The beginning of organizations among people for their mutual benefit is lost in antiquity. Such a beginning must go back to early man's first discovery of certain benefits in community living—for protection, for joint labor, or for cooperative hunting. Through family, tribal, or other social type of grouping there developed certain codes of conduct and recognition of the need to conserve and share natural resources, such as water in desert areas. Thus, organizations of a sort began eons ago; but organization specifically and solely for the development and use of river flows for agriculture came later.

In historical times there are references to water supply systems for irrigation. In 2250 B.C. an Assyrian emperor decreed that man and beast had the first claim on water, with the irrigation of crops coming next. Other water uses and functions have been added to reach the contemporary multiple-use concept, but the ancient decree still holds. Man still has first claim.

From ancient Assyria and Mesopotamia, irrigation for the production of food and fibre spread slowly but inevitably throughout the civilized world. Irrigation was born of necessity, and followed a tortuous path requiring innovation, pioneering spirit, and experimentation. But, like a flood picking up speed and volume as it moved, irrigation became an irresistible force. The joint use of facilities, even in their simplest form, and the more sophisticated multiple-purpose concept of water use created situations and problems which by their very nature required cooperative effort for satisfactory solution. To meet these needs water user organizations, often originating in crude form, came into being.

As the population expanded to and within the arid river valley of the western United States, the need for formal organization among water users soon became evident. By way of broad definition, a modern water user organization in the United States is any conservancy district, irrigation district, water district, water association, or other like organization,
created under State law, having contractual capacity, taxing or assessment authority, and empowered to function in programs of water use for various purposes.

A century of irrigation development in the United States has demonstrated emphatically that strong water user organizations have been essential to the successful planning, financing, construction, operation, and maintenance of water resource development projects. Without such organizations progress in water resource development would have been greatly retarded. The form and role of water user organizations evolved over the years from small ditch companies faced with relatively simple operational problems to master conservancy districts which are charged with a great diversity of financial and operational responsibilities. Modern organizations provide the sophisticated legal means by which groups of family farm people can combine their efforts to plan, finance, build, and manage project facilities for multiple water use, and to make necessary assessments and collections of money to carry out those functions.

Although effective water user organizations have emerged in many countries, not all areas of the world have followed such a course, and, coincidentally, not all have achieved the rich productive and economic benefits that usually stem from sound water resource development projects. Several basic situations have contributed to lack of progress in many areas of the world. Chief among them are the historically prevalent systems of land ownerships, tenure, social castes, and forms of government. Too often developing nations, currently making energetic efforts to develop their important land and water resources, are failing to recognize the significance of strong local water user organizations which can, and should, eventually assume major responsibility for management and operation of the water systems. Specifically, in many areas the planning and construction are performed unilaterally by an arm of the government. In frequent cases where land reform is involved, this is accomplished by government edict. Families are moved to assigned units with insufficient regard to the family qualifications and adaptability to the new circumstances. No part of the construction costs for the irrigation works are assessed to the direct beneficiaries, nor are the annual operation and maintenance costs assessed to or collected from the water users. Frequently the operator of the system is a government employee who does not fully recognize his obligations or responsibility to the water users he serves.

These circumstances contribute to lack of sympathetic management policies and procedures by the system operators as well as to lack of personal interest in and responsibility for the irrigation works among the users. The resulting inefficient and ineffective use of water and lack of care of leaky ditches, unprotected metal surfaces, poor concrete, clogged drains, seeped lands, excessive operational losses, inefficient management, disgruntled water users, and general lack of prosperity. Where strong water user organizations have been established, we find stable, efficient, effective management of resources and usually a high degree of local pride in the system, which is reflected in good care and maintenance of facilities. Benefits to the settlers and the nations involved could be
greatly enhanced by adoption of programs which give careful attention to the selection and training of settlers and formation of water user organizations with authority and responsibility for management, care, and at least partial financing of the common water supply facilities.

Exportation of United States' Reclamation Experience to the World

The Bureau of Reclamation has been engaged in programs of assistance to other countries in water resource development for many years. Since 1950, about 1200 engineers and scientists from about 60 nations have trained in the United States with the Bureau of Reclamation. During the same period the Bureau has sent numerous engineers and scientists to about 50 countries. Currently the Bureau of Reclamation has about 100 of its technical employees in 8 foreign countries in long-term assignments and has a steady flow to other foreign countries for short-term assignments. In connection with the Bureau's foreign activities program and through participation in activities of the International Commission on Irrigation and Drainage, I have had the personal opportunity to visit about 25 Asian, European, African, Middle Eastern, and South American countries and to obtain limited but firsthand knowledge of water development problems, progress, and accomplishments in the vitally important field of water resources development.

