NEYRTEC AUTOMATIC EQUIPMENT FOR IRRIGATION CANALS

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ABSTRACT:

The French Company ALSTHOM has developed a line of simple equipment for automatic level control and constant discharge control in canal irrigation systems. The paper includes a description of this "NEYRTEC design" equipment, typical applications and some considerations on the installation, operation and maintenance requirements.

INTRODUCTION:

It has been now admitted that well engineered automatic canal water control, as eliminating the shortcomings of the manual control is a very efficient way to better system operation and water management, and, more precisely, to high conveyance and distribution efficiencies, as also to equitable and flexible distribution.

It should be clear that canal automation does not necessarily implies sophisticated equipment, external power supply, and frequent or delicate maintenance.

The purpose of this paper is to present the range of automatic, simple, reliable and efficient canal control equipment as designed and developed by the French Group ALSTHOM under the name of NEYRTEC (formerly known as NEYRPIC canal equipment).

This equipment, which has been successfully and profitably applied to a number of irrigation systems throughout the world for several tens of years includes:

- . automatic level control gates
- . constant flow distributors (or so called "modules")

LEVEL CONTROL GATES

Operating principles

All NEYRTEC automatic irrigation gates are radial gates operated by one or several floats rigidly fitted to the gate leaf. The floats operate in wells or tanks in which the water levels depend on the control relationship applied f (H,h), H and h denoting the upstream and downstream water levels respectively.

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The equilibrium of such radial gate leaves is independent of the hydraulic thrust acting on the skin-plate. Consequently, the only acting torques are that resulting from the weight of the gate leaf (Cp) and that due to the buoyancy of the floats (Cf).

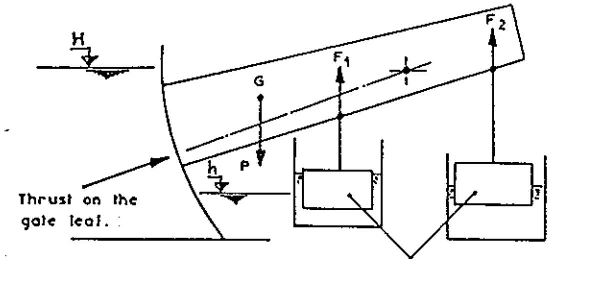

Figure 1 - Design principle of NEYRTEC automatic gates

The moving gate assembly is balanced by counterweights, or by the addition of ballast, to meet the following conditions:

a) Neutral gate equilibrium when the specified control relationship is satisfied.
b) Any deviation from the reference level such that f (H, h) $= \varepsilon \neq 0$ results in a gate leaf movement and a flow variation tending to cancel it out.

The application of these principles to each type of NEYRTEC automatic gate is explained hereafter.

AMIL constant upstream level gates

Control relationship : H $\simeq$ A (constant).

All AMIL gates are surface gates with a single float on the upstream face of the gate leaf, i.e. immersed in the water upstream.

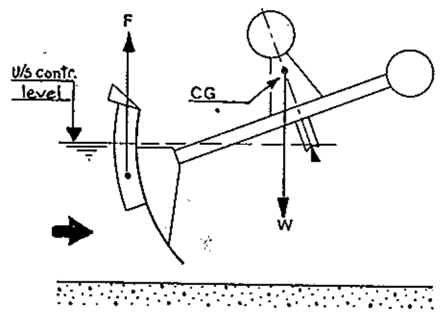

Figure 2 - AMIL gate - Operating principle

The moving gate assembly is ballasted for neutral equilibrium when the water level is at the gate hinge line elevation.

If the upstream level falls below the hinge line, Cf becomes smaller than Cp, the gate closes, and in so doing restores the reference upstream level. A rise in the upstream level causes the reverse process.

Though the standard gates are designed for sluices of standard trapezoidal cross-sections, the gates leaves are adaptable to any open cross-sectional configuration (e.g. semi-circular and oval prefabricated canal sections).

The standard range consists of 21 gate sizes with 9 different radii.

