ADVANCES IN CIVIL ENGINEERING - A SYMPOSIUM

INTRODUCTION

By DONALD R. WARREN, '38

Structural and Civil Engineer, Los Angeles, Calif.

The advance in civil engineering can best be appraised by considering the visual results of the profession, through a comparison of the engineering structures of the past with those of the present. Let us reflect upon the water supply and sanitation systems today with those of twenty years ago. Think of the increased use in electrical energy, with its spider-like lines delivering power from the impounded water of the distant mountains to even the humble homes. Observe the broad boulevards and freeways, with stately grade separations and impressive bridges, and recall the winding roads of 1920. Then we can realize the progress that has been made in civil engineering.

The social standards of man have been greatly improved by the applications of engineering knowledge in the solution of society's problems. As a direct result of the utilization of scientific knowledge by the engineer, the world has become more efficient, it offers more conveniences, greater safety, and better health conditions to the masses. The inherent financial requirements to satisfy the ever increasing demand of civilization for greater convenience and comfort, often coupled with the intangible economic returns on these investments, has centered the civil engineering activities in governmental subdivisions.

The harnessing of the relief problem upon the construction industry, by the federal administration, has increased both the number and size of civil engineering projects. Federal expenditures and loans on public work has made the Boulder Canyon project, the Colorado River Aqueduct, the San Francisco-Oakland Bay Bridge, the Columbia River project with its Grand Coulee and Bonneville dams, the flood control works, and numerous other projects possible. Civil engineering is a service to society, and by its nature will always be closely allied to governmental activities. However, there are indications that the rate of demand for civil engineers in federal service is declining.

Civil Engineering

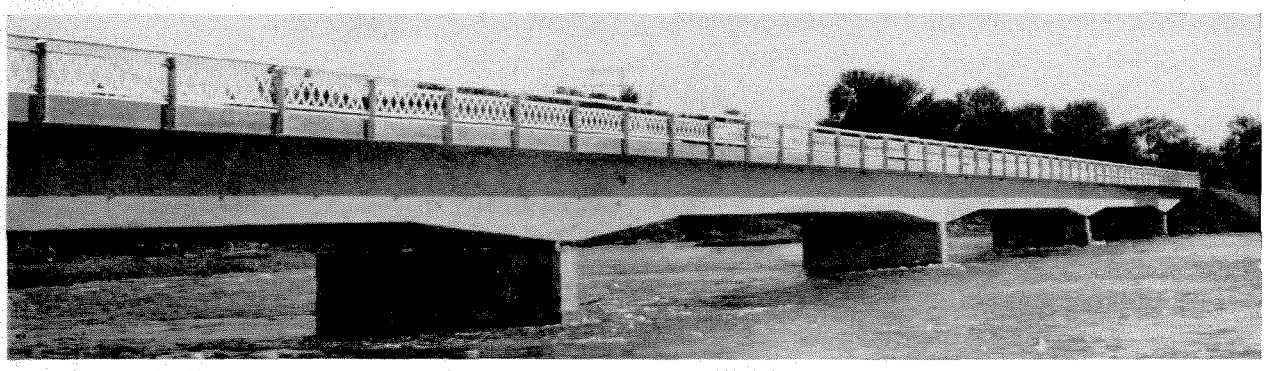
Randalls Island, N. Y., Traffic Circle
Triborough Bridge in Background

The Public Works Administration (PWA) activities are to terminate this summer. The widespread dissatisfaction with the Works Project Administration (WPA) and work relief policies, combined with demand for economies in governmental expenditures, has caused Congress to greatly reduce appropriations for this work. With the public debt fast approaching the statutory limit of 45 billions, government expenditures for public works must be further reduced. On the other hand, the European situation has made Congress defense-minded, and vast appropriations for the Army, Navy, and Air Corps have been made.

At the same time there is a lessening of governmental expenditures, there is a general improvement in economic conditions. This general improvement is stimulating private business, and the civil engineer holds a favorable spot in the program of the future. Legislation is also improving his status by enforcing more rigid control of the engineering practices. With the adoption of the engineering license law by Idaho, there remain but six states in the union where the public is not protected by law from the untrained and inexperienced engineer.

