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BRADLEY H. YOUNG

Bradley H. Young received his B.S. degree in 1935 followed by his M.S. degrees in 1936 and 1937 in mechanical and aeronautical engineering from California Institute of Technology. He has been engaged as a maintenance engineer for PanAmerican - Grace Airways in Lima, Peru, for the past seven years.

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H. A. EINSTEIN

Dr. Einstein received his training as civil engineer in Zurich, Switzerland, where he received his Ph.D. in 1936. He worked as designer in the European steel industry. Since 1931 his work has been in hydraulic research, first for the Swiss Government and since 1938 for the U. S. Soil Conservation Service, where he specializes in sedimentation problems.

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A. C. NESTLE

Mr. Nestle received his B.S. at California Institute of Technology in 1928. Since graduation he has been engaged by the Texas Co. Producing Department in natural gas and gasoline operations. For the past eight years, he has been specializing on drilling fluids.

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HARRY K. FARRAR

Mr. Farrar was graduated from the California Institute of Technology in 1927. He joined the technical staff of the Bell Telephone Laboratories in New York, until 1941 when he became a member of the Southern California Telephone Company where he is now engaged in transmission engineering.

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The Truth Shall Make You Free

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August-September, 1944

The Engineer and Postwar Planning

By HARRY K. FARRAR

THE action in Washington recently in forming the Committee on Postwar Research is an important indication of the extent to which engineers and scientists are being enlisted in postwar planning and of one type of planning which is now being undertaken. This committee, with Charles E. Wilson as chairman and men who have been active in the Office of Scientific Research and Development as its other members, is reported to have as its objective the preparation of the United States to defend itself in any future war.

Although engineers naturally prefer that the results of their efforts be used for good, they cannot assure that their products will not be used for evil. Before the present war many people expressed the hope that with advances in transportation and communication the peoples of the world would learn to know and understand each other and as a result there would be no more wars. The evidence now indicates that better transportation and communication have resulted in extending wars farther and farther until warfare now involves practically all of the world and its consequences are not confined to the battlefield as they were years ago but now death and destruction reach people and establishments throughout the warring nations.

This characteristic of present warfare will be greatly intensified in the next war. This is reflected in another type of postwar planning which has for its purpose the protection of power generation and power users from disaster foreshadowed by that visited by British bombers upon the Eder and Moehne dams in Germany. Airplanes undoubtedly will become capable of carrying loads of explosives which can seriously break such dams as Boulder, Grand Coulee, Bonneville, and Shasta. This probability is discussed in the June 22 issue of "Public Utilities Fortnightly," by J. E. Bullard, who recommends that utilities maintain a reasonable proportion of capacity in steam plants and that they urge industries to locate on the upstream side of large dams to avoid destruction by flood which would result from wartime attack on the dams.

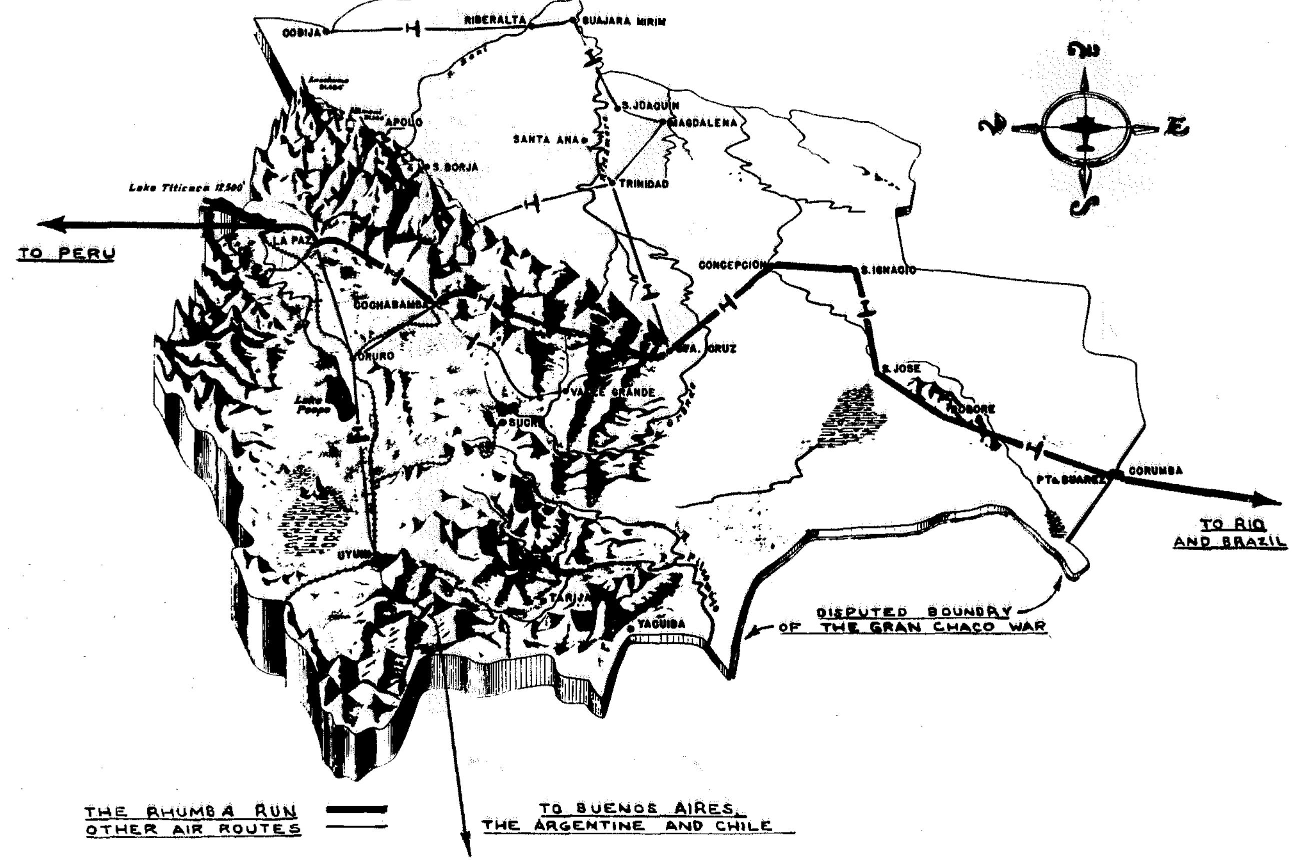
Destructive use of his products is not the fault of the engineer, for the devices used so catastrophically in war are the results of his efforts to make peacetime life more pleasant. In wartime the engineer works harder further to perfect these same machines for the protection of his nation. In turn, what he achieves under the extreme urgency of war is, in the ensuing period of peace, adapted to satisfying peacetime wants. We can now confidently foresee that such adaptation to peaceful wants is again about to begin. When sufficient time following the war

Harry K. Farrar

has elapsed, peacetime living will profit from the accelerated development. In this way, those who survive the war will receive a profit from it in the form of greater satisfaction of their wants. Whether this is a net profit is very doubtful indeed.

Engineers would rather see technical progress made more slowly if war is the only means to accelerate it. However, those who remember the effort following World War I to secure peace through making an effective League of Nations and World Court and later saw these agencies fail as the world drifted toward war, probably feel that wars will recur and that the world will continue to get accelerated scientific development from time to time. The story of this nation just prior to the present war shows that there can be no successful isolation. We had

(Continued on Page 16)



Sketch map, Bolivia and the Rhumba Run.

RHUMBA RUN

By BRADLEY YOUNG

Part I

NEXT Monday morning promptly at 5:30 a.m. a loaded DC-3 transport will pull away from the ramp at Lima, Peru. Under a low overcast the air is clear and a little cold. Eastward the coming day-break lies as a thin, faint line of light above the hills. Away from the platform glare, red and green wing-tip running lights are the only part of the plane visible as it turns into the far end of the runway. In the cockpit the captain eases the throttles forward, starting his engine check. Propellers full low pitch, mixture rich, carburetor air cold, cowl flaps trail, and the super-chargers whirling 18,000 times a minute to cram their load into the cylinders. The engines idle back a moment, then break to a full-bodied roar. Twenty seconds later the plane hurtles the low adobe fence at the south boundary of the field and is off. Back under the tail the lights of San Lorenzo Island and the harbor at Callao drop away and rapidly disappear. The pilot climbs steadily and prepares to go on instruments as he enters the solid overcast. Seventy miles south of Lima the plane breaks through and is on top of the clouds at 9,000 feet. In a short time the sun shoulders its way above the towering rock wall of the Andes that parallels the course. Passengers draw their window curtains against the glare, stretch, and turn to the early morning edition of the "Comercio." One of the most remarkable flights to form a part of modern transport aviation is well under way. It is a flight that cannot be forced into the commonplace even by the monotony of day-in and day-out repetition. Its beginning lies back in aviation developments started more than 18 years ago. Some of the reasons for its more unusual features are rooted deeply in the wild, rough geography of the continent, others lie in customs that have grown up since the beginning of South America as a vast crown colony of Spain.

As in other professions the men that fly this route have a marked lack of reverence for the work nearest at hand. Put a "Fast Express" on the company's schedules, describe it as such in travel folders, and the pilots promptly dub it the "Gee Whizzer." In the same way the "Transcontinentál" of the timetables has been known since its start as the "Rhumba Run" to those responsible for its execution.

Starting in Lima the Rhumba Run follows the barren, arid coast of southern Peru to the Chilean border town of Arica. Climbing out of Arica the pilot slips on an oxygen mask, winds open the valve, and heads eastward toward the high Trans-Andean passes leading to Bolivia. The purser comes forward and soon oxygen is also hissing gently through supply lines to the passenger cabin. Beyond the Andean passes the ground widens to a high tableland. Passing over this and on eastward the plane cuts a corner of Lake Titicaca. Beneath, flocks of pink flamingoes move on diagonal tracks. Their wings beat the thin air rapidly as if trying to catch up with their long outthrust necks. Farther below some Indians move the big reed sails on their balsa boats and don't even look up as the plane passes. With the lake behind, the first stop in Bolivia is made at La Paz. From La Paz the route swings southeast to Oruro and Cochabamba. Overnighting at this point the plane again leaves on daybreak for Santa Cruz to the east. Beyond Santa Cruz the line saw-tooths back and forth to take in a number of smaller towns from Concepción to Roboré and Puerto Suarez. Ten minutes after taking off from Puerto Suarez the pilot noses into his approach glide, calls for the flaps and gear down, and lands at Corumbá, Brazil, in the very heart of South America.

Corumbá is a small, quiet town and a pleasant place to stop for the night. After dark the stars burn with a winking yellow light in a sky of tropical velvety blackness. Whole families sit at little sidewalk tables in front of the Bar Americano. They speak Portuguese in low tones punctuated with occasional laughter. Mingling with this are the river sounds of the Paraguay as it flows past the cliffs at the end of the street. Misnamed, the Bar Americano is really an unsophisticated ice cream parlor. If you ever make it, ask the waiter for a tall glass with two scoops of ice cream and a bottle of chilled Guaraná. This last is made from a rich, full-flavored Brazilian fruit of the same name. Pour the Guaraná over the ice cream. After the heat of a long day's flight it makes a better soda than any ever set on the counter of the corner drug store at home.

Although it begins in Peru and ends by joining *Panair do Brasil* in Corumbá, the Rhumba Run has its main sweep over Bolivia. In a space about a sixth as large as the United States, Bolivia possesses a greater diversity in climate and geography than any other area three times its size on earth.

Roughly the country can be divided into three sections. To the southwest lies the great Andean Altiplano. This vast plateau is more than two miles above sea level. Its rim is bound by great serrated ridges of the Cordillera that rise another mile and a half above the plateau floor. In this region is located most of the Western Hemisphere's tin, now vitally needed for the defense of the Allies. The quantities that exist here of manganese, chrome, ore, wolframite, and other minerals now coming out in a growing stream have not been more than guessed at. Also in the same area on the south shores of Lake Titicaca lie the ruins of Tiahuanaco. Locked in a high bleak wilderness of rock, they may mark the birthplace of civilization in the western world. More surely they mark the beginnings of civilization in South America and represent a race of people gone long before the Incas.

