AUTOMATION IN MICRO IRRIGATION

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INTRODUCTION

Seventy years ago, the world population was 2.5 billions, while the water resources were sufficient to feed all. Nobody was worried about drought and famine, as they believed someday it will rain and there is enough ground water too. Now in 2011 population is 7 billions and irrigated area is also doubled. With limited water resources the world has to find a solution to produce more crops with the same available water while more than one billion people suffer hunger. One of the most efficient ways to apply least water and produce more crops is micro irrigation. In micro irrigation water is distributed using a hydraulic pipe network that conveys water to the plant so that crop water requirement is met with a minimum of water loss.

Thanks to technology development, micro irrigation area in 2000 developed to 3 million Ha, then extended to 6 million Ha. In year 2006, Micro irrigation is capable from minimum up to full automation so that a farmer can closely monitor irrigation operation including fertigation and chemigation.

In Iran 1 million Ha, out of 8.5 million Ha, irrigated lands are equipped with pressurized irrigation systems from, which 50% is micro irrigation systems. Bureae of New Irrigation Systems Development in the Ministry of Agriculture established an intelligent agro meteorological station in Karaj city experiment station in 2009, which saves 35% water and energy (Fig. 1). This successful experience helped experts to develop intelligent meteo stations and automation provinces of Iran. In Golestan province, it is planned to erect 6 other automatic micro irrigation equipments for precise irrigation management by the technical support of a private Iranian company.

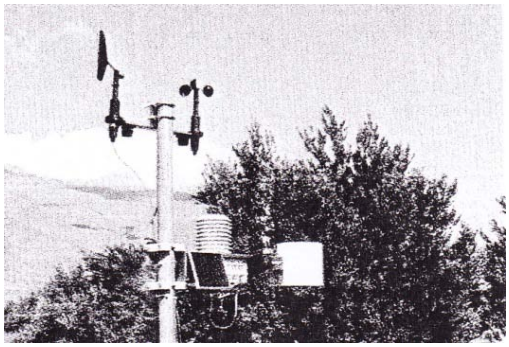

Figure 1. Automated intelligent meteo operation in field, Karaj- Iran

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Automatic micro irrigations are classified as open loop systems or closed.
a) Open loop System: Farmer decides when to irrigate and how much water to use. So he sets the time in controller (device which combine an electronic calendar and clock), which provides 24 volts to the valves for specific zones. As long as the voltage is applied, electric valves stay open and irrigation goes on. Most remote control valves are normally closed until the solenoid on the valve is actuated by controller. Control valve remains open until such time as the solenoid is actuated. Controllers are either electromechanical (Fig 2) or electronic (Fig3).

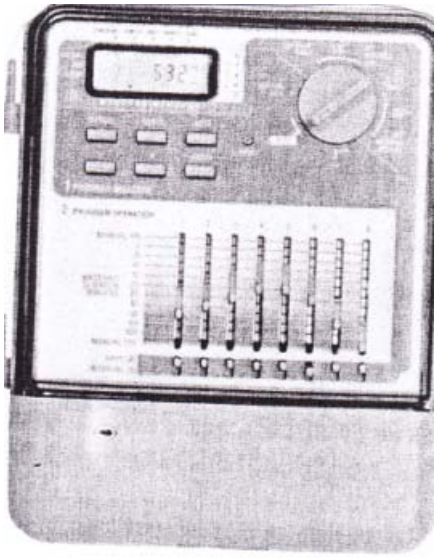

Figure 2. Electro Mechanic Controller

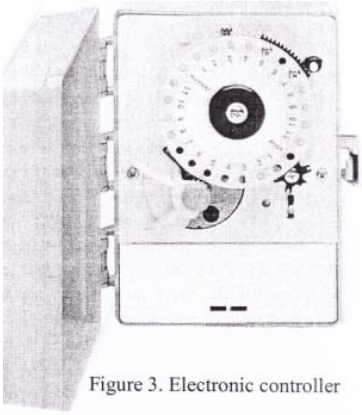

Figure 3. Electronic Controller

Valves are control devices for specific zones.(Fig4) is a common electric solenoid valve usually installed on manifold pipe in micro irrigation.(Fig5) shows a wireless valve with 3 key to set hour, AM, PM, Day in a week powered with a season-life battery.

