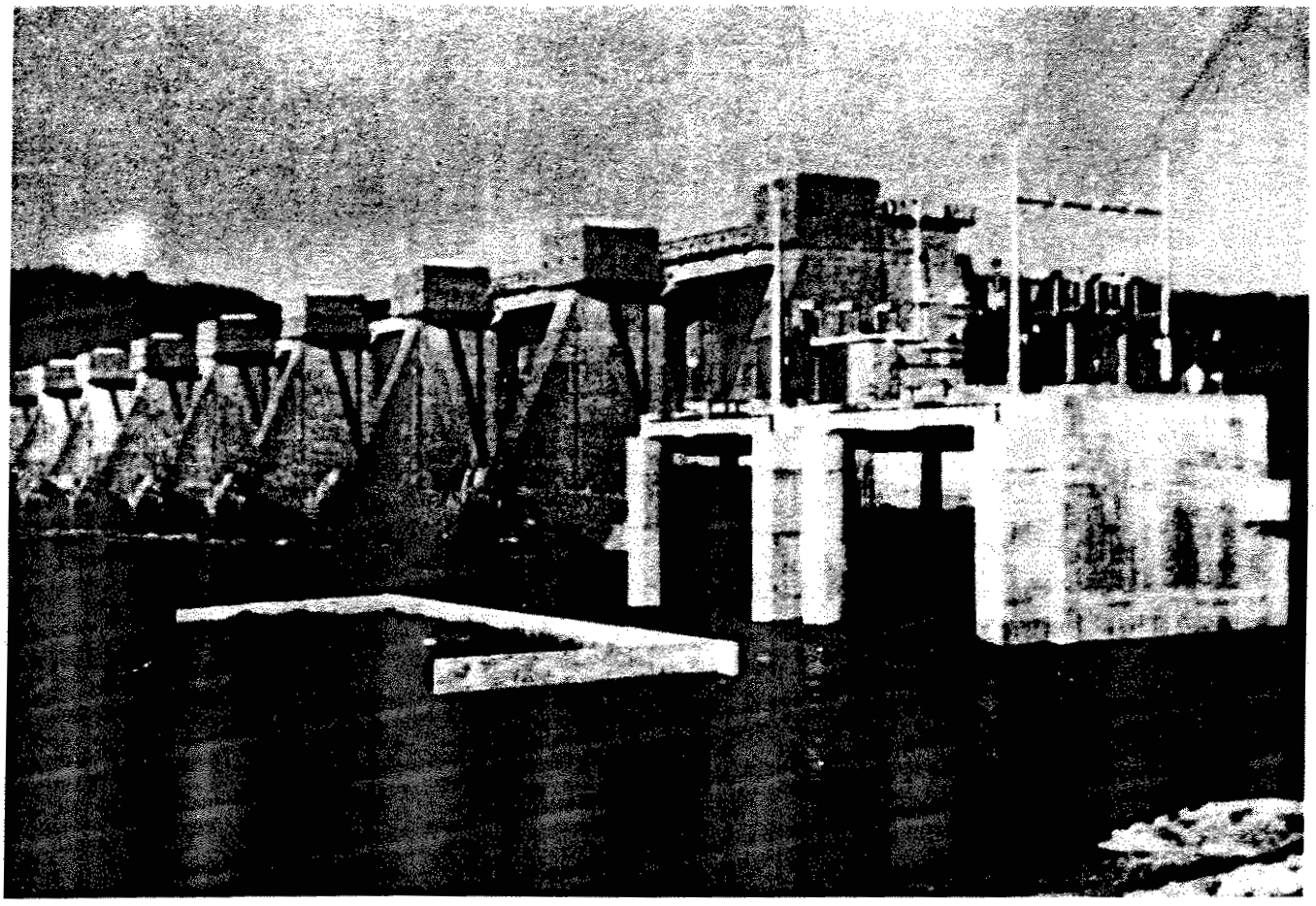
SESSION
WORKSHOP NOTES

Session (4-12)
"Martinsvile Hydroelectric Pwr - Fast draft Tube Gate", Eric Wirzberger, Mannesmann Rexroth, Lohr, Germany

Martinsville hydroelectric power station



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Martinsville hydroelectric power station

Client: City of Martinsville
Consulting engineers:
Bechtel, San Francisco
General contractor: INGRA, Zagreb
Contractor for steel structure:
Metalna Maribor

A run-of-river power plant was constructed in the Ohio river during the period between 1984 and 1987. The plant primarily comprises an 8-gate weir system and a power station situated on the left-hand bank of the river as seen in the direction of flow.