To the north and east of the Altiplano are the Departments of the Pando and the Beni. This region is a land of mahogany, native almonds, dye woods, and high grade rubber. Farms of cotton, corn, and semi-tropical fruits spot the river banks. The highways between these patches are the rivers themselves, floating a strange collection of boats. Loads of vegetables move from place to place on balsa rafts. Some of the Indians have graceful dugout canoes hollowed from solid logs of lignum vitae. Their lines are as smooth and clean as a six-meter yacht. One farmer near Riberalta has a contraption made of six such canoes lashed together and powered by four old outboard motors. Steering a straight course and keep-

AT LEFT:
Native balsa boats on 12,-500-foot high Lake Titicaca, at the northwestern edge of the Altiplano.

ing all four engines going at the same time is a real feat of marine engineering. Back of the river farms run wide stretches of grazing land dotted with longhorn cattle. In the southeast of Bolivia lies the Chaco. The upper part of this is mostly jungle with some more farm and grazing land. Southward the ground dries and the vegetation thins. Near Tarija the country appears to be a waste. It's the same sort of waste that tops the world's great oil reserves from Kettlemen Hills to the Persian Gulf, for underneath are the rich Tarija and Chuquisaca petroleum deposits.

BOLIVIAN AIRLINE BEGINNINGS

The difficulties of ground transportation between these sections of Bolivia are immense. Twenty years ago no one had any reason to know this better than Hans Grether. Grether was a German railway engineer, oddly enough the first to conceive of an airline as a solution to Bolivia's transportation problem. In 1924, Grether managed to interest Guillermo Kyllman, the driving force in the firm of Kyllman-Bauer. This importing company had agencies in all of Bolivia's key towns, considerable influence with the banks, and definitely represented Big Business.

Late in 1924, agitation was started publicly for an airline. This was done mostly by German colonists in the vicinity of Santa Cruz and Cochabamba. These colonists started a collection for purchasing a plane to be presented to the Government on the centenary of Bolivia's Independence from Spain. The idea was that this plane, owned by the Government, would be operated to furnish a commercial air transport service. The plane chosen was a German Junkers and the factory sent Walter Jastram from the Junkers Technical Mission in Argentina to Bolivia to carry out the preliminary spade work in the selection of routes, etc. With this done the colonists deemed the time ripe and put in their order for the first plane, a single-motored affair carrying four passengers and a crew of two. Named *El Oriente* by the colonists, the plane was one of the Junkers Company's most famous models. As far back as 1919 a group of these all-metal low-wing monoplanes had been sent to the States where they established a number of flight records and carried part of the early airmail.

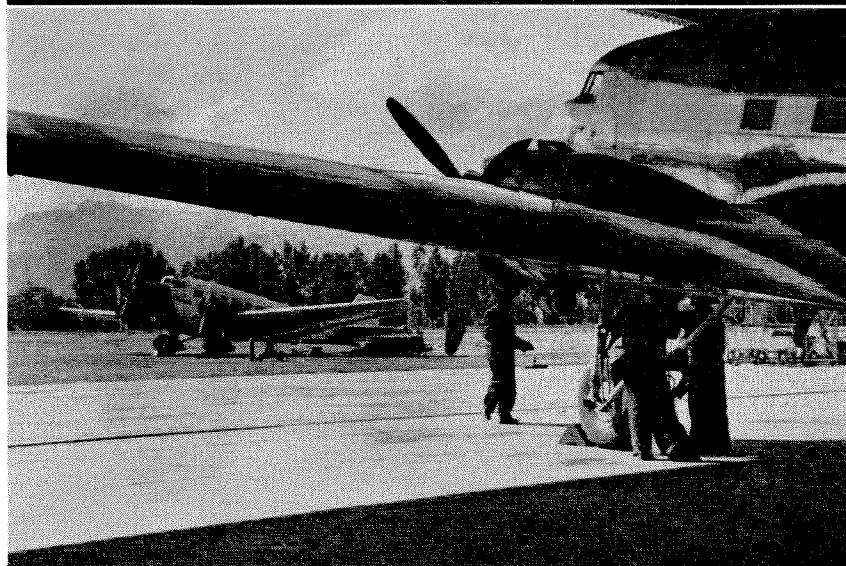
El Oriente finally arrived in Cochabamba during July of 1925 after a long trip by boat and rail from Germany. As pilot the Junkers Company sent along Willy Neuenhofen who made the first flight on August 6 between Cochabamba and the town of Sucre. In a short period a number of flights were made to Potosi, Oruro, and Santa Cruz for the purpose of stirring up interest in the new venture. On August 16 the plane was formally presented to the Bolivian Government by the colonists as originally planned. There was quite a ceremony. The railway had aided by shipping the plane free of charge from Arica to Cochabamba. The Ministerio de Fomento had aided in securing gasoline. The President of the Republic was named *Padrino* or Godfather to the enterprise, and after the Bishop had blessed the plane with a liberal sprinkling of holy water everyone was very cheerful. Guillermo Kyllman made a fine presentation speech and indicated that the first route was to be between Cochabamba and Santa Cruz. This was the first portion of what is now the Rhumba Run. The only concerned person not present at the ceremonies was Jastram. A bad case of *soroche* or altitude sickness was enough to cause him to lose all interest in the proceedings. The first official flight was made late in September by Pilot Neuenhofen, with a mechanic, and some Government officials. They made the trip in a fast hour and 45 minutes, only 10 minutes slower than the scheduled time today. By surface means it still takes two weeks to cover the same ground in good weather, and as long as two months when the weather is bad, as it often is. This new airline was to be a real aid to Bolivian progress.

OTHER SOUTH AMERICAN BEGINNINGS

At the same time developments were getting under way in Bolivia other South American skyways were being opened. Junkers had already sent a commercial mission to Argentina. In 1922 a similar mission was sent to the Central American countries. Gomez, "iron dictator" of Venezuela, had been approached for a franchise there. In Colombia the German-controlled airline *Scadta* was well underway. Having its start in 1919 as one of the world's first commercial airlines, this organization was to become particularly strong. In a few years it had mushroomed to the point where the Colombians could claim more miles of airline per inhabitant than any other country on the globe. In Brazil, Chile, and other South American countries the story was the same. The German Junkers Company was not the only one at work. Aero Postale, later to become famed as Air France, was trying for a real foothold on this new ground.

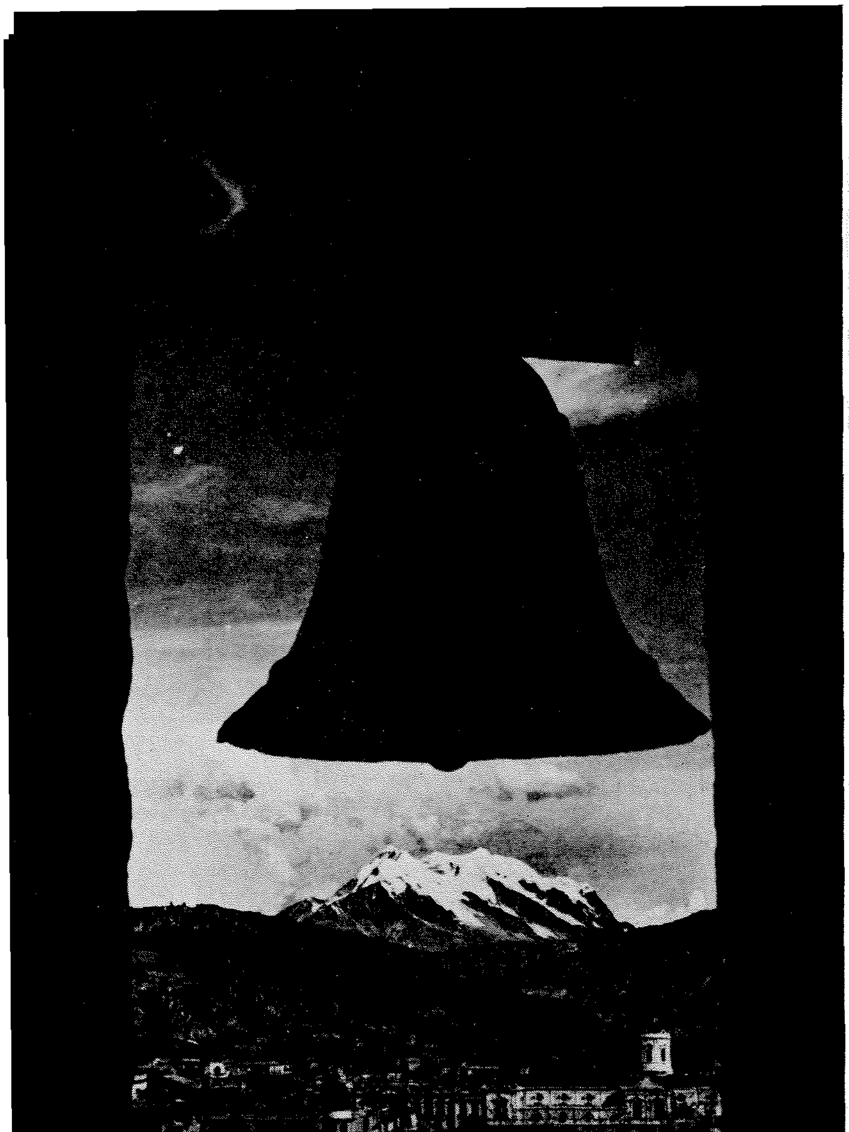
There were American interests too. The year 1926 found Juan Trippe resigning from his newly-formed Colonial Air Transport Company. The backing bankers couldn't see anything beyond their 200-mile run from Boston to New York. In 1927 Trippe started the forerunner of Pan American Airways with a one-plane one-hop airline running from Key West to Havana. Fourteen years later this same line had grown to a 90,000-mile system serving hundreds of cities in more than 60 countries.

In Peru there was the beginning of an airline development that would later touch Pan American and the Junkers interests mightily. Peru, for all its mineral wealth, has largely an agrarian economy. The backbone of this economy is formed by thousands of irrigated acres of fine long-staple cotton spread up and down the dry Peruvian coast. With the cotton was the inevitable boll weevil. Growers were just beginning to find that a most successful way to combat this pest was by airplane dusting. In 1926 the old Huff-Daland Company specializing in this work sent a young man to Peru as their general manager by the name of Harold Harris. He was more than manager. He was chief pilot, mainstay of the mechanical staff, purchasing agent, comptroller, bookkeeping supervisor, and general fixer-upper. His qualifications were an engineering degree from the California Institute of Technology, flight time on the Italian front in World War I, and some harrowing years as test pilot for the United States Army. Dusting cotton in a place as remote as Peru wasn't too easy even with this excellent background. In addition to the dangers naturally incident to the type of flying involved there was the problem of equipment maintenance. Break a plane or engine part and the crop, the small portion the boll weevil had left, might well be harvested before a replacement piece could arrive. In the succinct words of Manager Harris himself: "It was hell." Nothing could make the desirability of an airline linking the Americas more apparent than a few of these occurrences. Harris worked on the idea. He landed in New York in 1927 and went at once to Richard Hoyt, part owner of the cotton dusting concern and executive in Hayden Stone and Company, old line New York bankers. Hoyt was also a friend of Juan Trippe and of the heads of W. R. Grace and Company. Started years ago by an Irish ship's chandler, Casa Grace now had a finger in every business pie on South America's west coast. They dealt in everything from copper mines to cotton, from rum and molasses to Panama hats. To them at the time an airline was just another small sized pie, but a pie they could not afford to keep their fingers out of. The final outcome then of the Harris-Hoyt-Trippe conferences was Pan American-Grace Airways or *Panagra*. Its first



AT RIGHT:

Views around the airports on the Rhumba Run: Top view—getting ready for the take-off at Santa Cruz. Second view—servicing a DC-3 on the Run. In the background is a Junkers 52. Third view shows a crowd of airport bystanders. Lower view—Panagra plane outside the Cochabamba hangar, high on the Altiplano.



