DELIVERY EQUIPMENT FOR A BETTER APPLICATION OF LIMITED WATER RESOURCES IN PRESSURIZED COLLECTIVE IRRIGATION SYSTEMS

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Abstract

One of the ways to solve the "bottleneck" between water delivery and irrigation scheduling is to adopt self-feeding electronic systems. These pieces of equipment don't need any radio or cable connection and they can make consumption to be selectively stored for each user in a dedicated recorder.
The user can thus select the volume for each single water withdrawal within his set time and the maximum deliverable volume stated by the Irrigation Authority.
In turn, the Irrigation Authority can perform a close supervision on consumption through the data stored.
By planning in advance the seasonal or monthly volumes that could be drawn by each single user, the Authority can also predetermine the set time, according to the available water supply.
All this makes management more efficient, allows to store large amounts of data selectively and, subsequently, analyze them statistically.
Studies on pilot areas in Southern Italy seems to give good results.

Résumé

Une manière pour résoudre le "goulot d'étranglement" entre la livraison de l'eau et le pilotage de l'irrigation consiste à utiliser des systèmes électroniques auto-alimentés. Ce sont des appareillages qui ne nécessitent aucune connexion par radio ou câble et qui permettent de mémoriser les prélèvements d'eau d'une manière sélective pour chaque usager grâce à un appareil enregistreur.
L'usager peut ainsi sélectionner le volume de chaque prélèvement dans les limites de temps et de volume établies par le Service d'Irrigation.
A son tour, le Service d'Irrigation peut contrôler la consommation réelle à travers les données mémorisées.
Grâce à une planification préalable des volumes saisonniers et mensuels qui peuvent être prélevés par chaque usager, le Service peut aussi préétablir le temps de fonctionnement par rapport à l'eau disponible.
Ce système permet d'améliorer la gestion, de mémoriser une grande quantité de données d'une manière sélective et, par conséquent, de les analyser statistiquement.
Les études menées sur des aires pilotes du sud d'Italie semblent donner de bons résultats.

Water, together with sun and earth, is the determining factor for the development of agriculture. Irrigation, i.e. the artificial watering of fields, has played for centuries a leading role in the economy and culture of mankind.

Fresh water resource is not unlimited on our globe. In the last decades, due to the continuous population growth, the fast rise in the socio-economic standards and the resulting increased consumption, water has become increasingly more precious, badly wanted for agriculture, civil and industrial uses.

Irrigation is by far the largest user of fresh water. In Italy, for example, on an annual needed supply of 50 billion cubic meters, almost 30 billions are requested by agriculture. Similar situations are present in various countries of temperate climates around the globe, where the largest concentration of agricultural production is located.

Associating the maximum land productivity with the least amount of water consumption is therefore a problem of vital importance in the world economy.

To this aim, imposing energies and resources by Governments, research and experimental Institutes, bureau of reclamation and agricultural associations, specialized industries and project managers are rightly dedicated.

On the other hand, these multiple initiatives and studies meet a critical point in passing from the research and planning stages to the practical application stage in open fields, and vice-versa.

In fact, disregarding particular situations, it is always very hard to transmit systematically and in due time to farmers in a given area (an area that can cover even thousands of hectares) the information needed, during the entire irrigation season, for the best use of water available for irrigation.

Inversely, it is also very hard for the Irrigation Authority and the connected Research Center, to obtain exhaustive and accurate information on water consumption, in terms of time and volume during the irrigation period, from the many different users supplied by the delivery network.

It is really the accuracy of these data that would allow the Irrigation Authority to check systematically whether the information and the suggestions given to individual farmers are understood and applied, or rejected because of ignorance, negligence, technical deficiencies or particular environmental situations. Of course, any further experimental research for improving irrigation practices can benefit from the above data for obtaining an optimal use of water in agriculture.

Briefly, it is a matter of continuously and systematically interfacing the Irrigation Authority and researchers on one side, and farmers on the other.

Methods and discussion

A global solution to this complex problem could be found using an Operating Center for planning and controlling water distribution. A capillary system connected to the users might control the entire area.