The weir system

The 8 weir channels are sealed by radial gates. The gates are actuated by mechanical drives as is still often the case in the USA.

The power house

The power house which, as already mentioned, is located on the left-hand bank, is equipped with two machine sets. The turbines are of the Kaplan tube type, arranged with their axis horizontal.

Technical data of the machine sets:

Turbine capacity	18.7 MW
Head	5,4
Water throughput	396 m^3/sec.
Propeller diameter	7300 mm
Speed	64.3 rpm
Generator output	18.8 MVA

The power house contains a gantry crane, and this is equipped with a main hoist of 1550 kN for installation and removal of the turbines and generators. An auxiliary hoist system, 2 x 150 kN, is also provided for stop log operations at the trash rack, and also for installation and removal of the emergency stop logs.

On the head water side are two vertical intake trash racks with a height of 22.9 m and a total width of 17.7 m. The intake to each machine is divided by a vertical pier. The intakes can be sealed off for maintenance purposes by means of the emergency bulkheads which are arranged behind the intake trash rack. The channels leading to each machine have a clear width of 2 x 6.5 m and a height of 16.8 m. Each of these two channels is equipped with a set of stop logs comprising 8 identical elements.

Arranged in the top stop log element (No. a) is a prefill valve which allows the turbine chamber at the rear to be gradually filled following completion of any maintenance work. The machine is shut down and the draft tube gate closed prior to positioning or removing the stop logs by the gantry crane.

On the downstream side of each turbine is a draft tube gate equipped with a hydraulic actuator. This gate shuts off the draft tube nozzle, which has a diameter of 11 mm.

Draft tube gate design:
The draft tube gates are of roller (fixed wheel) design. Each gate is equipped with 2 x 7 rollers. The hydraulic cylinder is centrally arranged. Owing to the low overall height of the outlet works structure, the cylinder is connected to the bottom main girder. During operation, the cylinder thus traverses into the gate structure. All the main girders are provided with the requisite openings.

The gates perform a number of important safety functions for the turbine. In the event of emergency turbine shut-down, they must close reliably within a very short time, even when there has been a complete failure in the power supply circuit. The gates with their seal construction are thus designed to ensure reliable closing under their own weight and the hydraulic (i.e. river water) forces acting upon them.

Hydraulic actuation of the draft tube gates

Each gate cylinder is of the pull-type design.

Cylinder specifications:	
Piston diameter	400 mm
Rod diameter	180 mm
Stroke	11400 mm
Pull force	1500 kN
Lifting speed	3,8 m/min
Lowering speed	
Emergency mode	18.3 m/min
Normal mode	2.2 m/min
Creep speed prior to full closure	0.61 m/min

During emergency closing, the three velocity phases are invoked one after the other so that the majority of the travel is carried out at maximum speed. Just before final closure, the control switches to normal speed and then to the creep mode.

Thus, during the final phase, the gate eases down onto the sill. The main control valves employed for this control chain are of the 2/2 logic valve design combined with a leak-free poppet valve and throttle valve. These are incorporated within a control block which is directly mounted on the gate cylinder.

However, owing to the requisite openings in the main girders, it was not possible to fit the control block, a large unit designed for a maximum volume flow of 2,000 l/min, directly to the cylinder head as would usually be the case. The control block therefore had to be placed at the top end of the cylinder near the cylinder cap. It is connected to the high-pressure port of the rod side of the cylinder by means of a welded peak-pressure line.

During the rapid lowering mode, the requisite additional volume is made up from an overhead tank arranged to the side of the cylinder.