Church bells at La Paz.

flight, operating then as Peruvian Airways, was made in September, 1928, from Lima north to Talara. The company's only plane was a Wright Whirlwind-engined Fairchild about as large as the family sedan.

By this time the Bolivian Junkers concern had become known as Lloyd Aero Boliviano, or *Lab*. No one seemed to know just how the name chosen was decided upon. There was no connection existing with the German Lloyd Shipping Company. The name of this firm was well known and carried great weight, however. It is probable that the word Lloyd was picked for the airline due to its connotation of large enterprise.

HEMISPHERE DEFENSE

Then, *Panagra* and *Lab* were as remote from each other as any two airlines could be. Thirteen years later the desire of the American Republics to transform hemisphere defense from a dinner topic to a working project brought a change. Axis-controlled airlines and those owned by North and South American interests were brought squarely against each other. The cause was not normal competition but something far deeper and more fundamental. Right from the start American airlines had stuck strictly to the air transportation business. Axis subsidized airlines had not. In Colombia ranking Luftwaffe flight officers were brought from Germany for familiarization training with *Scadta*. The *Scadta* routes passed within 250 miles of the Panama Canal Zone. The volume of airline meteorological information sent to Germany from Colombia and other countries indicated that the recipients had more than an academic interest in South America's weather. At what were the Nazis aiming? They were shooting for more than the profits to be gained in hauling air passengers for hire. At Dakar the Axis Powers were only a little more than 1600 miles from Natal on South America's hump. This is much nearer than the Japs were to Pearl Harbor. At Natal a Nazi toe-hold might be much more worth the effort. A network of strategically placed airports and routes and a group of experienced pilots to fly them would be of inestimable value in an offense against the Western Hemisphere. The Nazis have known this for years. The Americans caught on too, but not so quickly. It took a few things like the Belmonte incident to wake them up. On June 9 a year ago Major Belmonte, the Bolivian Air Attache to Germany, mailed a letter to German Minister Wendler in La Paz. The letter, which was intercepted, read as follows: "We have received all maps showing the most favorable spots for landing. These show me once more that you and your staff are doing excellent preparation for the realization of our plan in favor of Bolivia . . . With the victory of the German Reich, Bolivia will need only work and discipline. . . . I will fly to Brazil upon your advice and take Cochabamba and Santa Cruz, where I have good friends." In Bolivia the present governmental regime and the large majority of the lesser citizens feel very strongly and very rightfully about a Bolivia by and for Bolivians. This convinced them that Señor Belmonte had held a one-man election and elevated himself to the position of *Fuehrer* against the coming of *der Tag*. Probably one of the least things it did was to reaffirm the belief of President Peñaranda and his ministers that government action in taking over *Lab* a month earlier had been in Bolivia's best interests. Presumably Belmonte, now very much a *persona non grata* at home, is still cooling his heels in Germany awaiting victory of the Third Reich.

If a Nazi thrust had come at South America, the fields and routes for which they had such plans would no doubt have been used against them. Bombers based in the interior would form strong backing forces for units flying from fields farther to the east in other republics. These planes could sweep South America's coast from the Orinoco to Cape Horn. Bolivia is a vast natural fortress for such an operation. Its front is protected by a million square miles of jungle. In a place where even the local boys get lost, no invader in tennis shoes is liable to walk through. Bolivia's railroad connections to the west coast ports of Antofagasta and Arica, and airline connections to the United States form an excellent back-door line of supply. Certainly at the start and in the middle years no one could foresee such a result from South American airline beginnings.

LAB—THE MIDDLE HISTORY

After its first flight in 1925 the progress of Lloyd Aero Boliviano was rapid. Bolivia recognized *Lab* through a supreme government decree and was induced to establish an annual franchise of 70,000 Bolivianos for a mail and cargo service. They also granted 130,000 Bolivianos to be put up with money of the *accionistas* or stockholders for the purchase of three more planes. Jastram at this time was ordered by Junkers to assume the technical directorship of *Lab* and make plans for extending its services. After a meeting of the *Lab* directors, the services of Jastram were accepted and he was appointed general manager. His work at the time wasn't made any easier by the loss of his best pilot, the man who had carried out all the company's first flights. Neuenhofen quit. He had been a test pilot for Junkers in Dessau before coming to Bolivia. In those days such a job couldn't have been much of a sinecure. Six months' flying over all sorts of Bolivian terrain in single-engined aircraft had convinced him however that the test pilot's job was the lesser of two evils. He returned to Germany and Junkers, later establishing a number of world's flight records. Jastram made plans for extending the airline into the Beni country but never got a chance to carry them out as he was removed from managership.

His successor was an amazing individual, Herman Schroth. This gentleman was the sort whose story is never completely told by the bare records on the books. The author first heard of Schroth's adventures from Ken Schlicher over a *salteña* in Cochabamba's Plaza Bar. Until 1941 Schlicher, of Pennsylvania Dutch descent from around Harrisburg, was the only United States citizen employed by *Lab*. He was hired by Schroth in 1935 to head the *Lab* Communications Department. Schlicher's qualifications for his new job were a very considerable knowledge of radio and an equally important ability to speak fluent German.

As the *salteñas* in the Plaza Bar are large and excellent, the Schroth story was drawn out in considerable detail. For the uninitiated, a *salteña* is a semicircular pouch of brown flaky crust with a filling that defies exact translation from Spanish into English. A close approximation could be obtained by mixing a bowl of chili, the filling from a mince pie, and a New England boiled dinner. The end result is surprisingly good.

As the story goes, Schroth came to Junkers and *Lab* with the background of a technical education from the University of Stuttgart, two years in the German Naval Air Service, and a short time spent in the Heinkel works at Warnemuende. He was quite a pilot, and in 1926 flew a Junkers from Germany to South Africa, being the first man to cross the Mediterranean by air. In 1927 Schroth assumed full managership of *Lab*. He also was chief pilot and held ex officio the job of general purchasing agent. This was a large order for a young man of 27. At the same time he was a representative and salesman on commission for Junkers. It was this last combination of salesman on one side of the fence and purchasing agent on the other that got him into eventual trouble. Still later this trouble was to have its part in causing the Nazis to lose their hold on *Lab*.

From 1927 until 1932 the expansion of *Lab* under the leadership of Schroth was rapid, if not too sound. In the north the rich Beni country was opened up. What had been a 45-day expeditionary trip from Cochabamba to Trinidad became an easy hour and a half ride. Cheese, hides, chocolate, the sun-dried and salted beef the Indians call *charqui*, and a host of other things began to move to the markets at Cochabamba, Cliza, and La Paz. Out also came an occasional sick or injured person who might otherwise have died from lack of hospitalization in the interior. Moving in from Cochabamba to Trinidad, Todos Santos, and Cobija were quantities of salt, kerosene, sewing machines, and a hundred different commodities. Frequent among these shipments then, as today, were dozens of sacks of *chuño*, a type of small Andean potato. These potatoes, grown only on the higher slopes of the Sierra, are processed by an alternate soaking in the icy mountain streams and then freezing. The final product looks like something normally used to feed a concrete mixer, but not a human being. As might be expected, their processing makes them practically indestructible. This is important in districts like the Beni where the hot damp weather and lack of refrigeration cause rapid spoiling of fresher vegetables.

Pushing in another direction the company began to fly farther eastward over the wide *llanos* or grass lands that lay beyond Santa Cruz. Aerial navigation here was difficult, much like the problem of traversing the ocean. Ahead, out of the haze, the horizon comes up hour after hour, flat and without landmark. Beneath, every passing kilometer of ground appears like every other one, a sun-dappled broadloom carpet of green trees and undergrowth. The air is hot even at 10,000 feet. The cockpit fills with a mixed odor of auto-pilot oil, lacquer, and hydraulic system fluid that the heat intensifies. Except in the passenger cabin where regulations stipulate otherwise the crew pushes along with rolled shirt sleeves and opened collars. During most of the year a large part of the land beneath lies flooded and impassable. This isolates the slightly higher planes of fertile well-drained soil that might be tilled or used for raising cattle. Except by air such spots lie as remote as the mountains of Tibet, with resources that might never be realized. In addition to forming an opening wedge in this new country the last extensions gave *Lab* and Bolivia a connection with Rio and the entire east coast of South America. This was effected through cooperation with the Condor airline in Brazil, another Junkers-dominated concern.

In 1932 came the War of the Gran Chaco. *Lab's* normal operations were subordinated to moving men and munitions into the combat zone of southeastern Bolivia. Ground transportation had not changed since Don Armando Ayolas crossed the Chaco in 1537. Below the shuttling planes long lines of pack burros moved slowly through the heat. In Bolivia some circumstance has produced a breed of burro almost ridiculous in appearance. These animals are covered with hair as black as a coal bin and as long as the wool on an Angora goat. The very young animals look like nothing but a pair of immense ears and eyeballs running around on a set of fur upholstered stilts. The older burros develop a white line of fur around the eye sockets. This, with their grey-white lips, turns them into animal counterparts of circus clowns or end men in a minstrel show.

During the Chaco the government was to all intents and purposes in partnership with the airline. More planes were purchased and at the end of the war the fortunes of *Lab* were definitely in their ascendency. After the war the government called for an audit of the company's books. This established their ownership of 42 per cent of the stock with the rest split about equally between the public, mostly German colonists, and the Junkers Company.

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Mr. Young's interesting article will continue in the October issue of Engineering and Science. The second instalment will describe the difficulties with Nazi-controlled lines, future possibilities for development of South American airline routes, and the difficulties encountered by pilots making the Rhumba Run. The October instalment will also be profusely illustrated.

Sediment Transportation Research

By HANS ALBERT EINSTEIN

SOIL erosion and sedimentation are two of the most powerful tools that nature has used in shaping this earth. Whole mountain ranges have been removed, new territories have been built by this instrument during geologic times and are still being built today. Both air and water act as carriers and both will, in time, step up their action enormously. It is usually during dust storms and floods that nature reaches deep into our daily lives and makes us conscious of the power involved. These are the times of catastrophe, when the engineer is powerless against the forces of nature. When these catastrophies occur frequently and especially when they cause loss of lives and property, the problem is generally recognized and placed in the hands of the engineer for study and counteraction. Only limited success has been achieved in many cases because our knowledge of the fundamental action, *i.e.*, the movement of sediment by fluid motion, is still very limited. For this reason, the engineer is still forced to rely upon his intuition rather than upon a sound theory.

TRANSPORTATION BY AIR

When air is the carrier, we are able to observe the movement in action. We can watch the wind pick up particles on an unprotected soil and lift them up to a considerable height. We can see whole clouds of particles being moved great distances without ever being allowed to touch the ground. These particles are held in suspension by the turbulence of the air. The turbulence appears as an irregular boiling movement superimposed on the main flow and constantly keeps the air-particle mixture well mixed. We can observe, then, how particles are settled out in places where the wind velocity is reduced and we can especially see a very efficient sorting of the moving particles, depositing coarse sand in one place, fine sand in another, while the still finer particles move as dust for great distances until they finally are deposited in some quiet spot. The wind will carry these fine particles for miles and miles in a short time, while the coarse sand is moved only a short distance. Wherever sand accumulates it begins to move slowly, creeping along the ground. If the depth of the loose sand increases, the characteristic ripples and waves are formed which will grow to the size of dunes if sufficient sand is available. (See *Fig. 1*). Dunes will slowly migrate in the direction of the wind, burying everything they encounter.

FIG. 1. Sand dunes showing characteristic ripples.

