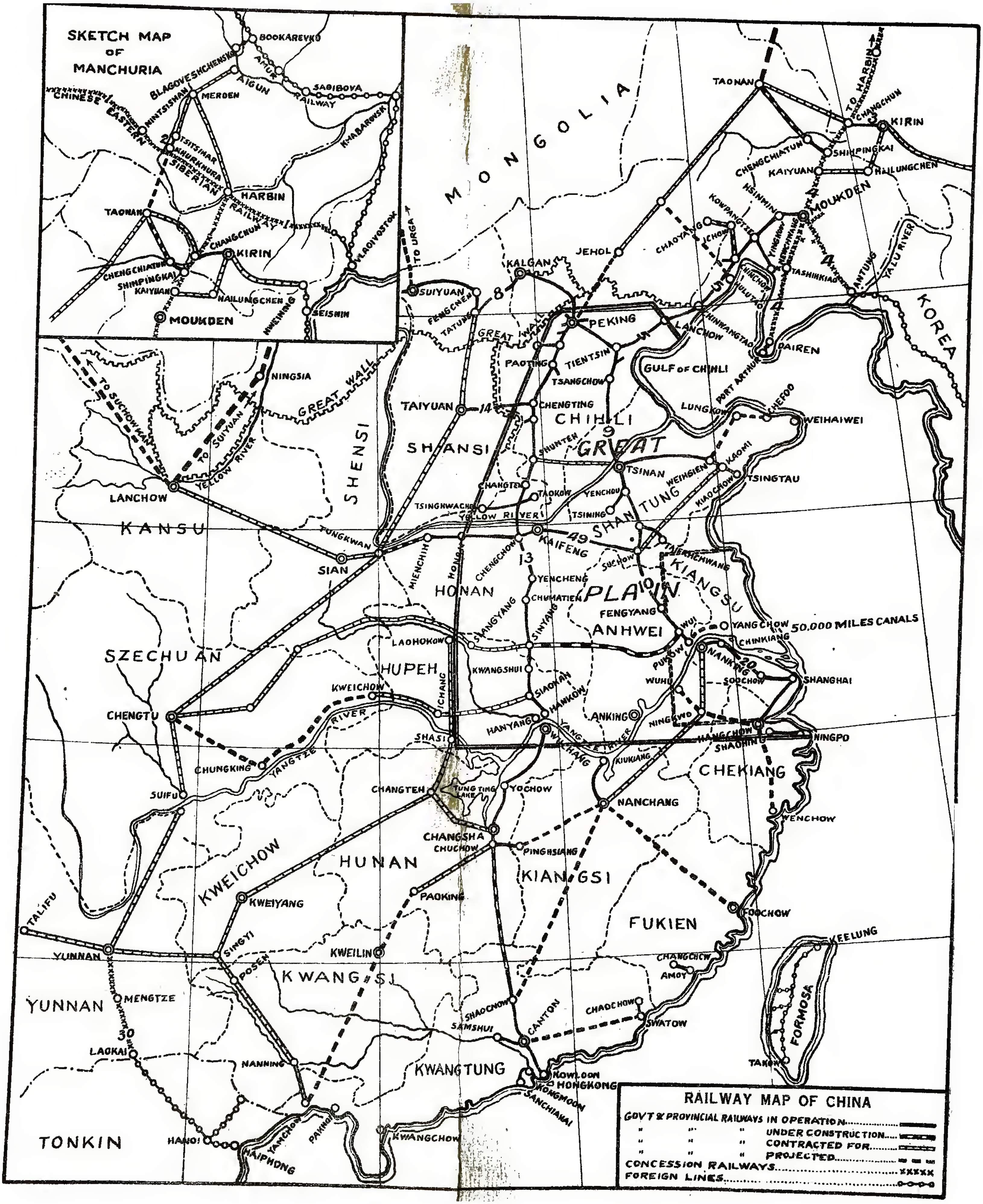
THE CHINESE RAILWAY SYSTEM

By H. STRINGER


SKETCH MAP OF MANCHURIA
BOOKAREVKO
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MERDEN
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KHABAROWSK
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SIBERIAN
HARBIN
TAONAN
CHANGCHUN
KIRIN
VLADIVOSTOK
CHENGCHIATUN
SHIHPINGKAI
KAIYUAN
NAILUNGCHEN
MOUKDEN
SEISHIN
TO URGA
MONGOLIA
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KIRIN
SHIHPINGKAI
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MOUKDEN
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FENGYANG
SINYANG
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YANGCHOW
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HUPEH
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WUHU
SOOCHOW
KWEICHOW
SIAOKAN
HANKOW
CHENGTU
ICHANG
RIVER
HANYANG
ANKING
NINGKWO
WUCHANG
YANGTSE
HANGCHOW
NINGPO
SHAOHING
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PINGHSIANG
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RAILWAY MAP OF CHINA
GOVT & PROVINCIAL RAILWAYS IN OPERATION
" " " UNDER CONSTRUCTION
" " " CONTRACTED FOR
" " " PROJECTED
CONCESSION RAILWAYS
FOREIGN LINES

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SHANGHAI

KELLY AND WALSH, LIMITED.

HONGKONG–SINGAPORE–YOKOHAMA–HANKOW.

1922.

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PREFACE

This book is printed by order of the Board of Communications of the Chinese Government.

I am greatly indebted to Mr. Tang Wen Kao, Director of the Peking-Mukden Railway and to Mr. L. J. Newmarch, Acting Engineer-in-Chief of the same line for making the necessary arrangements with the Board.

The chapter on Pioneer Railway Location may perhaps be criticised as an irrelevancy. It is introduced to direct attention to a question of vast importance to a country which has practically all its railway future still before it, and also because location along pioneer lines is believed to be suited to existing financial conditions.

The Bibliography of the subject is extremely limited. I wish to express indebtedness to the following:—*Railways and Collieries in North China,* C. W. Kinder, C.M.G.; *Construction of the Lu Han Railway,* T. J. Bourne, C.B.E.; *Railway Construction in North China,* E. H. Rigby and W. O. Leitch.

The above are publications of the Institution of Civil Engineers. *Railway Enterprise in China,* P. H. Kent, M.A.; *China Year Book; Far Eastern Review.*

I also wish to express my thanks to the Editor of "Engineering" for permission to reproduce Chapters 5 and 7, which were published originally in that paper, practically in their present form.

TANGSHAN, April 1922.

THE CHINESE RAILWAY SYSTEM.

CHAPTER I

RAILWAY HISTORY

CHINA'S history in this respect began with Sir M. Macdonald Stephenson's attempt to obtain a concession for a railway connecting Soochow with the port of Shanghai, a project now incorporated in the Shanghai-Nanking Railway. This was in 1868 and came to nothing owing to the opposition of Li Hung Chang, then the local Viceroy.

Following this abortive attempt nothing was done till 1876 when the 10 mile railway connecting Shanghai with Woosung at the mouth of the Yangtse was constructed under the supervision of Mr. G. J. Morrison. This railway was of 2′ 6″ gauge, and was used for passenger traffic only. Following on complication with the Central Government owing to the suicide of a native on the railway, it was purchased by China at cost price in 1877, after running for a year. The Government decided not to operate the railway, tore it up and shipped all the materials to Formosa where it was intended to construct a railway, presumably for strategic purposes, connecting the southern and northern portions of the Island.

This island was thus the next scene of railway activity. Here also matters were for a time under the direction of Mr. Morrison, and later Mr. Matheson, both in a consulting capacity only. Military labour was very largely employed here, and owing to inexperience no very rapid progress was made. By 1889, 11 miles had been built and at the time of the Japanese occupation in 1895 about 30 were in operation. The gauge of this railway was 3′ 6″ and the rails 36 lb.

On the mainland nothing important occurred as regards industrial development until 1878 when workable coal was discovered at Tangshan in the province of Chihli about 80 miles east of the port of Tientsin. This was due to Messrs. R. R. Burnett and J. M. Molesworth working under the patronage of Li Hung Chang, then Viceroy of the Metropolitan province, who was desirous of finding an independent source of coal supply for China's mercantile marine, and the Navy then in the making under British advice. In the initial stages of the development of this colliery the coal was transported over a mule tramway seven miles long to the Lutai canal, west of Tangshan, which was connected with the sea. However in 1881 Mr. C. W. Kinder, who had in the meantime become engineer and manager to the concern, managed to overcome local and other powerful prejudice to the extent of allowing the use of a locomotive secretly built out of materials from the scrap heap of the mine. This locomotive replaced the mules and was the beginning of the railway system of the country, for it amply demonstrated to those in authority at the time the economy of rail transport. This great advance made, it was a short step to eliminate the canal altogether with the result that by 1888 the mule tramway had been converted into a railway of 40 miles giving the mines direct access to the sea at the port of Tangku, on the Peiho, about 40 miles below Tientsin, which was also reached by the railway in 1888 (October). Following this the line progressed slowly, owing to financial difficulties and changes of court policy. Eventually the extension westward continued until Peking was reached in 1898. Strategic reasons connected with the great military base at Shanhaikwan on the Great Wall decided the extension East of the Tangshan mine district.[1] This line was completed to Shanhaikwan

[1] This district extends from Tang-shan to Ku-yeh which was connected by rail with Tang-shan in 1890.

in 1893 and had been extended a further 40 miles east of this town by 1896 for military reasons based on the need for rapid access (more particularly in the winter when transport by sea was impossible) to the Manchurian port of Newchwang.

Up to this the railway had been built with Chinese capital, and was in 1894 the sole property of the Government,[2] but the indemnities resulting from the disastrous war with Japan of 1894–5 crippled China financially, and at the same time inspired her with a desire to strengthen her military position in North China. The result of this was the first foreign railway loan contracted with the British for the extension of the above railway eastward to the port of Newchwang. This with the extension towards Mukden to Hsinminfu was completed in the autumn of 1903 and now comprises with the older portions of the line what is known as the Peking-Mukden Railway; for since this date, with the exception of the short extension of 37 miles into Mukden, expansion has stopped, largely as the result of Japanese opposition.

This completes a brief history of the Peking-Mukden Railway, China's first real railway, and it will now be necessary to revert to the year 1896 when Russia and France first came into the field of competition for the development of the country. The Russian Far Eastern policy of this time was inspired by the desire for an ice-free port on the Pacific, a project not possible of attainment without Chinese co-operation. The Treaty of Shimonoseki which terminated the China-Japanese War in 1895 gave Russia an unequalled chance of securing this. By this treaty China ceded to Japan the Liaotung peninsula in southern Manchuria in addition to paying an indemnity. This district contained a port which, it was thought, would on development, meet with all Russian requirements, and its passing to a rising power like Japan inspired such

[2] The China Railway Company which built the line from Ku-yeh to Tientsin was acquired in 1894.

opposition on the part of Russia and France that it was retroceded to China six months later. Further in order to increase Chinese indebtedness, a Russo-French loan of £15,800,000 was raised to pay off the indemnity in part.

As a *quid pro quo* for these good offices China signed the Cassini Convention in March 1896 which ratified the Chinese Eastern Railway agreement made with Li Hung Chang in the previous November. By the terms of this and a later agreement of 1898 Russia was allowed to construct that portion of the Siberian Railway which traverses the Northern part of the Chinese province of Manchuria, together with a branch from Harbin to Port Arthur, which was leased in 1898 as a naval base. Further, Russia acquired all development rights within a railway zone the extent of which was never specified, an agreement practically placing all development in central and northern Manchuria in Russian hands. By the terms of this agreement the management and control of Russia over the railway to be built was absolute, China having no voice whatever, but after the lapse of 36 years the line might be purchased at cost price and after 80 years it became the absolute property of China without payment. In 1895 the Russo-Chinese Bank was chartered to finance and carry through the Russian railway schemes with a capital of £11,200,000 of Russo-French money, and a fixed deposit of 5 million taels of Chinese Government money. The proposed mileage of the railway was 950 for the part to complete the Siberian System, that is from Manchouli to Suifunho, and 646 for the Southern Branch from Harbin to Port Arthur, a total of 1,596 miles.

France as her reward obtained the right to extend projected Annam Railways into Chinese territory, a right not exercised till 1898, though various railway schemes were sanctioned and abandoned by the French in the interval.

In all these negotiations Russia was greatly helped by Li Hung Chang, who was convinced by the results of the Japanese War that only a strong military power could be of real assistance to China in the event of further attempts at aggression and that therefore Russia with a huge army available in the East was the right ally for China, at any rate until the army and navy were modernised; a scheme which he endeavoured to push to the utmost of his ability though with only local success in the case of the army.

As the result of the success of her diplomacy Russia, who thus originated what has since been known as the "conquest by railway and bank" policy, next attempted to gain control of the Peking-Mukden Railway, which by this time had been extended into Manchuria. To do this Russia in 1897 demanded the right to employ Russian engineers on the construction of the extra-mural or Manchurian extension of this line and attempted to secure the dismissal of Mr. C. W. Kinder, C.M.G., who was then chief engineer of the railway. This design failed as the result of representations by the British minister as did also Russian attempts to prevent the British loan for the extension of this railway to Newchwang. The British success in these negotiations resulted from the dismissal of Li Hung Chang, Russia's great ally, from the Chihli vice-royalty, which occurred in September 1897. Finally in 1899 it was mutually agreed between Russia and Great Britain that the Peking-Mukden Railway should never be alienated to any foreign power and that a policy of non-interference should be followed as regards Russian development schemes in Manchuria and those of Great Britain in the Yangtse Valley, an agreement not carried out to the letter by Russia who was in the main responsible with France for the failure of the British to construct the Peking-Hankow Railway.

The construction of the Peking-Hankow Railway was first proposed in 1889 by Chang Chih Tung who was made viceroy at Hankow to push the scheme, and thus make this place the centre of China's steel industry.

The idea met with the approval of the Central Government who pushed the scheme with considerable enthusiasm, so that, pending negotiation for financing the whole line, the British engineers of the Peking-Mukden Railway were ordered in 1897 to begin construction of the first section of 100 miles from near Peking to Paoting-fu. This work was completed in 1899 when this section was handed over to the Belgian syndicate which eventually secured the contract in May 1897.

The awarding of this contract, which marked what is generally known as the beginning of the "battle of the concessions," inspired considerable British and American opposition as China had previously negotiated for this loan with both parties. British opposition was however mainly inspired by the fear of Russian aggression in the Yangtse Valley, as the Belgian syndicate had obviously Franco-Russian proclivities (four-fifths of the capital being later subscribed in Paris), and the completion of this line would be a link in the proposed Russian scheme to join up French interests in South China with those of Russia in the North. However, Russia again carried the day as the terms offered by the Belgian syndicate were at first[3] more advantageous than those proposed by other capitalists and China was persuaded that a concession to a supposedly weak power was most to her advantage after her experiences with Russian methods in Manchuria. British acquiescence to the concession was obtained by a grant of the construction rights for two railways running out of Shanghai, the Ningpo-Hangchow Railway and the Shanghai-Nanking Railway, also the Canton-Kowloon Railway and the Pukow-Hsin Yang Railway which linked up what is now the southern terminus of the Tientsin-Pukow Railway and the Peking-Hankow Railway. American opposition was disregarded as the Spanish War absorbed all attention and energy. To finance these purely British concessions and the loan to the Peking-Mukden Railway, the British and Chinese Corporation was formed in 1898.

This brings us to the year 1898 which marked the entry of Germany into the struggle for concessions and

[3] The concession terms were revised later.

political advantage. German aims were without doubt initially inspired by a desire for a naval base in the Far East.

The murder of two German missionaries in the province of Shantung towards the close of 1897 gave Germany the necessary opportunity which she was not slow to seize, for the port and bay of Kiao Chao, as it was then called, were immediately occupied and the occupation made permanent by a lease of a strip of territory in the following March. Coupled with this agreement Germany obtained exclusive railway and mining rights in the province of Shantung as far as the use of foreign capital was concerned. This agreement enabled Germany to veto the financial arrangements made in 1898 (August), with an Anglo-American syndicate for the construction of the Tientsin-Pukow Railway, a project which was thus delayed till 1908 when the line was constructed by Germany and Great Britain jointly.

The seizure of Kiao Chao was the signal for the making of similar arrangements by Great Britain, France and Russia, who leased respectively in the same year the harbour of Wei Hai Wei also in the province of Shantung, the port of Kwang Chou Wan in Kwangsi province and the ports of Port Arthur and Talienwan in Manchuria.

This gave Germany the province of Shantung as a sphere of influence, for on the occupation of Wei Hai Wei Great Britain agreed to seek no development rights in that province. In this way as a consequence of the mutual distrust and greed of the Powers another sphere of influence was created to retard the natural development of the country. These spheres of influence were as follows: Russia in Manchuria and Mongolia, Germany as just stated, Great Britain in the Yangtse Valley, and France in the provinces of Yunnan and Kwangsi.

In this year also Great Britain obtained the right to construct the Burma-Yangtse Railway a project interfered with by the South African War and never since revived. France at the same time obtained the right to construct the Yunnan-Fu extension of the Hanoi Railway.

The year was also marked by considerable investigation and survey work by the Peking Syndicate, a British concern which had obtained in 1897 the sole right for a period of 60 years to open, work, and construct the necessary railways for the purpose of working the coal, iron, and petroleum deposits in the provinces of Shansi[4] and Honan within an area bounded on the south by the Yellow River and on the north by the Great Wall.

At the same time America by the formation of the China American Development Company first decided to take a hand in China's modernisation. This Company obtained in 1898 the concession for the construction of the Canton-Hankow Railway on exceptionally favourable terms. Owing very largely to Belgian opposition, probably inspired by France and Russia, American management of this concession proved a failure, the concession being cancelled in 1904 on payment by the Chinese Government of £1,500,000. This Company was also responsible for the American surveys made of the Peking-Hankow Railway in 1897.

The year 1898 is thus easily the most momentous in China railway history, possibly in its general history. Its most disastrous feature was the creation of the spheres of influence.

The year 1899 saw little activity beyond the development of existing concessions. The construction of the Manchurian extension of the Peking-Mukden Railway was continued, as was also that of the Chinese Eastern Railway. The only diplomatic event of industrial importance was the signing of the Scott-Muriaveff Convention by which a policy of non-interference was agreed on between Russia and Great Britain in the matter of railway concessions in Manchuria and the Yangtse Valley. In this year also the small railway of 70 miles between Chuchow and the collieries at Pingshiang was completed by American

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[4] The Shansi rights were surrendered in January 1908 on payment of Tls. 2,750,000.

engineers for the Chinese capitalists who then controlled the Hankow steelworks. Further at the same time the completed portion of the Peking-Hankow Railway built by the British engineers of the Peking-Mukden Railway was handed over to the Belgian concessionaires. On this railway 85 lb. rails rolled in Hankow were first used, an event of considerable importance in the industrial history of the country.

This brings us to the year 1900, which incalculably delayed the progress of the country, for in June of this year the anti-foreign Boxer rebellion broke out. The immediate results of this were the stoppage of all railway construction, the occupation of practically the whole of the Peking-Mukden Railway by Russian forces, and the destruction of the line between Peking and Tientsin. Following the fall of Peking the Peking-Mukden Railway was managed by the British Railway Administration, an organisation of distinctly military leanings. This management repaired and ran the railway from Peking to Shanhaikwan, beyond which the Russians were in occupation and by whom considerable construction work was done on the uncompleted portions of the line. On the re-construction of the Peking-Tientsin line the line, previously double-track, was re-laid as single.