A separate power unit is provided for each gate, and these units are installed in the power house. The oil tank in each case is dimensioned to allow the entire volume contained by the cylinders to be emptied.

Mounted on the oil tank are three pump sets with a total delivery of 380 L/min and a total drive rating of 135 kW.
Also mounted on the oil tank itself are the pilot control valves for the lowering motion, which are grouped together for easy overview within a single control block. The valve control system for initiating the emergency and normal lowering modes is, for safety reasons, of redundant design.

The oil tank is of the normal design employed in civil engineering structures, with a return filter, two silica gel filters for air dehydration, pressure valves for pressure-less start-up of the pumps, pressure switches to monitor the pumps, and all the necessary measurement and monitoring devices.

Owing to the very limited space available, the position measuring system was designed as a hydraulically driven winch. The measuring rope for continuous monitoring of the gate stroke is wound onto, and unwound from the hydromotor-driven rope drum, and this is coupled to a gear limit switch with 7 signal positions.

The signal positions are as follows:
Gate closed
Gate in prefill position
Gate open
Gate under leak-oil control
Gate leak-oil control fault
Initiate medium velocity
Initiate creep speed

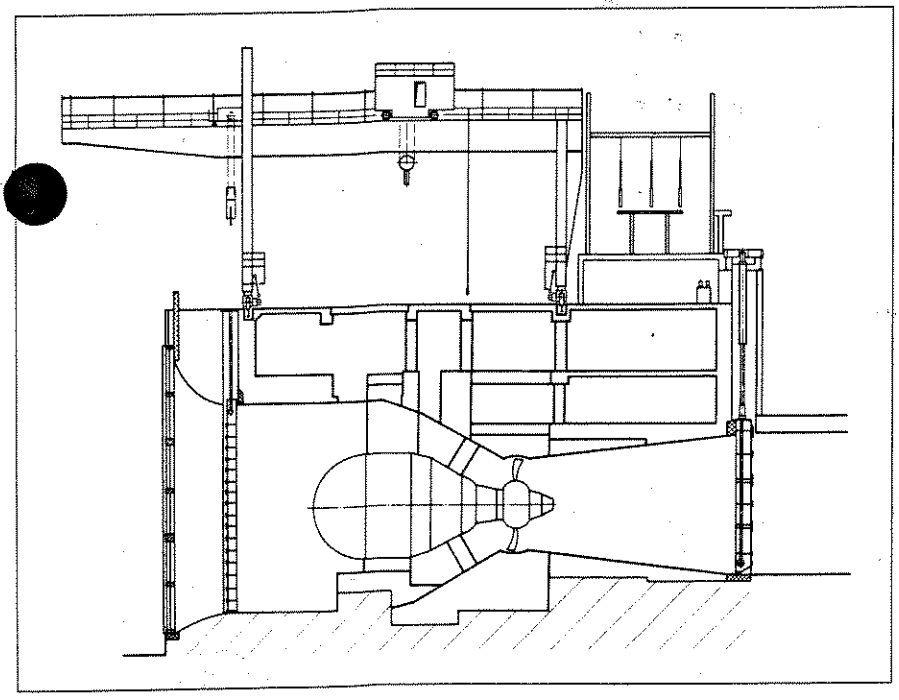

Fig. 2: Cross section through the power house

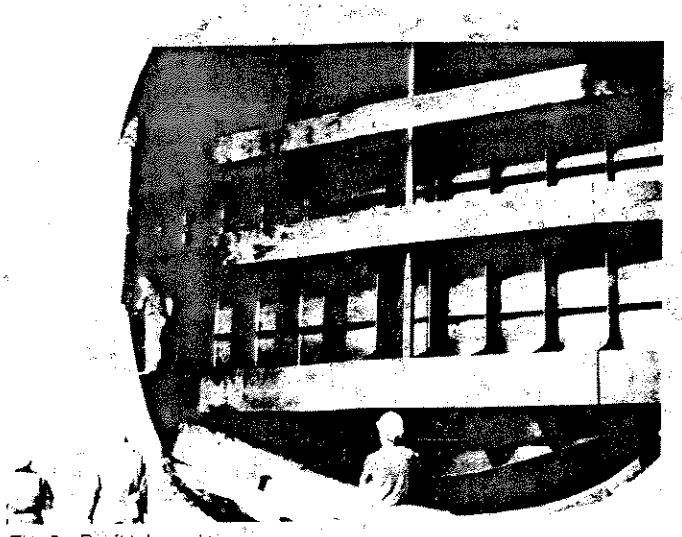

Fig. 3: Draft tube gate

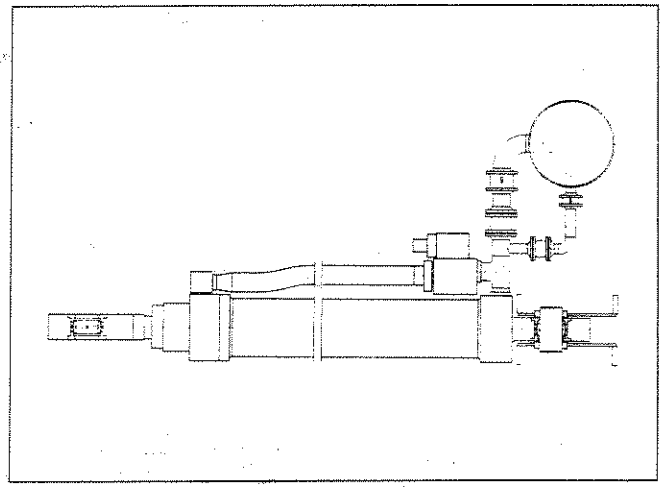

Fig. 4: Draft tube gate cylinder

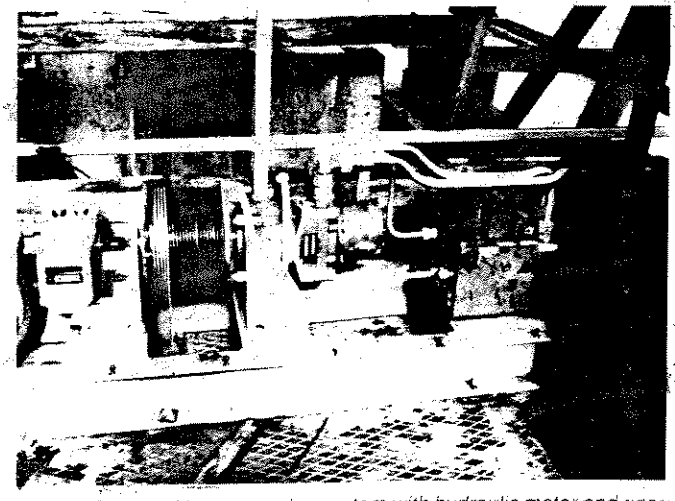

Fig. 5: Gate position measuring system with hydraulic motor and gear limit switches

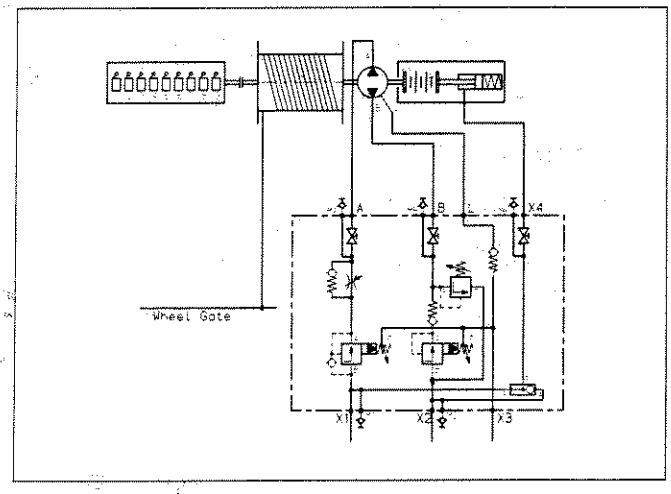

Fig. 6: Gate position measuring system with hydraulic motor and gear limit switches