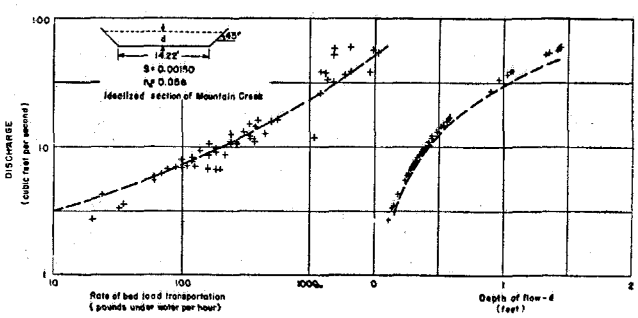


FIG. 2. Measured bed-load transportation and water depth in Mountain Creek compared with theoretical values. Crosses indicate measurements; the curves indicate theoretical values.

Entrainment of particles by moving air is very common; it can be observed in all its phases in one's own backyard as well as on the desert. Still, very little systematic knowledge is available about it. Quantitative studies of any kind that would allow the prediction of sand movement are especially rare. The obvious reason for the lack of systematic information is the difficulty of measuring and recording the steadily changing moving force of the wind.

TRANSPORTATION BY WATER

The movement of water, on the other hand, is restricted to certain channels. It is much more regular and predictable, and, in general, better known. It is, therefore, understandable that the movement of solid particles entrained by water is more thoroughly investigated than in the case of air. The following remarks will be restricted to water entrainment and transportation, but it may be understood that many of the principles involved hold for air as well.

Practical sediment problems in a river can be studied with any hope of success only if the entire watershed is considered. The term, watershed, as used here includes all the area and the streams in this area that will contribute runoff to a given river section. The term, sediment, includes all solid particles that come in contact with a moving fluid and are heavier than the volume of fluid they displace. Sediment settles in the fluid, in our case, water, and the settling velocity of a given particle in still water is one of its most important characteristics. The settling velocity depends on the size, shape, and specific gravity of the particle, and to some extent on the temperature of the water. By far the greatest range of variability is found in the grain size. In the following discussion sediment may be described either by its grain size or its settling velocity, with the fine sediment having low settling velocity and the coarse sediment high velocity.

BASIC FACTS OF TRANSPORTATION

One of the main assumptions usually made in studying sedimentation problems is the independence of the moving grains; that is, the presence or movement of one grain will not directly affect the movement of another grain. This fact makes sediment movement accessible to treatment by statistical methods. It may not be assumed, however, that the presence of sediment in water will not affect the flow. To find the effect of the total sediment load on the flow as a whole is one of the main problems. Let us consider the watershed above a given observation point or section on a river. According to the assumption

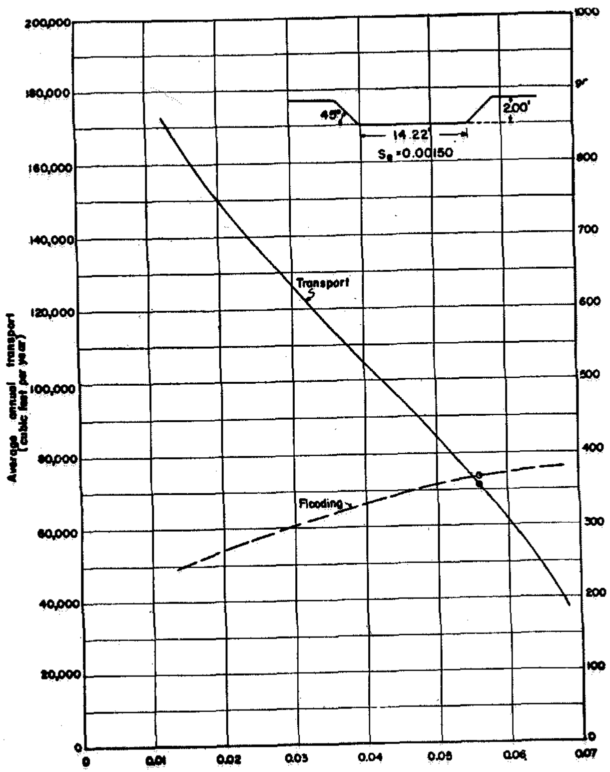


FIG. 3. Average annual transport of bed load in Mountain Creek for various roughnesses of the banks.

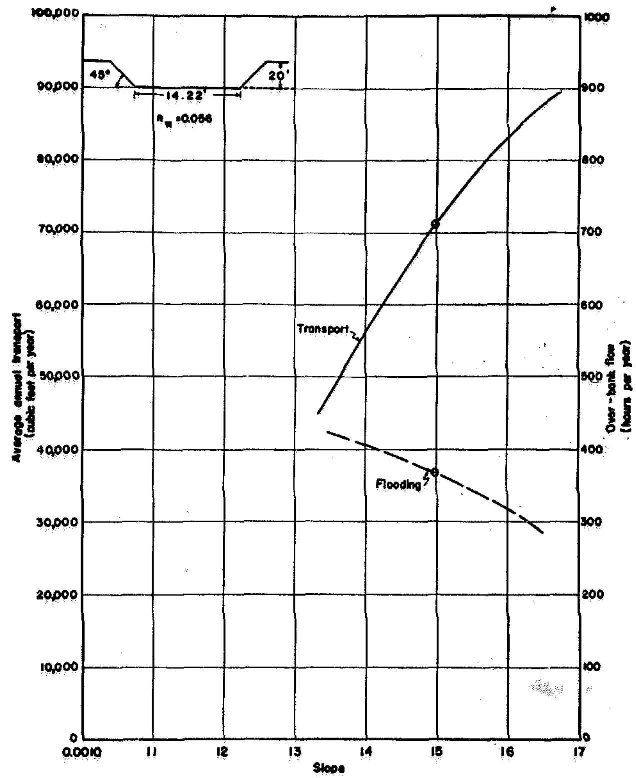


FIG. 4. Average annual transport of bed load in Mountain Creek for various slopes.

of independent motion, the movement of the different grain sizes can be studied independently, once the influence of total load on the flow is known. (This influence is usually of the order of a correction.) The finest grains, that is, clay and fine silt, will never be settled out in the river system because the flow velocities are everywhere sufficient to keep them in suspension. The particles are picked up by the water somewhere in the watershed, *e.g.*, on the stream banks, and, once in movement, they will move with about the average water velocity until they pass the observation point. The rate at which the finest particles arrive at the section depends only upon the rate with which they are eroded in the watershed. Erosion again is influenced in a certain watershed by many factors, such as distribution and intensities of rain, dampness of the ground, vegetal cover, temperature, and size of rain drops. The rate of erosion, and with it this fine load, can definitely not be expected to be a direct function of the discharge in our cross section. All attempts to find this relationship for different rivers have failed. Only a general tendency is found for concentration to be higher with higher discharges, especially in large watersheds. The total amount of these fine particles in a river, which is "washed" straight through the system without being temporarily deposited in the river channels, has been called the wash load. (1)* A certain regularity is found often in the pattern followed by the sediment load as the flood goes through its different stages. Where such a pattern exists, it is possible to apply the unit graph method (2), which can be used to good advantage for the interpolation of the concentration between measurements especially in smaller sized watersheds.

These remarks about wash load make it clear that the rate of wash load in a stretch of a river cannot be influenced by any structural protective and training work in the river itself. However, it can also be seen that erosion control measures in the watershed have an immediate and full effect on this part of the load. For the same reasons the wash load has no effect whatsoever on the stream bed. A change of the rate with which this material is moving down the stream system will not give rise to a change in either cross section or profile of the stream. Its presence only becomes significant when the flow of the water is retarded sufficiently to allow deposition as in reservoirs and on flood plains or when the water is used for domestic and irrigation purposes. It is also clear now that the rates of investments and total amounts of this material that are moved in a certain river system can only be determined by a continuous sampling program which may be aided by certain short-cuts as the above-mentioned unit graph method.

The coarse particles within the stream load behave entirely differently. Their motion is slow and intermittent, and they usually take years for the same travel from their origin in the watershed down to the reference section, which the wash load covers during a single flood. Instead of being in suspension, these particles move essentially along the bottom. They do not move continuously, but are settled out on the bed for longer or shorter periods.

In reaches where the stream has less transporting power, these particles are deposited in great numbers and cover the whole bed. There the stream flows over a bed consisting of its own sediment only, and it becomes what is usually called a graded stream. The sediment particles which are moved over this bed are continuously exchanged for particles in the bed, and there is no distinction between the moving particles and the bed. They are equivalent in every respect and the movement of these particles can be interpreted as the movement of bed material. This type of sediment movement is of the greatest importance to the river engineers because there exists a definite relationship between the flow of the stream and its transporting capacity, and the stream bed

*See Bibliography, Page 17.

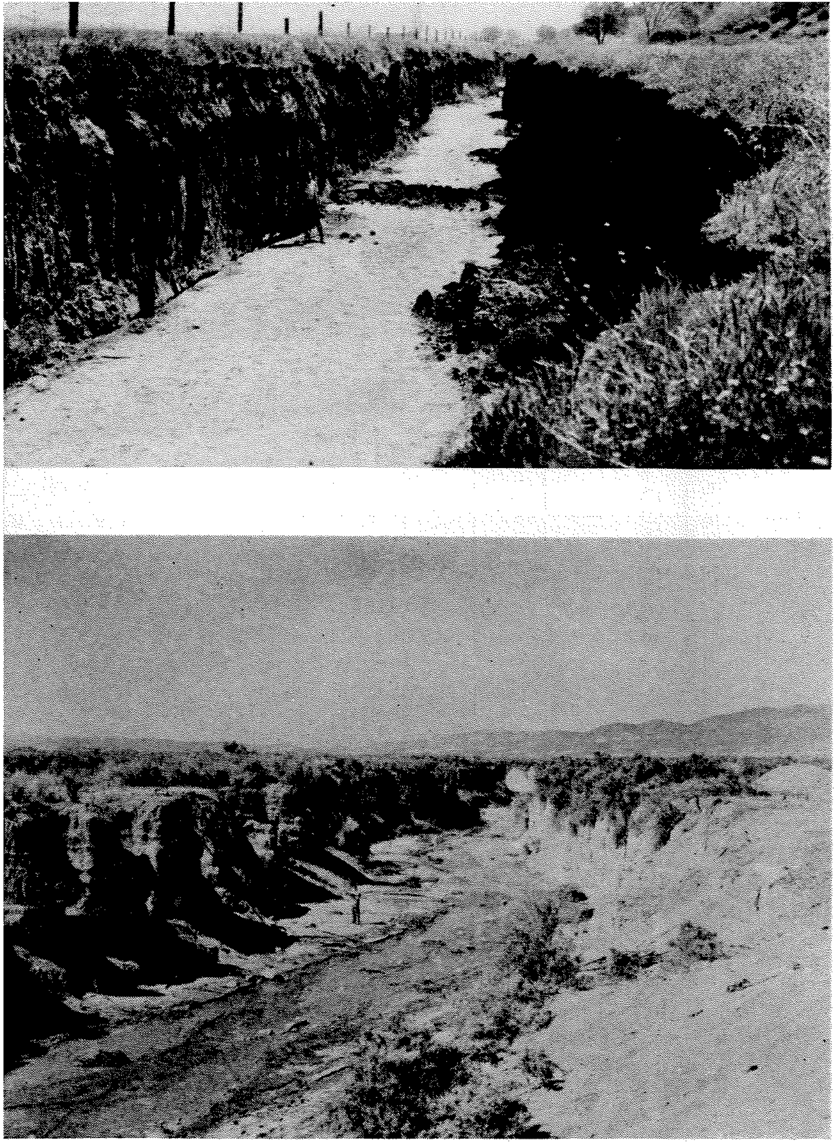


FIG. 5. Views of canyons formed by rapidly eroding streams.

can only be stable if the rate at which sediment is supplied from upstream equals this transporting capacity. Any difference between the capacity and the incoming rate has to be taken care of by scour or deposition on the bed.