This state of things obtained till 1902 when the railway was handed back to the Chinese Government and the Russian and British troops were withdrawn as was also the international garrison at Shanghai, the occasion for which was thought suitable by Germany to announce that in future she intended to compete for railway and other concessions in the Yangtse Valley, thus contravening the Anglo-German agreement of 1898 which defined this as the British sphere of influence. Great Britain, pre-occupied with matters in South Africa, acquiesced with consequent loss of prestige. China paid the price of belief in the powers of a mob of crazy fanatics in an indemnity of £62,000,000, which further crippled finances not yet recovered from the effects of the Japanese War.

The year 1903 was an uneventful one as far as railway affairs were concerned, but work was resumed on the completion of the Manchurian extension of the Peking-Mukden Railway. The Belgian concession for the Pienlo Railway was also obtained.

1904 was another year of diplomatic activity and was marked by the completion of the German concession line from Tsingtau to Tsinanfu. This line was 284 miles long and was a concession railway on the lines of the Chinese Eastern Railway in which China had no voice in the construction or management, the right of purchase at some future unspecified date being merely reserved by her. Germany also held the right to hold and develop mining properties for a distance of 10 miles on each side of this or any other line built by her in the province of Shantung.

America in this year abandoned the concession for the Canton-Hankow Railway and Great Britain as the result of a loan to China for the redemption of the American concession rights, acquired rights of construction for the Hupeh-Hunan section of this railway.

Simultaneously America and Great Britain in conjunction with France (by virtue of the Anglo-French agreement of 1896 by which co-operation was agreed on between France and Great Britain in the development of the provinces of Yunnan and Szechuan) acquired rights for a first option on any loan contracted for the construction of the Hankow-Szechuan Railway.

The Peking-Mukden Railway was completed and the extension into China of the French Laokay-Hanoi Railway begun in this year as well as the construction of the Shanghai-Nanking Railway by the British.

The most important event of the year from every point of view was the outbreak of the Russo-Japanese War, for the subsequent Russian defeat marks the rise of Japan to the position of a first class military power and the birth of the Japanese ambition to dominate China industrially.

The War was brought to a close by the Treaty of Portsmouth in March 1905 by which Russia surrendered all her rights to the Chinese Eastern Railway south of Changchun together with the naval base of Port Arthur and the Harbour of Dalny. The mileage of the main line thus surrendered was about 439 miles, much of which had been converted from the Russian 5′ gauge to the Japanese 3′ 6″ for military purposes during the War. Japan had at the same time hurriedly constructed a 2′ 6″ gauge railway to connect the port of Antung on the Korean border with Mukden the capital of the province of Manchuria. Japan viewing with apparent doubt her ability to finance the costly re-construction of these railways, in this year entered into an agreement with American capitalists for joint ownership and working of the railways and any mining concessions in South Manchuria. The policy which inspired this agreement was quickly reversed and the agreement anulled, the alleged reason being the opposition of the Chinese Central Government, the real being the discovery of ability to borrow British money without any restrictions whatever. This policy of perpetuation of Russian aims decided on, Japan further to protect her interests induced China to agree not to build any line in this province parallel to the South Manchuria Railway. This agreement in Japanese hands has seriously hindered the development of the Peking-Mukden Railway in this province.

At this time American capitalists were also invited to begin negotiations for the flotation of a loan for the construction of the Hankow-Szechuan Railways by Anglo-French capitalists. American interest was however lacking and the scheme was deferred, to the subsequent regret of all, for later Germany demanded and obtained a share in financing the scheme.

In October of this year the construction of the Peking-Kalgan Railway was begun, an event of considerable importance as it was the first railway to be constructed entirely by Chinese engineers. The surplus revenue of the Peking-Mukden Railway provided the funds for this enterprise. The construction of the Peking-Hankow Railway was completed and that of the Kaifengfu-Honan Railway (Pienlo Railway) begun in 1905 under Belgian management.

1906 was a year of considerable importance, for Japan as the result of a loan of £12,000,000 obtained in Great Britain formed the South Manchuria Railway Company with a capital of £20,000,000, half of which was owned by the government. Japanese gratitude for this assistance was shown by the purchase of the whole of the material for the re-construction of the railways in America.

At the same time American negotiations began with Russia with regard to the sale of the remaining portions of the Chinese Eastern Railway, to be carried on in desultory fashion till 1909 and finally wrecked by bad diplomacy, on the part of America.

1907 saw the opening to traffic of the re-built South Manchuria Railway now converted to 4′ 8½″ gauge after being first 5′ and then 3′ 6″. The purchase by the Peking-Mukden Railway of the Japanese light railway connecting Hsinmintun, the terminus of the Peking-Mukden Railway, with Mukden was also made. This line was reconstructed and opened for traffic in the same year.

It should also be stated here that the successful construction of the Peking-Kalgan Railway apparently gave an impetus to railway expansion under purely native auspices about this time, resulting in the formation of various private railway companies without government backing or guarantee. The best known of these was the Chekiang-Kiangsu Railway Company which started to build in 1905 a line given as a British concession in 1898, and the southern section of the Canton-Hankow Railway which took over the American Concession for Kwangtung province in 1904. Another of some note was the Kiukiang-Nanchang Railway Company whose difficulties afforded Japan a chance of interfering in railway finance in the Yangtse Valley. Almost without exception these enterprises have been unsuccessful and have eventually been taken over by the government to be merged into the trunk system.

The year 1908 was chiefly remarkable for the vetoing of the Fakumen Railway project by Japan on the ground that it infringed the parallelism agreement entered into by China with regard to railway construction parallel to the South Manchuria Railway. The proposed line was a branch of 200 miles from the Manchurian portion of the Peking-Mukden Railway. Japan has since done nothing to develop the district affected by this railway. This year also marked the inception of the Anglo-American schemes for the free development of the province of Manchuria in accordance with the provisions of the Treaty of Portsmouth of 1905 by which both Russia and Japan subscribed to the Open Door principle for this region.

For these schemes China is indebted first to Yuan Shih Kai, and in a less degree to, Tang Shao Yi who was appointed governor of Mukden in 1907. With the idea of combating the rise of Japanese power and exercising China's undoubted rights, everything was done to encourage the employment of Anglo-American capital, and this resulted in the proposed founding of the Manchurian Bank, which was to be financed by America and act as the financial agent of the vice-regal government in its development schemes, the first of which was to be the Chinchou-Aigun Railway. For this railway an Anglo-American combination was formed and the construction agreement was ratified by the Manchurian Government in 1909, and by the Imperial Government in 1910. Further than this the scheme has not progressed, partly as the result of a change of policy on the part of the Central Government consequent on the Empress' death in November 1909 but mainly as the result of Russo-Japanese opposition. The Anglo-American rights are of course still valid.

1908 was also marked by Germany's intention to take a larger share in China's development, for at this time she asked for and obtained (in spite of strong British opposition) in 1909 a share in financing the Hankow-

Szechuan Railways. The construction of the Tientsin-Pukow Railway (Northern Section) was also begun under German auspices. In the matter of the Hankow-Szechuan Railway Germany of course broke faith with the British Government as was expected after the German declaration with regard to non-recognition of the Yangtse Valley as a British sphere of influence made in 1902.

At the same time the Central Government was involved in considerable diplomatic difficulty owing to the refusal of the natives of the district traversed by the Ningpo-Shanghai Railway to employ foreign engineers or capital on the construction of this railway. This line was a British concession awarded in 1898, for which a loan of £1,500,000 had been raised and a British engineering staff appointed in 1908.

The Shanghai-Nanking Railway was completed in this year and the Belgian loan on the Peking-Hankow Railway redeemed by an Anglo-Japanese-French loan giving full control to China.

As the result of German machinations of the previous year over the Hankow-Szechuan Railways, America found it necessary in June 1909 to insist on recognition of her claims to participate in the construction of these railways. This was to result in May 1911 in the formation of the Four Nations Group organisation to finance this scheme. This Group consisted of financial representatives of the governments of Great Britain, France, Germany and the United States.

The construction of the Southern Section of the Tientsin-Pukow Railway under British management was undertaken in February of 1909.

The most remarkable railway occurrence in 1910 was the promulgation in January of Mr. Knox's neutralisation scheme for the Manchurian Railways controlled by Russia and Japan. By this these railways were to be bought up by an international syndicate together with all mining rights acquired by either party in Manchuria, control to devolve on the syndicate. Unfortunately America neglected to seek the co-operation of the parties principally concerned who at once combined to upset a scheme aimed at the destruction of their illegally acquired rights in this region. This resulted in the much to be regretted Russo-Japanese Entente with regard to Manchuria, the initiation of another era of Russian expansionist Far Eastern policy and the death of all hopes for the natural development of one of China's richest and most easily opened up provinces.

The construction of the Kirin-Changchun Railway was also put in hand by the Chinese Government who were thus able for the first time to assert their right to develop Manchuria.

Japan however protected herself by saddling the line with a Japanese loan although China had control of the construction and operation of the railway until 1915, when Japan demanded and obtained a ruling voice in the management. The line is 80 miles long and a branch of the South Manchuria Railway.

1911 was mainly remarkable for the Imperial Edict of May 9 relating to railways, which it is said was a contributory cause to the unrest which had been on the increase ever since the death of the Empress Dowager and which finally resulted in the Revolution of the following October which placed the Republic in power. By this edict it was ordained that all trunk lines, under construction or projected, were to be taken over by the Government, while branch lines were to be undertaken by the people according to their ability. This edict, the wisdom of which has since been recognised by the Republican Government, was the result of the difficulties encountered from the provincial control of the construction of the Shanghai-Ningpo Railway and of the proved inefficiency and extravagance of construction undertaken in a number of instances by native companies.

Of the effect of the Revolution on the railways, there was of course a complete cessation of all loan negotiation until 1912, and no new construction was undertaken; while that in hand, notably in the case of the Tientsin-Pukow

Railway, was seriously interfered with. In point of fact the Southern Section of this railway saw the deciding phases of the struggle and was considerably damaged in the process. In the disturbance of 1912 which resulted from disagreements in the revolutionary factions this railway and the Nanking district were again the scene of most of the fighting. During the whole of the disturbances hostilities were confined to the Hankow district of the Peking-Hankow Railway and the Nanking district, the Northern Railways suffering hardly at all owing to the presence of foreign troops agreed to by China in the Peace protocol of 1901. Towards the end of 1912 the now stabilised Republican Government was able to turn its attention to re-organisation and in order to raise money for this the Crisp Loan for £5,000,000 was floated in September 1912 and the five Nation Re-organisation Loan for £25,000,000 in May 1913.

Russia and Japan obtained a guarantee that the proceeds of this loan should not be used for development purposes in Manchuria and Mongolia.

1913 was remarkable for the inauguration of a forward railway policy by the Republican Government which resulted in arrangements for a number of loans for constructing new and old concessions. Further a commission was appointed to unify railway accounts and statistics, a much needed reform which has brought China into line with the most up to date in this matter. The contracts and agreements signed in this year were as follows:—

Tatungfu-Chengtu Railway.—The contract for this, a line about 960 miles long was awarded to a Franco-Belgian Corporation. This line will connect Tatung on the Peking-Kalgan Railway with Chengtu in the province of Szechuan, which is also the proposed junction of the Hankow-Szechuan Railways and the Yunnanfu-Szechuan Railways.

Sinyang-Pukow Railway.—The final agreement for this, a concession granted to the British and Chinese Corporation in 1898 was signed in November.

Shasi-Singyi.—This contract was signed on December 18 between Pauling and Company, the British contractors and the Board of Communications. The terms were a new departure for China the line being constructed on a percentage of cost basis and pledged as security to the builders.

Arrangements were also made with the Germans to start construction and raise the necessary capital for the system of railways allocated to them in the province of Shantung and negotiations took place between the Japanese and Chinese Governments for the construction of a network of railways in South Manchuria.

In November of this year a contract was signed with the Banque Industrielle de Chine for the construction of harbour works at the port of Pukow on the Yangtse opposite Nanking and the construction of a bridge over the Yangtse River at Hankow. This was followed in 1914 by another agreement for a railway through the province of Kiangsi to the capital of Yunnan province, a distance of about 1,000 miles. The above bank is a Sino-French concern and this agreement is of some subsequent importance.

In addition to the agreements just cited an agreement was signed with the British and Chinese Corporation in March 1914 for the construction of a railway from Nanking to Hunan connecting with the Hankow-Canton Railway at Chuchow south of Changsha, the estimated length of line being about 1,000 miles for which it was proposed to raise a loan of £8,000,000. Two small provincial companies were to be taken over and incorporated in the new line. An engineer-in-chief was appointed and considerable survey work was undertaken from this time until 1916 when all work stopped owing to the War.

This also was the subsequent history of the Pukow-Sinyang Railway on which a small amount of construction work was done in addition to survey. Survey work on the Hankow-Szechuan Railway was also put in hand to be stopped in 1916 when it was decided to concentrate all efforts on the completion of the Hupeh-Hunan section of the Canton-Hankow Railway as this railway was nearing completion as regards the length as far south as Changsha.

During 1914 the government took over the two sections of the Kiangsu-Chekiang Railway from the provincial companies whose management had not been financially successful and whose construction capital was exhausted. The management of these lines was handed over to the Shanghai-Nanking Railway who undertook the connection of the termini at Shanghai a length of 8½ miles and made fit for operation the partially constructed 60 miles at the Ningpo end of the line. This work was completed in 1916. The German Tsingtao Railway re-opened in November 1914 under Japanese management.

With the exception of the above the outbreak of the European War completely checked all railway activity, all the big schemes being left in abeyance owing to the state of the international money market.

1915 was chiefly remarkable for the presentation by Japan in January of the Twenty-One Demands in which exclusive privileges were demanded for Japanese subjects in Manchuria and railway rights not only in Shantung and Manchuria but also in the Yangtse Valley, for a railway connecting Nanchang with Hangchow on the Coast, and another connecting Nanchang with Wuchang opposite Hankow. This last demand infringed British rights and was not agreed to, but China had to consent under protest, in which she was joined by the Allied powers, to the Japanese inheritance of German railway and other development rights in Shantung, the extension of the leases of the South Manchuria Railway, with the Antung-Mukden Railway and the ports of Dalny and Port Arthur, to a term of 99 years and the handing over of the control and management of the Kirin-Changchun Railway. Japan also acquired priority rights for capitalising railway and other developments in Eastern Inner Mongolia.

The most important event of 1916 was the outbreak of the Civil War which seriously interfered with the construction of the Canton-Hankow Railway and reduced the earning power of the open lines, more particularly the Peking-Hankow Railway.

An agreement of considerable importance was also concluded with the American Siems Carey Corporation for the construction of some 1,500 miles of railway and the reconstruction of the Grand Canal. This involved the Government in considerable difficulty as the first railway proposed infringed Russian rights, the second French rights in the province of Kwangsi, acquired by virtue of a secret treaty in 1914 in which year a French Company also secured exclusive rights for the construction of a railway from Yunnanfu to Suifu in the province of Szechuan thus ignoring British rights. Finally the railway settled on was the extension westwards into Szechuan of the Pukow-Sinyang Railway and presumably a natural development of that British concession.

Towards the end of the year the deviation line of the Peking-Mukden Railway bringing the port of Chingwangtao into direct connection with the Peking-Mukden Railway was completed and opened for traffic.

An agreement was also signed in March with the Russo-Asiatic Bank for the construction of the Harbin Mergen-Blagoveschensk Railway a length of 666 miles for which a loan of £5,000,000 was to be raised on the termination of the War.

In 1917 Japan protested that the Grand Canal scheme of the Siems Carey Corporation just cited infringed her special rights in the province of Shantung acquired as the result of the Twenty-One Demands and as a result was admitted on terms little short of equality in the loan of £1,200,000 to be floated to finance this.

The same year saw the declaration of war with Germany and the consequent elimination of all German elements from the management of the Tientsin-Pukow Railway (Northern Section). Chinese personnel almost entirely replaced the German on this line.

Severe floods also caused great damage to the Peking-Hankow Railway to such an extent that it was practically closed to traffic for three months over a large portion of its length. The northern section of the Tientsin-Pukow Railway also suffered considerably.

The year 1918 was chiefly memorable from a railway point of view for a record financial year for the railways under government control and this in spite of the fact that the Peking-Hankow Railway did not have a normal year owing to disturbances due to the civil war. The following are average results:—

Revenue per Kilometre	$14,195	best $21,392
Expenses ,,	$ 6,274	
Net Revenue	$ 7,921	best $14,311
Interest, etc., @ 5%	$ 2,844	
Surplus	$ 5,077	
Operating Ratio	44%	best 33%
Per cent. earned before paying interest and improvements	10.4%	best 22.7%

Japan also constructed and opened for traffic the Ssupingkai branch of the South Manchuria Railway whose proposed westward extension to Taonanfu will infringe the Anglo-American rights acquired under the Chinchou-Aigun Railway agreement of 1910.

Further Japan made loan agreements in October for the construction of four lines in Manchuria with a mileage of over a 1,000 and an estimated cost of £15,000,000. These are as follows:

From Taonanfu to Jehol and from Taonanfu to Changchun. From Kirin to Kaiyuan and from a point to be selected on the Taonanfu-Jehol line to a seaport, a line presumably crossing the Peking-Mukden Railway, while the Taonanfu-Changchun line is also a proposed branch of the Chinchou-Aigun scheme.

At the same time the Japanese Government expressed a desire to reach an understanding with China on the question of railways in Shantung and obtained the following concessions previously held by the Germans. Kaomi on the Tsingtau Railway to Hsuchoufu on the Tientsin-Pukow Railway; and from Tsinanfu on the Tientsin-Pukow Railway to Shuntefu on the Peking-Hankow Railway. The total mileage of these concessions is about 460, estimated to cost £7,000,000.

Simultaneously Japan put forward a scheme for the establishment of a National Ironworks under the supervision of Japanese experts, the loan for this to be 100 million Yen.

With the Armistice the question of unification of railways was first mooted. The instructions given to the Chinese delegates in Paris as to the future railway policy were as follows:

All railways constructed, under construction or to be constructed under existing agreements by foreign capital shall be consolidated under one uniform management and the capital of these railways consolidated into a joint loan with the railways as security. The Chinese Government shall employ foreign experts to assist the Chinese in the administration of the railways until such time as China shall have repaid the loan.

There followed as a logical consequence of these Chinese proposals the initiation of the Banking Consortium to finance China. The aims of this Consortium are:

1. Apart from industrial and railway loans at present being carried out all present and future loan agreements and options shall pertain to the new Consortium. If any contracts or options are held by financial interests not members of the Consortium means shall be devised to induce them to hand these over.

2. Russia to be included when a recognised government is formed and also Belgium as soon as feasible.

3. The Groups forming the Consortium each represent one national group only and may not act as agents for other national interests.

4. Industries and railways shall be dealt with as a comprehensive whole and the Consortium shall instruct their engineers and representatives to suggest and submit a comprehensive programme.

5. The Japanese Group to participate on equal terms in the Hukuang Railway loan.

Summed up, these aims mean solidarity in international finance and the end of the spheres of influence and special rights which have done so much to retard the development of the country. Realisation of these aims is still very much in the air however for things have been complicated by the refusal of the Sino-French Banque Industrielle de Chine to join the Group and the Japanese attitude over the exclusion of Manchuria and Mongolia from the scope of the Group. The concessions of the French Bank are of great potential value and the capital necessary for their development is estimated at $225,000,000, while if the Japanese contention is allowed they sacrifice nothing by joining the Consortium. It is to be hoped that it will be found possible to reconcile the various divergences of opinion, for on the supply of foreign capital the development of the country hinges.