Civil engineering activities have been most pronounced in the eleven western states. Although these states have but ten per cent of the Nation's population, they did twenty per cent of our Nation's highway construction in 1939. In heavy construction, which includes dams, tunnels, canals, excavation work of all kinds, river improvements, etc., one-third of the Nation's total for 1939 was in these western states. It is interesting to note that in the United States, the per capita expenditure for civil engineering construction is $22.00, while in the eleven western states the per capita expenditure is $42.00 — nearly double the amount.

Ingenious application of engineering has been particularly noticeable in the construction of bridges with great spans, of bridges with foundations extending to unprecedented depths, and of floating or pontoon bridges. The earth fill dam on the Mud Mountain Flood Control Project in Washington, with a height of 420 feet, establishes a record for this type of dam. The advance in construction methods is emphasized by the all-time monthly record of placing 530,000 cubic yards of concrete in Grand Coulee Dam. The use of conveyor belts for long distance transportation is being extended with the construction of a nine mile conveyor to transport 10,000,000 cubic yards



Civil Engineering

Box Girder Bridge at Yakima, Washington

of aggregates for the Shasta Dam. There has been a marked increase in the capacity and power of earth moving machinery.

The ever increasing size and importance of engineering projects depicts the advance in civil engineering. The civil engineers have given a creditable account of themselves in recent years. Their scope of activity is increasing and the Nation's future will be to a large extent measured by the tempo of engineering achievements.

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ADVANCES IN STRUCTURAL ENGINEERING

By DONALD F. SHUGART, '22
Structural Engineer, Los Angeles, Calif.

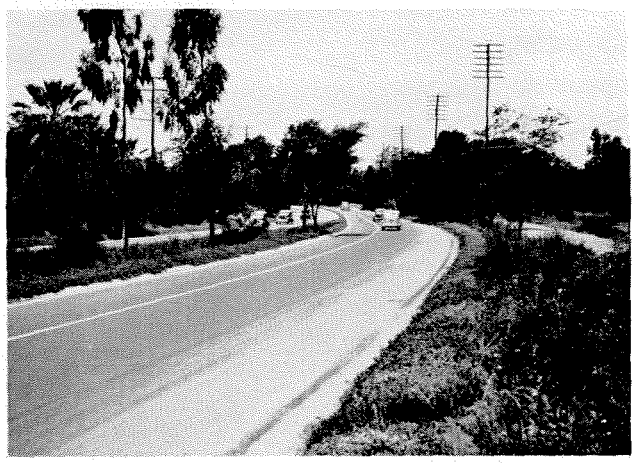
The professional growth of structural engineering during the past two decades has been marked in California by three significant events. First, official recognition came in 1929 with the passage of the Civil Engineers Act. This was followed two years later by an amendment acknowledging structural engineers as a distinct group within the broader field of civil engineering. In 1933 the Long Beach earthquake awakened the general public to the existence of and the necessity for this profession. Shortly thereafter the Field Act was passed to assure the safety of construction of California school buildings; this Act further served to establish Structural Engineers as a responsible professional group. The Structural Engineers Associations of Northern and Southern California have aided materially in the healthy growth of the profession, by their consistent efforts to raise its standing and standards.

However, many problems remain to be solved, not the least of which is the establishment of some reliable standard which wil give the public a greater measure of assurance that a Consulting Structural Engineer possesses not only the required technical knowledge, but also sound and mature judgment, as well as professional stability and permanence.

One of the greatest contributions to the technical knowledge of the structural designer during this period was the publication of the method taught and used by Professor Cross for the analysis of continuous and rigid frames. This method has had very widespread acceptance and is now quite generally used, with a resultant lessening of the work and shortening of the time required for a proper design. It should be noted here that rigid frame action has come to be quite generally recognized in the design to resist both vertical and lateral loads, and the additional work involved in this type of analysis has resulted in many attempts being made to find design short cuts or shorter design methods. Thus it is that we may thank the earthquake for providing the incentive to improve our structural design, this incentive finding its expression in the new requirements in official building codes.