Many long-settled nations like Nigeria and Afghanistan, as well as newly settled nations like Brazil, are just becoming aware of the tremendous social and economic benefits that can be achieved through sound, coordinated development of their land and water resources. In both cases the Bureau is assisting in compiling basic inventory data on the land and water resource development potentialities of these countries with subsequent development of plans for implementation of specific projects. A major parallel objective is to train technically qualified nationals in the specific fields of engineering, hydrology, land classification, geology, and economics, and in the modern techniques of water resource planning and project formulation. In many countries the Bureau's role extends beyond the investigation and planning phases to assistance in actual design and construction of project works. Where the project operation has been involved, assistance has been given not only in operational policies and procedures but also in the establishment of water users organizations and in creating an understanding of the responsibilities and functions that such organizations should perform in the successful project development and operation.

Beginning of Irrigation Development in the United States

Many countries have long and exciting histories of irrigation development and the important role it has played. Others have done little. A history of water resource development in the United States is briefly traced herein to reveal how the water user organization has developed and the role it plays in the successful development and operation of projects.
Recorded history of western United States makes many references to the hardships which early settlers endured because of inadequate or erratic rainfall. The area of the 17 Western States, being the portion of the contiguous states of the United States west of the 100th meridian, is largely arid or semiarid. A total of about 750 million acres, or two-thirds of the area west of the 100th meridian, has soil suitable for farming, but because of moisture limitations, a large part of the area is suitable only for grazing or marginal production of dryland grain.

The American Indians, as far back as A.D. 800, recognizing the need for irrigation in the Southwestern United States, diverted water from tributaries of the Rio Grande and Colorado River to their fields. The Indians, and later the Spaniards and Mexicans, continued to expand irrigation in the Southwest. The first recorded developments by white men occurred in California in 1769. Actually, the afternoon of July 23, 1847, has become popularized as the beginning of modern irrigation in the United States. It was on that afternoon that a band of Mormon pioneers built a small diversion dam across a creek to divert water to five acres, which is now a part of Salt Lake City, Utah. By the spring of 1848 the Mormons had 5,000 acres under irrigation; and by 1890, it was increased to 16,000 acres. The important contribution of the Mormons to reclamation is not their initial diversion of water, but their pioneering in the field of irrigation engineering, water law, and community cooperation. Their laws for appropriation of water and for establishing priority of use became a pattern for other western states. Also, the mutual water companies which have flourished under the Mormon development in Utah are based on the fundamental concept of a community cooperative undertaking in which the members share according to the size of their farms.

Migration to the west was continuous principally because of the hope for easy wealth from mining and livestock production. The growing need for food and forage crops caused irrigation farming to expand along river bottom lands. Initially, stream diversions and irrigation ditches were simple and crude, but as the adjacent benchlands were developed construction of facilities to serve them became more difficult and expensive. Farmers met the problems by forming associations and community cooperatives through which they undertook the construction of additional, and sometimes costly, irrigation systems to serve new areas.

By 1870 individuals and associations of farmers had constructed irrigation facilities to serve an estimated 250,000 to 300,000 acres, with most of the work having been done by the individual members of the organized groups. By 1890, through a wide variety of private, speculative, and promotional schemes, the irrigated area in the West had grown to approximately three and one-half million acres.

The natural flow of the streams and rivers was generally adequate for irrigation requirements on the expanded area throughout the first half of the irrigation season or until the end of the flood season. Then the natural river flow dropped sharply and became insufficient for the irrigation requirements. The need for water storage reservoirs for stream flow regulation became clearly apparent.
While private enterprise had managed to bring successful irrigation service to an impressive and substantial acreage of land, a point had been reached where further development needed greater support by Federal and state governments. Demands developed on the Federal Government to participate financially in irrigation development for (1) providing water storage in reservoirs on streams so that lands already irrigated could obtain a supplemental water supply to meet late summer irrigation deficiencies, and (2) providing a full water supply for new lands, the needs of which could not be met from the natural river flow.