In 1918 a Railway Clearing House was founded in Peking to deal with the through booking arrangements instituted by the Government and foreign lines. As a result of a traffic conference held in 1919 the scope of this department is to be enlarged to admit of a more satisfactory system of car interchange. Rules have been made to regularise interchange, the chief of these being that no wagon is to remain away from its home line more than 12 days and that equivalent car capacity must be provided by the foreign line. The difficulty which will make the scheme of limited usefulness, until standardisation of rolling stock is found feasible, is the multiplicity of standards of car design prevailing which makes repairs away from the home lines a virtual impossibility.

In 1919 apart from the Consortium negotiations, the only events of railway importance were the appointment of a foreign commission of experts to deal with railway standardisation matters, and the Japanese loan of 3,000,000 Yen for repairs and reconstruction on the Peking-Suiyuan Railway, a line never before mortgaged to a foreign power. In making this loan, it is apparently tacitly assumed that Japan has somehow inherited the Russian priority rights of finance for this line, acquired as the result of an agreement made in 1912.

An event of minor significance was the amalgamation of the Peking-Suiyuan and Peking-Hankow Railways which should result in considerable economy as far as administration is concerned.

As a result of the cancellation of Mongolian independence, the Peking-Urga Railway project has been revived after being pigeonholed since 1912. The railway would, at any rate initially, be purely strategic.

The year was fairly satisfactory from a railway point of view, but there were further disturbances in Hunan which interfered with the construction of the Canton-Hankow Railway, the northern 200 miles of which were added to the open lines, the total addition to which amounted to 505 kilometres or 316 miles. 384 kilometres were under construction during the year.

The most important event of the year 1920 was the unexpected announcement in July of Japanese acceptance of Consortium terms entirely without reservation as to Manchuria and Mongolia.

Railway finance was stagnant, but in May a loan agreement was signed with a Dutch syndicate in co-operation with the Belgian-Chinese Railway and Tramway Company. The Dutch Syndicate Neerlandaise is to issue 50 miliion florins for the construction of the port and railway between the Tientsin-Pukow Railway and the sea. The Belgian concern will issue 150 million francs of which half at least is for the construction of the west section between Kwang Yin Tang and the Yellow River. China will receive 91% and pay interest at 8%. The terms generally are drawn on the line of the 1912 agreement for this line, with preference as to purchases to the countries supplying the money.

Further in November 1920 a loan agreement was signed with The Peking Syndicate for a 75 kilometre extension to the Tao Ching Railway, constructional control being vested in the Syndicate.

Also on October 2, an agreement was signed between the parties concerned in the control of the Chinese Eastern Railway, which placed the railway under a Russo-Chinese Board of directors. The main provisions of this agreement are given in Chapter 4.

Lack of funds prevented any new construction work of any magnitude, while the open lines suffered considerable disorganisation as the result of the trouble in the North which resulted in the fall of the Anfu party and its replacement by the Chihli party in August. The railways principally affected were the Peking-Mukden and Peking-Hankow Railways, which were practically under military control for a period of six weeks.

As the result of the change of government the Urga railway scheme was shelved once more and the amalgamation of the Peking-Suiyuan and Peking-Hankow Railways was revoked. Control of the Board of Communications passed to Mr. Yeh Kung Cho, an official with great experience in the conduct of railway affairs.

From the railway point of view the year 1921 will rank as no *annus mirabilis* in China's annals.

Railway finance was again dull. Apart from the Railway Car Loan for some 6 million dollars practically nothing was done. This loan though small is worthy of record as being China's first attempt to finance herself from within. The loan was floated by an Association of 27 Chinese Banks. The terms are very moderate, the issue price being 95 and interest 8%. The object of the loan being to provide rolling stock for the Peking-Suiyuan, Peking-Hankow, Tientsin-Pukow, and Shanghai-Hangchow Railways, the loan is secured on the revenues of these lines, the banks also reserving supervision rights over these lines in case of default.

Financial disaster was a feature of the year. The Banque Industrielle stopped payment in May and there was a financial crisis in Chinese finance in November, which the government banks managed to weather. These confidence-shaking factors coupled with a "wait and see" attitude for which the Washington Conference was responsible were accountable for a state of financial suspense. The Consortium still awaits recognition and the attention of the Washington Conference has so far been concentrated, as far as railways are concerned, on the settlement of the Shantung question. China has agreed to purchase the Shantung Railway for its cost price of 53 million gold marks plus any betterments for which Japan has been responsible.

What railway construction work has been done has been mainly in the nature of development work for existing lines.

Considerable activity has been shown on the Peking-Mukden line where the construction of the Chaoyang mineral line of 120 miles has been started. The line is also being double-tracked from the mine district to the sea-port of Chinwangtao, a length of about 90 miles. For this work a short term loan has been arranged with the British and China Corporation. Further the line from Shanhaikwan east to Chinchou was relaid with an 85 ℔. rail—a distance of 114 miles. Four hundred 40 ton cars were also ordered during the year.

A foreign Commission of engineers was appointed to adjudicate on the tenders for the reconstruction of the 3,000 metre bridge over the Yellow River crossing of the Peking-Hankow Railway. The contract was awarded to a Belgian firm in co-operation with Pearson and Company, the British contractors. The southern portion of this line was placed under military control during the latter part of the year.

The Northern Section of the Canton-Hankow Railway was under military control for four months of the year. Construction has made no progress owing to lack of funds.

On all the government lines an effort was made to acquire additional rolling stock. The contracts for rolling stock to be purchased by the Car loan were awarded in June, the order being divided between the Peking-Hankow, Peking-Suiyuan, Shanghai-Hangchow and Tientsin-Pukow Railways.

The metric system was adopted during the year as standard for the railway service.

APPENDIX.

Woosung Railway.

The earliest steps in this matter were taken in 1865 by Shanghai merchants, Jardine, Matheson & Co. being prime movers. Land was bought and Mr. H. Robinson selected as an engineer. Capital gave out and the scheme was dropped until Mr. A. Sheppard, instructed by Mr. Gabrielli was sent out in 1874. Mr. Sheppard made the necessary survey and did some construction work. The work was then stopped. In 1875 the scheme was placed before Mr. Rapier of Ransome and Rapier who advised a 30″ gauge and 26 lb. rail. This suggestion was adopted and work was started in January 1876 under the superintendence of Mr. G. J. Morrison who completed the line.

CHAPTER II.

THE GROWTH OF THE RAILWAY ADMINISTRATION.

IN the early days of the Western invasion, China's decentralised form of Government, that is Viceroy rule loosely controlled by hyperbolic and often ambiguous edict from the Son of Heaven, naturally conduced to personal treatment of questions relating to the adoption of Western ideas.

Thus it was that Li Hung Chang, when Governor of Kiangsu in 1863, sure in the support of reactionary Peking, was able to quash the petition of Shanghai merchants for a concession to construct a railway from Shanghai to Soochow. He also incidentally checked all ideas of railway construction under entirely western auspices, by the announcement that China, when she felt the need of railways, would construct them herself and at her own time. This wrecked Sir M. Macdonald Stephenson's schemes for a trunk system, and postponed the advent of railways till the abortive tramway attempt of the Woosung Railway in 1876.

Li Hung Chang, mistakenly conservative in what he believed at the time to be China's best interests, was destined to be China's greatest pioneer in all matters relating to the spread of Western notions and ideas. A native of the province of Anhui, of an official but inconspicuous family, excelling in Chinese learning, he only came to the front when transferred from civil government to a post on the staff of general Tseng Kuo Fan at the time of the Taiping rebellion. Eventually the suppression of this ghastly and lengthy rebellion was largely due to him assisted by the "Ever Victorious Army" under General Gordon, and it was to the experience gained during this period of Western methods and ideas that he owed his pre-eminent position as an administrator of foreign affairs.

He has been not inaptly called the Greatest of China's many Great Men, not unjustly when it is considered that he piloted a ship of state progressively unseaworthy, for a period of 25 years through the uncharted seas of Western diplomacy. Unquestionably he was the first to perceive the corollaries of the impact of the West upon the East, to realise China's military impotency and the crying need of Westernisation solely for defensive purposes, and to foresee the outcome of Japanese modernisation. His appreciation of these matters led him to discourage to the utmost of his ability reactionary and anti-foreign tendencies which only had the effect of involving China with the West, while he instituted in his own viceroyalty of Chihli a re-organisation policy in the hope of bringing China into line with Japan. The outcome of this policy was the creation of the Peiyang squadrons with the assistance of Captain Lang, the fortification of the naval bases of Port Arthur and Wei Hai Wei with German and French aid, and thorough re-organisation of the military forces of the province, also under German tutelage. The need of independent coal supply for his navy and also for the China Merchants Steamship Company in which he was largely interested led Li, in conjunction with Tong King Sing, to encourage the mining ventures at Tangshan in 1881 and the building of the earlier portions of the Peking-Mukden Railway. Later, appreciation of the strategic value of railways ensured his continued support of the extension of this railway through a long period of financial difficulty and reactionary opposition in Peking; policy which bore fruit in the creation of an Imperial Railway Administration in 1891 for the extension to Shanhaikwan from Kuyeh and the placing of the whole line under Government control in 1894. The creation of the Government railways is thus Li Hung Chang's work but the encouragement of industrialism was another of his multiple activities, for he took a principal part in the foundation of the cotton and silk spinning industry in Shanghai. Li Hung Chang's place in history rests on his fame as a great negotiator and not as a pioneer, for, from the period of the Taiping rebellion until his death in 1901 he had the thankless and dangerous task of limiting to the best of his ability a process of spoliation, a result in the majority of cases of Peking's obstinate perseverance in the belief of Chinese pre-eminence in matters of intellect, civilisation and military might. He conducted the negotiations, which led to the Treaty of Livadia Revision in 1880 over the Russian invasion of the province of Ili, he made the treaties which terminated the French War of 1884, the Japanese War of 1894, which was his downfall, and finally the negotiations terminating the Boxer rebellion. In every case he extracted the utmost for his country, making capital out of the dissensions and jealousies of the Powers concerned and pursuing, with a courageous contempt for the make-believe party in Peking the only possible course open to a clay-footed colossus. He had to purchase powerful friendship and if he chose Russia, who in the light of present events is to decry him? Li Hung Chang was a patriot, and his greatest quality unswerving loyalty to his Empress to whose continued support he owed all, even life itself.

To revert, after the victory of Li Hung Chang's early reactionary policy over the question of the Soochow Railway, European schemes were pigeonholed for better days, and it remained for Ting, Governor of Formosa and Fukien to revive interest in railway matters by the suggestion that the building of strategic railways in Formosa might be of considerable assistance in the long continued pacification of that turbulent isle. Ting was succeded in his governorship by another progressive, Liu Ming Chan, whose schemes were considerably advanced by the bombardment of the capital of Formosa during the French War in 1885 and the subsequent proposed removal of the capital inland, a scheme entailing the provision of railway communication with the coast. Liu Ming Chan resigned his governorship to a non-progressive in 1891 and his railway policy was reversed, rather fortunately, as Formosa was ceded to Japan in 1895. Later in 1889 we find him supporting Chang Chih Tung in his advocacy of the Peking-Hankow Railway construction.

Following Ting's proposals for Formosa, Li Hung Chang and Tong King Sing started the mines at Tongshan, and the Kaiping tramway in 1878. Tong King Sing was at this time Director General of the China Merchants Steamship Company. He visited England in connection with mining matters in 1882; as a man of business he was not remarkable.

It was as the result of opposition to the extension to Tungchow of the railway just mentioned that Li's great rival Chang Chih Tung is first heard of in connection with railway matters. He, assisted by the re-actionary party actuated by smaller motives, bitterly opposed the linking-up of the capital and the sea by railways, on strategic grounds, based on increased vulnerability, China being already powerless at sea. As an alternative he suggested the construction of the Peking-Hankow Railway, advancing the opinion that at the initial stages foreign nations only constructed trunk lines and also urging the strategic value of the scheme. This was in 1889 and he and his party prevailed with the consequence that the construction of the Peking line was postponed till 1897. The bridge over the Peiho at Tientsin was abandoned when practically complete, also as a minor result of this retrogressive victory.

The most unlooked for result of Chang Chih Tung's proposal for the construction of the Peking-Hankow Railway was his immediate transfer to Hankow for the promotion of the scheme. There he was to learn the futility of attempting—at the then stage of the country's development—such a vast undertaking without the assistance of foreign capital, and to initiate between the years 1890 to 1895 the Government Steel Works at Hankow. Again in 1895, fired by patriotic fervour and the need for wholesale reform revealed by the complete breakdown of the Japanese War, he memorialised the Throne on the question of constructing the Peking-Hankow Railway and further proposed its extension to Canton and advocated construction of a line between Shanghai and Soochow. Unpractical as always, these lines were to be constructed with Chinese capital only, their purpose being entirely strategic, no other developments were to be permitted, the sole idea being to eliminate as far as possible transport by sea where he considered China most hopelessly vulnerable. In detail, the scheme was worthy of the man who proposed to oppose the landing of Japanese troops by digging concealed pits on the coast, but the main idea bore fruit and the construction of the railway was begun by the administration of the Peking-Mukden Railway, then called the Imperial Railways of North China.

With the construction of the Peking-Hankow Railway the concession era began, and it was to cope with these thorny problems that the Board of Control for Mines and Railways was created in 1898 as an offshoot of the Tsung Li Yamen which since 1860 had controlled all questions relating to foreign affairs. The first Chief Commissioners of this body were Wang Wen Shao and Chang Yun Hua. As an institution it was characterised by no great virility, and railway business continued on the same personal and somewhat haphazard lines as before. This Board disappeared with the Tsung Li Yamen in 1906, to be succeeded by the present Board of Communications which also failed to check the decentralisation process which still remains an ineradicable feature of government, though now less pronounced in the railway department than in others.

To return to Chang Chih Tung, in 1904 we find him active in the negotiations which resulted in the abandonment by the American-China Development Company of the Canton-Hankow Railway concession, and also urging on the Dowager Empress the need for radical reform in educational matters with the result that the old classical[5] examinations for official appointment were abolished, but,

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[5] These examinations were revived on Western lines in 1906, but successful candidates were not employed.

characteristically, replaced by no substitute, thus adding fuel to the ever increasing fire of discontent.

Later he continued to be prominent in the "sovereign rights," and "China for the Chinese" agitation which bore fruit in the well-known Pukow terms for railway loans. The Four Power Group negotiations for the Hukuang Railways werc his work completed just before his death in October 1909. Typical mandarin of the old régime Chang Chih Tung was a lukewarm advocate of the centralisation policy and supported a certain degree of local autonomy in railway matters. A great scholar, absolutely impeccable, patriot before all, Chang Chih Tung commanded universal respect and unquestionably wielded enormous influence which was, as in the case of his prototypes Tso Tung Tang, Tseng Kuo Fan and Liu Kun Yi, as often as not misdirected, owing to political myopia which refused to look facts in the face and continued to invest with reality the mirages of the old conservatism.

Chang Chih Tung's declining years were remarkable for the rise to power of the Young China party under the ægis of Li Hung Chang and his great protégé Yuan Shih Kai, who, re-actionary to the extent of supporting the Empress Dowager in the *coup d'étât* of 1898 which wrecked Kang Yu Wei's drastic reform programme, and left China with a puppet Emperor, both realised that the Manchu policy of excluding the foreign-educated was not only futile but a grave menace to political stability. Thus it was that the members of Yung Wing's United States educational mission of 1875 came to the front; the most prominent being Tang Shao Yi, once Premier of the Republic and holder of high office under the Empire; Liang Tun Yen ex-president of the Wai Wu-pu; Sir Cheng Tung Liang, K.C.M.G., Minister in Berlin, First Secretary in London in 1897, and Director-General of the Canton-Hankow Railway in 1909; Liu Yuk Lin, Minister in London; Jeme Tien Yu, who emerged from the comparative obscurity of a divisional engineer on the Peking-Mukden Railway in 1905, to build the Kalgan Railway and subsequently hold a pre-eminent position as an expert on Chinese railway affairs. Tong Kai Son who represented China at the Hague Opium Conference, was another prominent member of this mission.

Of these, Tang Shao Yi, together with two officials of the old but progressive type, Sheng Kung Pao and Tsen Ch'un Hsuan, made the railway history of the period 1904 to the outbreak of the Revolution in October 1911. In the case of Tang Shao Yi and Sheng Kung Pao, as regards railway matters, it must be remembered that they were in the position of subordinates carrying out the policy of Yuan Shih Kai in the case of Tang Shao Yi, and Li Hung Chang and Yuan in the case of Sheng Kung Pao. Yuan Shih Kai is therefore entitled to more than passing mention.

Yuan Shih Kai, Li Hung Chang's faithful henchman, owed his first prominent appointment as Chinese Resident at Seoul to his patronage and rendered good service there for 12 years in asserting China's rights as suzerain power in Korea. Viceroy of Shantung in 1900, and deploring the anti-foreign policy of the Government, he sternly repressed all disturbance in his province, and was promoted to the Chihli vice-royalty in the following year, succeding his great patron in this position and continuing his policy until the Russian defeat upset the political equilibrium of the Far East and the World generally in 1904–5. He was active in 1904 in co-operating with Chang Chih Tung on the question of educational reform. Following the Russo-Japanese War Yuan Shih Kai inaugurated a pro-Anglo-American policy for the development of the province of Manchuria on the lines laid down in the Treaty of Portsmouth, a policy which was to send Tang Shao Yi to America on a special mission, and later make him Governor of Mukden. Unfortunately for China Yuan Shih Kai was dismissed from office in January 1909 and his policy with regard to Manchuria was reversed at once to become pro-Japanese in tone. Yuan remained in retirement till made Hukuang Viceroy on the outbreak of the Revolution in 1911 and from this time till his death in 1916 he was

China's most prominent man, guiding her through the troublous times of revolution to the creation of the Republic, in which as a convinced monarchist he had little faith, his term of office as President being a virtual dictatorship. Holder at one time or another of practically every high office under the Empire, Yuan was Director-General of the Northern Railways in 1902 and it was as a result of his policy in that position that the Kalgan Railway was built, the first large railway undertaking to be placed under purely Chinese management.

Tang Shao Yi, protégé of Li Hung Chang rose to power with Yuan Shih Kai whose secretary he was while Korean Resident. Director of the Imperial Northern Railways in 1900 and subsequently in 1906 of both the Peking-Hankow and Shanghai-Nanking Railways, he rose to great power for a short time in 1907, holding simultaneously the offices of President of the Board of Communications, Vice-President of the Wai Wu Pu and High Commissioner of Customs. Suffering temporary eclipse the same year, he was sent to America over the organisation of the Manchurian Bank to be financed by New York, and on his return became governor of Mukden in which capacity he conducted the abortive negotiations with regard to the construction of the Fakumen Railway by British capital, and also the initial arrangements with Anglo-American capital over the Chinchou-Aigun Railway. Resigning this post on the fall of Yuan Shih Kai he again held appointments in the Board of Communications until made President on the dismissal of Sheng Kung Pao in October 1911. In railway matters as a great believer in the Young China movement, he supported the "sovereign rights" party in their agitation for local autonomy over the Shanghai-Ningpo Railway and thus encouraged the decentralisation policy which subsequent events showed to be extremely unwise. Extremely prominent during the Revolution, first as Imperial Delegate, and later as first premier in which capacity he showed consummate skill in loan negotiation with the foreign Powers financing the Republic, he resigned the Premiership in June 1912 to become Adviser to the President (Yuan Shih Kai) on state affairs.