These basic facts have very important consequences in the natural river. Below a graded stretch of a river the rate of bed material movement is a function of the discharge. Short term deviations of the incoming sediment load from the load that the stream can carry are fully counteracted by temporary deposition or scour on the bed, without permanent change to the latter and its flow characteristics. Systematic deviations in one direction, however, will gradually change the hydraulic characteristics of the stretch by modification of the cross section or the profile and will, gradually, adapt the carrying capacity of the stretch to the average incoming load. The carrying capacity of an undisturbed graded stretch of a river will, therefore, allow a rather close estimate of the average sediment production in the watershed above for coarse material.

THE TRANSPORTATION LAW

During the last century, a theory has been proposed by Dubois which interpreted the movement of bed material as a laminar motion of the bed. The resulting tractive force formula for transportation of bed material had two constants which varied with the bed material and flow conditions and which had to be determined empirically in each case. The extreme variability of these constants made the formula almost worthless and gave rise to the development of new formulas based on different principles in recent years. A very attractive approach has been tried by Shields (3), who based the development of his formula on the principles of dimensional analysis only. Unfortunately, this method in itself is not sufficient because the problem contains too many variables for the number of equations available. A recent method described by the author (4) which bases the rate of movement not only on the average flow but also on the turbulent fluctuations, seems to have more chance of success. At least it eliminates all "variable constants" and reduces a multitude of conditions into a well-defined single curve.

But no matter which equation is used, the relationship between the flow and transportation exists and can be determined. This has been done for a great range of conditions during past years. The next step is the application of the equation of transportation to the natural river. Systematic studies were made by the Soil Conservation Service on this problem during recent years by simultaneously measuring transportation and flow conditions in rivers and by subsequent analysis of the data under application of the above mentioned transportation laws. Good agreement has been found between the measured and the calculated values for transportation and water depth in terms of discharge as shown in *Fig. 2* for Mountain Creek. This good agreement over a considerable range of conditions proves both the transportation law and the method of application to be correct (5).

APPLICATION

Fig. 2 shows distinctly that the movement of bed material is a function of discharge and that the sequence of discharges is unimportant. The annual transportation through a cross section of the river can, therefore, be calculated, based on the duration curve of the flow. The duration curve itself has the great advantage of being very similar for different streams and it can be derived rather accurately for any stream from records of similar streams. Based on such a duration curve, the annual total transport and the duration of overbank flow has been calculated and plotted in *Figs. 3 and 4* for varying bank roughness and varying average slope respectively in the case of the above mentioned Mountain Creek. The curves of *Fig. 2* are plotted for the actual section where the roughness of the banks is $m_w = 0.056$, the slope $s = 0.00150$, moving a total bed load of 71,000 cubic feet per year. By comparison of *Figs. 3 and 4* it can be seen directly how the stable slope will change if the average annual load changes. For example, a load increase from 71,000 to 90,000 cubic feet per year would increase the slope from 0.0015 to 0.00168. *Fig. 3* shows that this increase can be avoided, for example, by smoothing out the banks. If the small brush surface with a roughness factor $n_w = 0.056$ is smoothed by a growth of grass with $n_w = 0.047$, the increased load can be moved without any change of slope.

Many other graphs of this kind could be shown for the same section describing the influence of some other factors on the transporting capacity which enable the engineer to predict the behavior of a bed-load carrying stream section. Today the analytical method of determining the carrying capacity of streams which underlies these graphs has been proved applicable to small streams and large ones with coarse bed material. The proof by

(Continued on Page 16)

MUD ENGINEERING

By A. C. NESTLE

MUD engineering, a comparatively new specialization, is of increasing significance as diminishing oil reserves emphasize the need for more drilling. Application of this particular technology is typical of many that are found in the nation's fourth industry, now of even greater importance in our present oil war. An understanding of how chemical engineering aids in the search for oil requires some explanation of the process of rotary drilling.

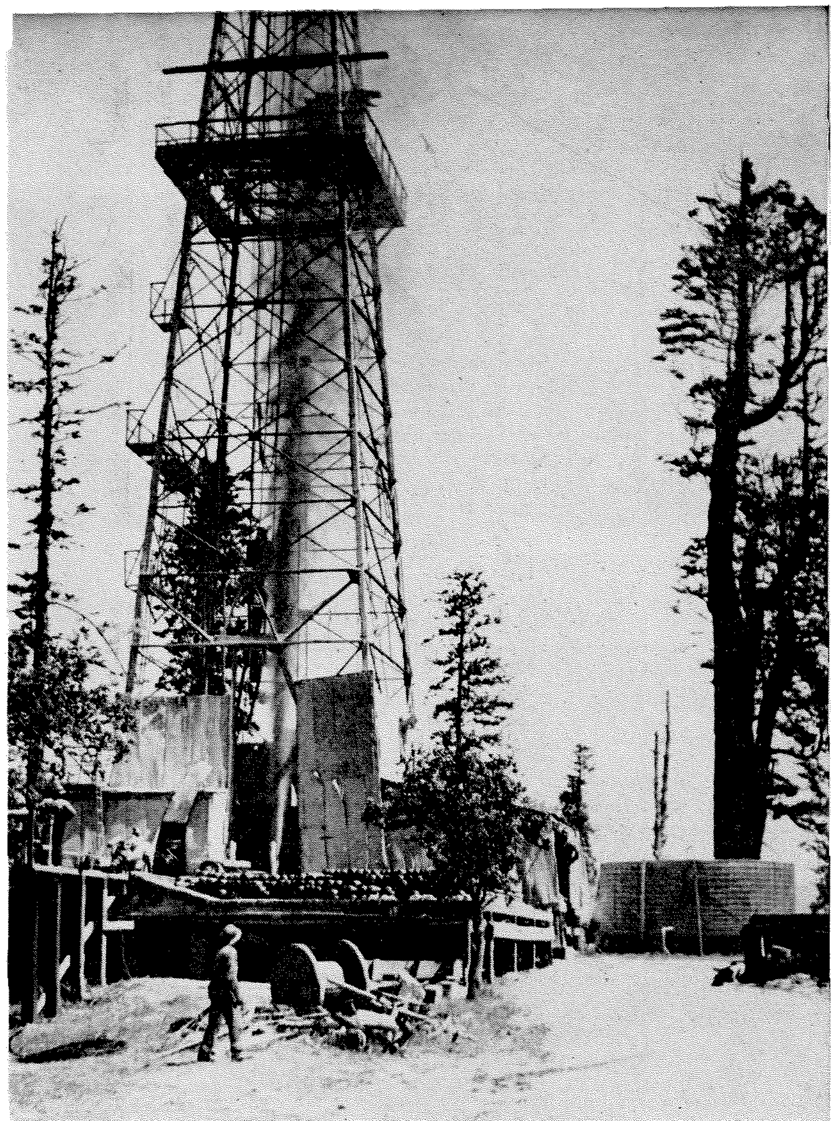
DRILLING OPERATIONS

Two principal methods have been used in drilling for oil and gas. In the older standard, cable-tool or churn-type method percussion tools are employed; however, for the most part this method has been superseded by the use of rotating bits. These bits are screwed on the ends of lengths of hollow pipe as needed. At the surface end of the assembly, torque is applied and rotation established through a bushing in which a special square, hexagonal, or octagonal member slides. In effect, the machine is a huge drill press driving a bit through a hollow shaft. Cutting force is applied to the bit by the weight of the string of pipe itself, although only a small fraction of this weight usually is needed. A lifting mechanism is required to control this force and to pull the pipe from the hole. Each time a bit becomes dull the entire length of pipe must be removed from the bore and stacked in the derrick in sections, the bit replaced, and then re-run back to the previous depth.

A large proportion of the time required to drill a well is consumed in making round trips into and out of the hole, at which time a dull bit is replaced by a sharp one. Shorter "round trip" time makes for economical operation and may be accomplished by more hoisting speed or higher derricks to accommodate greater lengths of the individual elements (usually three or four pipe lengths) of the racked drill pipe. Derrick height for deep drilling is limited by other considerations and standardized at 136 feet. Hoist flexibility requires several gear ratios to attain high speed with the pipe load of a few hundred to 200,000 pounds. Electric motors, steam or internal combustion engines are used to power the rotary and lifting mechanisms, as prime movers for pumps, and for other requirements.

Circulating fluid and pumps constitute one remaining major element of the rotary drilling process. The mud is forced via a hose and swivel into the rotating drill string, down to and through holes in the bit, where jetting helps drill soft formations, where it lubricates, flushes, and cleans and then returns to the surface. The mud carries the drilled cuttings up the annulus between drill pipe and hole wall to the top, where they are separated and discarded. Other functions of the mud depend on its constituents and treatment. Desiderata such as control of potential hazards from formation characteristics or content, proper removal of cuttings, helping to keep the hole free and minimizing the formation of cavities are some of the functions which have been attained with some success. Progress and improvement along these lines have required a great deal of time and research from simple beginnings.

The percussion method of drilling uses water to facilitate bailing the cuttings out of the hole, but as there is no circulating fluid, mud problems are non-existent.

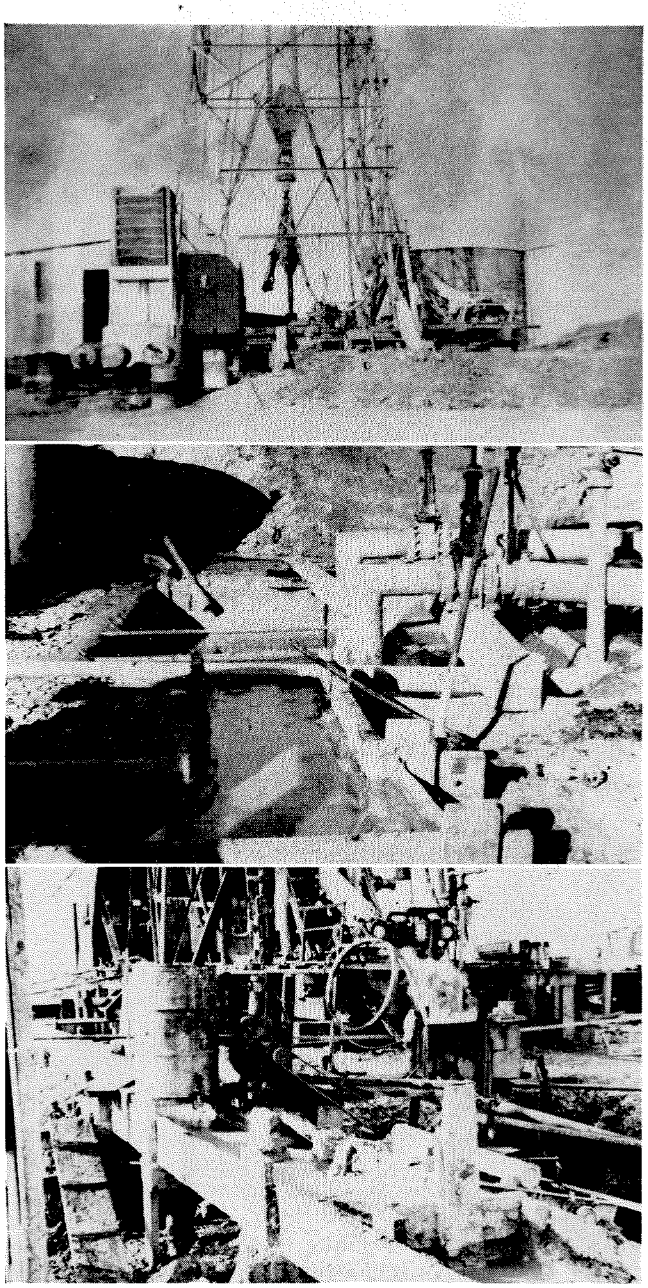


Drilling rig in the California woods.

