ENGINEERING IN CHINA

by Professor F. J. Sanger

INTRODUCTION: China has gone a long way beyond pigtails, 6" finger-nails, and mandarins even in most of her 450 millions remain primitive gardeners. For at least 4,000 years the problems of river floods and irrigation have been before the Chinese and there are historical records of unusual engineering ability in controlling rivers and cutting canals. Many of the old canals still exist and do their job of linking up the Yangtse with other rivers and thus providing good waterways in a country which is so mountainous that highways are almost impossible to construct between the centres of population which are in the main river valleys. Progress has been slow because of the superabundance of human labour, the difficulties of transport, and the philosophy of ancestor-veneration: with such a philosophy a nation looks backwards and remains static. This article is based on an 11 years' residence in Shanghai with travel within a 500 miles radius and on interviews and correspondence with engineers, many my own graduates from a British Technical Institute where I was Dean of Engineering and Building. The Institute was at Shanghai which is the industrial centre of China as well as its chief port.

PRIMITIVE ENGINEERING: A short description of engineering achievements seen in travelling around the countryside reveals the natural ability of the Chinese. In the hills of Shantung for example one occasionally comes across a waterwheel driving a flour mill through wooden gearing; the wheel may be 15' in diameter, and not one trace of metal is to be seen. This absence of metal fastenings is very noticeable in primitive machinery. Home-made spinning wheels and looms entirely of wood are common in the small villages. In the rice fields (which have to be flooded when the small plants have been transplanted to it) are ingenious paddle pumps driven either by manpower on an endless chain moving up a sloping rectangular channel by means of sprocket wheels at the ends. The upper wheel is driven by a treadmill with two people walking on it or by gearing from the buffalo-shaft. Usually a conical roof of straw protects the buffalo which is a valuable source of mechanical power but it is unusual to see protection for the much-less-valuable human-beings. The efficiency of such a pump is quite high and in a few days the field is flooded by muddy water from the irriation ditch or creek. In the canals, rivers and creeks one sees junks and sampans. The junk is a well-known Chinese ship which has not changed in a minute particular for many centuries. Pieces of junk have been fished up from a 600' depth in the Shanghai "mud" on which the city is built--that junk was sailing the China Sea quite a long time ago. Sampans are small boats for three or so passengers with a single sculler at the stern for propulsion. Both junks and sampans have a spoon-shaped hull which makes them efficient: ships though rather slow and travel in a sampon is like bobbing about on a cork. On country roads and in cities too are carts, wheelbarrows and open-sided trucks towed by men--not horses. These vehicles are an insoluble problem in city streets owing to their very narrow tires and very high wheel-loadings. In the cities it is customary to have blocks of stone in lines at the correct spacing so that the coolies may guide the wheels on to the stone track where there is less road-friction (and the sheet asphalt surface is not cut into ever-deepening ruts). Rickshaws came from Japan, but are now very useful vehicles for the general public in China, and a nuisance for other street traffic. They are beautifully made, for lightness, strength, balance and comfort and the pneumatic tire has done a great deal to make a rickshaw ride a very pleasant experience if one can forget about the puller Rickshaws are used for carrying freight as well as persons and in the narrow rough lanes between the fields are valuable means of transport. Chinese well-drilling is still practised and for depths to 500' has advantages over foreign mechanical equipment. The method originated in Shantung and all the well-drillers seem to be from that Province. The hole is drilled by a steel chisel bit on the end of a bamboo rope made of thin strips slipped together. The top end of the rope is fastened to the horizontal strings of a 20' bow made of perhaps a dozen more bamboos. Just above the ground level is a wooden crossbar on which two men shove down to dig the hole; when they let go and the tension in the bowstring raises the bit for the next shove. The hole is filled with muddy water to prevent caving in and sometimes steel casings are used nowadays. The bit is withdrawn (for sampling or for other purposes) by a 20' diameter bamboo wheel: two men walk on a treadmill made of rungs near the periphery of the wheel and the bamboo rope is wound on the rim of the wheel. The similar Canadian method uses a cantilever spring of course, instead of the bow.

Chinese bridges vary considerably from a simple granite slab to marble arches. Long-span bridges are of bamboo--the Chinese have appreciated the value of the suspension principle. (Suspension bridges of bamboo can still be seen in Japan also). Small-span bridges of the better type are invariably circular arches, but it seems as though the arch-principle has not been used and the bridge really consists of two cantilevers built out from each abutment and then finished off with a curved soffit. This is not true of every bridge though--many are of such dimensions as to be quite unstable as two cantilevers. The road over the bridge is often small stone steps, making walking easy but not assisting the wheeled vehicles very much. Since the approaches are only a few feet above water level the bridge rises in a big hump.