Sheng Kung Pao, another satellite of Li Hung Chang, but an official of the old type, took a leading part in all the early railway loan negotiations. Appointed in 1896 Administrator General of the Lu Han (Peking-Hankow) and Southern Railways he was responsible for the loan agreements for the Peking-Hankow, Peking-Syndicate, Chengtai, Pienlo, Canton-Hankow, and Shanghai-Nanking Railways. He was appointed Junior Vice-President of the Board of Communications in March 1908 and became its President in 1911, in which capacity he negotiated the Hukuang Railway Loan, and as an ardent advocate of a centralisation policy for railways, was responsible for the famous edict of May 1911 which decreed that all trunk lines under construction or projected were to be taken over by the Government and that branch lines might be constructed by the people according to their ability. This edict precipitated the Szechuan Revolt which was to usher in the Revolution and caused Sheng's disgrace, dismissal and retirement to Japan. Throughout an advocate of westernisation he was one of the largest shareholders of the China Merchants Steamship Company, and the Hanyang Ironworks and was unfortunately largely responsible for the introduction of Japanese capital which has deprived the steel works of much of its usefulness as a national asset. He died in 1916.

Tsen Ch'un Hsuan, also an official of the old type, is remarkable as having perceived the benefits of a national system of railways. After holding many important appointments he was created President of the Board of Communications in 1907 in succession to Tang Shao Yi and while in that position strongly advocated repressive measures in dealing with the attitude of recalcitrant provincials in the matter of the Shanghai-Ningpo Railway, advice which was unfortunately disregarded. His tenure of office was also noteworthy for a memorial showing extraordinary appreciation of the country's railway needs as set forth in a proposed trunk system. In February 1912 he was appointed Director-General of the Hukuang Railways, a position resigned in June 1913.

Sheng Kung Pao's centralisation policy, though repudiated by the Manchu Government, was revived by the Republican Government and has since been persevered in, with the result that practically all railways except the concession lines are now under Government control. Under the Republic a railway construction programme was agreed on, the outcome of which was the numerous railway loan agreements made in 1913. With extended control the Board of Communications has been able to systematise railway operation by the inauguration in 1913 of a system of railway accounts and statistics. This most necessary reform was carried out by a commission under the presidency of the present (1920) Minister of the Board H.E. Yeh Kung Cho and Dr. C. C. Wang. Further in 1918 a Railway Clearing House was instituted for facilitating car interchange, and through booking arrangements, while in the following year a commission assisted by foreign experts was appointed to review the question of standardisation as a whole. With these reforms China's railway administration may be said to have passed the pioneer stage. The first comprehensive railway report, issued in 1915, signalises this.

CHAPTER III.

THE GOVERNMENT RAILWAY SYSTEM.

Chinese Government Railways 1918–1919.

Kilometres.

1918	5,524
1919	6,027 (420 Kilometres Branch Line)

Cost per Kilometre.

1915	$75,226
1918	$78,275
1919	$81,144

Operating Cost per Kilometre.

1916	$5,250
1918	$6,274
1919	$6,426

Cost Rolling Stock.

1918	$72,185,670

Trains per Day.

1918	12
1919	11

Total Train Kilometres.

1918	23,398,242
1919	24,702,583

Operating Cost per Train Kilometre.

				Maintenance.		
	General.	*Traffic.*	*Running.*	*Equipt.*	*Way.*	*Total.*
1918	$0.28	$0.18	$0.35	$0.30	$0.35	$1.45
1919	$0.27	$0.20	$0.37	$0.31	$0.39	$1.54

Number of Locomotives. Total.

1918	653	(320 Goods.)
1919	707	362 Goods. 136 Shunting.

Average Tractive Capacity Tons.

1919	9·609 Passenger.
	10·579 goods.

Kms. run per year per locomotive.

1918	47,152
1919	47,654

Number of Goods Cars.

1918	10,772
1919	11,273

Total capacity Tons.

1918	246,849
1919	265,185

Tons hauled per Year.

1918	18,551,684
1919	21,391,078 (2% only, through shipments).

	Ton Kilometres per year.		*Goods Train Kilometres.*
1918	3,425,807,677	34% Mineral, 32% Agricultural	13,295,485
1919	3,863,101,876	50% Mineral, 20% Agricultural	14,304,886

Tons per Train.		*Tons per Kilometre of line.*
1918	257 Tons	3,357
1919	270 „	3,353

Cost Coal per Train Km.		*Per Engine Km. Kilogs.*	*Kilogs. per Train Km.*	*Price (per ton)*
1918	0.21	18.76	26.98	$7.86
1919	0.22	18.43	27.29	$8.13

Maintenance per Kilometre per annum.		*Track only.*
1918	$1,509	$493
1919	$1,602	$613 labour 32.3%

Engineering employees per kilometre main line.	
1918	3.8
1919	4.2

Track.—The following are the regulations of the Government with regard to axle loads on different weights of rail:

Weight of rail.	*Axle load.*	
30 to 45 lbs.	8 tons	
60 to 75 lbs.	13 tons on drivers	12 on stock
80 to 100 lbs.	20 tons on drivers	15 on stock

The rail weight standard for all main lines in the country is the 85 lb. with the single exception of the Peking-Mukden Railway, 231 miles of which is laid with 60 lb. rail. The timber sleeper is usual and is as a rule of Japanese oak, though jarrah has been employed on the Shanghai-Nanking and Canton-Kowloon Railways. The steel sleeper has been adopted on only one government line, the Pienlo, but is standard on two concession lines—the ex-German Tsingtao-Tsinan Railway and the French Yunnan Railway. Particulars of these sleepers are as follows:

Railway.	*Wt. of rail.*	*Wt. of steel sleeper.*		
Pienlo	85 length 39′ 8″	131 lbs.		
Tsingtao Railway	60 lbs.	110 lbs.	1,760 to mile	4′ 8½″ gauge
Yunnan Railway	50 lbs.	79.2 lbs.	2,000 „	Metre gauge

The life of the oak sleeper is from five years in South China to nine or eight in North China. Experience with Jarrah Sleepers is satisfactory very few having been renewed to date.

Ballast 700 *fang*[6] per mile under the 60 lb. rail (6″ under sleeper) 900 under the 85 lb. rail (10″ under sleeper).

Sleepers spaced 14 to the 30 foot rail under 85 lb. rail, 13 under 30 ft. 60 lb.

The average number of men per mile employed on track is about three with an inspector to each 70 miles.

Gauge 4′ 8½″ with the exception of the metre gauge Chengtai Railway. Of the non-government lines two are metre gauge, the French Yunnan Railway and the branch railway connecting Tsi Tsi Har with the Chinese Eastern Railway which is 5′ gauge also.

Grade and Curvature Limits one in 120 and 1,000 feet radius. This has been departed from in heavy country such as that traversed by the Peking-Suiyuan Railway where grades through the Nankow Pass are 1 in 30 uncompensated and curves 500 feet in radius.

The various government railways in operation in 1918 their financial position, and cost per kilometre are tabulated below:

Railway.	*Surplus.*	*Kilometres. (Main & Branch) line.*	*Cost per Kilometre.*
Peking-Hankow	$13,387,867	1,312,913	$78,630.80
Peking-Mukden	13,979,600	974,834	70,715.58
Tientsin-Pukow	2,714,515	1,106,840	91,646.23
Shanghai-Nanking	907,199	327,098	93,889.52
Shanghai-Hangchow-Ningpo	— 136,487	286,398	77,253.96
Peking-Suiyuan	1,410,905	495,067	59,035.69
Cheng-Tai	1,455,019	242,950	91,119.92
Taokow-Chinghua	120,393	152,453	48,395.14
Kaifeng-Honan	147,231	185,000	73,289.49
Kirin-Changchun	276,237	129,906	51,824.00
Chuchow-Pinghsiang	3,238	90,500	53,191.56
Canton-Kowloon	— 594,950	143,296	108,763.53
Canton-Samshui	No report	48,924	No report
Changchow-Amoy	— 165,651	28,000	94,415.44
Chinese Government Railways	[7] 33,505,116	5,524,179	78,275.19

[6] 1 *fang* = 110 cubic feet.

[7] Includes $2,000,000 depreciated notes at face value.

These figures relate to the year 1918. It will be observed that the financial, position is excellent and that only two railways, whose mileage is unimportant were run at a loss. The Canton-Samshui is omitted as it is in the hands of the Southerners and makes no returns.

The total foreign debt on railways at present aggregates $264,156,938. This constitutes about two-thirds of the capital invested in railways which amounts to over 428 million dollars.

Amortization of the foreign loans is only paid out of surplus in the case of the Peking-Mukden and Chengtai Railways, in other cases out of Government funds.

The profit on the railways amounts to over 12% on the foreign capital invested.

The cost per kilometre given here includes betterments up to the end of 1918 and in the majority of cases, the Peking-Mukden Railway excepted, will approximate closely to the original construction cost. Generally speaking the Government railways are built to very good standards, the class of work comparing well with other countries but without exception they are under-equipped as regards rolling stock and engines, the only railway at all approximating to accepted standards in this respect being the Peking-Mukden Railway.

An analysis of the construction costs under various heads is given on page 41 for the railways as a whole and four[8] principal lines.

For an appreciation of these figures some details giving an idea of the country traversed should be given. As regards track all the lines, except the Peking-Mukden in part, are similarly equipped with an 85 lb. rail but the

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[8] The Tientsin-Pukow Railway is not given here as it was constructed under joint loan. See under Railways in detail (4), Chapter IV.

Items.	Peking-Hankow.	Peking-Mukden.	Shanghai-Nanking.	Peking-Suiyuan.	Chinese Government Railways.
PART I.—CONSTRUCTION ACCOUNTS 1918	$	$	$	$	$
C. 1 General Expenditures ..	11,236,966.62	6,020,246.96	2,403,516.03	2,369,159.92	45,374,864.76
C. 2 Preliminary Expenditures ..	41,359.85	301,316.41	47,061.25	207,720.19	2,677,499.86
C. 3 Land	3,463,726.46	1,510,162.42	2,981,035.25	1,123,097.59	18,049,718.25
C. 4 Formation	5,897,086.19	2,717,801.42	2,079,109.72	2,747,235.00	28,172,337.47
C. 5 Tunnels	237,837.51	..	374,642.40	533,083.17	1,969,252.92
C. 6 Bridgework	14,916,848.30	10,415,177.91	2,734,178.25	3,420,652.47	64,556,368.46
C. 7 Line Protection	79,660.08	203,124.43	64,924.01	34,508.35	952,485.33
C. 8 Telegraphs and Telephones ..	364,885.92	233,336.13	104,479.55	158,131.48	2,003,171.36
C. 9 Track	18,829,619.69	13,742,883.78	7,153,095.49	6,160,808.25	84,219,060.56
C. 10 Signals and Switches ..	891,986.28	1,003,877.54	129,086.15	337,531.74	4,092,190.09
C. 11 Stations and Buildings ..	6,107,778.24	4,928,594.15	2,549,349.92	2,034,647.48	28,552,424.43
C. 12 Central Mechanical Works ..	681,869.14	2,505,780.94	575,147.11	241,907.96	6,230,021.06
C. 13 Special Mechanical Works ..	107,878.40	..	128,627.55	..	338,342.37
C. 14 Plant	1,181,269.32	664,700.46	347,840.30	104,766.77	4,015,894.09
C. 15 Rolling Stock	17,968,094.15	16,771,469.73	5,048,634.84	6,616,041.08	72,185,670.49
C. 16 Maintenance	1,887,491.63	156,342.10	..	446,672.66	5,112,368.74
C. 17 Docks, Harbours and Wharves	..	133,051.35	654,459.49	..	1,737,596.46
C. 18 Floating Equipment	..	130,231.00	..	..	383,360.90
Total Part 1	83,894,357.78	61,438,096.73	27,375,187.31	26,535,946.11	370,622,627.60
PART II.—FINANCIAL ACCOUNTS.					
C. 19 Interest during Construction	12,230,846.00	..	3,133,610.02	2,137,369.30	42,654,685.46
C. 20 Exchange	..	..	189,843.94	less 26,048.19	499,765.01
C. 21 Unclassified	11,509,699.73	..	654,043.99	..	21,109,962.00
Total Part II	23,740,545.73	..	3,977,497.95	2,111,321.11	64,264,412.47
Total Part I & II ..	107,634,903.51	61,438,096.73	31,352,685.26	28,647,285.22	434,887,040.07
Deduct-Receipts on Capital Account	7,383,976.57	..	641,610.55	1,157,263.35	19,610,869.09
Total Cost of Road and Equipment	100,250,926.94	61,438,096.73	30,711,074.71	27,490,021.87	415,276,170.98
Cost of other Physical Property ..	..	467,730.61	..	..	467,730.61
Cost of Non-Physical Assets ..	2,415,028.59	7,865,702.80	..	1,466,572.04	12,657,632.72
Total Cost of Property Carried to Balance Sheet	$102,665,955.53	$69,771,530.14	$30,711,074.71	$28,956,593.91	$428,401,534.31

Shanghai-Nanking Railway has jarrah sleepers instead of Japanese hardwood as used on the other lines.

The Peking-Hankow Railway has the following bridging. 875 bridges of a total clear opening of 16,309 metres. This includes the famous screw pile bridge over the Yellow River of 103.30 metre spans. 1,285 stone bridges and culverts of a total length of 1,544 metres 28 iron and stone bridges of a total length of 201 metres. Five wood bridges of a total length of 52.5 metres. This amounts to a grand total of 2,193 bridges of a clear opening of 18,108 metres or approximately 74 feet per mile. The first 90 miles from Peking to Paotingfu, constructed in 1897–99 at a cost of £5,300 per mile, had earthwork and bridgemasonry for double track. Openings averaged 100 feet per mile over this length. There are also two tunnels, one through rock of 340 metres, and one through earth of 323.50 metres.

The Peking-Mukden Railway has openings exceeding 100 feet per mile, and eight bridges totalling 156 piers were founded by compressed air. The mileage under 85 and 60 lb. rail is respectively 376 and 231 miles. The 81 miles from Peking to Tientsin is built for double track as regards earthwork and bridge masonry. The line was under construction from 1881 to 1904 a circumstance not making for economy. The cost analysis given here is based on a valuation only made in 1914.

The Shanghai-Nanking Railway has openings which total 30 feet per mile and one double track tunnel of 1,320 feet length. The earthwork and bridge masonry from Shanghai to Soochow—54 miles—is double track. Earthwork is light generally.

The Peking-Suiyuan Railway has as regards the heavy length of 122 miles from Fengtai to Kalgan the following features: openings which exceed 50 feet per mile, very many cuttings in solid rock, and 5,400 feet of lined dry rock single track tunnelling executed at a cost of $98.7 per foot. The cost of this section was Tls. 65,570 per mile no interest paid on capital:—

Total Kilometres Main and Branch Line in China 1919

	Kms.	Kms.
Government Railways:—		
In Operation		6,027.258
Operation by construction forces:—		
Lung-Hai	368.300	
Hupeh-Hunan	15.289	383.589
Total Government Railways		6,410.847
Provincial and Private Railways:—		
Kwangtung	225	
Kiukiang-Nanchang	136	
Sunning	171	
Swatow-Chaochowfu	42	
Nanking City	11	
Chung Hsing Mining Co.	52	
Liu Chiang Coal Mine	12	
Tayeh Mining Co.	30	
Ching Hsing Mining Co.	15	
Kailan Mining Administration	16	
Taiyaokou Mines	29	
Tsitsihar City	29	
Ma Chiapu Narrow Gauge	5	773.000
Total subject to control of the Ministry of Communications		7,183.847
Concessioned Railways:—		
Chinese Eastern	1,722	
South Manchurian	1,107	
Shantung	451	
Yunnan	465	
Canton-Kowloon (British Section) ..	35	3,780.000
Total Kilometres of railway in China (Miles, 6,813)		10,963.847[9]

The railway system now in operation in China is located principally north of the Yangtse River. The Shanghai-Nanking, the Shanghai-Hangchow-Ningpo and

[9] A decrease of 37 kilometres compared with 1918, due to corrections.

the Hupeh-Hunan lines extend the system into South China. Plans for future construction promise to connect up other short lines in the south so as to duplicate there, ultimately, the facilities now serving the north. Excluding from consideration the dependencies, Mongolia, Turkestan and Thibet, China has approximately 172 square miles of territory and 33,700 population for each kilometre of railway. Per mile of railway, China has approximately 276 square miles of territory and 54,000 population. Korea has 71 square miles of territory and 13,000 population per mile of railway, India has 40 square miles and 8,600 population, Japan has 16 square miles and 8,000 population, and the United States has 12 square miles and 3,800 population per mile of railway. The extent of waterways in China will always serve to keep these average figures higher in China than in countries not so favoured.

With regard to the *railways under construction* the Lunghai Railway is dealt with under the Kaifeng-Honan Railway of which it is an extension.

The history of the construction of the Hupeh-Hunan Section of the Canton-Hankow Railway has been a chequered one. Initially it was faced with the usual difficulty of incorporating a native company controlling a section of 33 miles of indifferent railway between Changsha and Chuchow. This was constructed by native companies and opened in September 1911 the cost up to September 1912 amounting to Tls. 6,500.000. This line together with an uncompleted 10 mile section was taken over by the Government in March 1913.

Construction under Government control began in December 1912, this being financed under the Four Power or Hukuang Railways Loan Agreement of 1911, by which a loan of £6,000,000 was to be raised for this and the Hankow-Szechuan Railways. By the Terms of this agreement the Engineer-in-Chief of this line is to be a British subject. The outbreak of the Great War greatly handicapped progress owing to the difficulty of obtaining supplies, America being the only available market, while the continued recurrence of disturbances resulting from desultory civil war from 1916 onwards has been another disturbing factor. Further, in spite of the fact that it was decided to shut down all work on the Szechuan-Hankow Railways and use the funds for construction of this railway, it has not been possible to do much beyond Changsha, which was linked up with Hankow in 1917.

Also a certain amount of construction work has been done on the Pukow-Hsinyang Railway, a line for which the final loan agreement for a loan of £3,000,000 was made in 1914. All work ceased in 1916 owing to lack of funds. A similar fate from the same cause, was that of the Nanking-Hunan Railway, another British concession, which stopped all preliminary work in the same year. Practically nothing has been done beyond survey work with the Szechuan-Hankow scheme as a whole, but matters are complicated here also by the Ichang Railway which must be incorporated. This was built between 1910 and 1911, totals about 33 miles of which only eight are in operation, the cost being about $3,000,000 while stores in hand for future construction were valued at Tls. 1,200,000. By the loan agreement the line will be constructed in three sections; French, American and presumably British, as the German interest in the Loan organisation has been cancelled. By the Consortium agreement Japan is to participate in this Loan, but whether as heir to German rights is not specified.

The last-mentioned line in this category is a branch of the South Manchuria Railway running West from Ssupingkai. Judging from the amount of money lent for the construction and considering the temporary character of the bridgework, much of which is timber, construction under Japanese auspices is likely to prove costly.

Of the private railways the only ones of any interest are the Kiukiang-Nanchang and Kwangtung Railways. The remainder are either derelict concerns dating from the outbreak of railway fever in the period 1904 to 1906 such as the Swatow-Chaochowfu and Sunning Railways, or mineral lines constructed to fairly efficient but second class standards. All with the exception of the Tsi Tsi Har Railway (17 miles), constructed in 1907 at a cost of £1,735 per mile, are of standard gauge. The Tsi Tsi Har line is metre gauge and has 30 lb. rails.

The Kiukiang-Nanchang Railway is a Chinese concern for which Japan has provided capital to the extent of Yen 2,400,000. The line is poorly constructed and in perpetual difficulty. It will doubtless be eventually merged into the Nanking-Hunan system of which it is a natural development. The line received imperial sanction for construction under native auspices in 1904, and construction began under a Chinese Company with a capital of Tls. 2,800,000 in 1906. At the end of 1915, 87 miles was in operation, but there is a break necessitating a ferry owing to an uncompleted bridge. The line is now under Japanese management.