The Irrigation Authority, by this automated, centralized and integrated system, is able to predetermine the watering schedule, regulating the time and volume to be supplied to each consumer according to the continuously changeable climatic and crop conditions and based on actual water availability. Furthermore, it might store data on consumption selectively for agronomic, administrative and statistic purposes, and also for scientific research.

A particularly significant application of this centrally controlled irrigation system distribution is the one built and being operated for the past 3 years in the irrigation scheme Garcia-Carboj, managed by the «Consorzio di Bonifica del Basso Belice - Carboj - Menfi» (Sicily - Italy).

This huge work, presently of worldwide importance for its vastness and number of controlled points, covers an area of more than 14,000 hectares, served by an

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almost 600,000 meters long pipe network, able to convey a maximum flow of 8,775 l s^{-1} and to deliver water to users through 14,000 hydrants entirely remote controlled by an Operating Center. The interconnection between the Operating Center and the users, and vice-versa, is integrated and continuous and, consequently, the Irrigation Authority has effective and exhaustive means to control and optimize the use of the irrigation resource.

However, a technological system so advanced is not generally applied at present in all agricultural environments, since it requires rotation delivery schedules, not always favourable, or desirable, instead of the «on demand» operation. Moreover, this requires considerable costs of transformation in the case of already installed irrigation systems built according to the traditional design criteria and, therefore, not planned to have a centralized automation.

In any case, for an appropriate and correct operation of such a complex structure, it is imperative to refer not only to an adequately dedicated project, but also to a reliable and efficient apparatus, particularly for the electronic parts that require a highly specialized technology, resulting from an extensive and expensive research in the field.

An interesting and different approach to the crucial problem of interfacing Irrigation Authority and users, is the use of two ingenious apparatuses, introduced on the market few years ago. These apparatuses allow to control the water delivered by each hydrant, without the need for external energy or the use of electrical network, by programming the time and volume and continuously storing the consumption by each farmer (Antonello, 1993; Antonello and Bianchi, 1995).

In the self-feeding electronic system (called «CVA», made by SIGMA, **figure 1**) each user (up to 16 for each hydrant) is provided with an electronic code key by which he operates the CVA and, by means of a valve with a latch solenoid, he can open the gate valve.

In order to control the quantity of water withdrawn, the CVA apparatus has a special device which receives and processes the impulses coming from the impulse-emitter placed on the flow meter. Consumption data are stored in a selective way and assigned to each user on a dedicated recorder.

The reading of the consumed water is made at the end of the irrigation season by a portable computer.

The CVA apparatus is fed by photovoltaic cells.

A recent advance of CVA, at least in some of its characteristics, is HYDROMAT (**figure 2**), also made by SIGMA.

The HYDROMAT is also a local peripheral electronic system, innovatory and polyvalent for the automatic, selective and controlled delivery of water from the hydrants.

It is suitable for use in agricultural areas shared by many different owners. Each user (up to 16 for each hydrant) receives an entry code for one or more hydrants.

The system is composed of a fixed device on the hydrants and a mobile part (electronic key or card) in possession of the consumer, preloaded with a given volume and a given time of delivery, with pre or post payment. The card contains a long duration battery to supply energy to the system. The apparatus allows the consumer to chose the volume to be drawn each time within a set time and the maximum deliverable volume stated by the Irrigation Authority. The system is not connected via cable or radio with the control center.

The described system does not require any local intervention by the personnel for the consumption readings and allows the Authority and the users to optimize the flow hydrograph.

It is obvious that with both these devices, the control by the Irrigation Authority on the individual user takes places according to:

a) real delivery: by storing the time or volume of withdrawal it is possible to chose pre or post payment and, if needed, with different rates;

b) possible delivery: through advance seasonal or monthly planning of the volumes withdrawn by each individual user, the set time can also be pre-established according to the available water supply.

The final purpose is, of course, optimal water use.