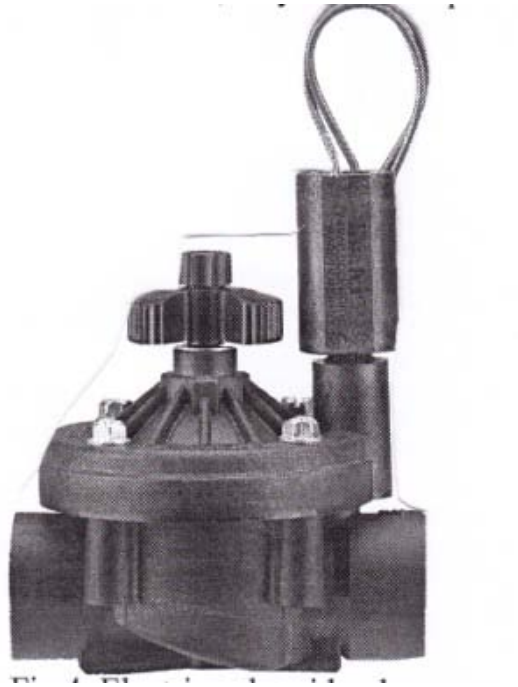

Figure 4. Electric solenoid valve

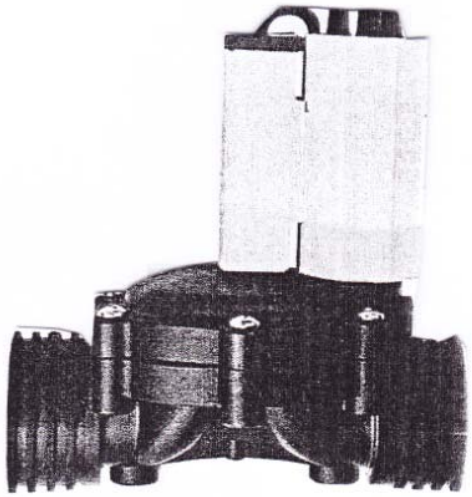

Figure 5. Wireless adjustable valve

Controllers are usually placed in pump station but some remote wireless valve controllers are used to monitor irrigation operation (Fig6). Portable programmers transmit irrigation command to electric valves by Radio wave or Bluetooth.

Figure 6. Remote Valve Controller

Another innovation is a soil humidity measuring and registrating device based on domain reflectometery technology (TDR). By combination of moisture sensors and TDR. Measurements can be read out and stored in Bluetooth module. These measurements are used to manage irrigation schedule precisely according to actual soil moisture condition in root zone.

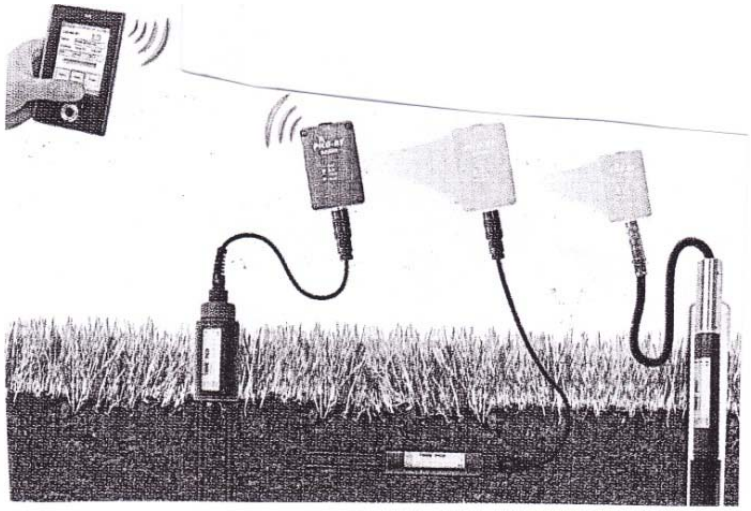

Figure 7. The trime-pico soil humidity measuring system

b) Closed loop system: The most standard irrigation controllers have time-based irrigation or water volume used controllers. Only a few newer irrigation controllers have the possibility to connect sensors like rain, soil moisture, wind, temperature, so can automatically run sensors based controls. Intelligent Central Automation (ICA) takes it a step forward using the internet as central command. Central part of ICA consists input port for sensors and output port for controllers and electric solenoid valves.