A railway, under construction by private agency, of considerable importance is the Kwangtung Railway, which will on completion link up Canton with Hankow *via* the Hupeh-Hunan Railway, now also under construction. Initially this railway together with the Hupeh-Hunan Railway was awarded as an American concession to the American-China Development Company in 1898 and arrangements were made to float a loan of £8,000,000 at a price of 90 on terms similar to those for the Peking-Hankow Railway. Largely as a result of Russo-French opposition (at whose instigation Belgium acquired a controlling interest in the Company with consequent complication with China, resulting in numerous and costly changes of management), progress of construction was unduly delayed with the consequence that popular agitation, in which the Hunanese were conspicuous, eventually compelled cancellation of the American concession on payment of a sum of £1,350,000. This money was lent by the Hongkong Government who thus acquired British construction rights in the Yangtse Valley or northern portion of the scheme. The work carried out by the American Company consists of

30 miles of completed line—the branch line from Canton to Samshui—and about 50 miles of completed earthwork on the main line for which a sum of £600,000 was paid and is included in the above loan. It will therefore be observed that America easily holds the record for costly construction in pre-War days, and this is perhaps due in part to excessive plant purchases intended for the bigger scheme; but the attempt to break the earthwork coolie, the most efficient mud-shifting machine yet discovered, to the wheelbarrow, and the employment of foreign foremen for supervision would produce results inconsistent with economy. When work stopped in 1904 the completed line handed over by the American Company was equipped as follows. Of the 30 miles the first 10 were double tracked with a 31 feet formation, and had 75 lb. track on steel sleepers fully ballasted with stone, the remainder had an 18 feet formation with the same weight of rail on Japanese sleepers on sand ballast. The stations were matsheds with the exception of that at Canton which cost about $18,000 while the rolling stock consisted of eight second hand locomotives and twenty 40 ton flat cars.

Since January 1904 construction has been in the hands of the Kuantung Mercantile Administration, a Chinese Company with a capital of $40,000,000 partially paid up. The line to the border of Hunan will be on completion 335 kilometres long of which 225 is in operation, but the back of the work is yet to be broken for, as located, the northern section of the line will entail the construction of some 60 tunnels aggregating 10,000 feet.

Loans.—With the exception of the length of line between Peking and Chung Hou So, about 40 miles beyond the Great Wall on the Peking-Mukden and the Kalgan (Peking-Suiyuan) Railway all the chief railways of the country have been built with foreign capital.

The terms under which this money has been obtained have of course improved as the country has advanced. Thus in the case of the British Loan for the Extra-Mural Extension of the Peking-Mukden Railway payment before the date of expiry of the loan entailed redemption of the bonds at 20% premium, while in the majority of later loans this has been reduced to 2½%. but a further clause has been added forbidding redemption of the loan before the expiry of a number of years generally 10 to 12½. In addition loan agreements subsequent to that of the Peking-Mukden Railway have a purchasing clause attached by which the loan syndicate is allowed a commission of 5% for inspection and other charges on all materials purchased. After 1908 this clause was further modified to allow China to purchase such materials in the open market, but it was specified that, prices being similar, preference was to be given to the country supplying the money, but if possible Chinese manufactures were to be utilised to the fullest extent.

The degree of government control over the foreign staff and policy has also varied considerably. Thus in the case of the Peking-Mukden Railway the British Engineer-in-Chief has full control over expenditure, and foreign employees can only be dismissed with his sanction. Similar procedure obtained in the case of the Franco-Belgian loans for the Kinhan, Chengtai and Pienlo Railways with the aforementioned addition of a purchasing clause and commission. In the case of the Shanghai-Nanking Railway Loan Agreement of July 1903 a change was made, control of expenditure, personnel, and policy being vested in a Board consisting of five members three of whom were appointed by the Corporation issuing the loan and the remainder by the Chinese Government. Somewhat similar procedure was followed in the case of the Canton-Kowloon loan but in this case all expenditure required certification by the British Chief Accountant before payment by the Managing Director who shared equally with the Chief Engineer and Chief Accountant the control of expenditure and personnel, dismissal of whom was contingent on mutual agreement between the Viceroy of Canton province (who appointed the Managing Director) and the British and Chinese Corporation. Further in this case the commission on purchases was compounded for the sum of £35,000.

In the case of the Tientsin-Pukow Railway Loan of 1908 much fuller governmental control was obtained. In this case construction and control were entirely vested in the government, the appointment of the chief engineer was made by the government subject to the loan syndicate's approval, the engineers-in-chief being under the control of the Managing Director. Dismissal of technical employees was subject to the approval of both engineers-in-chief and Managing Director with the Director-General as Arbitrator in case of dispute. The Director-General controlled the funds absolutely, with the consequence that materials were tendered for in the Open Market, but there was the usual commission to the loan syndicate on materials purchased. This agreement remains the basis for most subsequent ones, with the exception of the agreement of 1913 made with Pauling & Co., the British contractors, for the construction of the Shasi-Singyi Railway. In this case the line was to be constructed on a percentage of cost basis and pledged to them as security. An abstract of the latest loan agreement made with the Siems Carey Company in May 1916 for the construction of 1,500 miles of railway is appended, as an indication of the terms now obtainable by the Government.

The concession lines remain to be dealt with. These are in order of importance the Chinese Eastern Railway, the South Manchuria Railway, the ex-German Shantung Railway and the Yunnan Railway. In all these concessions the control of the concessionaires over the railways is absolute, China incurring no financial liability whatever. In every case the right of eventual purchase by the government is reserved and in the case of the Chinese Eastern and South Manchuria Railways, the railway after the lapse of 80 years from the date of opening, becomes the property of the Government without payment. In the case of the South Manchuria Railway this period was extended for 87 years from 1915. Another usual clause in these concession agreements is one giving exclusive mineral rights within a certain area. In the case of the Chinese Eastern and South Manchuria Railways this zone is quite indefinite, but in the case of the Shantung Railway is defined as 10 miles on either side of the railway.

The following are the salient features of the Shantung Railway agreement first made in 1898 and amplified in 1900. In the first place it was arranged for a Sino-German Company to inaugurate a railway system for the province, the first line to be constructed being the Tsingtau-Tsinanfu Railway. Secondly the Chinese Government was to afford every facility and protection to the representatives of the Company, and all arrangements in connection with the works specified shall be determined by a conference of Chinese and German representatives. Thirdly, the Chinese Government should allow German subjects to hold and develop mining property for a distance of 30 *li*[10] from each side of the railways and along the whole extent of the lines. Certain places, minerally important, were here specified.

Fourthly, German capitalists were to have priority rights in the event of China desiring to finance development work within the province. Lastly, Germany undertook not to introduce foreign troops or to transport them or munitions outside the 30 miles zone of the port of Tsingtau, but it was specified that if the offices of the Company were seized by an enemy and control lost, then the military forces of the Chinese Government would no longer assume the responsibility of protecting the line. In this case presumably Germany could take what steps she considered necessary.

Nothing was paid to China for this or any other concession, but a clause was inserted in the agreement reserving the right of purchase, but neither period nor terms were specified. With regard to the presence of foreign troops on the other concession lines this is permitted in the case of the South Manchuria[11] and Chinese Eastern Railways, but has no official recognition on either the Shantung Railway, since the Japanese occupation, or the Yunnan Railway.

A table of railway loans is appended:

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[10] 3 *li* = 1 mile.

[11] Japan maintains 15,000 troops at least for policing the railway zone.

RAILWAY LOANS.

Date.	Title, Source, etc.	Currency.	Principal amount.	Interest per cent.	Issue price.	Amount received by Chinese Government.	Term of Redemption.		Principal outstanding on December 31st, 1919.	Security.
							Years.	Date.		
1898	British and Chinese Corporation Loan for Imperial Railways of North China	£	2,300,000	5	97	90	45	1944	1,437,500	Government Guarantee and Revenue of and Mortgage upon the Railway.
1898	Franco-Belgian Loan for Peking Hankow Railway.	£	4,500,000	5		90	30	1928	Redeemed in 1908	
1902	Russo-Chinese Bank Loan for Shansi Railway.	Fr.	40,000,000	5		90	30	1932	30,150,000	Government guarantee, and Property of Cheng Tai Railway.
1903	Franco-Belgian Loan for Kaifeng Honan Railway.	Fr.	41,000,000	5		90	30	1939	41,000,000	Government guarantee, Revenue and Property of Kaifeng Honan Railway
1907	" " " (Supplementary Loan)									
1903	British and Chinese Corporation Loan for Shanghai Nanking Railway.	£	2,250,000	5	97½	90	50	1953	2,900,000	Profits of and Mortgage upon the Railway.
1907	" " "	£	650,000	5	100	95½				

RAILWAY LOANS.—*(Continued)*

Date	Title, Source, etc.	Currency.	Principal amount.	Interest per cent.	Issue price.	Amount received by Chinese Government.	Term of Redemption. Years.	Term of Redemption. Date.	Principal outstanding on December 31st, 1919.	Security.
1905	Pekin Syndicate Loan for Taokow Chinghua Railway.	£	700,000	5		90	30	1935	695,700	Government guarantee, Revenue and Property of Taokow Chinghua Railway.
1905	„ „ „ (Supplementary Loan)	£	100,000	5		90				
1905	Hongkong Government Loan for redemption of Canton Hankow Railway Contract.	£	1,100,000	4½		100	10	1915	Principal has all been paid off.	
1907	British and Chinese Corporation Loan for Canton Kowloon Railway.	£	1,500,000	5	100	94	30	1937	1,500,000	Profits of and Mortgage upon the Railway.
1908	Anglo-German Loan for Tientsin Pukow Railway.	£	3,000,000	5	98¾	93	30	1938	4,625,000	First Charge upon likin and internal Revenues of Tls.3,800,000 a year in the Provinces of Chihli Shantung and Kiangsu.
1909	„ „ „	„	2,000,000	5	100	94½				
1908	British and Chinese Corporation Loan for Shanghai Hangchow Ningpo Railway.	„	1,500,000	5	99	93	30	1938	1,387,500	Surplus of Peking Mukden Railway.
				4½						

1908	Anglo-French Loan for Redemption of Peking Hankow Railway.	„	5,000,000	5	98	94	30	1938	4,750,000	Sundry taxes of Tls. 4,250,000 a year in the provinces of Chekiang, Kiangsu, Hupeh and Chili.
1908	Japanese Loan For Kirin Changchun Railway.	Yen	2,150,000	5		93	25	1934	The unpaid portion was added to the 1917 Loan.	
1909	Japanese Loan for Hsinmintun Mukden Railway.	„	320,000	5		93	18	1927	142,222.24	Revenue of the Railway and railway property.
1910	Anglo-German Supplementary Loan for Tientsin Pukow Railway.	£	3,000,000	5	105	95	30	1940	3,000,000	First charge upon likin and certain internal taxes of Tls. 3,600,000 a year in the provinces of Chili, Shantung Kiangsu and Anhui.
1910	„ „ „	„	1,800,000	5	Not yet issued but £900,424.6.4 and £300,000 have been advanced					
1910	London, City, & Midland Bank (Peking Hankow Railway redemption Loan.	„	450,000	7	108	97½	10	1920	90,000	Surplus of Peking Hankow Railway.
1910	Yokohama Specie Bank (Peking Hankow Railway redemption loan).	Yen	2,200,000	7		97½	10	1920	440,000	Surplus of Peking Hankow Railway.
1913	London, City, & Midland Bank (Peking Hankow Railway redemption loan)	£	194,400	7		91	7	1920	38,880	Surplus of Peking Hankow Railway.

RAILWAY LOANS.—(*Continued*).

Date.	Title, Source, etc.	Currency.	Principal amount.	Interest per cent.	Issue price.	Amount received by Chinese Government.	Term of Redemption. Years.	Term of Redemption. Date.	Principal outstanding on December 31st, 1919.	Security.
1911	Yuchiuanpu Loan (Yokohama Specie Bank)	Yen	10,000,000	5		95	25	1936	10,000,000	Government guarantee. and Tribute grain conversion tax Tls, 1,000,000 of Kiangsu.
1911	Hukuang Railway Loan (Four Nations Group)	£	6,000,000	5		95	40	1951	6,000,000	Hupeh Hunan salt and likin revenues and Hupeh rice tax to the amount of Tls. 5,200.000 a year
1912	Nan-Hsun Railway Loan (East Asia Industrial Co.)	Yen	5,000,000	6½		95	15	1927	5,000,000	
1914	Nan-Hsun Railway Loan (East Asia Industrial Co.) (2nd Loan)	Yen	500,000	6½		95	15	1929	500,000	Revenues of the Railway and the railway property
1914	Nan-Hsun Railway Loan (East Asia Industrial Co.) (3rd Loan)	Yen	2,000,000	6½		95	23	1937	2,000,000	

1912	Lung-Tsing-U-Hai Railway Loan	£ Fr.	4,000,000 100,000,000	5	95	85	40	1952	4,000,000	Government guarantee and Mortgage upon the railway.
1916	Lung-Hai Short Term Loan	Fr.	10,000,000	7		95	4	1920	10,000,000	Ordinary Loan bonds Fr. 30,000,000
1919	Lung-Hai Short Term Loan	Fr.	20,000,000	7		93	5	1924	20,000,000	Ordinary Loan bonds Fr. 50,000,000
1913	Pukow Sinyang Railway Loan (Chinese Central Railways Limited)	£	3,000,000	5	Not yet issued but $207,256.3.5 have been advanced					Revenues of and Mortgage upon the Rly.
1913	Tung Cheng Railway Loan.	£	10,000,000	5		Not yet issued but £770,217.6.6 and Fr. 5,798,518.95 have been advanced.				Government guarantee and mortgage upon the railway.
1913	Shanghai Nanking Railway (land loan).	£	150,000	6		92	10	1923	120,000	Profit of and mortgage upon the Railway.
1913	Ssu Tsen Railway Loan (Yokohama Specie Bank).	Yen	5,000,000	5	86½	81	40	1956	5,000,000	Profit of and mortgage upon the Railway.
1914	Nanking Hunan Railway Loan (British and Chinese Corporation).	£	8,000,000	5		Not yet issued but Tls. 2,486,000 have been advanced.				Revenues of and mortgage on the Railway.
1914	Sha Hsing Railway Loan (Messrs. Pauling & Co., Ltd.).	£	10,000,000	5		Not yet issued.				Government guarantee and mortgage upon the railway.

RAILWAY LOANS.—*(Continued)*

Date	Title, Source, etc.	Currency.	Principal amount.	Interest per cent.	Issue price.	Amount received by Chinese Government.	Term of Redemption. Years.	Term of Redemption. Date.	Principal outstanding on December 31st, 1919.	Security.
1914	Ching Yu Railway Loan.	Fr.	600,000,000	5		Not yet issued but Fr.32,115,500 have been advanced.				Profit of and mortgage upon the Railway.
1914	Shanghai Fengching Railway Loan.	£	375,000	6		91	20	1934	375,000	Surplus of Peking Mukden Railway.
1915	Advance from British and Chinese Corporation.	Tls.	2,100,000	7			4	1919	—	Surplus of Peking Mukden Railway.
1916	Chuchow Chinchow Railway Loan.	G$	10,000,000	5		Not yet issued but G$1,000,000 have been advanced.				Mortgage upon the railway.
1916	Pin Hui Railway Loan.	Rouble	50,000,000	5			Not yet issued but Rouble 1,000,000 have been advanced.			Profit of and mortgage on the railway.
1917	Kirin Changchun Railway Loan,	Yen	6,500,000	5		91½	30	1947	6,500,000	Revenues of and mortgage upon the Railway.

1918	Ssu Tsen Railway Short Term Loan.	Yen	2,600,000	7		1	1919	1,600,000	Government guarantee, Revs. of and mortgage on the Railway
1918	Ssu Tsen Railway Short Term Loan.	$	400,000	9½		1	1919	400,000	
1918	Taokow Chinghua Railway Loan (Increase of Rolling-Stock)	G$	300,000	8		5	1923	240,000	Government guarantee revenues of the Railway
1918	Kirin Huaning Railway	Yen	20,000,000	5		40			
	Taokow Chinghua Railway Loan (Increase of Rolling. Stock)	G$	467,066.04	7½			1930		Government guarantee revenues of the Railway
1919	Hunan Hupeh Section Short Term Loan	Tls.	2,000,000	8					Surplus of Peking Mukden Railway
1919	Peking Suiyuan Railway	Yen	3,000,000						
1921	Car Loan Chinese Banks	$	6,000,000	8	95				

Definitive Agreement between the British and Chinese Corporation (Limited) and Director-General Hu respecting the Peking-Newchwang Railway Loan. (Abstract).

THIS Agreement is made between his Excellency Hu, Governor of Peking, as Administrator-General of the Railways of North China within and without Shan-hai-kuan, acting under the authority of the Imperial Chinese Government, hereinafter called the "Administrator-General" of the one part, and the Hong Kong and Shanghai Banking Corporation, for themselves and on behalf of the British firm of Jardine, Matheson & Co., representing as joint agents the British and Chinese Corporation (Limited), hereinafter called the "Corporation" of the other part:

To the carrying out, within a period of three years from the date of this Agreement, of certain improvements and additions to rolling-stock on the existing lines between Peking and Shan-hai-kuan, recommended by the European Chief Engineer, and estimated by him to cost about 1,500,000 taels.

To the construction of a railway line from Chung-hou-so to Hsin-ming-tun, and one from a point on that line near Shih-san-chan to Ying-tzu, and of a branch line from Nu-erh-ho to the collieries of Nanp'iao.

This loan shall be a first charge upon the security of the permanent way, rolling-stock, and entire property, with the freight and earnings of the existing lines between Peking and Shan-hai-kuan, and on the freights and earnings of the new lines when constructed. The Administrator-General shall, during the continuance of this loan, maintain the railway buildings, works, rolling-stock, and dependencies in good order and condition, and shall increase the rolling-stock from time to time to such extent as shall be necessary for the requirements of the traffic.

The principal and interest of this loan are guaranteed by the Imperial Government of China, and in the event of default in payment of interest or repayment of principal at due date, the Corporation shall immediately notify the Imperial Government of China thereof, and the Imperial Government of China will thereupon provide the funds necessary to meet such payment in sterling in London. In the event of the Imperial Government of China being unable to provide the funds necessary to meeting a payment of interest or principal when called upon by the Corporation to do so, in terms of this clause, the said railway lines and entire property shall thereupon be handed over to representatives deputed by the Corporation to manage, on their behalf, until principal and interest of the loan have been redeemed in full, when the management will revert to the Railway Administration. It is provided that should arrears of interest or principal be for a small sum, and it appear desirable to the Corporation to extend the due date of their payment for a term not exceeding three months, it shall be open to the corporation to do so.

This arrangement, which differs from other contracts in that the Administrator-General retains control of the railway lines so long as the principal and interest of this loan are regularly paid, has been agreed to in consequence of the friendly relations which have long existed between the Contracting Parties.

During the currency of this loan the Chief Engineer of the railways shall be a British subject. The principal members of the railway staff shall be capable and experienced Europeans, who shall be, as at present, appointed by the Administrator-General of the Railways, and may be, in the event of their misconduct or incompetency dismissed after consultation with the Chief Engineer.

If there are Chinese with sufficient engineering or traffic experience they may be appointed as well as Europeans.

Should it be necessary to appoint a new Chief Engineer, such appointment shall be made in consultation with the Corporation.

In addition to the above, a capable and efficient European Railway Accountant shall be appointed, with full powers to organise and direct the keeping of the railway accounts, and to act with the Administrator-General and the Chief Engineer of the railway in the supervision of receipts and expenditure.