The Federal Bureau of Reclamation

Irrigation in the west reached around 9 million acres by 1900, but the rate of development at that time appeared to have slowed down appreciably. A large percentage of the easier projects had been built and capital was hard to obtain to finance the larger and more complex undertakings. Many great conservationists, like Theodore Roosevelt, Francis G. Newlands, and Gifford Pinchot, gave active support to a program of western resource development. This broad interest was instrumental in passage of the Reclamation Act of 1902, under which Federal government participation in the financing, construction, and operation of irrigation projects was made possible.

The Reclamation Act of 1902 authorized the Secretary of the Interior to investigate, construct, and operate Federal Reclamation Projects for the irrigation of the arid and semiarid western United States. The construction costs, which were generally low, were to be repaid by water users on the projects in ten annual installments. Public lands on the projects were to be made available without cost to settlers under homestead laws in family-sized farms. Title to the land did not pass to the homesteader until final payment had been made of the construction charges allocated to his lands for irrigation facilities; at that time he would also acquire a paid-up water right subject to the payment thereafter of his proportionate share of the annual cost of operation and maintenance of the irrigation works. As the number of projects increased, the numerous individual water right contracts became increasingly difficult to administer. This fact, and other experience with the Federal Reclamation program, soon demonstrated that amendments to the 1902 Act were needed.

The requirement for repayment of construction costs in a 10-year period, as provided by the 1902 Act, proved to be unrealistic. The Act of August 13, 1914, authorized a 20-year repayment period and authorized the Secretary of the Interior to designate water users associations or irrigation districts to act as fiscal agents of the United States for the purpose of collecting water users annual payments. On May 15, 1922, Congress authorized the Secretary of the Interior to contract with legally organized districts, and to dispense with water-right applications on the part of individual landowners and entrymen. The Act of December 5, 1924, authorized a plan for determining annual payments due the United States based on 5 percent of the average gross crop value in a district for the immediately preceding 10-year period, and on May 25, 1926, a 40-year repayment period was authorized in lieu of the crop repayment plan.
The most far-reaching amendment to the 1902 Act was the Reclamation Project Act of 1939, which provides for flexibility in determining the annual rate of repayment for new contracts, again on a crop-income basis, but total repayment must be made in 40 years for distribution systems. A development period of not to exceed 10 years was authorized during which project farmers would prepare their lands for irrigation, establish suitable crops, and attain reasonably full farm productivity before beginning their repayment of project construction costs. This Act also authorized the United States to allocate portions to flood control and navigation on a nonreimbursable basis. This made feasible for construction many projects where water users alone could not reasonably be expected to repay the entire costs. Additionally, the Act of August 14, 1946, provides for nonreimbursable allocations to the preservation and propagation of fish and wildlife for new projects. Thus the multiple-purpose features of Reclamation projects were formally recognized and irrigation was no longer required to underwrite the total cost of multiple-purpose water projects. The most recent legislation in this connection is the "Federal Water Project Recreation Act" of July 9, 1965. Under that Act one-half of the separable costs allocated to recreation and to fish and wildlife must be repaid by a non-Federal public body. That entity or agency must also agree to assume operation and maintenance costs and responsibilities for those functions. This legislation is of such recent origin that no actual operating experience is available.

General Types of Water Users Organizations

Being bound by the Act of May 15, 1922, to contract with legally organized districts and to dispense with water-right applications on the part of landowners and entrymen, the Bureau of Reclamation then must look to the type of organization with which it contracts for the repayment of Federal funds expended in the construction and operation and maintenance of multiple-purpose projects. Construction costs of a project allocated to irrigation must be repaid without interest by the irrigators to the limit of their reasonable payment capacity, with reimbursable irrigation costs beyond such ability to be returned from power revenues derived from the project. Additionally, once the project has been completed and is in operation, whether by the Government or by the water users organization, all operation and maintenance costs must be borne by the water users and must be paid in advance. When water is available for municipal and industrial use, a contract with a municipality or an industry is entered into for full payment of the municipal and industrial allocations, with interest. Agreements are also entered into with organizations for repayment of costs associated with fish and wildlife enhancement, and recreation.