The state of art continues monitoring weather station and soil moisture logger line, allows merging these technologies with remote access and intelligent control operations via the internet with no PC software and just the internet browser you program directly irrigation or fertilizer injection based on crop, specific evapotranspiration, or soil moisture deficit. Conversely it will stop the irrigation cycle automatically when the soil water content has reached saturation value or a simply set value. A manual option allows running the system on manual mode or on time based as well. The website utilizes wireless

communication by regular internet connection from each field station to navigate and automate all functions from anywhere in the world.
ICA is available in various models, for instance 2 channel or 5 channel system which are designed to interface with standard irrigation controllers. These models are controlled via sms from our website, and need permanent power supply using charger. One sophisticated controller is designed to work with DC valves and solar panel only. These controllers can control 1 to 8 DC solenoids or a pump, fertilizer injection, back-flash filtration control. One model of ICA can control up to 6 relays or one pump, one fertilizer injection and one back-flash filtration control.
ICA determines the optimal irrigation schedule based on seasonal and site parameters like soil type, slope, precipitation, ET, growth stage, etc. Alerts are sent through website when a fault occurs. Text message are sent to mobile phone and email address. The system automatically modifies irrigation schedule based upon daily ET, changing crop stages, soil moisture as well as plant watering requirements. Reports are available to show web and field activity to allow detailed analysis of the system's efficiency as well as manual operation from the web page or by password through mobile phone (by sms command) or PDA's.
ICA consist of internet based controllers and web services, on the field climate. Webpage are converting sensor data into intelligent control operations. Secured wireless two-way communication via GPRS and automated system alerts via email or sms. Automatic or manual rain shut off alert is possible. A solar power supply voltage, 6 volt is required. A 24 hour, 1 week, 365 days ET synchronization is possible. Flow report, daily ET information by built in tools is accessible too.

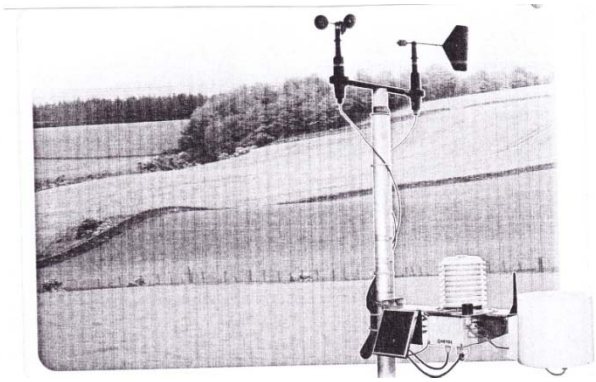

Figure 8. Internet Meteo for measuring climate factors, ET and continuous monitoring soil moisture

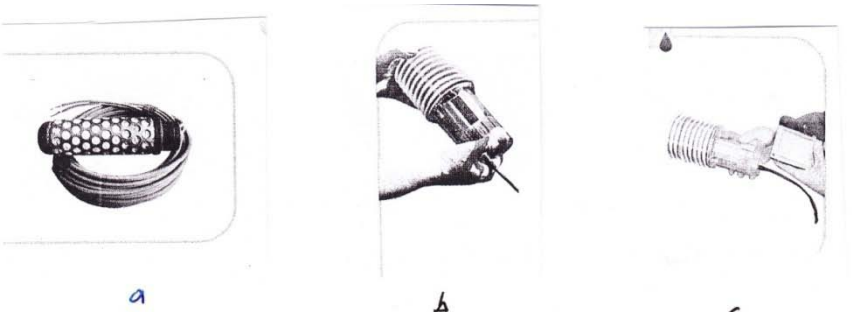

Figure 9. a) soil moisture sensor which measures soil moisture potential in centi-bar, b) all information are saved and could be seen in its screen, c) by infra Red Ray all saved data are transmitted to central PC