Early rotary drilling crews used water as a circulating fluid; however, it was soon found that clay from upper strata produced muds and that better results followed. Thus, born of necessity, the development of mud technology was slow in its early stages, although progress has been accelerated by a realization of the role improved muds play in drilling operations. The oil industry has found that efficient drilling and profitable completions require muds made from carefully selected materials along with adequate field control. The importance of proper drilling fluid preparation and use cannot be overemphasized. Deep drilling has become increasingly successful almost in proportion as the mud engineer has increased his knowledge and experience.

MUD FORMULATION

Raw materials used for mud making are usually selected clays and are judged by properties of water mixtures of them. Their suitability is determined by various criteria, among which are the volumetric yield of a given clay, soluble impurities, abrasives content, and filtration characteristics. The last of these is a measure of the watery filtrate expressed from the mud when it is forced against porous media. The major physical properties desired and controlled when possible by the operator are as follows: density at a pumpable viscosity, *pH*, alkalinity, thixotropy, and filtration performance. Density is adjusted in an effort to keep formation fluids in place and at times to reduce harmful effects of formations sensitive to excessive filtration or improper *pH*. The



UPPER VIEW: Swivel and hose. CENTER VIEW: Mud ditch where chemical treatment is given. LOWER VIEW: Chemical treatment drum over mud ditch.

control of *pH* may be useful in viscosity reduction, thixotropy change and the tendency of some formations to contaminate the mud with inferior material. A certain degree of gelling is desired to hold cuttings in place when circulation is suspended; hence thixotropic properties of muds are altered by various means. Certain characteristics may be tailored in so far as it is possible to fulfill the requirements of particular jobs.

Mud is mixed in the field at the rig by simple means. Water is circulated through a jet mixer which creates a suction. Clay is shovelled or dumped into a cone above the jet and thus introduced into the water. Hydration and circulation help to make a more uniform mix. Some ready-mixed muds are available in areas of considerable activity, but the added cost of transporting water precludes universal use of this simple expedient. Chemical treatment usually is given by means of mixes added directly to the flowing mud during its passage from hole to pump through open ditches. A small tank or tanks, from oil drum size up, are spotted over the ditch and provided with water and steam or other heating means. Additions to the mud are proportioned from these tanks.

When high-pressure-formation fluids such as water, gas or oil are suspected or encountered, or when other less tangible factors lead to the use of increased density muds, special clays may be required, plus high-density fine-ground mineral additives. Among the latter, silica, limestone, barytes, hematite and gelena have been used. At times an excess of mud density over some critical value causes the hole to take fluid through various possible mechanisms. A combination of high-pressure-formation fluids plus critical density for fluid loss may occasion one of the most difficult of mud problems. Added complications may include a high-density mud requisite for pressure control and a few pounds per cubic foot density differential between backflow and lost mud. If the backflow is due to salt water under high pressure, too low density can cause contamination and ruining of the expensive weighted mud, whereas a slightly higher density may cause large fluid losses. Fortunately usual problems are less severe.

Chemical treatment is valuable in most applications and under certain conditions its use is imperative. Should it become necessary to control excessive viscosity when using high-density mixes or at other times, more clay extra additives or chemical viscosity reducing agents may be employed. Reagents are used to reduce viscosity, change *pH*, alter gel formation, improve filtration, deflocculate solids, and for other minor purposes. Complex phosphates, organic colloids like various tannins, sodium carbonate, bicarbonate, and hydroxide find frequent application. Often, tons of chemicals may be used on one job, the majority of which may be of a flexible ratio, tannin-phosphate treatment. Even larger quantities have been used on longer jobs necessitated by deeper drilling or special problem wells. Since the usual chemicals cost from three to 30 cents per pound, it can be seen why expenses often run into thousands of dollars.

Although there is no direct relationship, the consumption of a ton of chemicals may be accompanied by the use of 10 tons of clay and perhaps tons of additive high density minerals. These materials have, in some instances, run the cost of mud alone toward the hundred thousand dollar mark. At the other extreme, a shallow well may be drilled in an area where clays or shales are penetrated which make satisfactory muds merely by being mixed with adequate quantities of water. Little or no chemicals may be required and the cost can be less than a hundred dollars spent for mud to commence drilling or for minor treatments. Other factors influencing mud needs or treatment complexity depend on the well's location.

In lease drilling, where adjacent wells are progressively drilled, costs may be reduced by salvage and piping of muds from one to another, which reduces consumption materially. Drilling costs, especially mud expense, usually will be less in successive wells. Here the mud engineer, operator, and drilling crew can cooperate through experience and mutual effort to use chemicals and clays more efficiently. Often costs can be cut in half or further reduced in the course of several jobs.

Prospect or "wildcat" drilling is more expensive, for mud must be more carefully prepared and controlled, with a reasonable factor of safety, particularly with regard to its density, to reduce blowout hazard. Formations penetrated, apart and aside from their contained fluids, influence the mud problem.

Although most shales are hydratable and disintegrate somewhat when wet by water, drilling in some areas, notably along the coast of the Gulf of Mexico, is complicated by thick zones of extremely sensitive shale. Drilling these beds is sometimes virtually impossible, because the hole cannot be kept open and may even close in on the rotary tools during drilling. However, extraordinary mechanical techniques, large equipment and careful mud control contribute to successful penetration toward the lower objective horizons. Both special drilling fluids and extensive chemical treatments have been used. Although high density fluids seem to help, the most important factor is to avoid watery filtrate penetration into shale, which causes it to constrict the bore and freeze the drill pipe and bit, slowing up the job or forcing abandonment. Sodium silicate and common salt mixtures possess desirable properties for this type of drilling and have been used extensively. Drilling with this mixture often yields cuttings similar to turnings from a metal lathe. The formation chips show scoring and bit marks. There has been some application of salt-silicate fluids in similar formations encountered in the San Joaquin Valley of California. Other formation types require different mud technique.

It is often desirable to treat the mud and use an accompanying mechanical technique which will reduce the amount of drilled material incorporated in the mud. With salt-silicate mud, a proper choice of bits, rotary speeds and applied force will increase the size of cuttings and reduce tendency to form powder which would be left in the mud when passed through shaker screens normally used to separate cuttings, and thus eventually become part of the mud. Excess solids in the fluid require more makeup and treatment and will thus raise mud costs. Water-clay muds suffer the same type of contamination, which may cause complications if the formation drilled makes lower density mud with poorer qualities than that desired for the job. Control of *pH* and the use of special reagents have been used to counteract this tendency. Formations with large size pores give rise to another type of problem.

Part of all of the circulating mud stream may be diverted by a gravel, conglomerate, fractured zone, or other extra porous formation, or by gross fissures and caverns. Loss of mud through such causes, which may be expensive and time consuming to cure, is frequently encountered, especially in certain areas. Lost circulation is treated by various means, including thickeners, fibrous or flaky materials, addition of selected solids, special reagents, and cementing. Extreme cases require the use of protective piping. Besides problems arising from formation variables, others due to special auxiliary mechanical operations may necessitate different attacks by the engineer.

Viscosity usually is reduced and the mud stream made uniform by treatment and careful control preparatory to several phases in the average well's history. These steps are taken to improve results when casing (a protective pipe string) is run, when formations are tested or cored by special tools, and when logging by electrical devices is done. Extra precautions may be necessary for the above and for other operations before the well is finished.

Specialized mud preparation for certain stages has proceeded beyond the simpler mixtures which were used for every purpose only a few years ago. Now various phases in the drilling may call for diversified treatments and control. The period after the hole is finished, or, in known areas, from before the producing formations are penetrated until the final conclusion of work, constitutes a stage in the job known as completion. Current belief backed up by considerable supporting evidence suggests that the use of carefully-selected completion fluids may result in increased production. The possible deleterious effect of water loss, which may block production by reducing the permeability of the formation to oil flow, should be reduced and any mechanical impediment mud cakes may offer to oil flow should be minimized. These muds may be water-clay mixes with special treatments or they may have entirely different constituents. Among those finding current usage are oil base muds, which take several forms, all using some petroleum oil or cut as the major fluid constituent; organic colloid muds, which are heavily treated with starch or similar agents; and positive colloid muds, recently suggested, which are mixes of lower-than-normal hydrogen ion concentration containing dyes and special clay muds. Low-density muds with a relatively weak concentration of special clays containing preponderantly colloid-sized particles have been employed and special efforts to reduce water loss to the producing formation have been made when regular muds are used. Frequent contamination of muds with ground set cement just prior to completion has been countered with special treatments, dilution, flushing or replacement with fresh mud. A casing usually is provided to keep the hole open, and is sealed with cement before completing. Since cement has a deleterious effect on ordinary mud, in that it both gels and thickens it, muds not harmed by cement are desirable. Here, too, other special treatments or fluids have been applied, all in an effort to enhance completion muds, and with the ultimate aim of increasing production. Coupled with new and different type muds and treatments are improved testing apparatus and instruments, with many more envisaged for the future.

MUD CONTROL AND TESTING

Ordinary control testing employs fairly simple tools. Among these are hydrometer type or beam-balance density devices, capillary tube funnel-shape and Stoermer viscosimeters, compressed-air-operated filter press, simple immersion tube or Stoermer viscosimeter gel meters, colorimetric gelatin strip and vacuum tube voltmeter glass electrode *pH* meters, screen or elutriative abrasives content devices and titrimetric salt content apparatus. Other apparatus has been used but the kinds named above find most common field application. Laboratory and research instruments are more complicated and include improved viscosimeters, filter presses, and analytical procedures for other chemical constituents. X-ray crystallographic spectroscopy and ultracentrifuging have been used in clay analysis. Efforts have been made to develop instruments capable of more than spot measurement.

Both viscosity and density have been continually indicated and recorded by instruments. Density meters are difficult to design and apply because of the thixotropic character of the usual mud. Some success has been attained with direct displacement types, particularly with a rotating float which also measured viscosity in a manner similar to the Stoermer viscosimeter, modified for continuous operation. A successful gravimeter presents a novel approach; it is described in detail.

The instrument consists of an indicator dial, voltage regulator and vibrator cell. The principle of operation involves the dampening effect of a dense fluid medium on a vibrating reed which, in turn, is actuated by an exciter coil suitably located so as to produce vibrations in the reed with oscillations of alternating current. The lower end of the reed is connected directly to a paddle, or vane, which is immersed in the fluid tested; hence the vibrations of the reed are transmitted to the vane. The reed and vane assembly is supported within the cell by ribbon or torsion type bearings located just below the reed member of the assembly. The free or upper end of the reed carries a magnetic coil over a permanent magnet, thus inducing a current which is registered on the indicator dial and which varies with the amplitude of *the period of vibration of the reed. With* this arrangement it is apparent that increasing resistance to vibration in the vane will increase the amplitude of vibration in the reed (assuming constant voltage and frequency of the exciter current) and thus generate more current from the magnetic field, which is registered by the indicator. Resistance to vibration in the vane is provided by the inertia resulting from the density of the fluid in which the vane is immersed. Theoretically, and apparently in practice, viscosity of the fluid is a negligible factor because the period of vibration of the vane is too small to exert any appreciable shear.

THE FUTURE OF MUD ENGINEERING

Development of other instruments like the gravimeter has been held up for the duration, but their usefulness has manifold possibilities in the future. Mud preparation and its chemical control are comparatively new and offer a fertile field for future improvement. Not only are varied fluids needed for specific applications but new treatments may be found. A great deal of fundamental work is necessary, as demonstrated by the comparatively little known about the common clays and the mechanics of treatments of their water suspensions.

As time goes on, and as drilling goes deeper past the present record, which is 600 feet short of three miles, mud treatment and control will be more and more helpful. Drilling must continue at an accelerated pace, for although more fields are found, they are smaller in reserves. Thus since the targets are smaller the firing must be greater and more accurate.