Improvements in the production and use of old materials, as well as the introduction of many new materials and construction methods, have all had their part in advancing this branch of civil engineering. Wide-flange structural steel shapes and larger rolled sections, made possible by new types of rolling equipment, have effected economies and improvements in steel design. The quality of structural steel has been raised and made more uniformly dependable. For unusual conditions of sufficient importance special alloys have been used to produce steels many times as strong as any formerly obtainable, thus making possible such structures as the Golden Gate bridge. Concrete structures have been improved mainly by careful control of materials, mixing and placing, resulting in sounder construction and higher strengths. The general acceptance of wood grade-marking has been a step forward, and the use of timber connectors and plywood in the jointing of heavy wood structures has opened a new field for wood design. The increased use of reinforcing steel in brickwork has enlarged its field, and there have been many examples of new forms of construction and construction materials. One of these is the Knap System of Wall Construction, which has recently completed an exhaustive testing program both here in Southern California and in the United States Bureau of Standards at Washington. The equipment of their new factory has just been completed and manufacture of the Knap units has been commenced.

Our modern world moves so fast that it is only in retrospect that we are able to fully realize the great strides we are taking, and the many advances which we can see in the past few years serve to stir our imaginations in an attempt to visualize the ones to come.



The Modern Well Planned Highway

ADVANCES IN PLANNING

By WALLACE C. PENFIELD, '26

Engineer-Secretary, Santa Barbara County Planning Commission

The term *Planning* is a general term to describe the evolution of the so-called "City Planning" movement. City planning has been recognized for centuries, but its economic value has only recently become fully understood, particularly in the United States. The spectacular, but haphazard, growth of American cities has resulted in huge economic losses which the American people are forced to pay for lack of foresight in laying out their cities in providing them with the modern means of transportation, recreation, and utilities.

In the early years of the Twentieth Century the city planning movement became popular on a rather superficial basis. It was devoted largely to city beautification, but neglected the more fundamental problems connected with the rapidly growing American city. As time went on it became evident that the close relationship between public expenditures and haphazard growth reflected heavily on the taxpayer's pocketbook, and the city planning movement became a matter of economics rather than art.

City planning came to include provision for proper transportation; the segregation of residential, business and industrial areas; the provision for proper recreational spaces and other necessities of modern community life.

Suddenly came the "mechanized era," outmoding centuries of city building in a single generation. The problem of adapting new requirements to old cities too firmly established to be abandoned has become acute. Likewise the necessity to adapt new towns to new conditions has become evident. City boundaries no longer exist on the physical landscape. The countryside which once was the exclusive domain of the farmers has now been invaded by city dwellers with all the crowding, waste and friction which the modern community develops. This has increased many fold both the opportunity and the responsibility of planning. For example, hundreds and thousands of dollars per mile are spent on major traffic arteries only to have them cluttered up and rendered inefficient and unsafe by abutting property owners. This is possible because of the old custom of using streets primarily for providing access to property. As a result, the traffic congestion in metropolitan areas has become so acute that entirely new systems of parkways and freeways must be built to prevent a stalemate.

Towns and cities are "spreading out," leaving behind them a waste of obsolescence and depreciation that is difficult to estimate. Rural areas are subdivided into 50-foot lots which throw an unbearable load on the traffic arteries, the rural school systems, and other public services, while the taxable values in the downtown areas suffer.

Planning is, therefore, no longer a local problem. It must include whole regions, which are tied together by common bonds. County and regional planning have come into being in an attempt to guide the ever-increasing development made possible by the new method of living. The State and Federal governments have recognized the necessity for more than local guidance in the management of natural resources, national and state facilities, and accordingly have instituted State and Federal planning agencies.

Planning, however, must still be done in the face of uncertainty. No one can say where invention will stop or envision the bearing which future scientific advance may have upon the manner of living and the form of our communities. We have advanced in a few centuries from the old fortified town to the modern super-highway, but not always in the easiest or most efficient way. With the ever-increasing complexities of modern life, the job of the planner becomes doubly difficult and doubly important, if our community structure as a whole is to function well enough to give us a decent place in which to live.