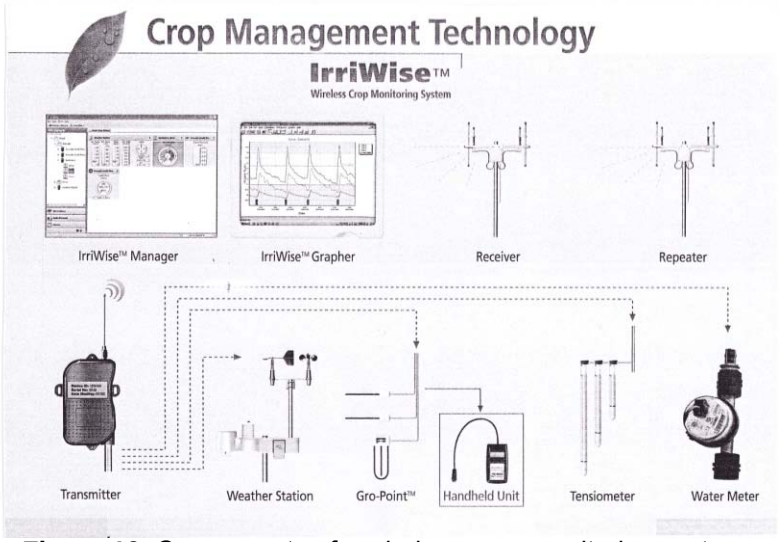

Figure 10. Components of a wireless crop monitoring system

In crop management technology, the system is designed to collect, consolidate and transmit information in real time from advanced soil moisture sensors, tensiometers and weather stations. Hence agronomists move from estimation to exact data they need for precise decisions. The result is better irrigation management decisions along with satisfactory improved crop quality and yield.

In fully automated system, the human factor is eliminated and replaced by a computer specially programmed to react to any changes in the parameters monitored by sensors. The automatic functions are activated by feedback from field units and corrections in the flow parameters by control of devices in the irrigation system until the desired performance level is attained. Automatic systems can also perform auxiliary functions such as stopping irrigation in case of rain, injecting acid to control PH, and fertigation.

In micro irrigation Automation is performed in all or part of system sections such as:

a) Pumping station and water filtration

b) Water conveyance and distribution system

c) Monitoring real-time precise crop water requirement

d) Irrigation system (in field, garden)

Pumping station and water filtration

Water quality is very important in micro irrigation. So water quality from physical and chemical point of new is to be investigated. When water resource is deep well, a new diver is used to measure ground water level, PH, and conductivity from 0 to 120 ms per cm, which its memory capacity is about 148000 measuring value with a 10 years life battery.

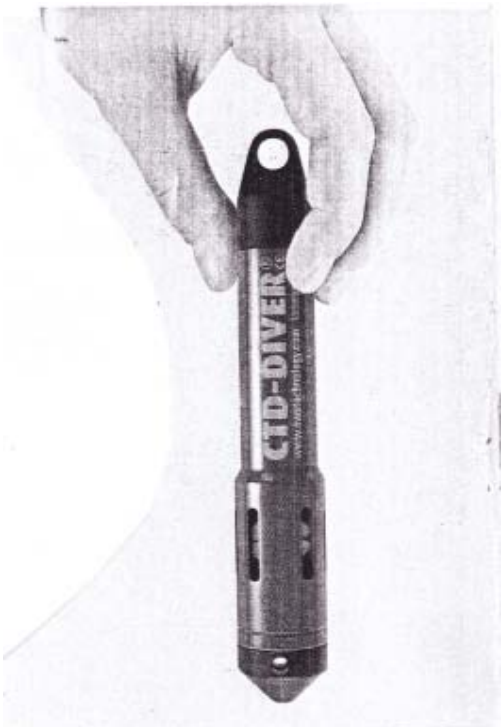

Figure 11. Compact data logger diver for measurement groundwater level, temperature, PH, and conductivity

For variable water demand, pumping system is used, the pump may have variable RPM (Fig12) or in the case of multiple pumps, pressure switch is used on discharge manifold to convert water pressure to electrical pulse to stop or start pumps according to pipe network water demand.