Smallest and largest gate sizes :

Designation	Max. discharge (m3/s)	Min. relevant Head loss (gate open) (m)	H above sill (m)
D 80 R 63	.180	.10	.40
D 800 R 450	50.	1.00	4.00

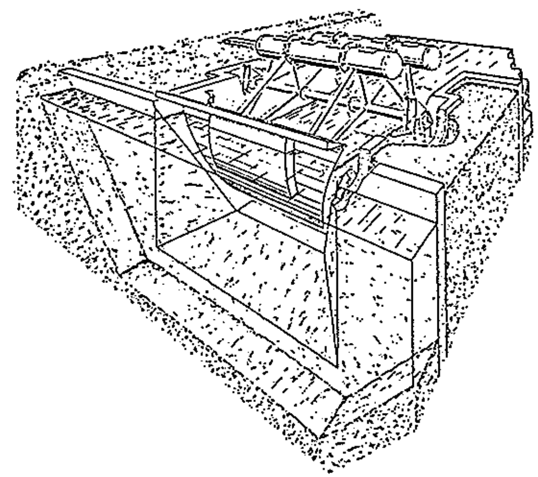

Figure 3 - AMIL gate - Typical layout

AVIS and AVIO constant downstream level gates

AVIS gates are surface gates, whilst AVIO gates control orifice flow. The control relationship for these gates is h $\simeq$ a (constant).

They have a single float immersed in a tank downstream of the gate hinge line, which communicates with the water downstream, either directly (through a slot) or through a pipe. The float and float tank are integral with the gate.

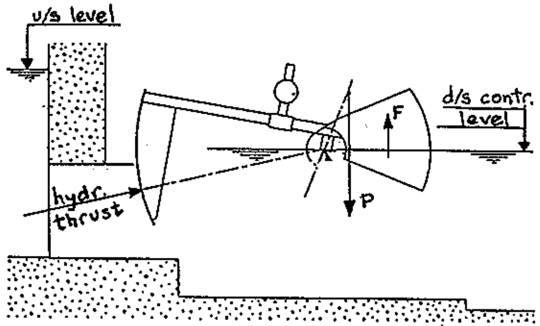

Figure 4 - AVIO gate - Operating principle

The moving gate assembly is balanced for neutral equilibrium when the downstream level is at the hinge line elevation.

If the downstream level falls below the hinge line, Cf becomes smaller than Cp, the gate opens, and in so doing tends to restore the reference downstream level. The reverse process takes place if the downstream level rises.

The standard range comprises 9 low-head and 11 high-head AVIS gates, 12 low-head and 14 high-head AVIO gates. The same framework, characterized by the outside float radius, is generally used for four different gate models (1 low-head and 1 high-head AVIS, 1 low-head and 1 high-head AVIO).

Smallest and largest gates sizes:

Designation	Max. discharge (m3/s)	Min.relevant Head loss (gate open) (m)	H - h (max)	h on sill (m)
AVIO 28/6 H.C.*	0.85	.13	1.1	.3
AVIO 280/630 H.C.	27.5	1.30	11.0	3.0
AVIO 280/1250 B.C.*	40	.70	5.6	3.0
AVIS 56/106 H.C.	.75	.06	.4	.56
AVIS 280/530 H.C.	45	.30	2.0	2.80
AVIS 280/600 B.C.	60	.34	1.1	3.15