The type or form of organization adopted by a water users organization is virtually important, for upon it depends not only the legal powers of the organization, but also the relations between the organization and the users of water. A public water users organization is organized pursuant either (1) to the specific detailed procedure in a general act of the State Legislature, or (2) to a special act of the State Legislature. Most of the organizations formed in the west were organized under general enabling acts, many of which require a favorable vote on the part of either the landowners or the general electors within the boundaries of the proposed project.
In the early years the principal type of water users organization was a Water Users' Association, which was a private corporation. This was essentially a mutual irrigation company formed under the corporation law of the State and members held stock in proportion to their irrigable acreage. The stock was appurtenant to the land, as was the right to the continued delivery of water. Assessments for payment of charges became liens upon both the stock and the land. The water users association was empowered by State law to enter into contracts with the United States to collect from its stockholders, for payment to the United States, the charges for construction, operation, and maintenance, and also to operate the project works when the United States deemed it desirable to turn the operation and maintenance over to the water users. The collection procedure of the association was sometimes unsatisfactory. The only way to collect delinquent charges from a water user was to prosecute and bring individual action. The United States therefore encouraged adoption of amendments to State statutes that would specifically authorize organizations to contract with the United States on Federal projects and urged replacement of water users associations with irrigation districts. This allowed collection of charges through district taxing machinery. Today the great majority of Bureau of Reclamation contracts are with irrigation districts.

The first irrigation district legislation was enacted by the Territory of Utah in 1865; however, most districts formed under that law have gone out of existence. In 1887 the State of California enacted irrigation district legislation which has served as a model for irrigation district statutes enacted subsequently in all the Western States, including Utah. Depending on the State statute, the organizations formed pursuant to these statutes are known as irrigation, water conservation, water improvement, or reclamation districts. In some cases, however, local improvement districts are formed under State enabling statutes within an irrigation district. In other instances irrigation districts are located within an extensive district of special type, such as a conservancy district. In these cases the functions of the overlying organization supplement those of the included organization.

Formation of Water Users' Organizations

The formation of an irrigation district is ordinarily initiated by a petition signed by some or all of the landowners within the proposed district. The petition is presented to and acted upon by the governing body or court of the county in which the largest acreage of land proposed for inclusion is situated. Hearings are held at which applications for the inclusion or exclusion of lands are passed upon. The county tribunal must find whether the State law has been complied with and fix the boundaries of the proposed district in order that lands that will benefit from the proposed project are included and that lands that will not benefit from the proposed project are excluded. In many states an election must be held and a favorable vote cast before the district may be declared organized. Since it is a public or governmental organization, irrigation districts thus can be created against minor opposition expressed by the voters of a part of the community. The lands of the objectors may nevertheless be included if they will benefit from the proposed project, and these lands, as well as those of the willing landowners, are subject to assessments for district purposes.
In some states the formation of a water district can be accomplished by a petition signed by a requisite number of landowners in the proposed district. This is followed by a hearing before the board of county supervisors, after which an organization election is held. In other states a water conservancy district can be formed, upon petition signed by the required number of owners of land, by the district court located in the area containing the largest acreage within the proposed district boundaries.

It is evident that, although the laws governing the formation of water user organizations differ from state to state, the one common factor is the desires and support of the local people evidenced in the form of a petition signed by individual landowners.

### Powers of Water Users Organizations

Water user organizations are public corporations or agencies, and have only such powers as are given to them by the State legislature. Their powers are thus prescribed by the State statute under which they are formed. The basic powers given are those necessary to accomplish the primary purpose for which they were organized, i.e., to provide water for the irrigation of lands and to tax the lands to pay the cost. The organization may acquire water rights, water supplies, and may acquire property by purchase or condemnation; it may construct and operate irrigation works; it may issue bonds or other obligations in order to obtain capital; and it may levy and collect assessments against the benefited lands within its boundaries to obtain revenues for the payment of interest and retirement of the principal of its indebtedness and for the necessary costs of operation and maintaining project works. In some cases this is done through its own district tax procedure, and in other cases it is done through the tax procedure of the county in which the district is located. Depending on the State statute, the organizations may also have the power to assess and collect tolls or charges for the use of water, either in addition to assessments or in lieu of assessments; it may make drainage improvements and assess the cost against the benefited lands; it may sell or lease excess water for use within or outside the district boundaries; and it may cooperate and contract with other districts and with State and Federal agencies.