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PROGRESS IN WATER SUPPLY AND PURIFICATION

By WILLIAM W. AULTMAN, '27

Engineer, Metropolitan Water District of Southern Calif.

The impetus given to construction of municipal waterworks by financial aid from the Federal Government has raised the industry into the realm of "big business." A census made by the Engineering News-Record reveals that now some two-thirds of the population of the United States is served potable water through some 12,750 waterworks. And while in the past there was a trend toward private ownership of waterworks, now only 27 percent of America's waterworks are operated by private utility companies.

The past few years has seen the start or completion of three large water treatment plants. The Milwaukee filter plant of 200 million gallons per day capacity was put into operation during 1930; the Minneapolis filter plant of 120 m.g.d. capacity is in the process of construction; and Southern California's Metropolitan Water District water softening and filtration plant of 100 m.g.d. initial capacity and 400 m.g.d. ultimate capacity was started in November, 1939, and is due to be completed in January, 1941. Each of these plants is unique in itself. The Milwaukee plant being built along more or less standard designs, the Minneapolis plant being built around the newly developed Spaulding Precipitators, and the District plant

(Continued on page 10)

plant of New York City are important additions to the activated sludge list.

Many new ideas in equipment and methods of treatment have been tried out in recent years. Mention may be made of the revival of interest in chemical precipitation, which was a popular method before 1900, and of the magnetite sand filters, in which the cleaning is aided by an electromagnet. Decisions as to the usefulness of these methods waits on the future.

Vacuum filtration of sludge is increasing in popularity in locations where density of population prevents drying on the land. The trend is strongly toward digestion prior to filtration. Elutriation before filtration, in order to reduce the chemical requirement for conditioning, is being practised in several places, as at San Francisco. Where there is not sufficient fertilizer market for the low-grade sludge cake, modern practice calls for incineration.

The utilization of gas from the sludge digesters is becoming common. The largest installation of this sort in the west is at the plant of the Los Angeles County Sanitation Districts, where engines totalling 400 H.P. are connected to generators to produce all electrical power requirements.

Engineers and scientists in the field of sanitation look on this record of progress with pride, and look to the future with anticipation of further interesting developments.

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ADVANCES IN FLOOD CONTROL POLICY AND ENGINEERING

M. E. Salsbury, '25
Junior Assistant Chief Engineer,
Los Angeles County Flood Control District

Flood control as a national policy, and the resultant change in scope and standards, has been the outstanding advance in the flood control field in recent years.

This recognition has come because of the ascending national aspect of flood control, the realization of the devastating effects of the interruption of transportation and communication even upon communities far from the disaster and a growing consciousness of the need for adequate national defense.

Floods of great magnitude no longer affect only those whose families or properties are touched by it, but reach out with profound effect upon large contiguous areas. The whole nation reacts socially and economically. Witness the Mississippi Valley floods of recent years, the New England flood in 1937, and the Southern California disaster of two years ago.

To provide needed control works the question always has been "Who shall pay?" With this as in other matters of community consequence, a gradual and logical transition has taken place through

(a) The individual living on the river felling trees along the bank to protect his land;

(b) A neighborhood banding together to pool its efforts against a common hazard, perhaps taxing or "assessing" themselves;

(c) A watershed or metropolitan area "district" being formed to protect cities and states;

(d) A national program authorized by Congress to combat the great flood menaces.

Each progressive method has been the result of a need, and evolved for the purpose of dealing with floods on a larger scale. Each has resulted in the ability to attack the problem more effectively with corresponding advances in engineering applications and standards.

With the advent of national participation Congress has required that each project show an economic justification, that the Federal Government should participate in the improvement of streams for flood control purposes "if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected."

Such a policy has brought about the formulation of a rather generally accepted method of determining the economic justification of a project. When the annual flood damages exceed the annual carrying charges of providing flood protection, the improvements which accomplish flood control are justified. The cost of the improvement is readily determined. Against this is set the benefits.