The term of the loan shall be forty-five years, and, subject to the modification mentioned hereinafter, repayment of principal shall be made, so far as regards the bondholders, in forty equal annual instalments, commencing with the sixth year.

Interest on the loan shall be charged at the rate of 5% per annum on the nominal principal, and shall be calculated on the balance of such principal at any time outstanding, payments of interests being made by the Administrator-General in accordance with the amounts and dates specified in the yearly Schedule to be provided.

The loan will be redeemed by annual drawings in London as provided for in the prospectus. Besides the drawings as provided for, the Administrator-General may, on giving three months' notice to the Corporation, call for extra drawings to be held for any amount. Bonds so drawn to be redeemed by the Railway Administration at 20% premium on their par value. Any such extra drawings must take place on the date of the ordinary drawing provided by the prospectus.

The price agreed upon for this loan is 90% net of the nominal principal, but should an unfavourable state of the market prevail at the time of issuing the prospectus the Corporation is hereby authorised to reduce the price of the loan, at its own discretion, to not less than 80% net to the Railway Administration.

Statutes of the Chinese Eastern Railway Company. (Abstract).

THE Company is empowered, subject to the sanction of the Chinese Government, to exploit, in connection with the railway, or independently of it, coal mines, as also to exploit in China other enterprises—mining, industrial and commerial. For the working of these enterprises, which may be independent of the railway, the Company shall keep accounts separate from those of the railway.

In virtue of the Agreement with the Chinese Government the Company shall retain possession of the Chinese Eastern Railway during the course of eighty years from the day of the opening of traffic along the whole line.

In recognition that the enterprise of the Chinese Eastern Railway will be realised only owing to the guarantee given by the Russian Government in regard to the revenue of the line for covering working expenses, as well as for effecting the obligatory payments on the bonds, the Company on its part binds itself to the Russian Government, during the whole term of the concession, under the following obligations:—

Goods imported from Russia into China by rail, and exported from China to Russia in the same manner, shall pay respectively an import or export Chinese duty to the extent of one third less as compared with the duty imposed at Chinese seaport custom houses.

In regard to the place of acquisition of materials for the requirements of the railway, the Company shall not be liable to any limitations. If material be obtained beyond the confines of Russia, they shall on importation through Russian territory be freed from payment of Russian customs duties.

The Company must commence the work not later than the 6th August 1897, and conduct it in such a manner that the whole line shall be completed not later than six years from the time when the direction of the line shall be finally determined and the necessary land assigned to the Company.

When tracing the line of the railway, cemeteries and graves, as also towns and villages, must, so far as possible, be left aside of the railway.

The tariffs for the carriage of passengers and goods, as also for supplementary carriage rates, shall be determined by the Company itself within the limits indicated in article 3.

The capital of the Company shall be fixed at 5,000,000 nominal credit roubles, and divided into 1,000 shares at 5,000 nominal credit roubles.

The shares to be issued at their nominal value.

The guarantee of the Russian Government does not extend to them.

AGREEMENT for the Construction of a Railway from Taokow to Chinghua, in the Province of Honan, made between H.E. Sheng Hsuan-Huai, Director-General of Railways, being thereto specially authorised by the Chinese Government and George Jamieson, C.M.G., Agent-General of the Peking-Syndicate, Limited, also being fully authorised by the said Syndicate.

ON the 21st May 1898 (Kwanghsu 24th year 4th Moon 2nd day) the Shansi Bureau of trade signed an Agreement with the Peking Syndicate for working coal and iron in the five following places, namely, Yu Hsien, Pingting Chow, Luanfu, Tsechowfu, and Pingyangfu in the province of Shansi, and on the 21st June 1898 (Kwanghsu 24th year 5th moon 3rd day) the Yu-Feng Company signed a mining Agreement with said Syndicate for mining in Honan in the neighbourhood of Huai Ching and north of the Yellow River. These Agreements were both ratified by the Tsungli Yamen, in pursuance of an Imperial Decree dated 17th May 1898 (Kwanghsu 24th year intercalary 3rd moon 2th day). In Article 17 of said Agreements it was stated that the Peking Syndicate, on notifying the Governor of the province, should be permitted to build a railway to connect the mines with a main line or with water navigation. In June 1902 the Peking Syndicate began to open coal mines in Sui Wu Hsien of Honan province, and at the same time gave notice to the Governor and obtained permission to build a railway from the said mines to Taokow, a port on the Wei River.

The cost of construction of the line from Taokow to Ching-hua Chen, including rolling-stock and monies expended by the Syndicate as estimated by the Chinese Engineer after verification of the proper accounts, is £614,600. But in order to provide a liberal sum to meet the expenses of working the line until it is fully developed, and the interest on the loan, the Director-General has fixed the amount of the loan at £700,000, in 7,000 bonds of £100 each. This loan is to bear interest at 6% per annum, and to be called the Chinese Imperial Government Honan Railway 5% (gold) loan of 1905.

Text of Identic Note exchanged the 28th day of April 1899 between Count Muriaveff, Russian Minister for Foreign Affairs and Sir Charles Scott, British Ambassador at St. Petersburg.

GREAT BRITAIN and Russia, animated by a sincere desire to avoid in China all causes of conflict on questions where their interests meet, and taking into consideration the economic and geographical gravitation of certain parts of that Empire, have agreed as follows:—

1. Russia engages not to seek for her own account or for Russian subjects any railway concessions in the basin of the Yangtse, nor to obstruct, directly or indirectly, in that region any applications for railway concessions supported by the British Government.

2. Great Britain, on her part, engages not to seek for her own account or for British subjects any railway concessions north of the Great Wall of China, or to obstruct, directly or indirectly, in that region any applications for railway concessions supported by the Russian Government.

The two Contracting Parties, having no-wise in view to infringe in any way the sovereign rights of China or existing Treaties, will not fail to communicate to the Chinese Government the present Arrangement, which, by averting all cause of complications between them, is of a nature to consolidate peace in the Far East, and serve the primordial interests of China herself.

Text of Supplementary Notes exchanged at the same time respecting the Newchwang Railway.

To complete the notes exchanged this day respecting the partition of spheres for concessions and working of railways in China, it has been agreed to record in the present Additional Note the Agreement arrived at in regard to the line Shanhaikuan-Newchwang, for the construction of which a loan has been already contracted by the Chinese Government with the Shanghai Hongkong Bank, acting on behalf of the British and Chinese Corporation.

The general Arrangement established by the notes referred to above is not to infringe in any way the rights acquired under the said loan Contract, and the Chinese Government may appoint both an English engineer and European accountant to supervise the construction of the line in question, and the expenditure of the money appropriated to it.

But it remains understood that this fact cannot be taken as constituting a right of property or foreign control, and that the line in question is to remain a Chinese line under control of the Chinese Government, and cannot be mortgaged or alienated to a non-Chinese Company.

As regards the branch line from Siaoheichan to Hsin-ming-tun, in addition to the aforesaid restrictions, it has been agreed that it is to be constructed by China herself, who may permit European (not necessarily British) engineers to periodically inspect it, and verify and certify that the work is being properly done.

The present Agreement is, naturally, not to interfere in any way with the right of the Russian Government, if it think fit, to support applications of Russian subjects or establishments for concessions for railways which, starting from the main Manchurian line is a south-western direction, would traverse the region in which the Chinese line, terminating at Hsin-ming-tun and Newchwang, is to be constructed. [This last clause is the basis for the extraordinary demands made by Japan in October 1918.]

The Siems-Carey Railway Agreement. (Abstract).

PEKING, May 17th, 1916.

1.—The Republic of China shall locate, build, and work steam railroads in China, the aggregate of which shall be eleven hundred (1,100) miles in length. We specially pledge to build said lines between the following points and such intermediate points as may mutually be considered advisable, namely:—

From Hengchowfu in the Province of Hunan to Nanning in the Province of Kwangsi.
From Fengcheng in the Province of Shansi to Ninghsia in the Province of Kansu.
From Ninghsia in the Province of Kansu to Lanchowfu in the Province of Kansu.
From Chungchow in the Province of Kwangtung to Lu Kwei in the Province of Kwangtung.
From Hangchow in the Province of Chekiang to Wenchow in the Province of Chekiang.

3.—The said Republic reserves the right at or before the time of the completion of the above mentioned 1,100 miles of railroad, to choose one expert railroad civil engineer, in which event you shall choose one, and the two thus chosen shall choose a third, to be known as the "Board of Engineers," and said Board shall determine whether the work then being done, or theretofore done, is being or has been economically performed, and if the majority of said Board shall decide that the work has been and is being done in an economical manner under this Agreement as compared with the cost of construction of other Chinese railroads, all things considered, then the said Republic obligates itself to construct an additional 1,100 miles of railway within said Republic, to be located by the mutual consent of the parties hereto; and all and singular the provisions of this Agreement shall extend and apply to the said additional mileage of railroad in the same manner and to the same effect and purpose as though said additional mileage had been originally made a part of and included in this Agreement; with this sole exception—that the interest rate and discount to be charged upon the bonds to be issued by the said Republic for the construction of said addition of 1,100 miles of railroad shall not be higher than the prevailing interest rate and discount for other Chinese Railway bonds at that time.

If the said Republic shall build an extension or branches of said first mentioned 1,100 miles, the same shall be one under and pursuant to the provisions of this contract as though originally included herein, excepting that the mileage thereof shall be reckoned a part of the aforesaid additional 1,100 miles and subject to the above exception regarding the interest rate and discount on bonds to be issued therefor.

All bonds issued in pursuance hereof shall bear interest at the rate of five (5) per centum per annum, payable semi-annually, and each issue of bonds shall be made payable by their terms fifty (50) years from and after the date thereof.

No payment of the principal of any such issue of bonds shall be made until after the expiration of twenty-five (25) years from after the date thereof, and the bonds shall so provide. Term of loan 50 years interest 5%.

5.—The above bonds to be sold by you at the New York Stock Exchange market rate for Chinese railroad securities for the time being, from which you shall be allowed and deducted a banker's commission of five (5) per centum of the par value of bonds for selling, which shall represent all expenses in connection with the issue of the said bonds such as underwriting, commission and brokerage, telegraph charges, advertising, postage, engraving, and printing of prospectus and bonds, stamp and legal fees.

6.—You shall have charge of and direct the work of locating, surveying, erecting water tanks and buildings of all kinds, constructing and equipping all railroads included in or contemplated by this contract, and also buying the materials, rolling stock, machinery, tools, appliances, and equipment and furnishings therefor and installing the same. And you shall be paid for your services therefor a sum equal to (5) per centum of the aggregate amount of all purchases made in behalf of said railroad, excepting of purchases of land for any purpose, *in each and every year from the time that this contract shall take effect, until the last of said bonds have been fully paid.* The said railroads, and all construction, surveys, locations equipment, materials, rolling stock, machinery, tools, appliances, installations, commissions, wages, salaries, and every thing whatsoever aforesaid, shall be paid from the proceeds of the sales of all of the said bonds, and said proceeds shall not be used or applied to any other use or purpose nor shall any part or portion thereof; and it is expressly understood that the moneys derived from the sale of all of said bonds shall be deposited and kept in a responsible bank to be mutually designated and agreed upon by us in advance, and the same shall be drawn and paid out from said bank for the uses and purposes herein expressed, and for no other uses or purpose whatsoever.

In purchasing machinery and materials preference shall be given to those of American manufacture when price and quality are at least equal; but whenever it shall be possible to purchase suitable supplies and materials of Chinese manufacture, price and quality being at least equal, the same shall be given preference over those of American or other manufacture.

7.—To secure payment of all of said bonds, issued or to be issued, said Republic shall at the time that the first issue of said bonds shall be made, execute and deliver to you a first Trust Mortgage upon said entire railroads, built or to be built, together with all rolling stock, equipment, real estate, machinery, buildings, tools, and all of the physical property connected with or appurtenant thereto on hand or to be added, in accordance with the forms of the American Law which are customary and usual in such cases to secure payment of said first issue of bonds and of all issue of bonds subsequently issued. The Trustee to be selected and chosen by mutual agreement of the parties.

8.—The Executive Head of the railroads shall be a Chinese Director-General appointed by the Government, who shall be assisted by a Chief Engineer, who shall have charge of the Engineering Department; a Traffic Manager, who shall have charge of the Traffic and Operating Departments; and an Auditor, who shall have charge of all matters usually pertaining to that office, and each shall be qualified by practical experience, shall be of approved ability and integrity, shall be chosen, recommended and vouched for by you, and appointed by the Director-General if he shall approve of the character and qualifications of the person nominated; but if he shall not approve in any case, he shall call upon you for another recommendation for the office. In the event of the Director-General considering any head of a department above-mentioned unfit to act, he shall upon consultation and mutual agreement with you cause his dismissal. It being understood that all of the above heads of departments shall at all times be men recommended by you. And if you shall subsequently discover that the standard of efficiency may be improved by substituting for any appointee another likewise recommended and vouched for, the incumbent shall be removed by the Director-General and the other substituted as above provided.

On or before the twenty-fifth (25th) day of each month you shall render a lump sum estimate to the Director-General showing the funds required to meet the expenditures for the ensuing month, and upon the approval of the Director-General, he shall notify the Auditor who shall prepare and turn over to you a check for said amount in your favor.

It is agreed that requisitions for equipment and material shall be submitted to the Director-General for his information and approval.

It is agreed that all contracts contemplated to be let by you shall be approved by the Director-General.

It is agreed that any check of twenty-five thousand ($25,000) dollars or more shall be countersigned by the Director-General.

It is agreed that any and all emergency expenses which pertain to the work contemplated by this Agreement, shall receive the approval of the Director-General.

In addition to the payment to you by said Republic of a sum equal to five (5) per centum of the aggregate amount of all purchases made in behalf of said railroads (excepting purchases of land for any purpose) in said proposition stipulated for your services therein mentioned, said Republic shall also pay to you a sum equal to eight (8) per centum of the aggregate amount of all other moneys expended for the construction of all of said railroads. As soon as any section thereof shall have been fully completed and put into commercial operation, then said eight (8) per centum shall cease upon such completed sections that are being commercially operated. Settlements and payments for both the five (5) per centum and the eight (8) per centum aforesaid, to be made at the end of each six (6) months from the date of the beginning of said work. And further, for handling and selling said bonds as in said proposition provided, as well as for the said services by you to be performed, twenty (20) per centum of the net profits derived from operating said railways, after paying all maintenance, operating and bond charges, shall be paid yearly to you at the end of each fiscal year up to the time of the payment of the last of said bonds, when all your rights shall cease and this contract shall terminate. By the term "bond charges" as above used, is meant the semi-annual interest on each issue of bonds during the first twenty-five (25) years from and after their date (during which time no payments of principal shall be made) and the semi-annual interest and four (4) per centum of the principal of each said issue to be paid in each and every year of the last twenty-five (25) years of the period for which said bonds are to run.

It is further understood that before any division of net profits shall be made in any year as herein provided, there shall be reserved and set aside out of the said annual net profits, a sum equal to five (5) per centum of said annual net profits, for a replacement fund, and a separate fund shall always be maintained for that purpose; it is understood, however, that if at any time said replacement fund shall have accumulated a sum in excess of the actual and reasonable requirements of said fund, such excess, by our mutual consent, shall be divided between us, you to receive twenty-five (25) per centum thereof as above provided.

It is further agreed that no commissions whatsoever shall be paid to you upon the salaries of any officer mentioned in this Agreement.

TSAO JU LIN,
Minister of Communications.

SIEMS & CAREY,
W. F. CAREY.

SUPPLEMENTARY AGREEMENT. (ABSTRACT).

It is mutually agreed that there shall be paid no eight (8) per centum or five (5) per centum commissions upon the interest payments paid for out of the proceeds of the loan during the time of construction or at any other time.

It is mutually agreed that inspection fees and incidental expenses connected with purchases which are not made upon the condition that such purchase shall be subject to inspection upon delivery in China, shall be borne by Siems and Carey.

TSAO JU LIN,
Minister of Communications.

SIEMS & CAREY,
W. F. CAREY.

Passenger and Goods Traffic Statistics.

Only those statistics of engineering interest are considered here.

Passenger Traffic.

In the 1918 Board Report the following results were recorded:

Average rate per passenger kilometre	Cents 1.10
Passenger kilometres per kilometre	423,869 per annum
Revenue per kilometre per annum from passengers	$4,703
Passenger kilometres per train kilometre ..	229
Passenger revenue per train kilometre	$2.54

A valuable addition to these statistics would be information as to the average seating capacity per passenger train.

Goods Traffic.

Up to the present the various railways have made their own classification for goods and fixed their own rates. Classification has recently been standardised—six classes being introduced—but this reform is not yet in force. Car interchange is feasible on all the government lines with the exception of the metre gauge Chengtai Railway. The lack of standardisation of car construction tends to restrict interchange as repairs away from the home line are a matter of difficulty. 12 hours is the stipulated time allowed for unloading cars, demurrage being at the rate of 50 cents per ton of car capacity per day. The following are rates per mile on the Peking-Mukden Railway.

	Class 1	*Class 2*	*Class 3*	*Dangerous*
Per ton of car capacity	5 cents	3½ cents	1¾ cent	7½ cents

Minerals are in class 3 and grain is carried at a rate of 3 cents.

	1918	*1917*	*1916*
Average goods revenue per kilometre.. ..	$7,960	$6,446	$6,331
„ „ „ per train kilometre	$3.34	$3.11	$3.01
„ „ „ per ton kilometre..	1.29 cents		

In 1918 a Railway clearing house was founded in Peking to deal with through booking and later car-interchange. By recently promulgated regulations no car can remain away from the home line more than 12 days and equivalent car capacity must be provided.

AVERAGE TON PER TRAIN, 1919, 1918, 1917, 1916 AND 1915.

Name of Line.	Tons of Goods per Train.				
	1919	1918	1917	1916	1915
1. Peking-Mukden	321	282	272	235	239
2. Shanghai-Nanking ..	320	298	325	312	287
3. Tientsin-Pukow	319	300	282	249	206
4. Peking-Hankow	295	291	264	258	230
5. Taokow-Chinghua ..	292	283	279	258	245
6. Kaifeng-Honan	205	186	172	148	105
7. Chuchow-Pinghsiang ..	191	193	173	179	169
8. Sha'i-Hangchow-Ningpo	164	180	177	143	149
9. Peking-Suiyuan	162	165	152	160	163
10. Kirin-Changchun ..	137	101	110	90	96
11. Hupeh-Hunan	121	(2)	—	—	—
12. Cheng-Tai..	110	105	106	108	(1)
13. Ssu-Tsen	109	(2)	—	—	—
14. Canton-Kowloon.. ..	34	44	43	(1)	(1)
15. Cangchow-Amoy ..	7	(1)	(1)	(1)	(1)
Chinese Govt. Railways	270(3)	257	244	227	206

(1) No solid freight trains. (2) Reported first in 1919. (3) *c.f.*

Australia	105	France	147
Austria..	195	Japan	116
U. S. A..	445	Germany	240
India	189		

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AVERAGE HAUL PER TON, 1919, 1918, 1917, 1916 AND 1915.

Name of Line.	Kilometres.				
	1919	1918	1917	1916	1915
1. Peking-Hankow	260	278	210	238	190
2. Peking-Mukden	151	151	148	131	132
3. Tientsin-Pukow	303	310	303	252	182
4. Shanghai-Nanking ..	225	224	220	218	204
5. Shanghai-Hangchow-Ningpo	119	113	104	94	89
6. Peking-Suiyuan	114	103	95	64	(1)
7. Cheng-Tai..	84	79	83	79	(2)
8. Taokow-Chinghua ..	72	72	69	75	78
9. Kaifeng-Honan	64	75	64	72	78
10. Kirin-Changchun ..	87	97	86	60	56
11. Chochow-Pinghsiang ..	86	77	94	93	93
12. Canton-Kowloon.. ..	61	67	61	57	53
13. Canton-Samshui.. ..	Not reported			9	28
14. Changchow-Amoy ..	16	8	21	19	(2)
15. Hupeh-Hunan	46	(3)	—	—	—
16. Ssu-Tsen	69	(3)	—	—	—
Chinese Government Railway	180	184	165	155	141

(1) In two sections. (2) No data. (3) Reported first in 1919.