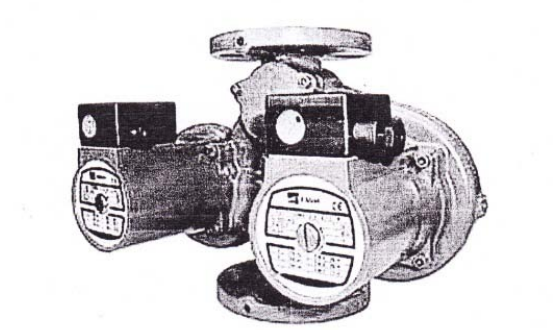

Figure 12. A booster pump with variable RPM

Automatic pump control valve protects electro pump against water hammer when electro pump is stopped, though starting is easy with low electric energy (Fig13)

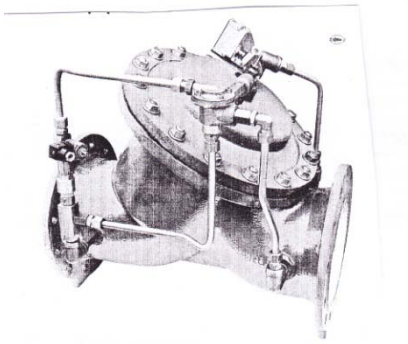

Figure 13. Automatic pump control valve

In micro irrigation filtration unit is in pump station or may be portable in field. When filtration unit is beside pump units, controller is used to start and stop pumps too. In fig 14 an automated filtration set is shown. A filtration system can be controlled in different way depending on the crop requirements and installation procedure installation and its needs (Fig 14a, Fig 14b)