In addition to direct benefits there are the indirect benefits such as prevention of loss due to interruption to transportation, loss of business, and such benefits as will accrue from a change in land use, increased property values and tax revenue. The intangible benefits are not readily determined and are reserved by the engineer as a margin of safety in his decision on justification. What value may be placed on a human life? Preventing an epidemic or sparing a community unfavorable publicity are worth some measure of flood insurance.

Advances have been made in recognizing different types of flood hazards and developing methods of combating them. An important example in Southern California is the hazard from debris floods. The tremendous damage and loss of life in the Montrose flood of 1934 was due almost entirely to debris flows. The "debris basin," or trap at the mouth of the canyon, has emerged as an effective means of removing large and floating debris from flood discharges. Control of the flood water then becomes a matter subject to hydraulic principles.

Upstream flood control, a broad term embracing preventive measures on the watershed such as fire protection, forestation, check dams, and erosion control, is rapidly gaining recognition. It is part of the national soil erosion program and is a valuable supplement to positive downstream flood control structures since it acts to prolong the life of basins and reservoirs.

Design has improved and construction methods have advanced in the flood control field as in others. With each year's increase in basic hydrologic data more accurate estimates of adequate sizes for reservoirs and flood channels can be made. Observation and continued experimentation combine to develop structures which will function more satisfactorily.

Large sums available from Federal sources have made possible the construction of entire systems of flood control, from source to outlet, of sturdy permanent structures and to standards of design and alignment wished for but only dreamed of by the engineer even a decade ago.

HIGHWAY ENGINEERING

By HARRY E. CUNNINGHAM, '26
Highway Engineer Economist, Public Roads Administration, Washington, D.C.

During the past 20 years, road building has undergone many important and vital changes both in practice and in technique. The experience and skill of laymen have been gradually reinforced by the work of highly trained technical men and scientific practices are rapidly replacing rule-of-thumb methods. The engineer, the economist, the chemist, and the architect have become indispensable to modern road building.

Twenty years ago about 350,000 miles of surfaced roads served 9 million motor vehicles. But only a fraction of this mileage was of dustless or high type surfacing. Compare this figure with today's more than 1,100,000 miles of surfaced roads in the United States serving nearly 30 million motor vehicles. Of this mileage roughly ten percent is high type dustless surfacing.

Yesterday a motorist could not travel far even on the main highway system without encountering rough and dusty roads. There were many speed restrictions in the thirties and often a motorist was fortunate if his car could go that fast. But motor car manufacturers were making rapid progress in providing the public with low cost, fast and comfortably riding automobiles and today we find few States with low maximum speed restrictions. Some States have gone so far as to substitute personal liability for reckless driving at any speed without limiting the maximum allowable speed.

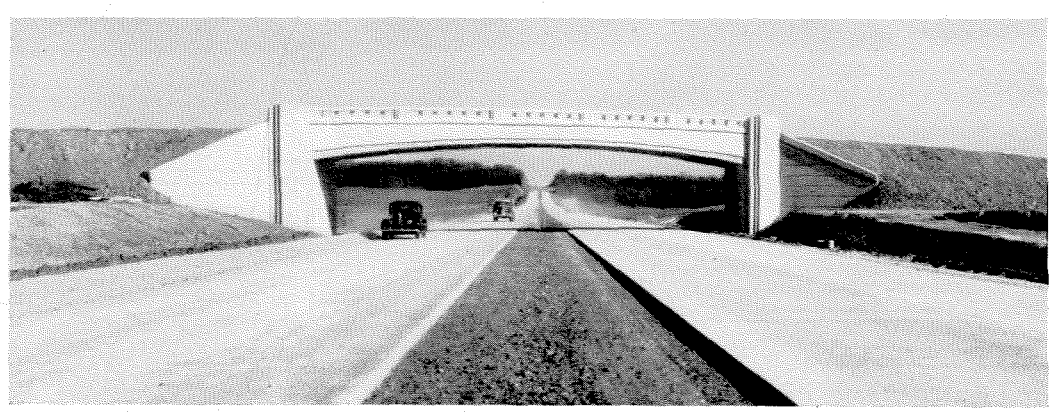
The earliest significant changes in highway construction occurred in design standards and in strength of materials. To the layman a batch of concrete was simply a combination of materials thrown together according to some formula and sufficient water added to make the mass flow easily. Then came scientific control developed from engineering research in the laboratories. Unheard of strengths of concrete were found possible permitting better design standards and economy of construction. It was then that one began to hear of the water-cement ratio and better testing of aggregates and cement as well as the water itself. Likewise the temperature of the aggregates, time and method of mixing, vibration compaction, and rigid control of curing with other operations all becoming essential elements of modern concrete road building.