TON KILOMETRES CARRIED PER TON OF CARRYING CAPACITY.

Name of Line.	Available Capacity of Wagons (Tons)	Ton Kilometres Carried.		
		Total Tons	Per Ton of Carrying Capacity.	
			1919	1918
Peking-Hankow	55,100	1,240,289,856	22,510	20,179
Peking-Mukden	85,294	1,004,620,248	11,778	12,603
Tientsin--Pukow	45,907	778,517,200	16,958	16,259
Shanghai-Nanking	10,922	304,141,692	27,846	23,271
Shanghai-Hanchow-Ningpo	14,234	58,564,016	4,114	3,615
Peking-Suiyuan	25,897	158,642,819	6,125	6,338
Cheng-Tai	12,810	97,801,062	7,635	7,000
Taokow-Chinghua	6,659	67,244,526	10,098	14,650
Kaifeng-Honan	2,096	31,767,374	15,156	13,154
Kirin-Changchun	4,765	51,914,951	10,888	9,120
Chuchow-Pinghsiang ..	3,684	50,084,212	13,595	7,889
Canton-Kowloon	1,549	4,966,651	3,206	4,151
Changchow-Amoy	180	34,811	193	272
Hupeh-Hunan	8,678	7,071,257	820	(1)
Ssu-Tsen	803	7,441,201	9,266	(1)
Chinese-Government-Rlys.	278,578	3,863,101,876	13,867	13,878

(1) Reported first in 1919.

TONS CARRIED PER TON OF CARRYING CAPACITY.

Name of Line.	Available Capacity of Wagons (Tons)	Total Tons	Tons Carried Per Ton of Carrying Capacity.	
			1919	1918
Peking-Hankow	55,100	4,762,812	86	72
Peking-Mukden	85,294	6,634,352	78	83
Tientsin-Pukow	45,907	2,661,782	58	52
Shanghai-Nanking	10,922	1,352,318	123	104
Shanghai-Hanchow Ningpo	14,234	494,497	37	32
Peking-Suiyuan	25,897	1,386,094	53	61
Cheng-Tai..	12,810	1,159,385	90	88
Taokow-Chinghua	6,659	932,544	140	204
Kaifeng-Honan	2,096	491,652	234	180
Kirin-Changchun	4,765	594,346	125	93
Chuchow-Pinghsiang ..	3,684	579,729	157	102
Canton-Kowloon	1,549	80,846	52	61
Changchow-Amoy	180	2,129	12	31
Hupeh-Hunan..	8,678	151,451	17	(1)
Ssu-Tsen	803	107,141	133	(1)
Chinese-Government-Rlys.	278,578	21,391,078	77	75

If the average length of haul per ton were the same upon each of the lines, this comparison would be satisfactory. But the average length of haul per ton varies widely, and it is manifestly unfair to expect a line whose average haul per ton is 200 kilometres to haul as many tons per unit of carrying capacity as a line whose average length of haul is only 100 kilometres. In order to include the element of distance in the comparison, ton kilometres produced per ton of carrying capacity is sometimes used, computed as in the following summary.

(1) Reported first in 1919.

TON KILOMETRES PER RUNNING DAY PER TON OF CARRYING CAPACITY.

Name of Line.	No. of leads.	No. of Days: Loading and Unloading.	No. of Days: For Running.	Ton Kilometres per ton of Carrying Capacity: Total	Per Running Day: 1919	Per Running Day: 1918	Per Running Day: 1917	Per Running Day: 1916
1	2	3	4	5	6	7	8	9
1. Shanghai-Nanking	123	246	119	27,846	234.0	148.2	94.0	94.0
2. Peking-Hankow	86	172	193	25,510	132.1	63.3	53.0	43.5
3. Kaifeng-Honan	234	234 (1)	131	15,156	115.7	71.1	29.1	34.0
4. Kirin-Changchun	125	250	115	10,895	94.7	57.4	22.5	23.4
5. Ssu-Tsen	133	266	99	9,266	93.6	(2)	(2)	(2)
6. Tientsin-Pekow	58	116	249	16,958	68.1	62.3	60.5	54.0
7. Chuchow-Pinghsiang	157	157 (1)	208	13,595	65.3	30.0	61.3	84.3
8. Peking-Mukden	78	156	209	11,778	56.3	63.3	53.0	43.5
9. Taokow-Chinghua	140	140 (1)	225	10,098	44.8	91.0	81.3	61.1
10. Cheng-Tai ..	90	180	185	7,635	41.3	37.6	23.5	24.9
11. Peking-Suiyuan	53	106	259	6,125	23.6	26.1	15.6	19.7
12. S'hai-Hang-chow-Ningpo	37	74	291	4,114	14.1	12.1	10.9	6.9
13. Canton-Kowloon	52	104	261	3,206	12.3	17.1	15.8	11.3
14. Hupeh-Hunan	17	37	331	820	2.4	(2)	(2)	(2)
15. Changchow-Amoy	12	24	341	193	0.5	0.6	0.7	0.5
Chinese-Government-Rlys.	77	154	211	13,867	65.7	64.5	49.1	46.9

(1) One day only allowed for loading and unloading.
(2) Reported first in 1919.

CHAPTER IV

RAILWAYS IN DETAIL—YEAR 1918.

Peking-Hankow Railway.

Kilometres.
1,312.9

Cost per Kilometre.
$78,630

Operating Expenses per Kilometre.
$6,076

Cost Rolling Stock.
$17,968,094

Trains per Day.
13

Total Train Kilometre.
6,055,679

Operating Cost per Train Kilometre.

General.	*Traffic.*	*Running.*	*Maintenance. Equipt.*	*Maintenance. Way.*	*Total.*
0.26	0.15	0.27	.28	.36	$1.32

Number of Locomotives.
114 Goods 67

Tractive Capacity Tons.
Passenger 420.204
Goods 733.846

Kilometres run per year.
58,741

Number of Goods Cars.
2,658

Total Capacity Tons.
56,065

Tons hauled per year.
3,932,208

Ton Kilometres per year.
1,093,928,104

Goods Train Kilometres.
3,755,179

Tons per Train.
291

Cost Coal per Train Kilometre.
.15

Kilogs.
24.92

Price (per ton)
$6.00

Maintenance per Kilometre per annum.
$1,671

Track only.
$374

Track. *Employees per Kilometre Main Line.*
2.8

Track.—85 lb. rail 30 feet long Hanyang Rails mostly, 13 sleepers to rail. 72 lb. rail branch lines and sidings. Gauge 4′ 8½″.

Construction.—The line from Peking to Paotingfu[12] was constructed by the British engineers of the Peking-Mukden Railway and handed over to the Belgian concessionaires in 1899 who constructed the line to Hankow in the period from 1902 to 1905—December—when the whole line was opened for traffic.

Loans.—This line was originally constructed by a loan of £4,500,000 obtained from a Franco-Belgian syndicate but this loan was redeemed in 1908 by another for £5,000,000 derived from Anglo-French-Japanese sources which gives the Chinese Government absolute control over the line. Interest on loan 5% and 30 years period.

Under the first loan agreement the concessionaires had complete control with all powers to organise the service, recruit the staff, and fix tariffs. They also retained 20% of any profits made after deducting working expenses.

Peking-Mukden Railway.

Kilometres.
974.8

Cost per Kilometre.
$70,715

Operating Expenses per Kilometre.
$7,081

Cost Rolling Stock.
$16,771,469

Trains per Day.
16

Total Train Kilometre.
5,639,816

Operating Cost per Train Kilometre.

			Maintenance.		
General.	*Traffic.*	*Running.*	*Equipt.*	*Way.*	*Total.*
.21	.15	.31	.27	.28	$1.22

[12] Cost of this line £5,300 per mile, openings 100 feet per mile, double track earthwork.

Number of Locomotives.		*Tractive Capacity Tons.*		*Kilometres run per year.*
127	Goods 109	Passenger	141.491	47,480
		Goods	1,015.699	

Number of Goods Cars.	*Total Capacity Tons.*
3,416	72,078

Tons hauled per year.
6,013,682

Ton Kilometres per year.	*Goods Train Kilometres.*
908,385,854	3,218,743

Tons per Train.
282

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.15	30.36	$4.96

Maintenance per Kilometre per annum.	*Track only.*
$1,606	$537

Track. Employees per Kilometre Main Line.
4.8

Track.—The mule tramway from Tangshan to Hsukochwang—a distance of seven miles—from which this railway originated was laid with 30 lb. rails. On this the *Rocket* of China, a four-coupled locomotive of strange design, ran for the first time on June 9, 1881. The gauge of this first line was 4′ 8½″, though it was at one time proposed as a 2′ 6″ gauge line in order to utilised the rolling stock acquired by China on the purchase and abandonment of the Woosung Railway in 1877.

On the extension of the railway, as it shortly became, from Hsukochwang to Lutai, a further 21 miles, in 1887 a 45 lb. Krupp rail was adopted and on the Tangku extension in the following year a 60 lb. rail was used, while the weight was increased to 70 lb. for the length between Tangku and Tientsin. Between Peking and Tientsin, constructed in 1897 the 85 lb. rail was put in and the line double tracked, but after the Boxer outbreak of 1900 this portion of the line was so badly damaged that it was decided to relay it as a single track and utilise the surplus rails on the construction of the 20 mile Tungchow branch built in 1901 and on relay work between Tangku and Tientsin.

All the extensions east of Tangshan have been laid with the 60 lb. rail which was replaced in the district of heavy traffic connecting the coal mines in the Tangshan district—the 15 mile section between Tangshan and Kuyeh —and Chingwangtao by an 85 lb. rail in 1915. At present the mileage under 85 and 60 lb. rail is approximately 262 and 345 miles respectively.

Track Standards

Rail Weight.	*Sleepers to mile.*	*Ballast to mile.*
45	1,936	700 fang
60	2,112	700 „
85	2,464	900 „

The standard sleeper is of Japanese hardwood 8′ 0″ × 9″ × 6″ and has a life of 9.2 years.

Grade and Curvature Limits are 1 in 120 and 1,000 feet.

Construction history.—As regards railway construction this line was the pioneer and has provided standards for both operation and construction for many of the subsequent railways. On this account its history is worthy of more detailed record. Begun in 1881 under imperial patronage but without the aid of imperial finance its early construction was continually interrupted, while it suffered much damage during the Boxer outbreak of 1900. These circumstances were not conducive of economy yet it stands to-day as the cheapest main line in the country in spite of the very large sums spent in betterments in recent years, and of the fact that its rolling stock equipment is on an altogether different scale to other lines.

The following is the chronology of the line.

1881 Tangshan-Hsukochwang tramway.

1882 Mr. Kinder general manager, mines and railway. Li Hung Chang's memorial to throne to extend line to Lutai. Kaiping Railway Company formed under management of Wu Ting Fang which took over tramway for £35,000, capital of the new company being £70,000.

1887 Completion of Lutai extension, 21 miles, at a cost of £34,000 which included one locomotive and forty, 10 ton cars. March 1887 the throne again memorialised by Li Hung Chang for further extension. This was allowed and the Kaiping Railway Company changed its name to the China Railway Company.

1888 April completion of Tangku extension and line extended to Tientsin which was reached in August of the same year. Cost of line from Tangshan to Tientsin £3,000 per mile.

1889 Abandonment of Tungchow extension project and of bridge across the Peiho at Tientsin.

1890 extension to Kuyeh completed which exhausted the capital of the China Railway Company resulting in the formation of the Imperial Railway Administration which extended the line to Shanhaikwan. Mr. Kinder's Kirin Survey with a view to Manchurian extensions.

1893 Shanhaikwan reached and railway continued to Chung Ho Sou 40 miles east, which was completed in 1896.

1894 China Railway Company taken over by the Government shareholders receiving 5% bonds.

1895 Peking extension sanctioned and completed in 1897 to Ma Chia Pu which was connected with the city by electric tramway in 1899. Double track railway cost £10,000 per mile.

1898 October Loan agreement for £2,300,000 signed by Hu Yen Mei Governor of Peking, with British and China Corporation.

1899 October Chinchou reached and construction track completed to Yingkow.

1900 to October 1902 British Railway Administration who extended the railway right into Peking and built the Tungchow extension. Russian administration until October 1902 of Manchurian portion of the line.

1903 completion of line to Hsin Min Fu, the total expenditure on the 588 miles being about £3,850,000.

Openings on the Peking-Mukden Railway exceed 100 feet per mile and eight bridges totalling 156 piers were sunk by compressed air. Openings per mile Tangshan to Shanhaikwan 180 feet approx. Shanhaikwan-Chinchou 194½ feet, Chinchou-Yingkow 73.1 feet per mile.

1907 purchase of Japanese light railway from Hsinmin to Mukden and completion of Mukden extension.

Railways protected from War damage by Treaty are somewhat of an anomaly, but this is the case as regards the Peking-Mukden Railway within the province of Chihli.

By the railway agreement incorporated in the Protocol of 1902 China is forbidden to keep troops within certain specified areas, must confine hostilities to a zone distant at least two miles from the railway and must not so damage the line as to cause traffic interruption for a greater period than 48 hours. Further prolonged suspension of normal traffic is forbidden between Peking and the sea and to ensure this a train under the protection of the troops of the Treaty Powers circulates in this district whenever hostilities occur.

Loans.—£2,300,000 made with the British and China Corporation in 1898 for the construction of the Extra-mural extension and secured on the railway then in operation. Date of expiry of this loan 1944 or if repayment desired before then bonds to be redeemed at a premium of 20%. A British Chief Engineer and Accountant were stipulated for by the loan agreement which had no purchasing clause as most subsequent agreements had—

There is also a Japanese Loan for Yen 320,000—period 1909 to 1927—secured on the Hsinminfu-Mukden extension and with the usual stipulations as to personnel, which are satisfied by the employment of a Japanese engineer and surveyor at Mukden. The loan is a 5% one.

Financially the railway has been progressively prosperous since 1903 when the return on capital was 4¾%, while in 1905 it reached 20¾% and stood in 1918 at well over 21%.

This railway from surplus profits provided the funds for the construction of the first 122 miles of the Peking-Suiyuan Railway built in 1906 at a cost of Tls. 8,000,000.

Development of the line as regards Manchuria has been checked as the result of the parallelism agreement with regard to railway construction concluded between China and Japan in 1905, the most notorious case being the vetoing of the Fakumen Railway in 1907.

The railway from its earliest beginnings till 1909 was managed by Mr. C. W. Kinder, C.M.G. to whom China owes her adequate gauge and the excellent standards of construction adopted.

Tientsin-Pukow Railway.

Kilometres.
1,106.8

Cost per Kilometre.	*Operating Expenses per Kilometre.*
$91,646 (*Construction*).	$5,723

(Northern Sec. £11,783 per mile)
(Southern Sec. £9,100 „)

Cost Rolling Stock.
$10,603,558

Trains per Day.	*Total Train Kilometre.*
9	3,773,492

Operating Cost per Train Kilometre.

General.	*Traffic.*	*Running.*	*Maintenance. Equipt.*	*Maintenance. Way.*	*Total.*
.35	.21	.36	.26	.42	$1.60

Number of Locomotives.		*Tractive Capacity Tons.*		*Kilometres run per year.*
76	Goods 38	Goods	415,996	51,364

Number of Goods Cars.	*Total Capacity Tons.*
1,392	33,390

Tons hauled per year.
2,315,832

Ton Kilometres per year.	*Goods Train Kilometres.*
719,268,055	2,390,462

Tons per Train.
300

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.18	27.45	$6.82

Maintenance per Kilometre per annum.	*Track only.*
$1,432	$527

Track. Employees per Kilometre Main Line.
4.0

Track. Northern Section.—82 lb. rail laid on 14 Japanese oak sleepers to the 11 metre rail. Every sleeper has tie plates an exceptional and unnecessary procedure in view of the short life of the sleeper.

Southern Section.—85 lb. rail 30 feet long. 14 sleepers to the rail where hardwood is employed, 16 in the case of creosoted oregon. Hard wood is usually Japanese oak but Jarrah has been employed to a limited extent.

Gauge 4′ 8½″. Grade and Curvature limits one in 150 and 1,000 feet curves on the Southern Section. 1,000 metre curves on Northern Section and one in 150 grades.

Construction.—This is of more than usual interest as the line was constructed under two managements, German and British, whose standards and ideals are conflicting.

Generally speaking the standards adopted on the Northern or German Section were those of the Shantung Railway which Germany had previously constructed, the more salient features of which are to the casual observer a more flamboyant and elaborate style of station architecture and the prevalence of grand scale lay out, indicated more especially in extravagant sidings and excessively long loops.

With regard to the work generally the country traversed is extremely easy, in the whole length of 390 miles there is only one length of about 40 miles through the

Shantung mountains which presents any engineering difficulty. The earthwork of the line would not average 10 feet bank throughout.

The bridges are few the amount of major bridge opening working out at 32 feet per mile minor bridges and culverts would at a maximum bring this up to 50 feet per mile. The largest bridge is that over the Yellow River of 4,078 feet clear opening, and this is worthy of some mention.

This river at low water, about eight months of the year, has a width of 700 feet at this point. The flood discharge (Maximum) is estimated at 400,000 cubic feet per second the velocity of the stream in this condition being 12 to 15 feet per second and its width 1½ miles. The river freezes in winter.

The bridge as built consists of nine spans of 91.5 metres two of 128 metres and one of 164 metres, the central one of 164 metres being a cantilever span. the suspended span being 360 feet long and the cantilever arms being 90 feet long each, this being the proportion of greatest economy for a span of 540 feet or 164 metres. The trusses throughout the bridge are spaced at 31 feet centres, and although the steelwork is designed for one track only there is thus width for and provision for two, on strengthening the bridge. The total weight of the steel-work is about 8,700 tons.

With regard to foundations and masonry, the height from low water to rail level is 44 feet. With the exception of the two river piers which were sunk by compressed air to a depth of 80 feet below low water or 65 feet below river bottom the remainder of the piers are founded on re-inforced concrete piles driven in open cylinders which were sunk 20 to 25 feet below river bed. The number of piles per pier varied from 90 to 240 and they were driven to from 55 to 65 feet below low water into hard clay.

There is very little doubt that the bridge as designed gave a maximum weight of steel work, provision not warranted by the exceptionally easy river conditions. Without question for this height an arrangement of twenty-one 200 feet spans or possibly four 200 feet spans for the dry weather flow of the river and the remainder thirty-three 100 feet spans would have effected large economy. On the latter design a saving in steel of 4,354 tons could have been effected. The bridge was let as a lump sum contract for £500,000 the official cost being £531,760.