The «capillary» nature of this control is of major importance. It is extended, or may be extended, to all the hydrants and, at the same time, it is «very flexible» in the sense that within reasonable volume and time limits it allows the us-

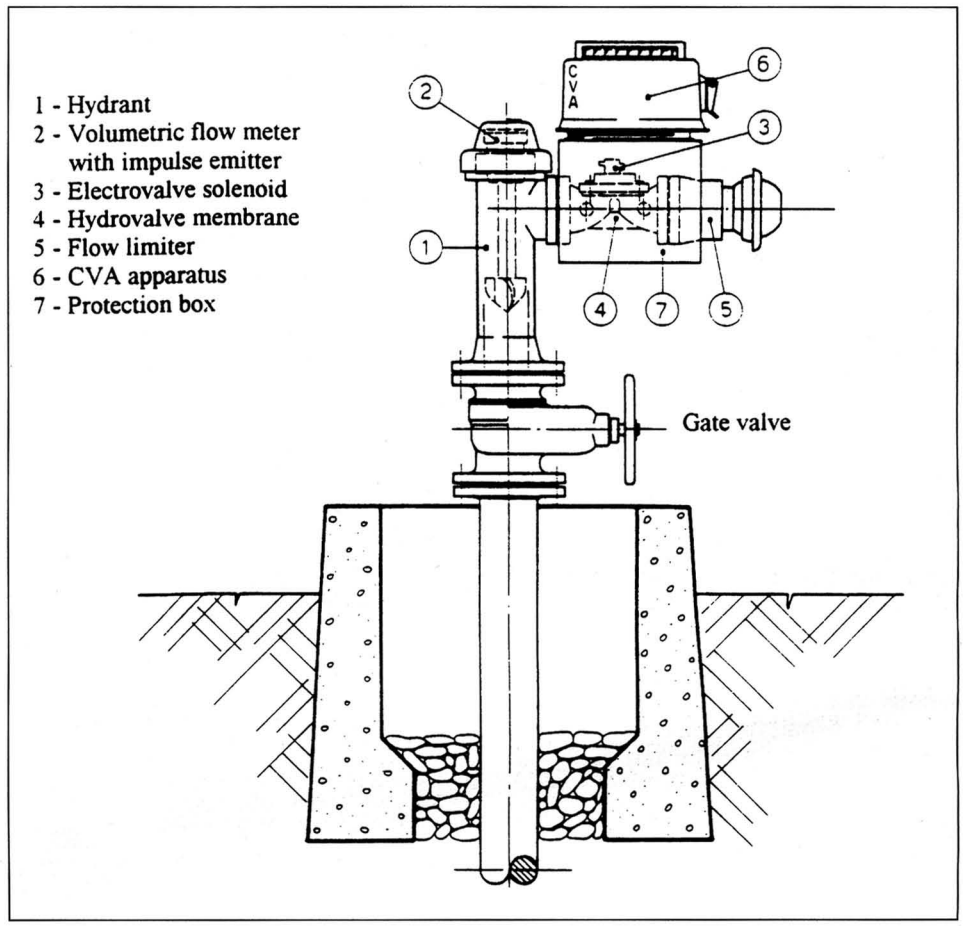


Figure 1 - Scheme of CVA apparatus, made by SIGMA.

er to carry out irrigation within his farm in the ways he thinks best.
Also the administrative side is greatly helped and rationalized since the water metering problem is overcome even when many farmers use the same hydrant. Furthermore, the above two pieces of equipment (CVA and HYDROMAT) do not require substantial and expensive modification in design and construction (e.g. cable installation). They represent a valid tool to improve, at low costs, the management of the irrigation systems already constructed or planned still in accordance with traditional criteria.
A concrete example, actually under study, is the transformation of two pilot areas of the low zone of the «Sinistra Ofanto» irrigation scheme in the province of Foggia (Italy), managed by the Consorzio di Bonifica della Capitanata (C.B.C., 1984).
The idea of transforming the two areas of the above irrigated land has risen from serious analysis of the changes in the users' behaviour, over time, with respect both of economic activity and social status.
The analysis of water needs and their seasonal distribution has required an accurate survey of the studied area. The «Sinistra Ofanto Irrigation Scheme», which covers about 22,500 hectares, is divided into seven districts, in turn subdivided into sectors from 20 to 300 hectares, within which the fields are served by hydrants, mostly with modules of 10 l s^{-1}, fitted with flow meters and flow limiters. The districts 4, 5, 7, 8, 9 and 10 are supplied by reservoirs, for a daily storage, filled by the main conduit coming from Capacciotti Dam (**figure 3**).
The entire pressurized irrigation system has been designed by Eng. Malossi and Santovito (1975) for operating «on demand», expecting a minimum head of 20 m at the hydrants, suitable for medium-small rotating sprinklers.
During the past years, with the rapid increase in the use of the irrigation facilities, critical situations have been noticed, especially in the peak periods, essentially due to the lack of pressure at the hydrants and the insufficient daily filling of the upstream reservoirs with the resulting frequent emptying of the network and dissatisfaction of users (Lamaddalena, 1995).
To prevent such inconveniences the Irrigation Authorities tried to apply rotational operation among the sectors, by opening and closing 50% of them, alternatively every three days.
Consequently, the delivery schedule has