In the field of soil stabilization and low cost bituminous surfacings the chemist and the research analyst proved their worth. Many miles of smooth riding and non-skid bituminous roads have given the motorist a dustless enjoyable motor car trip that would not have been possible with the knowledge of the 1920 road builder. Besides providing these social benefits this use of oil has greatly benefited the oil industry of the country. The scientist has, in this way, made substantial advances in road building possible, an enterprise involving in recent years an annual expenditure exceeding a billion dollars.

But modern highway construction has gone far beyond the smooth surface and strength of material stage. Trained experts are engaged in detailed studies of highway planning. The accident experience of highways is analyzed to determine corrective measures both as to road design and as to motor vehicle equipment and operators. Present day speeds require high standards and highways built to earlier requirements are in need of modernization. Added to the rebuilding program is the problem of new arterial routes and the need to separate opposing traffic streams. The experience of one State showed for a 4-lane undivided highway 0.31 accidents per million vehicle-miles and when the highway was reconstructed to a 4-lane divided roadway the accident rate was reduced to 0.13 per million vehicle-miles. To eliminate the crossing of traffic streams at intersections, clover-leaf separation structures have proven successful as well as overhead or underpass arrangements where it is unnecessary to move from one highway to the other. Motorists want this class of highway and are willing to pay for it as evidenced by the tax burden borne uncomplainingly by vehicle owners and operators.

Unfortunately the motorist does not always receive what he pays for as constant raids are made upon the highway fund. Diversions to non-highway purposes of money collected by motor vehicle taxation reached the alarming rate of 16 per cent of the total income in 1936. These conditions greatly impede highway construction, improvement, and maintenance, and the demand for modern new highways is but a small part of the road building problem facing highway officials.

The cost of constructing a mile of 2-lane paved highway in the Twenties averaged between $25,000 and $35,000. In 1940 with modern standards and if the highway is to be of the dual-lane divided type its cost may run from $100,000 to $150,000 a mile plus the cost of bridges and grade separation structures.



A Preview of Pennsylvania's 160 Mile Turnpike — Which Will Have No Speed Limit or Intersection at Grade

Partially Completed Pavement and Reinforced Concrete Rigid Frame Overpass.

Recently there was presented before the United States Congress a master plan of express highways providing unusual features for safety and convenience of travel on rural roads and more efficient conduct of traffic streams into and across cities with belt-line distribution roads around larger cities and hy pass roads around many of the small communities. In non-mountainous areas the highway would have a maximum of 3 degree (1910 ft. radius) curves and 3 per cent grades and in mountainous sections maximum of 4 degree (1432 ft. radius) curves and 4 per cent grades. Highways of this class would cost in the neighborhood of $200,000 a mile and would require considerable reconstruction of city street arterials where coinciding with the express highway system.

Contrary to common opinion most traffic approaching a large city wants to enter the city. Al too frequently is found the case where wide and well designed rural highways stop abruptly at the corporate limits of cities forcing large volumes of traffic to enter narrow congested streets. While a solution of the problem of rural traffic is well started, the city street problem with respect to arterial routes has hardly been touched.

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ACKNOWLEDGEMENT

The Alumni Review wishes to thank the American Society of Civil Engineers, publishers of "Civil Engineering," and tbe Metropolitan Water District of Southern California for the use of the cuts accredited to them.

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LETTERS

The following letter was addressed to Stuart Seymour, '26.

Lungchiho Water Power Project
National Resources Commission
Changshow, Szechuen, China.
November 29, 1939.