The Engineer and Postwar Planning

(Continued from Page 3)

neutrality legislation and we were determined not to be provoked into war, but the isolationists would not foresee that the decision was not ultimately in our control. Actually even they were unwilling to accept the conditions Japan and Germany would have imposed upon us. They should have abandoned their isolationism after Pearl Harbor—and many did. Yet it appears that there are still enough of them left to make both major political parties afraid to take an unequivocal stand in favor of joint force to oppose aggression. The pattern of thought on postwar planning is not now significantly different from that following World War I. It does not appear, therefore, that the present war will be the last.

Reluctant though one may be to accept the implication of such action, it seems wise in our postwar planning to recognize that seriously destructive wars occur about once per generation and that as time goes on they become more extensive and more destructive. The action in starting now to prepare for World War III seems realistic and sensible. The disheartening effect of planning in the midst of one war for the one to follow in about 30 years is somewhat relieved by the knowledge that most postwar planning is for peace.

The engineer is amused by some of the imaginative predictions that some advertisers are making. He knows that extravagant claims cannot be fulfilled, that unfair advantage is being taken of the fact that non-technical people have recently heard more than usual about the usefulness of science. But the engineer knows also that the war has given tremendous acceleration to many developments such as jet and rocket propulsion, the combustion gas turbine, welding processes, electrical communication, electronic heating, X-ray inspection, plastics, and to almost every other scientific process and product.

Although winning the war is still the primary purpose of engineers, they know that the first day of peace will see most of them return to projects abandoned a few years ago and to planning new peacetime projects not believed necessary or economical before the war. Their efforts will be demanded by civilians almost as urgently as they are now needed by war and it will be difficult to explain to potential buyers why their postponed wants cannot be fulfilled immediately. Conversion of war production was remarkably rapid and complete but, very fortunately and in spite of the misguided isolationists, it started long before we were actually at war. Because it started so early many people do not realize how long the process of conversion actually required nor do they realize that the conversion was planned years before it was started.

Reconversion to peacetime production probably will not proceed as rapidly as did conversion to war goods production since reconversion will not be of such vital importance to survival and its costs will have to be borne to a larger extent by private capital. Because it will proceed more slowly, it should start earlier. The indefiniteness of V-Day makes it difficult to know just when reconversion should start but it is probable that those who have not already at least started to plan reconversion will find postwar competition extremely hard to meet.

The importance of starting reconversion as early as possible is attested by the recent agreement of the War Production Board, the War and Navy Departments, and of the War Manpower Commission to permit the manufacture of civilian goods hitherto prohibited or restricted in the plants of companies which have labor and machinery not needed in the war effort.

Sediment Transportation

(Continued from Page 12)

field measurements is still missing for large streams with fine bed material.

Often conditions are too complicated for analytical treatment. Irregular shaped cross sections or profiles, confluence of streams or temporary deposition of bed material are some of the complicating factors. In these cases the direct analytical method may be supported by model studies which can give quantitative results for transportation problems if they are based on the rules given by the laws of transportation (6). Model studies of such sediment problems have been performed using either sediment of the same or of different specific gravity in model and prototype.

The analytic determination of the transporting power of different stream sections gives the engineer a tool to predict the future development of streams with a movable bed. *Figs. 5a and 5b* show the canyons into which two small streams developed when their transporting power exceeded the available sediment supply. Thousands of acres of the most valuable valley lands are made unusable for agricultural purposes by similar developments. Hundreds of thousands of dollars are spent every year to prevent and repair damages to our communication systems due to channel cutting. But just as much or more damage is caused by streams flowing in channels with insufficient transporting capacity. When the transporting capacity is insufficient the stream channels fill up, flooding adjacent land which may include roads and residential sections. Accompanying this flooding will be a deposit of sediment. In their economical importance the direct sediment damages are often surpassed by the indirect damage. If a stream is cutting as shown in *Fig. 5*, all tributaries and side ditches will cut, too. The whole water table under the remaining areas will be lowered and the soil dried out. Channel filling will bring a raised water table and in humid regions extensive swamp conditions can be expected, with all their consequences.

The analytical method of calculating a bed-load carrying stream is being developed by the Soil Conservation Service for its own needs in finding appropriate means and methods for the stabilization of such streams. The same method can be used to study any bed-load carrying stream from the standpoint of flood control and channel stabilization. It is to be hoped that after this war the scientific treatment of such problems will find a greater development, based on the work that has been done and that is still being done within the research organization of the Soil Conservation Service.

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(4) *"Formulas for the Transportation of Bed-Load,"* by H. A. Einstein, Trans. Amer. Soc. Civ. Eng. Vol. 107, 1942, pp. 561-573.

(5) *"Bed-Load Transportation in Mountain Creek,"* by H. A. Einstein, unpublished report of the Soil Conservation Service, Greenville, S.C. November, 1942.

(6) *"Conformity Between Model and Prototype,"* A symposium. Discussion by H. A. Einstein, Proc. Am. Soc. Civ. Eng. Vol. 69, No. 4, pp. 531-535, April, 1943.

ALUMNI NEWS

ANNUAL JUNE BANQUET

In normal times, Commencement Day in June is the date set for the annual Alumni Banquet. The Class of 1944 which, in peacetime, would have graduated in June, received their degrees in February and have now scattered to all parts of the world. However, the alumni selected the traditional month for their annual reunion, and on June 22, 170 alumni assembled in Pasadena.

In the absence of the commencement exercises, the alumni were conducted on a tour through the new wind tunnel now under construction in Pasadena. The group then gathered at the Meteorologist Mess Hall on the campus (the Athenaeum facilities were not available due to shortage of help) for the banquet. Late reservations exceeded the capacity of the hall, and 21 alumni found it necessary to hold their banquet at the campus coffee shop.

The election of officers resulted as follows:

President..............................Harry K. Farrar '27
Vice-President..............................Earle Burt '15
Secretary..............................Victor V. Veysey '36
Treasurer..............................Karl Hegardt '32

Members of the Board: Joe Lewis, '41; J. Stanley Johnson, '33; and Frank Weigand, '27. Board Members to continue in office are Grice Axtman and Donald S. Clark. Grice Axtman and Joe Lewis have joined the Military Service and Frank Weigand has resigned, making new appointments necessary. Paul Hammond, Wendell Miller and Charles Varney are to fill these offices. Ernst Maag, ex-president, will be retained, according to the revised by-laws, to attend board meetings in an advisory capacity.

Mr. Maag, as retiring president, presided at the dinner, and introduced Mr. Farrar, the new president. Mr. Farrar called on representatives from the reunion classes for short talks. Virgil Morse, '24, told of his search for the Soil Conservation Laboratory, which was mentioned in the directions to the mess hall. Upon inquiring the location of the laboratory from someone on the campus, he was directed to the Mudd Building.

News of members of the reunion classes which was given at the banquet may be found listed among the Personals.

At the close of the banquet, the men adjourned to a lecture room in Arms Building to hear Lawrence G. Fenner, '30, and Mark Serrurier, '26, discuss informally some of the interesting problems of the wind-tunnel project.

SAN FRANCISCO CHAPTER

Due to wartime conditions and transportation difficulties the usual bi-monthly meetings were temporarily discontinued during the past year. However, a few alumni have been regular attendants at the Monday noon luncheons at the Fraternity Club at the Palace Hotel in San Francisco.

A preliminary poll indicated that a good attendance of Tech men and their wives could be expected for the fifth annual Sports Day and picnic at Howard Vesper's home at "Cactus Rock" in Oakland. In spite of gasoline rationing an attendance of 33 alumni and their wives enjoyed a very pleasant afternoon on Sunday, May 28.

Absence of the younger set was noticeable in that very little enthusiasm could be stirred up for the usual softball game between the "old" grads and the "young" grads. Lack of a suitable playing field was a contributing factor but it was evident that most alumni were more interested in Howard's well-equipped play room where several lively games of ping pong and pin ball were held.

This served to whet the appetites of those present and everyone enjoyed the picnic supper served in the patio. News of other alumni was passed along and a community "sing" was held in front of the outdoor fireplace. The following alumni were present:

Kenneth B. Anderson	'24	Hilmer E. Larson	'27
Lawrence W. Baldwin	'35	Donald F. Morrell	'24
Marshall A. Baldwin	'27	D. S. Nichols	'28
Robert B. Bowman	'26	D. J. Pompeo	'26
Edward Dorresten	'24	Lee W. Ralston	'27
Howard Fisher	'27	Ted Vermeulen	'36
Dave G. Harries, Jr.	'23	Howard G. Vesper	'22
Alex J. Hazzard	'30	Gordon K. Woods	'42
Maurice T. Jones	'26		

A short business meeting was held, during which Howard Fisher, the outgoing president, gave the report of the nominating committee. The following officers were elected for the coming year:

Alex J. Hazzard, '30..............................President
Marshall A. Baldwin, '27..........Vice-President
Maurice T. Jones, '26..........Secretary-Treasurer

Some colored slides of last year's swimming party at Bob Bowman's pool were shown. Bob announced that the next swimming party would be held on September 3, and invited all alumni and their ladies to be his guests on that day. Bob has constructed a lovely swimming pool on his ranch near Concord, California, and everyone who can possibly go will surely have a very enjoyable time.

The meeting was concluded by a showing of motion pictures.

Any Tech man who may be in the Bay region is invited to join the alumni group which meets at 12 o'clock each Monday at the Fraternity Club Dining Room, second floor, Palace Hotel in San Francisco.

Maurice T. Jones, '26, Secretary,
908 Curtis Street,
Berkeley 6, California.

ATHLETICS

By H. Z. MUSSELMAN
Director of Physical Education

IN the Spring sports, Caltech teams showed up well against the toughest competition, though only one squad produced a team to equal the championship records of the cross country and basketball squads earlier in the year.

The golf team swept through an undefeated season with two wins over both U.S.C. and U.C.L.A., and climaxed the season by winning top honors in the Intercollegiate Tournament. The four-man team of Bob Rosecrance, Larry Hudson, Joe Phelps and George Osgood easily outdistanced all opponents in the Tournament with a team score of 618, while Bob Rosecrance won low medal honors with a 76-73—149.

With only Caltech and Occidental of the original Conference schools sponsoring track teams this year, Dr. Floyd Hanes' track squad won the mythical Conference Championship by subduing the Tigers in a dual meet 67 1/3 to 62 2/3. Every event was packed with thrills and it took the Beaver's winning relay team to cinch the meet. Don Tillman, with a mark of 47 feet 3 inches, broke the Caltech shot record of 47 feet 3/8 inch made by Bill Shuler in 1932. Bernie Wagner cracked another Tech record with the fine time of 1:58.4 in the 880, breaking Folke Skoog's 1932 mark of 1:58.7.

The Engineers clearly demonstrated their superiority by winning the Conference meet with 75¼ points. Oxy finished second with 57 and Redlands trailed with 31¾. Tom Carter, Student Body president, won the 100 and 220. Other double winners were George Gill in the mile and two mile, and Don Tillman in the shot and discus. The Beavers scored in every event, and placed two men in eight of them.

In other dual meets, Tech bowed to U.S.C., 74-57 and U.C.L.A. 72-59. In these meets Caltech placed in all events, but lacked first place strength.

Winning three relays and four open events, Tech found little difficulty in rolling up 57 points to take top honors in the College Relays. Occidental finished second with 26¼ and Redlands third with 18 points. Only a sprinkling of Junior College men competed. Tech teams were clocked in 1:31.5 in the 4-man 880, 3:29.7 in the mile and 11:05.7 in the distance medley.

Entering 10 men in three open events and four relays in the West Coast Relays at Fresno, Caltech finished fifth in the University division, behind U.S.C., Olympic Club, California and U.C.L.A. Tom Carter was nosed out by Duffy of Cal in the 100, and Don Tillman placed third in the shot and discus. The distance medley and two mile relay finished second behind U.S.C., while the half mile and mile teams finished fourth.