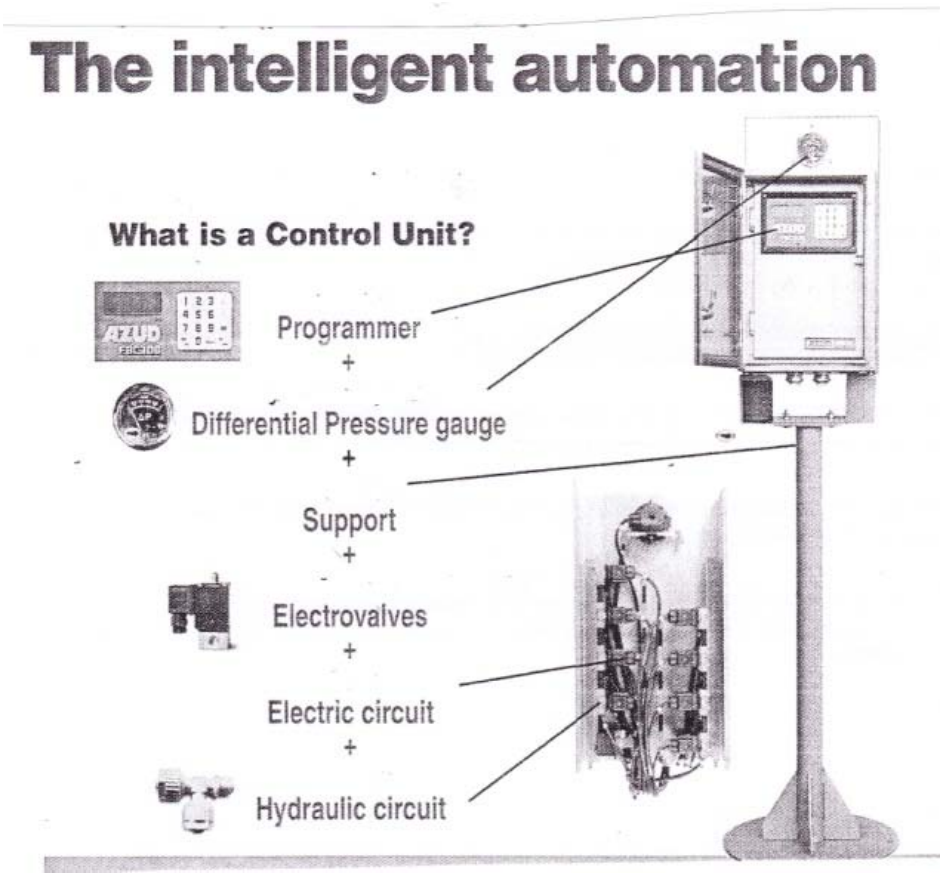

Figure 14a. Components of an intelligent control unit in micro irrigation

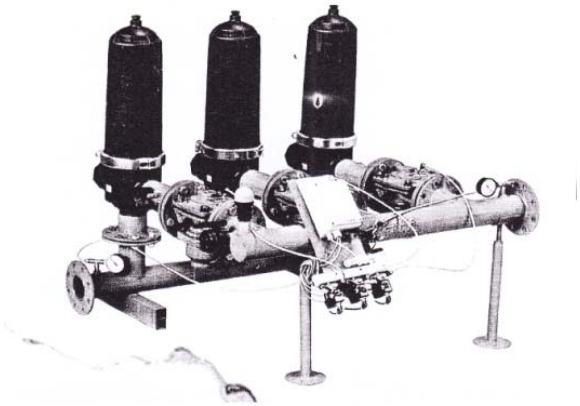

Figure 14b. An automated filtration set consist of controller, hydraulic valves, self cleaning and automatic backwash helix disc filters, manometer, air relieve valve

The Programmer (controller) operates the system manually or automatic. In manual mode, the operator sets performance mode to manual by preset time of backwash (e.g. every 10 hours) and backwash duration (e.g. 20 seconds), In automatic mode the operator selects ΔH mode, then programmer orders backwash action by the help of differential pressure gauge (e.g. 0.4 bar). Automatic filtration order from programmer to hydraulic valves are transmitted by hydraulic or electrical circuit, by closing or opening hydraulic valves, filtration or backwash action is monitored. In low quality water case, due to clogging filters in short time, difference between inlet and outlet pressure in each filter is remarkable so cleaning times are more in a certain time (day or week).

Water conveyance and distribution system

In micro irrigation, distribution system from water resource to field is pipe network. To control and monitor pressure, flow and pipe, different control devices are used. Manometer are widely used to control flow pressure, the pressure reducing and flow control valve is used in main or sub main pipes to control discharge with a preset constant pressure. (Fig 15)

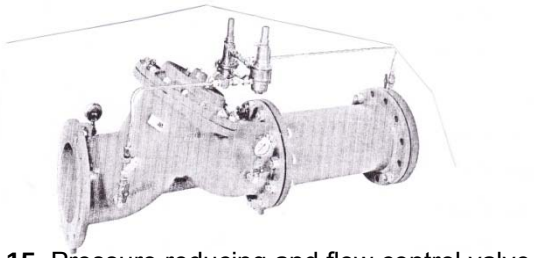

Figure 15. Pressure reducing and flow control valve

Hydraulic remote controlled valve is used to open or close flow by the help of a tri-pass remote hydraulic relay on top of the valve (Fig 16). The standard type is available in open (NC) or closed (NO) and connected to controller by hydraulic micro tubes.