Lumber is also used for bridges of course but generally stone is preferred. Bamboo has many applications in primitive Chinese engineering. Drain pipes and water supply pipes of bamboo split longitudinally are very economical. In the hills one sees these pipes running from mountain pools or streams to houses below where simple tanks are put into the ground for storage. The tank is allowed to overflow if supply exceeds demand and the stored water remains pure. In modern building the bamboo is used for scaffolding: at the top of each pole is a sprig from a shrub to prevent unfriendly devils sitting on the top and causing accidents. Chinese roofs are well-known: the interior details may not be though. Chinese did not discover the "frame" principle and the roof truss is a combination of beams and struts. A heavy beam is laid across the columns; then two short posts are added to the beam at a smaller span and another beam is laid across them. Then two more short posts at smaller span, beam, posts, and so on until the roof is completed. Light rafters are added and the roof is tiled with the upturned pitched eaves which are so attractive. Even in modern buildings, Chinese architects retain the traditional eaves and heavy roof although the building below is modern in design and construction. Sometimes one comes across monstrosities in reinforced concrete imitating ancient designs of pavilions or pagodas but such things are quite rare. The usual principle in dwelling houses has been a stressed frame with light partitions. Formerly the stressed members (columns and beams) were of wood, occasionally of stone, and nowadays reinforced concrete is often used instead. Bricks and tiles have been used for centuries--so have mud and straw which are still the building materials of millions of people.

Highways in China are still primitive, and it should not be forgotten that two hundred years ago (a very short period in Chinese history) roads in England were mudtracks. But in recent years some good roads have been built for military purposes just as they were in Europe. Practically all the highways are earth roads. Short stretches have been stabilised with portland cement but were found to be inadequate against the narrow-tired carts although very good for automobiles. In mountainous regions where stone is available without extremely difficult transport, broken stone is used for waterbound roads. Labour is hired from the villages--men, women and children in thousands. Rolling is by stone rollers hauled by animals or by men. Gunpowder is obtainable almost anywhere--it will be remembered that the Chinese knew of gunpowder a long time before we did, but had not the sense (or otherwise) to kill one another with it, employing the new invention of firecrackers--Chinese still love a big bang, and celebrate with firecrackers as often as possible. In 1937 one of my graduates was trying to build a highway with kaoliang straw. In North China the natives grow the kaoliang, a tall reed resembling sugar-cane in appearance, for the grain which is fed to animals. Kaoliang also provides a very potent wine very like vodka but more powerful still--at a Chinese feast it behoves the visitor to be on his guard when the host says "Kan pei" (i. e. "bottoms up"). The roads in wet weather are muddy tracks; in dry weather piles of dust. In between times the surface is good. Near the towns an attempt is made to stabilise the road by various means including the rolling-in of ashes and treatment by salts. Nevertheless the Burma road is a monument to China, and one can never forget the perfect road from Nanking to the Sun Yat Sen Memorial on Purple Mountain, in every way the equal of the best western parkways.

Little can be said about Chinese railway engineering. Railways were introduced against considerable Chinese opposition about a century ago. Travel on the railways is interesting but hardly an engineering subject, and does not come in here. A locomotive driver has quaint ideas on lubrication, in common with most Chinese. He sees no point in oiling his engine when it runs so well without oil. The way in which modern locomotives have been piled up and abandoned on the railways is almost unbelievable.

There is no aircraft industry in China. Like every other race the Chinese have speculated about human flight and legends tell of flights made by men using home-made planing surfaces, but the stories about the Chinese love of kites are not untrue. It is still possible to see kites more than 100' long moored to stout posts. The top is a big dragon head in bamboo and paper; the body is made of sections fastened to the strings. This is perhaps wandering from the subject again, and to mention the custom of putting flutes in the wings of doves so that they make pleasant noises as they wheel around is also wandering, but interesting perhaps, and is remotely connected with flying. Chinese make good pilots incidentally.

To end this section on primtive engineering attention should be called to the crippling effect of the lack of metals. The superb craftsmanship of the Chinese should be noted too, and with modern metals, machinery, and education, there is no limit to their capabilities: Chinese excel in manual skill, patience, hard work and ingenuity. The pride in craftsmanship still exists and spiritual values are very important. When one sees the poorest families living in rotting boats with personal possessions practically zero, living from day to day on garbage and odds and ends, and playing and laughing in their rags--they have something which we have lost.