When assessments are levied by a water users organization they become a lien against the lands and if the assessment is not paid, the lien is subject to foreclosure and the land sold at a tax sale. In addition, some State statutes give the organization the right to refuse to deliver water to lands for which assessments have not been paid. Assessments are usually levied annually. The principal methods of apportioning the assessments are (1) a uniform rate per acre applicable to the lands benefited; (2) ad valorem, or according to the full cash value of the land, either including or excluding improvements, computed annually; and (3) according to the benefits derived from the organization improvements. In most of the Western States the collection of the organization's assessments is made by county tax collectors at the same time as the general tax collection
is made. The statutes of a few of the Western States provide either that the district shall have its own tax collection procedure entirely independent of the county, or that they may elect to make their own collections or utilize the services of the county tax officials. When tolls or charges are made for the use of water, either in addition to or in lieu of assessments, they are collected by the organization itself, and in some cases the payment must be made in advance of the delivery of water. Sometimes the tolls or charges are made on a uniform rate per acre and sometimes on a rate per unit of water delivered. Generally, districts formed for irrigation purposes are political subdivisions of the State in which they are organized and are exempt from payment of Federal income tax and, depending on the State in which organized, some are exempt from payment of State income taxes.

Most water users organizations have the power to issue bonds which contain a promise to pay a definite sum on a definite date, with attached interest coupons payable annually or semiannually. The interest rate, denominations, maturities, and procedure for the sale of bonds are governed by State statutes. The security behind assessment bonds issued by a water users organization is the organization's power and duty to levy assessments upon the benefited lands to obtain funds to pay the interest and principal as due. If the proper officials neglect or refuse to levy such assessments, the bondholders may compel the levy by court action. Revenue bonds are secured by a pledge of specific revenues, such as those derived from the sale of water or power. Some organizations have the authority to issue either assessment or revenue bonds.

Water Users Organization Management

The history and development of water related organizations in the United States has revealed certain basic principles which are paramount in the successful operation of the water users organizations. Basically the organization should be "grass root" oriented—by that we mean that the water users should have an active voice and major responsibility in the planning, development, operation, and maintenance of the facilities. Through this means, a high degree of pride of ownership and sense of responsibility is developed by the water users which is reflected through the development and operation of the facilities. In a country in East Africa where this "grass roots" relationship has not been established and maintained water users have displayed little interest in constructed facilities to the extent that in some areas they have not been utilized. Water users were not "brought along" with the development and operational plan and little success has been achieved.

To bring about this close working relationship, directors are elected by the water users to serve as their representatives. The management of water related organizations, whether they be irrigation districts, corporations, partnerships, or associations is generally vested with these directors. The directors normally employ a manager of superintendent and delegate to him the responsibility for the day-to-day operation and maintenance of the system under the policies set up by the board of directors. The importance
of choosing and adequately compensating a well-qualified manager of integrity and ability to get the job done should not be overlooked. There is a danger that the drive for organizational prestige and status may become too great. In some countries too much emphasis is often placed on building elaborate headquarters or on the number of employees and the yearly organizational expenditures rather than the actual work accomplished. In their haste to get on with water resource development projects, some countries in Southeast Asia have unduly emphasized construction and have failed to take into account the equal pressing need for long-term operation and maintenance of completed facilities.

The primary objective of management is to deliver water equitably to all the users at the lowest possible cost commensurate with proper maintenance of the system and the type of service for which the water users are willing and able to pay. To meet this objective, the directors and managers must keep themselves well informed on new developments relating to engineering, maintenance materials, equipment, personnel management, legislation, or operating methods which may affect operating efficiency and economy.

The expansion to multiple use, increase in the number of projects, and the economic pressures for greater efficiency in operation and maintenance have prompted many project operators to suggest that a vocational program covering subjects closely related to their work be sponsored by the Bureau of Reclamation. Carefully planned and periodically repeated training programs consisting of lectures, discussions, and laboratory studies have been organized by the Bureau's technical headquarters in Denver, Colorado, and have proved to be highly beneficial. Through these training sessions, a long-standing need for closer relations and better communication between project managers and Bureau technicians appears also to have been met.

Operation and Maintenance by Water Users Organizations

In the United States, the early framers of a national policy for the development of western irrigation resources clearly recognized the importance of water user organizations and believed that projects should be operated and maintained by the benefited farmers.1/ It consistently has been the policy of the Bureau of Reclamation to transfer responsibility for operation and maintenance of water control facilities to water users' organizations as soon as facilities are complete and reasonably well stabilized, and the water users organization is competent, willing, and financially able to operate and maintain the facilities. Experience over the years has demonstrated that early transfer of these responsibilities develops a high degree

1/ Section 6 of the Reclamation Act of 1902 provided that "* * * when the payments required by this Act are made for a major portion of the lands irrigated from the waters of any of the works herein provided for, then the management and operation of such irrigation works shall pass to the owners of the land irrigated thereby, to be maintained at their expense * * *."
of local interest and responsibility for the project and enhances its success. To protect the Government's investment, however, title to the project works remains in the United States until otherwise provided by the Congress.