Two weeks later, this group of 10 men finished fourth in a meet at Modesto. Curry of U.S.C. was given the decision over Carter in a photo finish in the 100, with Duffy of Cal a poor third. Harold Yates, who has been throwing the weights on even terms with Tillman all year, took third in the shot. U.S.C. won both medley and mile relays with Caltech finishing second, while the Engineer two-mile team placed fourth.

Entering a complete team in the Pasadena games on the local oval, the Beavers placed third with 21 points. U.S.C. continued to demonstrate its local supremacy in winning the meet with 61 points, while the San Diego Marines placed second with 33. Highlights of this meet were Carter's victory over Curry of U.S.C. in the 100 at 10 flat, and the 220 in 22.3s. Don Tillman cracked another Caltech record when he sailed the discus 142 feet 3 inches to erase the mark of 140 feet 1¼ inches established by Bill Shuler in 1931.

In the newly-aligned baseball league, U.C.L.A. grabbed the championship, dropping only one game in a 10-game schedule. U.S.C. finished in second spot with eight wins, Redlands third with six victories, followed by Caltech, Oxy and Pepperdine with four, three and none respectively in the victory column.

With an entire new team and no men of experience, the Tech team found tough competition in this new league, and not until late season could a satisfactory lineup be found. Of the four Tech victories, two were over Pepperdine, one from Redlands, and one by forfeit from Oxy, when an epidemic on the Tiger Campus caused the Bengals to cancel and forfeit the last two games on their schedule. Wayne Timm, pitcher, who was the only Tech man selected on the All-Conference team, was one of the leading hurlers in effectiveness, but weak hitting and loose fielding dropped many ball games.

The tennis squad lost twice to U.S.C., split matches with U.C.L.A. and won the only match played with Pepperdine. Stan Clark, number one man on the squad, proved to be one of the finest singles players among the southern California colleges. He represented the Institute in the National Collegiate Tennis Tournament at Northwestern University the last week in June. Clark, after winning his early matches, ran into Francisco "Pancho" Segura, 1943 N.C.A.A. Champion from Miami University, in the quarter finals and lost in straight sets.

FOOTBALL ON LIMITED SCHEDULE

SEVERAL weeks ago the Institute made the following announcement:

"At a recent meeting of the Board of Trustees of the California Institute of Technology, it was decided that Intercollegiate Football should be abolished as a part of the Institute's athletic and physical education program. Special permission was given, however, for an Institute team to play a schedule of four to six games of football with other college teams between now and October 7 of this year. This permission is given in order to accommodate circumstances associated with enrollment of Navy V-12 students at the Institute. The proposed schedule is in process of being arranged."

A squad of over 100 men greeted the coaches, Chief Specialist Mason Anderson and Paul Ackerman, at the opening practice. While there are only a few college lettermen in the squad, probably more than 40 per cent of the men have played high school football.

By necessity, the season must be short as final exams, commencement, and a two week vacation period in October make it impractical to play games later than October 7. A schedule of four games has been arranged with the only college teams in this area which are playing.

Friday, September 15, 8:00 P.M.—Redlands—at Rose Bowl.
Friday, September 22, 8:00 P.M.—Redlands—at Redlands.
Saturday, September 30, 12:15 P.M.—U.S.C. Reserves—at Coliseum.
Friday, October 6, 8:00 P.M.—U.C.L.A. Reserves—at Rose Bowl.

PERSONALS

1911

R. V. WARD is still developing flood control rights of way and plans for San Bernardino County.

1918

JOSEPH HARTLEY recently purchased the Rex Paint Company in Los Angeles, now known as Hartley Paint Company.

1922

LINNE C. LARSON, a captain in the Corps of Engineers, was transferred to Muroc Army Airfield, Muroc, Calif., as Resident Engineer.

MAJOR GLENN WEBSTER is an R.O. T.C. instructor at Oregon State College.

1924

LYALL A. PARDEE, senior civil engineer for the City of Los Angeles street and parkway design division, is in charge of personnel engaged in planning and designing the city's $176,000,000 parkway system for the metropolitan area. This is a postwar project.

LIEUTENANT COLONEL EDWARD D. LOWNES has been in charge of Army construction in western Canada for the past year.

FRED GROAT is with the War Production Board in Washington.

1926

C. E. WEINLAND is on leave of absence from the Johns-Manville Corporation and is now engaged in war research work on one of the projects on the Institute campus. He has a 15-year-old daughter and a seven-year-old son.

LIEUTENANT L. C. WIDDOES, U.S. N.R., is stationed at the Naval Air Station, Whidby Island, Wash., in connection with the development and improvement of aerial torpedoes.

HERBERT INGERSOLL is a prisoner of the Japanese, but was alive and well according to word received by his wife from the Red Cross in the spring. Messages not over 25 words in length may be sent to him addressed: Prisoner of War Mail, Captain Herbert Victor Ingersoll, American P.O.W., Military Prison Camp No. 2, Philippine Islands, Via New York.

LIEUTENANT COLONEL JOSEPH MATSON, JR., has been visiting in Pasadena. He is an assistant to the District Engineer, Brigadier General Hans Kramer, in the Hawaiian District.

ARTHUR B. ANDERSON is now employed by the Southern California Telephone Company as plant service foreman in Pasadena. He completed 15 years of service with the company in January.

1928

LIEUTENANT COLONEL PHIL DURFEE has been awarded the Distinguished Flying Cross for performance of duty under extreme flying conditions while serving in the Aleutians.

DICK FOLSOM is professor of mechanical engineering at the University of California.

1929

CHARLES A. BOSSERMAN is employed at Boeing on the "B-29" Super Fortress. His engineering group plans the functional tests which are conducted on each part and installation in each B-29 airplane, including the starting of the engines and routine flight tests. Before working on the B-29 he was in charge of all plumbing, which includes all pipe line work, etc., on the Sear Ranger and the Boeing Clippers. He has two sons and a daughter, and is active in Boy Scout Cub work.

1933

LIEUTENANT COMMANDER JOHN WARFEL is an administrative officer in charge of the jet propulsion development for the Navy. He joined the Naval Reserve in 1935 and received his training at the naval flying school at Pensacola. He was then assigned to duty aboard various aircraft carriers.

CAPTAIN EDWIN R. KENNEDY is now in China with the Air Forces.

LIEUTENANT DICK A. PLANK, U.S. N.R., formerly with the Bureau of Ships, is now connected with the Naval Ordnance Department and has been transferred from Yorktown, Va., to San Francisco. His second child, a daughter, was born in Pasadena in April.

1934

LIEUTENANT COMMANDER WILLIAM C. DUNN, U.S.N., received his M.S. degree in aeronautical engineering from the Institute on June 30, and on July 15 reported to the Naval Air Station, Quonset Point, R. I., for a tour of duty in the assembly and repair department there.

1936

JOHN P. KLOCKSIEM is now employed by Douglas Aircraft Co., Inc., experimental flight test division, and is located at the Los Angeles Municipal Airport.

1938

EVAN JOHNSON, of the Kellex Corp., New York City, is the new secretary-treasurer of the New York Chapter, replacing Bob Custer of the Texas Company who was recently transferred.

1939

ENSIGN JOHN J. BROWNE is engineering officer on a new destroyer that has been in action in the Pacific.

ROBERT B. HOY, geologist for the New Jersey Zinc Company, is now doing exploration work for that company. A daughter, Mary Ellen, was born to the Hoys on March 4.

1940

BUD SAMUELS left Lockheed to join the Navy in June. He had been a research engineer.

RICHARD L. SULLIVAN is chief engineer of the Mid-Continent Airlines, Inc., in Minneapolis.

1942

JACK HOAGLAND visited the campus while on leave after 13 weeks training at Camp Farragut, Idaho. He expects to be sent overseas soon with a rating of engineering design specialist.

LIEUTENANT (j.g.) JOHN F. McCLAIN, JR., U.S.N.R., and Miss Esther Dechant were married on August 12 at Coronado, Calif.

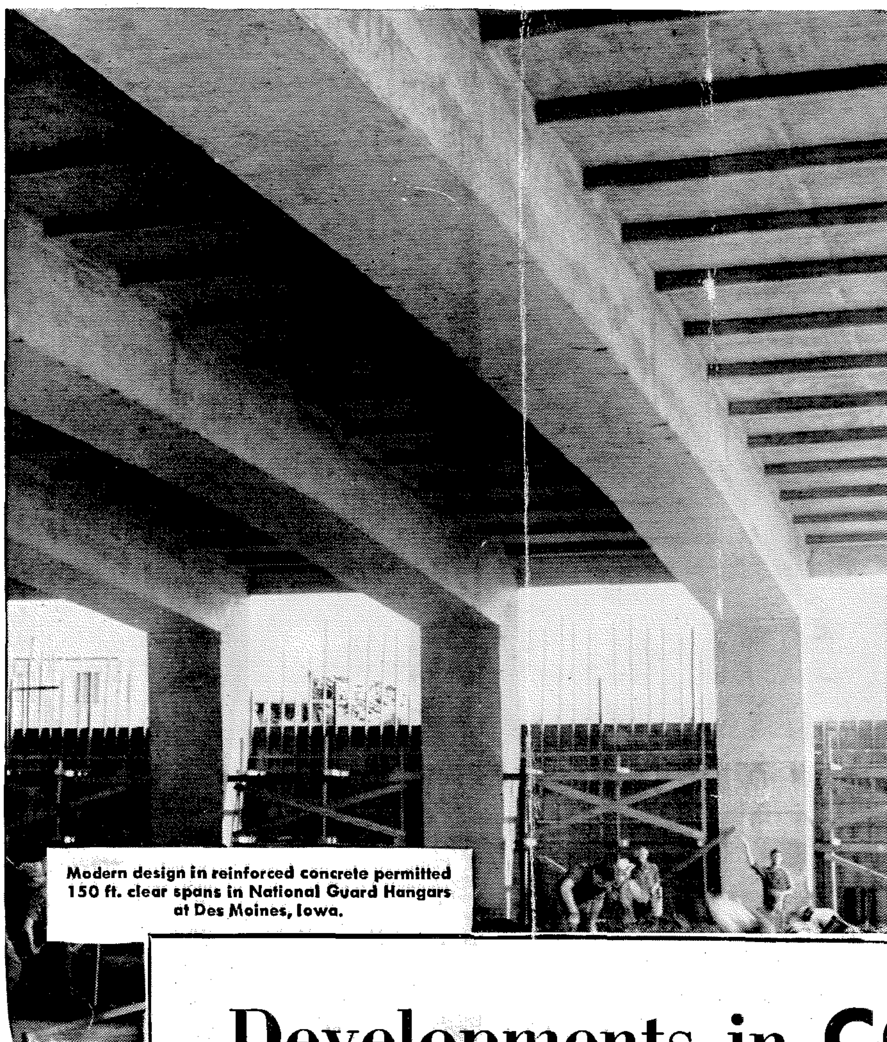
HENRY V. ROESE resigned his position as assistant naval architect with the Supervisor of Shipbuilding, U.S.N., Terminal Island, Calif., and has enrolled in the U. S. Maritime Service. On June 16 he was assigned to the U.S.M.S. Training Station, Avalon, Calif.

ROBERT GREENWOOD returned to England in March and has been assigned to the Colonial Service. He will be sent to a post in Nigeria, Africa, as a geologist.

1943

ENSIGN ROBERT L. BENNETT is taking a 16-weeks course in the Aviation Gunnery Officer's School, Naval Air Technical Training Center, at Jacksonville, Fla.

ENSIGN ROBERT M. FRANCIS was married to Miss Louise Bennett at Long Beach, Calif., on April 16. Ensign Francis graduated in Aviation Ordnance at Jacksonville, Fla., in April and is now stationed at the Naval Air Station, San Diego.



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