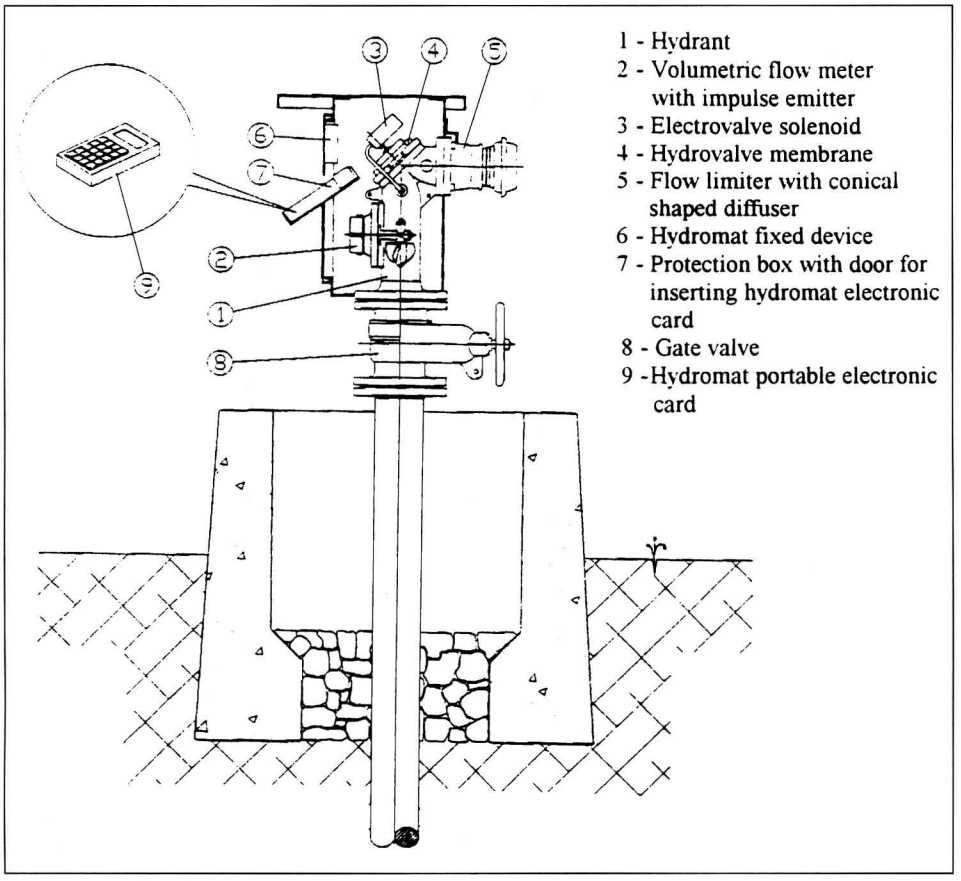