The maintenance of water control works in a satisfactory condition is a prerequisite to the continued success of a project. To assure that the works are properly maintained to perform the functions for which they were constructed, it has been found desirable to examine the works periodically. This examination not only assures that the facilities are being maintained in a manner to serve their multipurpose functions, but also provides an opportunity for Bureau and the local organization personnel to discuss operation and maintenance engineering problems and project management. The periodic examination of facilities has been met with enthusiasm by the water user organizations. Their managers recognize they have the responsibility of operating facilities costing the water users millions of dollars and welcome the opportunity to share the responsibility with Bureau of Reclamation examination teams. Since such teams are composed of individuals who are experts in their respective fields, they bring new ideas and methods for improving the operation and maintenance of project works. Other countries have initiated similar inspection programs.

Flexibility and System Modification

In many countries, as was so in the United States, irrigation and multiple-use projects are developing from the simple to the complex. This is as it should be with the local populace gaining practical experience and education, thus enabling them to build for tomorrow on today's experience. In the process of complete evolution it will be necessary to modify and change some of the earlier-built systems. If foresight and flexibility are built into a water resource development plan from its inception, fewer changes will be required and those necessary can be more easily woven into the ultimate plan. In the Western United States there are countless examples of independent early-built systems which now need to be reorganized into more efficient operating units.

One typical area north of Denver, Colorado, includes 8 canals on the north side of St. Vrain Creek, all heading within a distance of about 4 miles. The upper 4 canals run parallel within a span of 300 feet. Two canals use the same diversion dam. The 8 canals have a combined length of about 100 miles and a combined capacity of approximately 900 second-feet. The individual canals range in capacity from 20 to 425 second-feet. The 8 canals supply laterals that have an estimated combined length of 200 miles and serve approximately 54,000 acres of land. By reorganizing the systems, the length of main canals could be reduced by about 48 miles, or 50 percent. About 150 acres of canal rights-of-way land could be returned to cultivation. I have seen almost an exact parallel of these circumstances in the Argandah area of Afghanistan. In both cases operation and maintenance economies would result from consolidation and simplification of diversion and distribution works, a large quantity of water could be saved and the amount of damaged land considerably reduced. These benefits can be gained only through cooperation among the water user groups or organizations.
A portion of the Cache Le Poudre River drainage in Colorado constitutes about 18,000 acres of irrigated land and is served by 4 major canals and 5 smaller ditches having an aggregate capacity exceeding 1,800 second-feet. A study shows that consolidation of ditches and rearrangement of storage reservoir space would reduce water losses from about 40 percent to 12 percent (a 28 percent saving) and that the length of canals could be reduced by 25 percent. As a further benefit, 20 percent more land could be irrigated with the water saved. Operation and maintenance expenses could be reduced significantly.

Many examples of uncoordinated and inefficient development and use of water are prevalent throughout the world. In the United States we seek to avoid such duplication of works in new systems and to correct it in rehabilitation of old systems. Again, water users organizations are fundamental to the cooperative attack that is required to implement corrective programs. Worldwide improvement in existing systems can materially extend available water to meet expanding population needs.

Water User Educational Programs

Water user organizations play an important role in the continuing education of water users and the exchange of ideas between Federal, State, and private water resource development organizations. Cooperatively sponsored conferences, tours, and workshops provide this educational media. At least one-half of the western reclamation states participate annually in well-organized meetings of irrigation districts with programs arranged for their mutual benefit. These annual meetings, such as are held in the Pacific Northwest States of Oregon, Washington, and Idaho and the four States of Colorado, Wyoming, Nebraska, and Kansas may be conference type or field tours. For conference-type meetings, panels are made up of experienced individuals who discuss special operating problems. Research and development with water use and its relationship to maximum crop production is given important attention. Field tours are arranged to permit on-the-ground review, inspection, and discussion of operating problems and their solution. The interest in these programs has steadily increased; arrangements are better, subject matter more stimulating and informative, and people are traveling great distances to avail themselves of these educational opportunities.

Dynamic Needs and New Sources of Water

As nations of the world we are joined in a united survival effort to provide enough food for a world population growing at an unprecedented rate. Some leaders paint a gloomy picture for the future—but there are many bright spots in prospect. Research in crop varieties, fertilization, plant diseases, and insect and weed control have already made and will continue to make great contributions to the total quantity and quality of food which can be produced. The future in this field continues to be most promising.