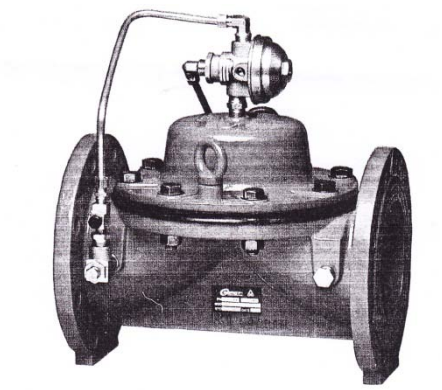

Figure 16. Hydraulic remote controlled valve

Metering valve is a combination of flow meter and hydraulic valve. The desired volume of water to be applied is preset. The valve opens and closes automatically when the assigned water volume has been delivered. Metering valves are used extensively in micro irrigation and are highly compatible to automation (Fig 17)

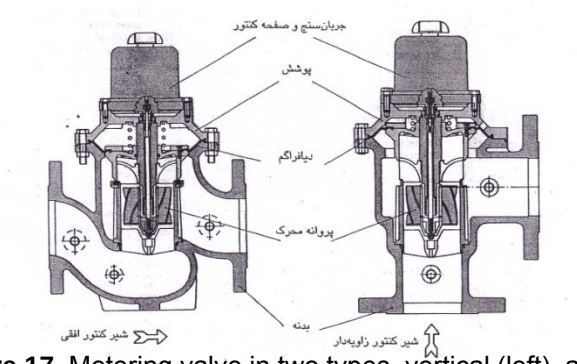

Figure 17. Metering valve in two types, vertical (left), angled (right)

PLC controlled valve acts by water pressure, pneumatic, by command transmitted from controller to two solenoid on top of it. (Fig 18)

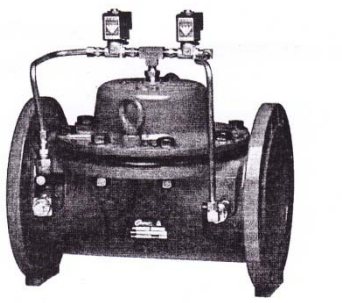

Figure 18. PLC controlled valve to control flow, pressure, open and close operations in pipe

To open or close valve automatically on pipes, different actuators are used, actuators function as hydraulic, pneumatic or electrical (Fig 19). Electric actuators need 250 volts 5Amp. AC or 30 volts 2Amp DC electricity source, battery, or solar energy. Automatic control is local (in different part of project) or central.

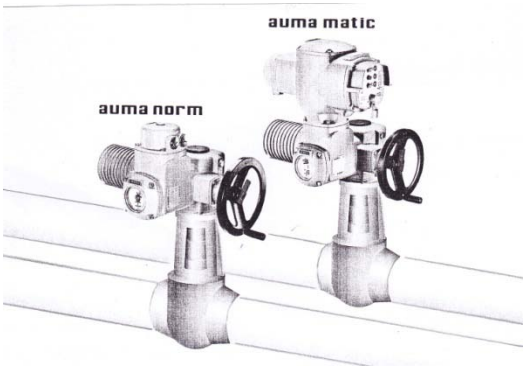

Figure 19. Two kind of electric actuator on pipe, normal or automatic to open or close valve

Monitoring real-time precise crop water requirements

One of the most important factors for optimum management of an irrigation system is to determine actual crop water requirement. This amount of water for a certain crop varies in different growth stages and are different in soils and climate changes. In closed loop automatic system, soil moisture variation are measured and stored in sensors next to the root, and then climatological measurement are stored, analyzed and transmitted to central room. In case of rain in field data correction is done too. This actual water requirement is the basis for a logical, well managed irrigation with high efficiency and minimum water loss.

Irrigation Control Center (ICC)

In this system, farmer can manage irrigation schedule, water consumption, fertigation, data processing precisely by the help of a remote control. This control center consists of:

- Irrigation management system (IMS)
- Controllers in farms or control room
- Remote communication terminals in farm or orchard
- A reliable two side communication system

ICC receives reliable information and data from different sites in field, sub units, cumulative water consumption, maintains water pressure constant in pipes while water discharge varies during irrigation period.

ICC also starts pumps according to preadjustment based on irrigation schedule. ICC investigates leakage in pipe network, and filters blockage in head control. ICC sends online alarms by cell phone, PDA or PC. ICC is compatible to developed IMS software to respond for urgent water demand variations, and provide report of energy used for each pump.