MODERN ENGINEERING: The Chinese have co-operated with foreigners and have picked up western techniques which they now apply although the number of Chinese engineers is so small. Very little steel is produced in China although the iron ore and coal are waiting to be used. One Chinese steel mill at Shanghai is producing reinforcing bars from pig iron and scrap in open hearth furnaces fired by gas made in a producer. I have inspected the works and have tested hundreds of bars for users in Shanghai with consistently good results. The steel is reliable and the slightly lower tensile strength and ductility as compared with British structural steel is not drawback when the properties are known. Works control of the pour is as strict as in any foreign steelworks. The Chinese are excellent founders in ferrous and in non-ferrous metals. Examples which come to mind are cast-iron links for chain grates, cast-iron lathe-beds, phosphor-bronze "brasses" for a steam engine and cast-iron pipes which I have bought and tested before acceptance with satisfactory results every time. The chain grate links were compared with British made links for replacements when British supplies were cut off and proved themselves to be the equal of the homeside product. Other steel products tested such as bands for cotton baling, spindles for textile machines, castings for miscellaneous articles and welded flanges all show the same good materials and workmanship. There must be hundreds of small workshops in Shanghai, but the output is very small of course. Chromium-plating works are kept very busy.

Shipbuilding firms have progressed well beyond wooden junks. The Government has a shipyard near Shanghai which has built Customs cruisers (on stocks and launched into the Whangpoo) complete with engines but with the help of foreign advisers. Other private firms built ferry boats and launches however entirely without foreign aid although the men and engineers have been trained by foreigners of course. There appears to be no reason why bigger ships should not be built in time.

There are Chinese firms making heavy electrical machinery but practically all of it is imported. At Hangchow on the coast of China there is a big generating station entirely under Chinese control. Special facilities are made for college students to take a course at the station in the summer vacations: these include the dormitories, public rooms and sports fields and gymnasium. A great deal of electrical equipment is now produced in China' lamps, fans, batteries, irons, radiators, heaters, kettles and telephone parts.

A most important requirement in industrial development is machine tools. About 1938 a big demand arose for machine tools for India and Malaya where armies were being equipped for the coming war. Shanghai engineers were interested and several Chinese firms began production, copying existing machines at first but soon designing their own. The Institute was recognized as the official inspecting body giving us a good insight into the industry. Our experience was that some firms could produce machine tools capable of passing the accepted tests with all that was required in quality and finish. Others were not capable of course, but the important thing was that most could make these first-class machines. A big proportion of the machines were medium duty lathes, but later on more elaborate machines were designed and produced including gear planers and milling machines.

During the War a big bicycle industry grew up in Shanghai. The bicycles are heavy because solid drawn tubing was (and still is) unavailable and welded tubing had to be used but the bicycles look just like the British machines and give good service. The chain is the difficult part in bicycle-manufacture, but here there are two good firms producing excellent chains with case-hardened working parts, made on quantity-production methods. The bicycle is a very popular machine in the Yangtse valley, not only for passengers, as it were, but also for freight. They are used for towing rickshaws in an interesting combination known as a pedicab, developed during the War. Another thing for which our War was responsible was the small gas-burner using hardwood, charcoal coal or anthracite. The producer was attached to the rear of the car or just behind the cab in a truck. Contrary to expectations the engine did not suffer seriously from tar and other things distilled although no scrubber was provided. The producers were made in little one-room factories. The War stimulated the production of automobile spares and in Yunnan one factory at least was engaged in making fuel pumps, for high speed compression ignition engines in trucks, some of the most exacting accessories to make. It is known too that factories at Chungking and elsewhere made small arms and machine-guns.

All around Shanghai there are small factories making plastic articles, fountain-pens, vacuum bottles, aluminum and sheet metal articles of all kinds, kitchen utensils, hand tools, flashlights, etc. The output is quite high but generally the lack of inspection gives unreliability. Several chemical works have been in operation for many years and Shanghai was well advanced i nthe manufacture of the sulpha drugs and hormone compounds as well as in commercial chemicals.

CIVIL ENGINEERING: Returning to civil engineering after the discussion of production engineering we might first note the modern buidings in Nanking, Kiangwan Civic Centre (just outside Shanghai) the new wharf for Kiangwan, and the air-conditioned cinemas in Shanghai designed by Chinese architects and engineers and built by Chineses contractors. Reinforced concrete is a very popular material owing to the cost of structural steelwork but Chinese engineers use steel frame structures where necessary. The bridge at Hanchow on the Ch'ien T'ang River (which has the biggest bore in the world) was an international project, designed by American engineers from data supplied by the Chinese government; the foundations were by a Danish contractor, superstructure by a British firm and erected by the foundations contractor, approach work by Chinese Contractors, and all supervised by Chinese engineers with a British adviser. The superstructure was in chromador steel and the foundations gave trouble in the swift river with a scour at the cofferdams. All the labor and much of the supervision was Chinese of course. Soon after the bridge was opened a peer and two spans were blown up by the Chinese advance in 1937.