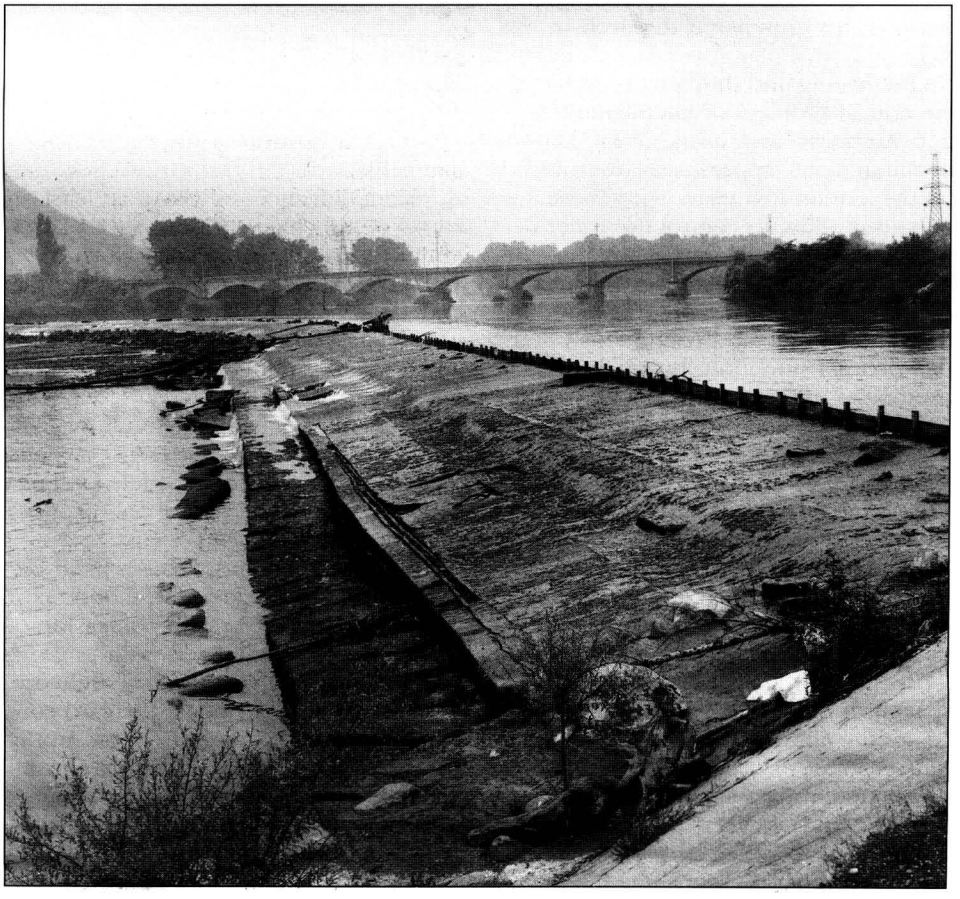