H.C * = high-head
B.C * = low-head

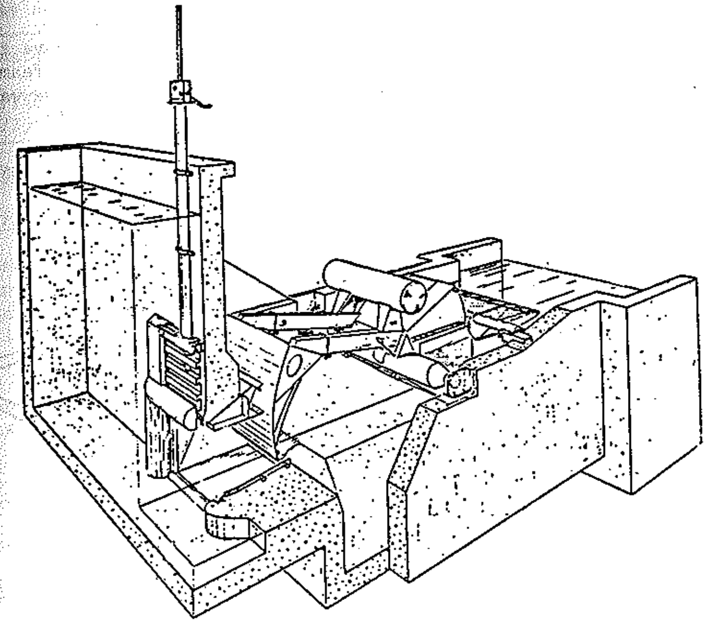

Figure 5 - AVIO gate - Typical lay-out

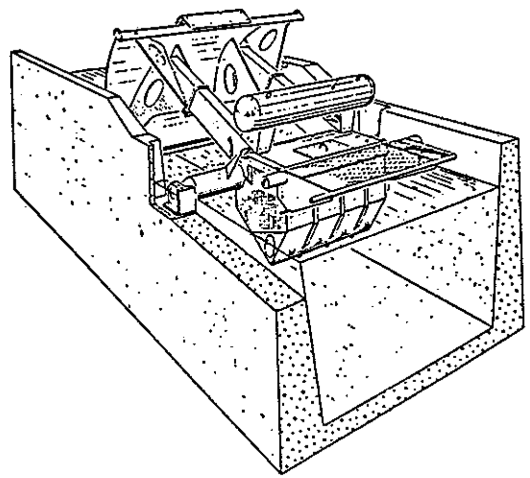

Figure 6 - AVIS gate - Typical lay-out

Composite-control gates

These include both surface and orifice-flow gates. They have two floats acting in opposition (one upstream and the other downstream of the gate hinge), each operating in a separate well in which the water level is governed according to the chosen control relationship through weirs and/or orifices.

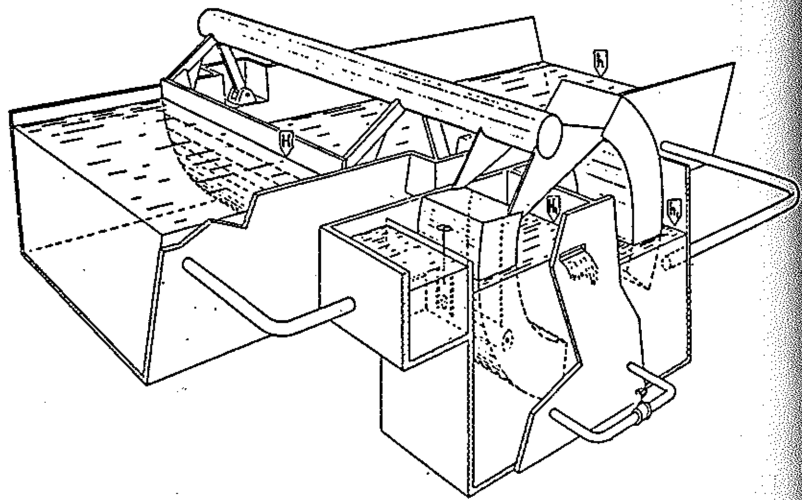

Figure 7 - Composite-Control gate

The moving gate assembly is balanced for neutral equilibrium for a constant, adjustable difference Δ between the upstream and downstream float well water levels (H_1 and h_1 respectively).

When $H_1 - h_1 = \Delta$ the gate is in neutral equilibrium

When $H_1 - h_1 < \Delta$ the gate closes

When $H_1 - h_1 > \Delta$ the gate opens

Direct connection of the upstream and downstream wells to respectively the upstream and downstream levels results in constant head loss control. By proper dimensioning and height setting of the supply and outlet control devices of the wells, this basic control type can be combined with constant upstream level control and/or constant downstream level control, and/or variable head loss control in relation with the upstream level, each type of control coming into action over a specified level range.

The standard range of composite-control gates comprises 8 basic surface and orifice-flow gates with small and large-radius floats, i.e. 32 models on the whole.

Smallest and largest gates sizes :

Designation	Sluice cross-section (m 2)	H_{max} on sill (m)
160/140 surface	2.12	2.55
315/355 orifice	13.2	4.4

DISCHARGE CONTROL

Baffle distributors

These devices of an original design deliver flow at a controllable constant rate from a canal or a free-surface tank, irrespective of substantial upstream and downstream level fluctuations within a specific range.

The practically constant discharge is obtained by fully static means consisting of a sill specially shaped for minimum head loss and one or two fixed baffles.

For rising upstream level a single-baffle distributor (for example) operates in two stages, which can briefly be described as follows :

a) Free-surface flow over the sill

b) Full orifice flow as soon as the overflow surface reaches the baffle. As the flow coefficient of the orifice is lower than that of the weir, this compensates the increase in upstream head to some extent.

The baffles of a double-baffle distributor are behind one another. As the first baffle constricts the flow, the second one can be set closer to the sill, forming a restrictor orifice. When the water upstream rises up to a specified level, the first baffle is flooded; the second one comes into operation and further restrains the increase in discharge.