Dear Stuart,

Your letter of July 18, 1939, and the "Class Letters" all reached me sometime ago. I certainly appreciated them and enjoyed reading them very much. I put my letter in and sent them to **Hsiao, '26,** who is now in Chugking, only 50 miles upstream on the Yangtze River. We meet each other very often.

Hsiao was recently promoted to Assistant Commissioner of the Bureau of Highways under Ministry of Communication. He is very busy reading reports and signing documents.

As for me, I am the director of the Lungchiho Water Power Project. This project consist of three power plants on the Lungchiho which is a small tributary of the Upper Yangtze river. The largest plant has a capacity of 38,000 h.p., with four units of 9,500 h.p. water turbine generators. The dam will be some 600 meters long and 30 meters high, which will create a reservoir of more than 25 square kilometers, with a storage capacity of 314,000,000 cubic meters. The waterway will be a 3 kilometer pressure tunnel. When this is finished, it will be the first large water power plant in China.

JAPANESE WAR

The war between China and Japan is the chief event in the Far East. By the penetration of the Jap's force into our territory she seems to be getting the upper hand. In reality we are on the winning side. Now she is stuck in the mud so to speak, and her fate is in our hands. The war may not end before the European war, but the outcome is certain that we are the victor. You Americans can help us to end this wrestling sooner, if your Senate will pass a law to prohibit the export of war materials to Japan. Our national policy is two fold, i.e., to resist Japanese invasion on one hand and to reconstruct a new China on the other. There are millions fighting at the front, but Hsaio and I are the soldiers for the latter work. If you came to China you would be surprised at the fast progress made in the past two years.

One big handicap is transportation. The traffic on the Haiphong-Kunming Railway is congested. With the non-wholehearted co-operation of the French, our goods move in very slowly. The highway through the mountainous district is a bottle neck, too. With these poor means of communication, some of our machinery ordered two years ago has not reached the site yet. We are doing our work with hand labor, and locally built things. The progress is surely slow, but the works are being carried on.

Our office is at the site. We have an engineering staff of about twenty, and about equal number of clerical staff. About one-third of the staff have their families here, forming a village of our own. We formed a glee club and athletic club to occupy us in the leisure hours.

AIR RAIDS

The location is about 50 miles from Chunking by air and is just on the air route from Hankow to Chungking. When the Japs make a raid on the latter, they always fly over us. Our system of air raid alarm is quite efficient. As soon as the Japs take the air at Hankow we know their intentions right away and make all precautions. When they are about 50 miles from us, we sound the alarm, telling the men to take cover. When we see they are gone, we come out to work again. In the night raids we don't give a damn. We just keep ourselves comfortably in bed, only the light in the vicinity is strictly under control. Though many bombs have been dropped on places some miles away from us, they never discover and bother us. Since they suffered many terrible defeats in air battles, now they dare not fly over us in the day time, but on those nights when there is a bright moon.

I think I have written enough for this time, I beg to stop.

Yours very sincerely,
Y. H. Huang, '26.

SINGAPORE

(Continued from page 9)

Association announced itself. This turned out to be *Bob Stirton,* '30, who is holding down the fort for the Union Oil Company in that part of the world. He said that he thought he was the only alumnus in Singapore. He and his wife then proceeded to show us the town and see that we were properly entertained. Bob had to leave for Bangkok by plane the next day so we didn't see very much of him, but Mrs. Stirton was very nice to us. Among other things she arranged a dinner at which we met the United States Consul, who had just returned from China where he had been with the Embassy in its flight up the river from Nanking to Chunking. Needless to say he had some interesting stories.

"We spent five days in Singapore and then left in the midst of a blackout the day after the sinking of the "Sirdhana" by mines in the harbor. We sailed for Calcutta via Penang and Rangoon. At Rangoon we met more people with Tech connections. This time it was *Dwight O. Smith,* '25, who is the physics professor at a Baptist College associated with the University of Rangoon. He was in Pasadena at the beginning of the year doing cosmic ray work with us, so once again we were driven around to see the sights. This time it was pagodas and Buddhas and the Burma road to China — 1200 miles from Rangoon."