Progress in the field of water management has been significant, but much remains to be done, not only in the field of research, but, more importantly, in adoption and implementation of the knowledge already at hand. Incentives must be found to induce people of all nations to take up new and improved
practices which will lead them to a more fruitful and abundant life. As a general rule acceptance of means to obtain better water use and higher irrigation efficiencies depends on the extent to which the results are economically beneficial to those who must pay the bill.

Water use studies made on a number of irrigation projects in the Western United States reveal that seasonal farm irrigation efficiencies vary from 35 percent to 80 percent, with a preponderance under 50 percent. These low efficiencies and consequent water losses are in addition to prevalent losses in storage, conveyance, and main distribution systems which occur through evaporation, seepage, and operation. Thus it is clear that with improved water management and irrigation practices large quantities of water can be saved for other uses, including expansion of irrigated areas.

One of the very interesting and perhaps most hopeful possibilities for improved water supplies seems to lie in the field of weather modification. The Bureau of Reclamation has a major role to play in this new area of research in the United States. It is estimated that 47.5 billion acre-feet of water pass over the United States annually in the atmosphere. Less than 10 percent falls on our watersheds. The opportunity for tremendous benefit from only a small increase in yield from the vast atmospheric resources offers not hope, but promise to all parts of the world.

Evaporation control research continues to offer good possibilities for water conservation, particularly in areas of little or no wind movement. Most of you, I am sure, are familiar with this work, which is essentially covering lakes and reservoirs with a monomolecular chemical film to reduce surface evaporation losses. Research in this field is proceeding in many countries.

Great strides have been made in techniques to desalt sea and brackish waters. Costs already are competitive with many water basin importation schemes and the outlook for greater economies is promising.

Clearly the modern trend is to make full and efficient use of the world's water sources--surface water, ground water, sea water, and atmospheric water. Water user organizations will play an important role in carrying forward this trend.

Accomplishments and Economic Impact

Since inception of the reclamation program in 1902, a total of 143 Federal projects have been authorized by the Congress ranging in size, measured by cost, from $94,000 to $1.5 billion. The total cost of authorized facilities is estimated at $7.5 billion, of which over $5 billion had been spent to June 30, 1965.

The acreage served in Federal Reclamation projects for full or supplemental water supply has grown from a modest beginning of 39,000 irrigable acres in 1905 to 9.6 million irrigable acres in 1965. In 1965, approximately 13.8 million people benefited directly in the use of reclamation project water;
1.4 million in the use of irrigation water; and 12.4 million in the use of water for municipal and industrial purposes. No attempt has been made to determine collectively the much larger number of people who receive substantial indirect benefits stemming from the agricultural production resulting from project irrigation. It is known, however, that water resource development in the moisture-deficient western areas of the United States has been one of the greatest factors in establishing the West as an asset to the Nation, rather than a dependence. Nearly every major population center west of the 100th meridian, outside of the seaport cities, had its origin at the site of an irrigation farming venture.

In America, wherever natural resources have been put to work, people have moved in and established homes. When the natural resources have been mismanaged, or used up, commerce runs down and people have to seek livelihoods elsewhere. When the Nation's transportation routes were developed—the rivers, harbors, canals, railroads, and highways—opportunity-seeking individuals were always pressing back the frontiers of the new regions. Vast reaches of the Nation would, today, be lagging in development had not irrigation been developed in the opening of these new frontiers.

Numerous studies have been made on various Federal Reclamation projects to measure the impact of irrigation on the economy on the local area, the state, and the Nation. Each study has shown similar contributions from irrigation although not in the same proportion.

A recent irrigation development promoted and encouraged by water user organizations and already proven to have tremendous economic impacts on the area, the state, and the Nation. Each study has shown similar contributions from irrigation although not in the same proportion.

A recent irrigation development promoted and encouraged by water user organizations and already proven to have tremendous economic impacts on the area, state, and Nation, is the Columbia Basin Project located in the State of Washington. Development of this one million acre project began in 1948 when irrigation water was delivered to approximately 100 acres of irrigable land. Although less than one-half of the total acreage has now been developed, spectacular growth has been evident in every major economic indicator as reported by the Washington State University in a study completed in 1966. In contrast, an adjacent comparison area similar in every particular with the area now irrigated, showed only nominal growth, or in some instances, an actual decline.