Chinese contractors are as good as any in the world and know as much about "Extras" and other devious means of increasing the value of a job. Sub-letting and sub-sub-letting etc. is customary so that the work is carried out by a large number of small contractors employing half-a-dozen men or boys. It is amusing to watch small boys bricklaying, laying a thin line of mortar around the edges and leaving the middle of the joint empty (unless the clerk-of-works is around). Rubble may be used to help put concrete in a column. Measurements for payment need careful checking. It has been discovered that sloppy concrete is easier to wheel and to pour. These are uncommon details however. The fact remains that the Chinese contractor and his men can do a perfect job. At the extension of the Shanghai Generating Station and American Superintendent and Resident Engineer were astonished at what the contractors could do. Outstanding feats which come to mind are the concreting of 1,000 cubic yards in one continuous operation, the raising of a 50-ton steel girder to support some breaching 150' in the air using poles, pulleys, ropes and men on the nearby boiler house roof. A big steam drum of about the same weight was dextrously steered through steel columns and beams into its place in the boiler house again with the most primitive equipment where modern appliances would have been of little use. In the Institute a squad of coolies unloaded three crates of the parts of a big boring machine and erected the machine with the help of three poles, rope and pulleys--and human muscle.

Excavation is almost entirely by hand using pick and shovel with bamboo baskets for carrying spoil. Contractors often use modern surveying instruments in setting out baskets but some still prefer ancient instruments, like the water-level I saw in use in 1935. The level is simply two cylinders connected by a flexible hose. Marks on the cylinders indicate levels. About 10 years ago, Dr. Terzaghi invented a very precise instrument called a misrometer hose level for measuring settlements inside buildings; it uses the same principle as the cruder instrument of the Chinese.

There is little to be said about foundations or I may be accused of trotting out King Charles' Head. For a very long time the Chinese have used short poles for strengthening poor ground. Foochow poles about 10 to 12 feet long and 6 inches in diameter are driven at close spacing and in some cases are beneficial, but, as an eminent British engineer once said, it is impossible to consolidate butter by sticking pins in it, and the Shanghai mud often resembles butter in consistency, so that quite a good deal of lumber has been wasted.

Chinese ideas on sewerage are interesting and unusual perhaps. It seems as though every effort is made to preserve the natural nitrogen cycle. Only the most important houses and buildings have septic tanks draining to the nearest water course; for most of the population carts pass along the streets every morning to collect the "night-soil" which is taken to a central station and loaded into boats which take it to the fields where after storage in earthenware kongs it is thrown back to the soil by long-handled dippers. Shanghai has main drainage for a good part of the city and two disposal plants (bio-aeration method), but that is essentially a foreign provision.

Water supply is normally primitive but in most towns water is available at a tap, even if several houses have to share one supply point. In the countryside the houses are near a stream and that serves for everything, water-supply, washing food and clothes (in the stream direct) and sometimes as the sewer although little valuable fertilizer is wasted by farmers.

Chinese professional engineers have two big societies to which they may belong. The Engineering Society of China is an international body with headquarters at Shanghai, and there is a purely Chinese Engineering Society.

CONCLUSION: China is developing rapidly. By foreign assistance both in China and by the education of students abroad, a body of engineers is being built up capable of bringing China up to a modern industrialized state but they have a very long way to go. And while the present political and economic conditions persist, everything is retarded still more. The War very seriously hampered this development too. Chinese workmen have all the skill required; Chinese engineers are as good as any in the world. The materials are there and China has a great future--but when will engineers be allowed to work in peace?

Carpentar Trisects Circle, Claims 384 Not 360 Degrees

from Montreal Daily Star.

San Antonio, Tex.--In these days of trisecting angles, it's not surprising when someone comes up with a trisection of a circle--but it is eye-lifting when Tom F. Black claims his trisected circle contains 384 perfect degrees, not the 360 which has served for many, many years.

A carpenter by trade, Black claims that the 360 degrees is a mathematical monstrosity -- and this is his proof.

Halving 360 degrees and each resulting figure one gets 180, 90, 45--and then the trouble begins with the final figure, some hard-to-calculate fraction.

Black's trisected circle of 384 degrees is divided thusly: 192, 96, 48, 24, 12, six and three--the final figure representing one each of his trisecting points.

His formal education consisting of the first six grades only, Black also discredits the mathematical term of "pi" which is commonly used as 3.1416.

Actually "pi," used to determine the circumference of a circle, is 3.141592, Black says.

Exactly, minutely and perfectly to measure the circumference of a circle Black submits a graduating scale of "pi" ranging from 3.141502 for a one-inch circle to 3.141599 for a nine-inch circle.

Armed with compass and pencil, Black is ready to prove his theories and had already invented, he says, a protractor to go with his 384 degree circle.

"I have found," says Black, "what man has searched for more than 3,000 years, the perfect way to measure the circumference of a circle."

LIFE

Baby's heads have no hair
Old men's beards are just as bare
Between the cradle and the grave
Lies a haircut and a shave.