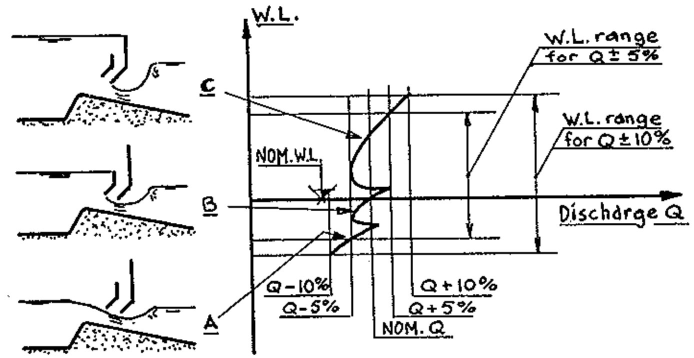

Figure 8 - Operating principle of double-baffle distributors

For example, the permissible upstream level ranges for series XX distributors discharging 20 l/s/dm are as follows :

	for Q ± 5 %	for Q ± 10 %
Single-baffle XX1	8 cm	11 cm
Double-baffle XX2	23 cm	28 cm

For a given series, the ratio between the permissible level ranges for single and double-baffle distributors is 1 : 2.9 for discharges varying by ± 5 % from the nominal rate, and 1 : 2.5 for variations by ± 10 %.

The required discharge is adjusted by fully opening or closing shutters varying in width by steps similar to those in a set of weights.

The shutters for lower series operating under low head, are flat, whereas those for the upper series are radial types.

The standard range of distributors comprises the four following series, which are designated according to their discharge per unit width :

X - 10 l/s/dm XX - 20 l/s/dm
L - 50 l/s/dm C - 100 l/s/dm

An additional series (CC - 200 l/s/dm) can also be supplied on special request.

Each series includes, both single and double-baffle types (marked by suffixes 1 and 2 respectively).

Series X_1 and X_2 each comprise 5 sizes from 30 l/s to 150 l/s.

Series XX_1 and XX_2 each comprise 12 sizes from 30 l/s t0 480 l/s.

Series L_1 and L_2 each comprise 20 sizes from 500 l/s to 1450 l/s plus additional units for 400, 800 and 1200 l/s.

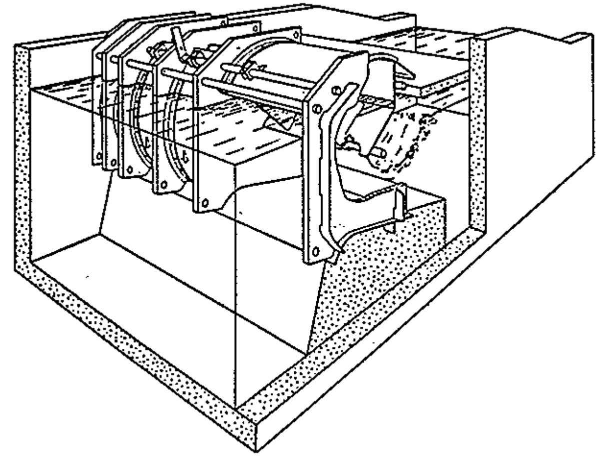

Figure 9 - L1-500 single-baffle distributor

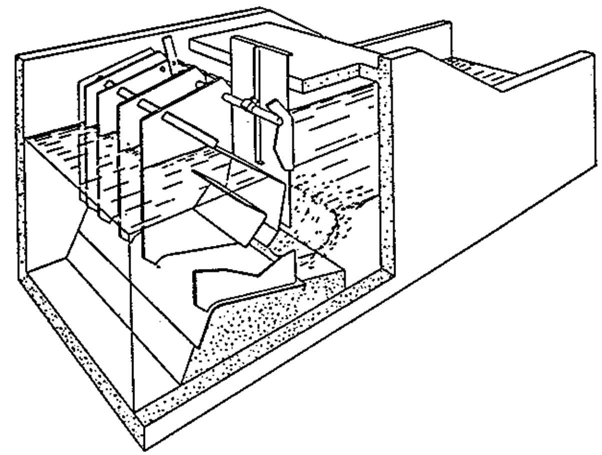

Figure 10 - XX2-150 double-baffle distributor

INSTALLATION, OPERATION AND MAINTENANCE

Installation

- Gates:

Except for the composite-control gates which require lateral float wells with their supply systems, the concrete structures receiving the automatic NEYRTEC gates are quite comparable to those for conventional radial gates, but for the trapezoidal control section. The AVIO gate includes a steel intake section, to be embedded in a rectangular orifice.