The project area grew from 608 farms in 1949 to 2500 farms in 1963. Gross farm income from crops and livestock totaled $76.2 million, which was six times greater per acre of cropland than was received from the comparison

area. Population and business establishment growth in the project area exceeded the comparison area by a ratio of 17 to 1. Freight shipments to and from the project area were 23 times and 8 times greater, respectively, than from an equivalent amount of land in the comparison area. In general, about 17 times as many people were supported from the same size area of cropland in the irrigated region as in the comparison dryland wheat-summer fallow region. Many other economic indicators were measured, each of which proved to have a much greater growth from the irrigated area than an equivalent acreage in the dryland comparison area. This same story may be repeated over and over again throughout the world as irrigation water is placed on arid drylands.

One need only look at these new frontiers today to know that irrigation was the catalyst responsible for creating the abundance of new wealth associated with each development.

Additional new wealth will also be created as further changes are made in the present status of two natural resources—land and water—where these resources might be combined in areas of favorable climate and an abundance of available man labor. Thus, the impacts from irrigation reach well beyond the initial water users.

**Outlook for the Future**

The United Nations Food and Agriculture Organization reported that the world population increased by 70 million last year with no increase in world food production. In the United States, our population is expected to go from the present 200 million to 468 million by the year 2020. This means that the nation must be prepared to produce nearly 2-1/2 times as much food as we are producing now, just to meet our own demands. Other countries throughout the world are facing similar or even worse situations. This presents a great challenge for the future. Mankind throughout the world must rise to meet this challenge.

Much has already been done as the result of improved technology. Great strides have been made, for example, in mechanization, in the development of new hybrid seeds, in the use of fertilizers, weedicides, herbicides, insecticides and so on. Agricultural scientists and engineers are talking about still more remarkable developments in the years ahead. Things like "indoor farms" where fruits and vegetables can be produced under greatly accelerated conditions using wide-spectrum fluorescent lights; new food-stuffs created from the protein of soybeans or algae that look and taste like meat; giant harvesters that pick, grade, package, and freeze crops all in one operation; robot tractors that will till and harvest by remote control, around the clock.

That brings us to water user organizations and irrigation systems of the future. With all the developments promised in other areas of agriculture, it is essential that irrigation development move ahead on an equal footing. It is not enough merely to increase the amount of land under irrigation. New concepts are needed in our specialty of water resource development just as they are in crop research, mechanization, and laboratory development.
One area of advancement almost certainly will be in automation. With farms growing larger as they are in the United States and in some other countries, it is increasingly important for the farmer to reduce or eliminate chores which are time consuming and relatively unproductive. We can look for irrigation distribution systems to be automated and remotely controlled, and perhaps even kept under surveillance by closed-circuit television.

The distribution systems may be tied electronically to soil-moisture sensing devices located in the fields. When these devices indicate that water is needed, the system will automatically feed water to the right place at the right time and in the right amount.

More and more, irrigation systems will be going underground. Underground pipe will be virtually free from deterioration and will eliminate ditches and the need to clean and spray and remove weeds at frequent intervals. There will be fewer weed seeds carried to the croplands by the irrigation water. We can eliminate many miles of project roads and increase the productive crop area. The result would be far lower operation and maintenance time and costs, increased production, and higher net income.

Laterals which carry more water than can be put into pipe economically will be lined to keep seepage losses to a minimum and to simplify the control of plant growth. Main canals supplying water to these laterals also will be lined.

Water user organizations will need to be geared up to develop and operate these complex multiple-purpose systems. It will be important to educate water users to the intricate problems resulting from complex and interwoven priorities for water supplies. Human and social problems, such as motivation and the protection of the rights of people and organizations dealing with water for multiple use, may be far greater and more difficult to solve than the engineering problems. Better trained specialists in electronics and mechanics will be needed to keep future control and regulation systems in order.

Projects are now being designed in some countries which include some of these new and unique features. The ability to include them in the design of a new system or in the rehabilitation of an existing system depends upon a number of factors, and the most important of them is an attitude of acceptance of the local populace, including their willingness to invest for future returns.

There is no other course open to us. Food and water are inseparable, and should we fail to develop them in the most responsible and beneficial way possible, the welfare of each nation and collectively the welfare and peace of the world hang in the balance. Great as our progress may have been in the past, the demands of the future—the demands of today—are far greater.