Automation in micro irrigation system (in field, garden)

For various crops and trees, different type of micro irrigation is recommended. Every kind of micro irrigation needs special devices on pipe network to manage irrigation automatically. The most common devices are controllers, electric solenoid valve, dripper or bubblers, which are compensated or self cleaning or antisuction. Micro irrigation may perform on ground surface or subsurface. In automatic subsurface drip irrigation (SDI), minimum water loss, maximum water application efficiency are achieved.

In addition to standard solenoid valves (Fig 4) to control different sub units, a new kind of valve called smart valve are available. Farmer stores irrigation schedule in a smart controller then controller is set on valve so all data are transmitted to any individual valve in field (Fig 20)

Figure 20. Irrigation data are transmitted to automatic valve by a digital smart controller

In field or orchard the simplest method for closed loop automatic irrigation is switched moisture-sensitive hydraulic controller consist of tensiometer, hydraulically connected to an activated valve (Fig 21). This simple device makes the basic irrigation decision of when to water and how much to apply.

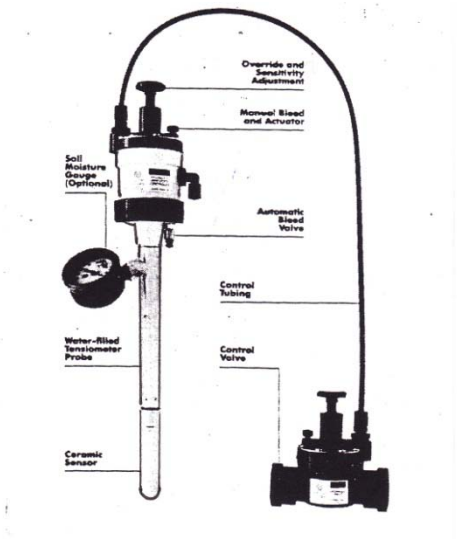

Figure 21. Moisture-sensitive hydraulic controller offers automatic irrigation control without the need for electricity or batteries

Distributors like bubbler or dripper are widely used. One kind of compensated bubbler with discharge from 20 to 40 Lit per Hour is good substitute for loop pattern. Regulated discharge is constant in pressure and topography variation (Fig 22).

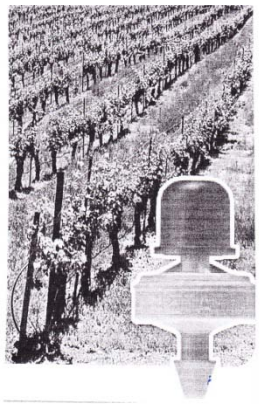

Figure 22. Regulated discharge bubbler in orchard.

A kind of dripper is self cleaning, antisuction mechanism, compensating in 0.7 to 4 bar range. At 0.12 bars opening is closed toward reverse flow into dripper (Fig 23).

Figure 23. A kind of dripper is self cleaning, antisuction mechanism, compensating in 0.7 to 4 bar range. At 0.12 bars opening is closed toward reverse flow into dripper.

A kind of dripper is available for subsurface drip irrigation with a special mechanism to prevent root penetration to outlet and orifice blockage due to soil moisture tension. SDi system is proper for orchards compatible to full automation with minimum seepage loss, soil surface moisture evaporation (Fig. 24)

Figure 24. Subsurface drip line lay out along pistachio trees in Iran (Left) and uniform moisture pattern beside pistachio trees

Different kinds of tapes are used in micro irrigation for row crops, vegetables, orchards. In Iran tapes are applied in potato, sugar beet, corn, tomato, melons, cabbage, egg plant,

cucumber, strawberry… Each kind of dripper, bubbler, tape and micro sprayers need its concern for filtration and pressure regulation.
Micro irrigation is the most compatible system to part or fully automation. Automatic micro irrigation helps farmer to have least person, high energy and water saving, minimum water loss in distribution network, prepare irrigation schedule based on actual soil moisture condition in root zone. Irrigation program is analyzed and modified due to variation of daily and seasonal factors (field, climate, crop, water, energy…) Experiments in Iran show magnificent yield increase, water saving and higher annual income for farmers after diverting from surface to micro irrigation.

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