Figure 2 - Scheme of the HYDROMAT apparatus, made by SIGMA.



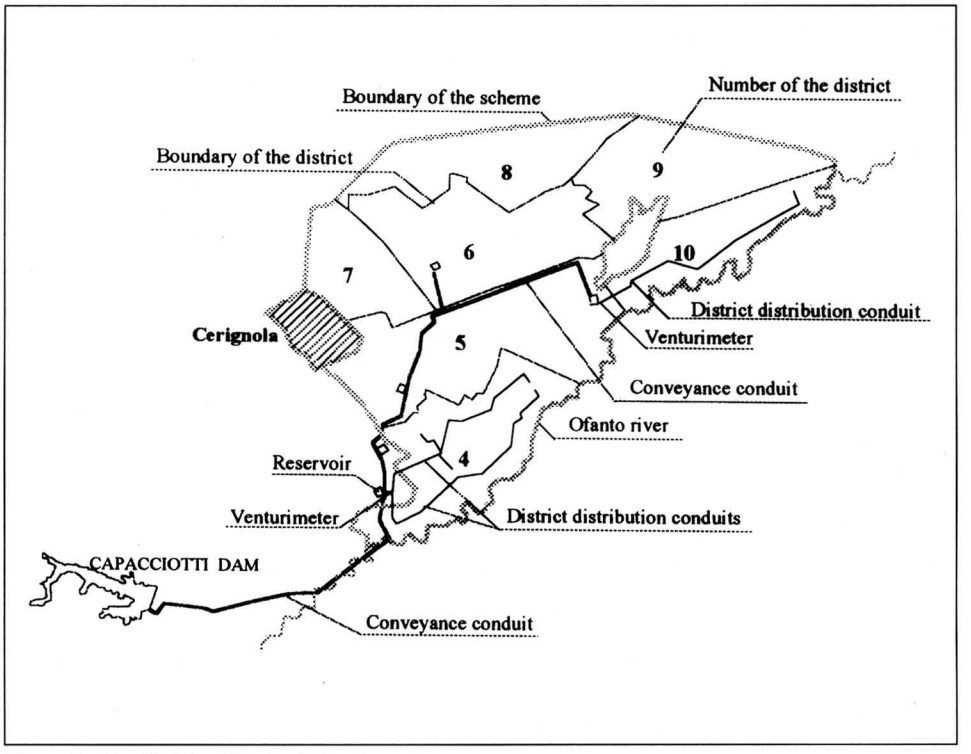


Figure 3 - The «Sinistra Ofanto» irrigation scheme.

been substantially changed from a full free «on demand» to a «restricted frequency demand» (Clemmens, 1987).
Unfortunately, this method has not given the expected results in water saving but has rather increased total consumption. In fact, during the rotations, for fear of future water shortage, farmers tend to withdraw as much water as possible, in terms of time and volume, as soon as their sector receives water. Consequently withdrawals are excessive for the needs of crops or in advance with respect to their growing stage (Ciollaro *et al.*, 1993; Lamaddalena *et al.*, 1995).
The same research has shown how the behaviour of farmers has been changing through years with respect to the designed assumptions. In fact, also the agronomic trends have undergone significant changes and consequently the farmers have modified their behaviour adopting different ways to distribute water (Lamaddalena and Ciollaro, 1993).
Further studies on the obtained information have clearly shown how the recurring shortages of the existing irrigation system could be satisfactorily, or at least acceptably, solved by inducing single farmers to modify the flow hydrographs, according to the global capacity of the irrigation system. This approach is expected to be better than the drastic 50% rotational-reduction between sectors with the consequent managerial difficulties for the control of the upstream gate valves.
Few years ago, the managers of the Consorzio della Capitanata have installed, in the above said experimental areas, more than one hundred devices of the CVA-SIGMA type, with the aim of knowing the water volume withdrawn by the farmers using the same hydrant. In fact, in some cases there are more than ten farmers for each hydrant and, with the flow meter installed on those hydrants, it is possible to know only the total volume delivered. Using the CVA apparatus they can solve the problem of water metering and, consequently, they can ask the farmers to pay the exact amount of money, according to the water volume they used.
On the basis of the evaluations reported in this paragraph, it seems possible to enlarge the actual aim of the managers of the Consorzio della Capitanata using the same CVA apparatus also for improving distribution and reduce water consumption of each farmer, so as to avoid wastes or unuseful concentrated withdrawals, without penalizing the «on demand» operation.
In fact, by installing some CVA devices on hydrants located in «particular points», and by programming theme in order to limit the volume to be deliverd and/or to avoid withdrawals during the daily peak periods, it is possible to push the farmers to modify the flow hydrographs in such a way to be compatible with the system capacity.
Trials have already been done on some hydrants to check the reaction of farmers to such limitations. They responded very well and accepted such shortage much more willingly than the drastic 50% three-day rotation between sectors. This approach is still under study for identifying exactly which hydrants need to be controlled. Furthermore, also the possibility of reducing the price for night-time withdrawals is going to be considered.

Final remarks

These studies focus on rationalizing withdrawals for a better use of water resource.
The first results look very promising. Completed by a deeper knowledge of the agronomic, hydrogeologic parameters and so forth, the adoption of hydroelectric apparatuses like CVA or HYDROMAT extended on a larger scale, seems to be the right approach for solving the «bottleneck» between water delivery and irrigation scheduling. In fact, too often this problem makes the management of the large irrigation networks difficult, insufficient, uneconomic and discouraging. ●

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