On site assembly (if any) and erection requires only bolted connections, and grouting of the embedded parts and supports, and can therefore be easily carried out by the main contractor or the works owner. However, special attention must be paid to proper height setting and horizontality of the gate hinge axis.

The gates counterweights are located for easy two-step on-site balancing with steel or gravel ballast to be placed first in the rear counterweight (AMIL gate nearly closed, AVIO and AVIS gates open), then in the upper counterweight (AMIL gate open, AVIO and AVIS gates nearly closed).

- Distributors :

As solid units, distributors are to be embedded in a rectangular channel section with a sill of traperzoidal profile. Of course proper height setting is essential.

Operation and maintenance :

As self-operating, automatic gates require no permanent attendance. Of course debris and weeds, if any, that may accumulate in front of the surface gates and keep them from fully closing, must be removed as necessary. Maintenance is restricted to greasing of bearings (only for large size gates) and touching up of paint coating.

Once set at the desired discharge and as far as the upstream level variations remain within the design permissible range, distributors require no re-adjustment until the discharge has to be changed according to the users' demand or supply schedule. This is a determining advantage over conventional types of turnout equipment which may theoretically have a better accuracy but require too frequent readjustments due to their sensitivity to level variations. Attendance and maintenance is restricted to removal of debris and weeds and to touching up of paint coating.

TYPICAL APPLICATIONS

Diversion turnout with adjustable constant discharge

This case is a direct application of distributors.

If the water level variations in the canal or reservoir are within the permissible upstream level range of the distributor, no further control equipment is required, provided the distributor is set at a convenient elevation.

If the upstream level variations exceed the permissible range, a device controlling a constant or slightly-variable water level such as an AVIO or AVIS gate will be required between the reservoir or canal and the distributor.

System (or system section) under upstream control

The intake at the head of the system is of the above-described type and the canal is fitted with a series of AMIL gates.

Close upstream of the AMIL gates, where level variations are low, the lateral offtakes require only distributors. Further upstream, where levels vary over a wide range, the offtakes are to be provided with a combination of an AVIO or AVIS gate and a distributor.

System (or system section) under downstream control

This application requires AVIS or AVIO gates at the head works and all the way down the canal.

Close downstream of theAVIO or AVIS gates, where level variations are low, the lateral offtakes require only distributors, and elsewhere AVIO or AVIS gates combined with distributors.

Transition from a canal to a pressure pipe system

As a general rule, a pressure pipe supply system operates under downstream control since each user must be free to dispose of the water he needs at any time by simply opening a tap or a valve.

If the pipe (irrigation or drinking water main) is supplied from a canal with constant downstream level gates at the head and over its full length, control continuity is ensured from users all the way up to the headworks; thus, a high degree of operation flexibility is achieved by simple means, as opposed to the complicated control problems generally raised by pressure pipes fed by canals under upstream control.

NEYRTEC equipment can also provide a simple solution to the opposite problem, i.e. connecting a pressure pipe to the free-surface system it supplies.

Related level control

Example 1 : System supplied by a hydroelectric power station (BENI MOUSSA - MOROCCO)

The operating diagram for the composite-control gates in this system includes two phases of constant upstream level control, the upper one providing a safety margin against overflowing, and the lower one corresponding to a minimum storage distributed over the canal reaches.

Between these limits the gates control a constant downstream level.

Example 2 : Main canal supplied with practically constant flow whereas demand is cyclic (TRIFFA - MOROCCO)

To allow optimum use of water, substantial storage must be available in all the canal reaches, which must all fill up and empty out according to the same cycle.

In addition to the phases of example 1, the operating diagram for this application includes an operating phase at constant head loss or with head loss increasing with upstream level.

CONCLUSION

As illustrated by the above examples, the standard NEYRTEC gates and distributors, used singly or in combination, provide a key to efficient irrigation and water supply system control in a simple and reliable form.

Although the matter of this paper is restricted to canal equipment, it may be useful to point out that ALSTHOM has also developed various forms of automatic control equipment for pressure flow which have marked a decisive step forward in this field.

As examples we can quote :

- Float operated self-centering disc valves for pipe outflow control and for head breaker tank equipment.

- Float operated cylindrical gates for low-head pipe outflow control.

NEYRTEC equipment for both irrigation and water-supply systems proceed from clever application of simple hydraulic principles, with the result of sturdiness and reliability, as required for long lasting service under severe working conditions.

Experienced all over the world, this equipment appears as a substantial cost-saving factor for more efficient use of available water resources as also for minor operation and maintenance requirements.