The line cost £11,738 per mile, the details being as below:

	Total.	*Per mile.*	
Land	$2,602,000	£556	
Earthwork	2,541,637	542	
Enclosure fencing	17,072	4	
Level crossing	112,547	24	
Bridges	10,838,051	2,317	
Yellow River	6,381,230	1,358	Total cost £531,769
Track	22,948,954	2,766	
Signals	924,208	198	
Stations	3,937,579	841	
Workshops	1,269,236	255	
Extra work	238,277	72	
Rolling stock	5,882,570	1,250	
General charges	4,967,425	1,062	
Extra charges	542,706	116	
Police	454,331	97	
Directorate	453,395	97	
Commission or Purchase	1,065,862	227	
	55,177,088	11,738	
% during construction	9,455,087		
Syndicate	1,399,449		
Exchange	941,397		
	$66,126,062		

With regard to the Southern Section of 238 miles the standards born of long experience on the Northern Railways prevailed to a great extent. The line which traversed much more difficult country entailing very heavy earthwork and the construction of bridging to the extent of 97 feet per mile was built at a cost of £9,100 per mile. The largest bridge over the Huai Ho consisted of nine, 200 feet spans the piers of which were all founded by compressed air.

History.—The line was constructed under a joint loan German and British, the Germans constructing the Northern Sections of 390 miles which traversed what was then the German sphere of influence and the British that portion of the line from the borders of Kiangsu to the Yangtse. As originally proposed the southern terminus of the line was at Chinkiang 50 miles further down the river and this railway concession was given to Yung Wing in 1897 who made a contract for a loan of $27,500,000 with Anglo-American capitalists. This contract was cancelled owing to complications with Germany as the result of rights acquired in the province of Shantung in 1898. Work on the Northern Section began in 1908 (June) and on the Southern Section in February of the following year. The line was opened for traffic in 1912 (June) on the Southern Section and March 1913 saw the line complete.

Loans.—The Southern Section was built with a British Loan from the British and China Corporation of the amount of £2,960,000, the Northern with German capital to the amount of approximately £6,000,000. The terms of the loan agreement were those instituted by Germany and generally known as the Pukow terms, the most important variations from previous procedure being the subordination of the engineers-in-chief to the Director and purchase of materials by tender in the open market. The term of the loan is for 30 years, amortization to begin after the lapse of 10 years, with right of redemption any time after this on payment of a premium of 2½%. Interest 5% price 93.

The line was operated under the above dual control until August 1917 when on China declaring war on Germany, German employees were dismissed and China elected to operate the Northern Section herself.

Shanghai-Nanking Railway.

Kilometres.
327.1

Cost per Kilometre. $93,889

Operating Expenses per Kilometre. $9,077

Cost Rolling Stock.
$5,048,634

Trains per Day. 19

Total Train Kilometre. 2,332,717

Operating Cost per Train Kilometre.

General.	Traffic.	Running.	Maintenance. Equipt.	Maintenance. Way.	Total.
.13	.26	.47	.24	.17	$1.27

Number of Locomotives. 33 Goods 10

Tractive Capacity Tons. Passenger 172.797 Goods 102.536

Kilometres run per year per Locomotive. 75,057

Number of Goods Cars. 437

Total Capacity Tons. 10,859

Tons hauled per year.
1,131,302

Ton Kilometres per year. 252,703,380

Goods Train Kilometres. 849,571

Tons per Train.
298

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.37	20.86	$17.91

Maintenance per Kilometre per annum. $1,225

Track only. $303

Track. Employees per Kilometre Main Line.
3.3

Track.—85 lb. rails[13] 36 feet long on Jarrah sleepers 9′ 0″ × 10″ × 5″ spaced 14 to the 36 foot rail or 2,060 to the mile. Sidings have similar sleepers spaced 1,760 to the mile. The line is bottom ballasted 8″ deep, the only line in China thus treated. Gauge 4′ 8½″.

Maximum.—Grade one in 200 minimum curvature three degrees (1,910 feet).

Construction.—The country followed was exceptionally easy. Openings averaged 30 feet per mile. There is one tunnel 1,320 feet long constructed for double track at a cost of $370,000. The earthwork and bridges as far as Soochow—54 miles—are also built for double track with a 30 feet formation, the single track formation width being 17 feet. Construction began in 1904 and the line was opened for through traffic in April 1908. 403 Bridges of total waterway 5,867 feet or 30 feet per mile.

Loans.—The preliminary agreement was signed in 1898 and the final agreement in July 1904. The agreement provided for the issue of £3,250,000 but the amount issued was only £2,900,000 the Chinese Government supplying (£221,373) Tls. 1,604,958[14] from the Treasury. The terms of the loan were practically those of the Kinhan Railway, but control is vested in a Board of five members of which three are nominees of the British and China Corporation who financed the line and the remainder appointed by the Chinese Government. The Corporation as usual receive 20% of the profits if any during the term of the loan—50 years, but redeemable after 12½ on payment of a premium of 2½%.

With regard to the financial position of the railway, it suffers much from water competition and numerous likin[15] barriers, but when the trunk system, of which it is merely

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[13] Rails are without angle fish plates and are flange drilled to prevent creep.

[14] This amount had increased by 1912 to £308,117.

[15] Internal customs.

a link, is complete it should pay all charges, which it cannot meet at present.

In 1914 the management took over the operation of the Shanghai-Hangchow Railway[16] and has since linked up the two systems at Shanghai and completed 60 miles of line at the Ningpo end.

Shanghai-Hangchow-Ningpo Railway.

Kilometres. Main and Branch Line.
286.4

Cost per Kilometre.
$77,253

Operating Expenses per Kilometre.
$7,216

Cost Rolling Stock.
$3,565,430

Trains per Day.
9

Total Train Kilometre.
996,421

Operating Cost per Train Kilometre.

General.	*Traffic.*	*Running.*	*Maintenance. Equipt.*	*Maintenance. Way.*	*Total.*
.24	.27	.76	.37	.43	$2.07

Number of Locomotives.	*Tractive Capacity Tons.*		*Kilometres run per year.*
24 Goods 12	Passenger	91.191	43,015
	Goods	147.198	

Number of Goods Cars.
506

Total Capacity Tons.
14,464

Tons hauled per year.
464,787

Ton Kilometres per year.
52,266,071

Goods Train Kilometres.
289,977

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[16] Better: "rendered fit for operation."

Tons per Train.		
180		

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.37	31.00	$20.68

Maintenance per Kilometre per annum.	*Track only.*
$1,512	$651

Track. Employees per Kilometre Main Line.
4.9

Track.—75 lb. rail. Manufactured at Hanyang.

Gauge 4′ 8½″.

Construction.—The line with the exception of the connection between the terminus of this line at Shanghai and that of the Shanghai-Nanking Railway opened in 1916 was constructed by Chinese engineers. Nominally a British chief engineer was in charge to conform to the loan agreement, but the attitude of the natives prevented his appointment being anything but a sinecure. The line from Shanghai to Hangchow was opened for traffic in 1909 and was handed over to the management of the Shanghai-Nanking Railway as a government railway in 1914 which completed and opened for traffic in 1915 the 60 mile section from Ningpo to Pokwan. The Ningpo-Hangchow Section is still under construction.

Loans.—The history of this line is remarkable for the difficulty in which the Government was involved owing to local objection to the introduction of foreign capital, and the decision of the Government, as expressed in the Edict of 1911 reserving important railway construction to itself was the outcome of this opposition. The railway was awarded as a British concession in 1898 but the Government alleging delay transferred the construction rights to two provincial companies in 1905. The British Loan for £1,500,000 was floated in 1908 on similar terms to that for the Tientsin-Pukow Railway with the exception of a clause allowing complete redemption at 2½% premium after the lapse of 10 years as in the case of the Peking-Hankow Railway. The proceeds of this loan were used by the native companies, as local opposition was so strong, as only to admit of compromise, resulting in the appointment of foreign engineers to sinecure posts and the unfettered control of government money by the provincial companies.

Peking-Suiyuan Railway.

Kilometres.
495.1

Cost per Kilometre.
$59,035

Operating Expenses per Kilometre.
$5,777

Cost Rolling Stock.
$6,616,041

Trains per Day.
7

Total Train Kilometre.
1,349,177

Operating Cost per Train Kilometre.

			Maintenance.		
General.	*Traffic.*	*Running.*	*Equipt.*	*Way.*	*Total.*
.51	.22	.41	.40	.58	$2.12

Number of Locomotives.		*Tractive Capacity Tons.*		*Kilometres run per year.*
55	Goods 26	Passenger	414.152	25,164
		Goods	424.212	

Number of Goods Cars.
852

Total Capacity Tons.
23,960
21,191

Tons hauled per year.
1,305,378

Ton Kilometres per year.
134,312,867

Goods Train Kilometres.
818,265

Tons per Train.
165

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.23	37.50	$6.10

Maintenance per Kilometre per annum.	*Track only.*
$1,577	$560

Track. Employees per Kilometre Main Line.
4.2

Track.—85 lb.

Gauge 4′ 8½″. Minimum curves 500 feet radius. Maximum grade one in 30 uncompensated, equivalent to one in 27.

Construction.—This was the first railway scheme of any magnitude undertaken and constructed under purely Chinese management. Work began in 1906 and in 1909 the first 120 miles to Kalgan was opened for traffic. The work in the region of the Nankow Pass where the grades are one in 30 was exceptionally heavy, there being over a mile[17] of tunnels in this 38 mile length and 50% of the cuttings were in solid rock as was most of the tunnel work.

The railway was opened to its present length in 1915 and construction is now in progress on a further 90 mile section terminating at Suiyuan which it is expected to reach in 1920.

The first chief engineer of the railway was H.E. Taotai Jeme Tien Yu, in 1905 an engineer on the Peking-Mukden Railway as were also many of his assistants. He was later consulting engineer to the Shanghai-Hangchow and Hankow-Canton (Kwangtung Section) Railways in addition to being chief adviser to the Board of Communications. At the time of his death in 1919 he was Chinese member of the International Board controlling the Chinese Eastern Railway. The cost of this first 120 miles section was Tls. 65,570 per mile.

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[17] Actual length of tunnels 5,400 feet built at a cost of $98.7 per foot (lined).

Loans.—This railway was built from the surplus profits of the Peking-Mukden Railway and though Russia acquired in 1912 priority rights if money was ever borrowed, the line was never mortgaged until 1919 when Japan advanced Yen 3,000,000 the tacit assumption being that Russian rights are inherited by that country.

Shihchiachuang-Taiyuanfu Railway.

Kilometres.
243

Cost per Kilometre. $91,119

Operating Expenses per Kilometre. $5,505

Cost Rolling Stock.
$4,963,705

Trains per Day. 12

Total Train Kilometre. 1,062,326

Operating Cost per Train Kilometre.

General.	*Traffic.*	*Running.*	*Maintenance. Equipt.*	*Maintenance. Way.*	*Total.*
.21	.15	.31	.27	.28	$1.22

Number of Locomotives.		*Tractive Capacity Tons.*		*Kilometres run per year.*
44	Goods 38	Passenger	35.040	25,612
		Goods	218.120	

Number of Goods Cars. 627

Total Capacity Tons. 12,810

Tons hauled per year.
1,131,581

Ton Kilometres per year. 89,668,796

Goods Train Kilometres. 851,235

Tons per Train.
105

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.10	19.92	$4.94

Maintenance per Kilometre per annum.	*Track only.*
$1,181	$331

Track. Employees per Kilometre Main Line.
2.5

Track.—56 lb. rail on wooden sleepers 6′ 6″×8½″×6″ spaced 1,760 to the mile.

Gauge metre.

Construction.—This railway is a branch of the Peking-Hankow Railway and was obtained as a concession by the Russo-Chinese Bank in 1898 who contracted with the Belgian Société d'Etudes de Chemin de Fer who built the Peking-Hankow Railway, to build the railway. The work was exceptionally heavy there being 19 tunnels in this length several of which are over 300 metres long. Construction began in 1903 and the line was opened for through traffic in October 1907. The line is the only metre gauge or non-standard Government Railway. The Russo-Chinese Bank has now no interest in this line.

Loans.—A loan for £1,600,000 was raised in 1903 in Paris for construction purposes.

Taokow-Chinghua Railway.

Kilometres.
152.5

Cost per Kilometre.	*Operating Expenses per Kilometre.*
$48,395	$2,798

Cost Rolling Stock.
$1,208,334

Trains per Day.	*Total Train Kilometre.*
6	367,272

Operating Cost per Train Kilometre.

			Maintenance.		
General.	*Traffic.*	*Running.*	*Equipt.*	*Way.*	*Total.*
0.24	0.10	0.25	0.17	0.40	$1.16

Number of Locomotives.		*Tractive Capacity Tons.*		*Kilometres run per year.*
7	Goods 6	Passenger	8,349	53,292
		Goods	59,949	

Number of Goods Cars.	*Total Capacity Tons.*
189	5,346
	4,576

Tons hauled per year.
935,081

Ton Kilometres per year.	*Goods Train Kilometres.*
67,037,061	236,406

Tons per Train.
283

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.14	25.06	$5.09

Maintenance per Kilometre per annum.	*Track only.*
$986	$571

Track. Employees per Kilometre Main Line.
2.8

Track.—75 lb.

Gauge 4′ 8½″.

Construction.—The line was built for the Peking Syndicate by Pearson & Co., the British contractors. Construction was begun in 1900 renewed in 1902 and the line completed and opened for traffic in July 1904. Openings 3,197 feet or 34.2 feet per mile in 177 bridges and culverts. No opening over 30 feet.

Loans.—This branch of the Peking-Hankow owes its origin to the Peking Syndicate, a British Company organised in 1897 with a capital of $100,000 to exploit the mineral wealth of Shansi and Honan. The concession was obtained in 1898 and the capital of the Company was then increased to $7,600,000. One of the most important clauses of the concession was the right acquired to build roads or railways or carry out conservancy work in rivers to secure transport from the mines. Owing to local opposition the rights of the Syndicate in the province of Shansi were purchased in 1908 for the sum of Tls. 2,750,000. Present capital of the Peking Syndicate £1,242,000.

With regard to loans the railway was purchased by the Chinese Government in 1905 for a sum equal to the cost of the line plus 10%. The amount of this loan was £650,000 and the term 30 years. A further loan for £800,000 was negotiated in 1914 for a term of 20 years the source of capital in both cases being the Peking Syndicate who also operate the railway for the Government and receive 20% of the net profits.

Kaifeng-Honanfu Railway.

Kilometres.
185.0

Cost per Kilometre.
$73,289

Operating Expenses per Kilometre.
$3,803

Cost Rolling Stock.
$1,707,059

Trains per Day.
7

Total Train Kilometre.
494,594

Operating Cost per Train Kilometre.

			Maintenance.		
General.	*Traffic.*	*Running.*	*Equipt.*	*Way.*	*Total.*
.21	.09	.32	.35	.45	$1.42

Number of Locomotives.		*Tractive Capacity Tons.*		*Kilometres run per year.*
10	Goods 5	Passenger	49.000	52,315
		Goods	49.000	

Number of Goods Cars.
200

Total Capacity Tons.
4,000

Tons hauled per year.
393,407

Ton Kilometres per year.	*Goods Train Kilometres.*
28,675,713	153,939

Tons per Train.
186

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.19	25.72	$7.40

Maintenance per Kilometre per annum.	*Track only.*
$1,197	$749

Track. Employees per Kilometre Main Line.
2.7

Track.—85 lb. on steel sleepers weighing 131 lbs. (64 kilograms). Rail length is abnormal for China 39′ 8″ (12 metres)

Gauge 4′ 8½″.

Construction.—As originally projected in 1904 the line was to connect Kaifengfu with Honanfu situated respectively east and west of the Peking-Hankow Railway and this is the line represented in the Board Report. It was opened for traffic in 1908 and in 1913 it was decided to proceed with the extension Eastwards to link up with the Tientsin-Pukow Railway and eventually to connect with the port of Haichow. The line was completed to Hsuchoufu, the junction with the Tientsin-Pukow Railway, in 1915 but is still under constructional control. The completed mileage is now 350.

Loans.—The first loan was for £1,000,000 floated in 1904 and this was followed by a supplementary loan for £640,000 in 1907. In 1913 in pursuance of the Republican railway programme it was decided to proceed with the bigger scheme and for this a loan of £4,000,000 was raised which was used to purchase the 60 miles of the Lotung Railway which was being constructed by the Honanese gentry west of Honanfu, and also to purchase 15 miles of the Tsinkiangpu Railway east of Hsuchoufu (another native concern) and to construct the 150 miles of line connecting Kaifengfu with Hsuchoufu. The absorption of these native undertakings was as usual a matter of considerable difficulty, especially in the case of the Lotung Railway which even now cannot be considered as entirely disposed of. The scheme as a whole, which aims at connecting Haichow with Sianfu, is known as the Lunghai Railway. The source of capital in every case has been the Franco-Belgian Compagnie General de Chemins der Fer et de Tramways en Chine. In 1919 there was considerable local agitation over the proposal to introduce Japanese capital for the Honan extension. The natives are now (1920) much exercised over the loan Fc. 25,000,000 at 8% raised in Holland for the Haichow extension.

Canton-Kowloon Railway.

Kilometres.
143.3

Cost per Kilometre.	*Operating Expenses per Kilometre.*
$77,253	$7,181

Cost Rolling Stock.
$1,419,916

Trains per Day.	*Total Train Kilometre.*
8	431,187

Operating Cost per Train Kilometre.

			Maintenance.		
General.	*Traffic.*	*Running.*	*Equipt.*	*Way.*	*Total.*
.46	.19	.89	.34	.51	$2.39

Number of Locomotives.	*Tractive Capacity Tons.*	*Kilometres run per year.*
12 Passenger	112.677	36,113

Number of Goods Cars.	*Total Capacity Tons.*
67	1,555

Tons hauled per year.
95,308

Ton Kilometres per year.	*Goods Train Kilometres.*
6,442,733	145,006

Tons per Train.
44

Cost Coal per Train Kilometre.	*Kilogs.*	*Price (per ton)*
.71	32.12	$22.13

Maintenance per Kilometre per annum.	*Track only.*
$1,338	$437

Track. Employees per Kilometre Main Line.
4.4

Track.—85 lb. on Jarrah sleepers 2,000 to the mile. Rails 36 feet long and standards generally as Shanghai Nanking Railway.

Gauge 4′ 8½″.

Grades Max. one in 150 and three degree curves.

Construction.—This was begun in the British Section in 1906 and the section was opened for traffic in October 1910. The work on this 22 mile length was exceptionally heavy, the costly feature being the tunnel work. There are five tunnels, the longest being 7,256 feet, the others, built for double track with an arch of 35 feet span, totalling 1,610 feet. The cost of construction was $13,284,425. There were 50 bridges all built for double track.

The construction of the Chinese Section whose statistics are here shown was undertaken in 1908 and completed in October 1911. Openings 37′ 0″ per mile. Land cost was very high[18] and Labour 100% higher than in North China.

Loans.—The financing of the British Section was undertaken by the Government of Hongkong, that for the Chinese Section by the British and China Corporation who obtained this concession in 1898, when the threat of the China-American Development Company (who were the concessionaires for the Hankow-Canton Railway at that

[18] Land 1st Class $326.7 per acre 2*s.* = dollar.
2nd „ $217 „ „ „
3rd „ $109 „ „ „

time) to make Canton into a first class port, inspired the scheme as a protective measure for the security of the commercial future of the Colony of Hongkong. The amount of the British loan was £1,500,000.

Chinese Eastern Railway.

Mileage.—Main line forming part of the Trans-Siberian Railway 1,073 miles or 1,700 kilometres and branch from Harbin to Changchun the junction with the South Manchuria Railway 202 miles or 324 kilometres.

Track.—65 lb. 35 feet long.

Gauge.—5 feet.

History.—This is the oldest concession railway. The agreement between the Russo-Chinese Bank (formed in 1895 for the financing of Russian commercial and political enterprise in the Far East), and the Chinese Government was signed on September 8, 1896 and provided for the construction of the main or Trans-Siberian portion only. In 1898 Russia secured the lease of the Liaotung-Peninsula for a period of 25 years and with it the right to construct the 600 mile branch from Harbin to Port Arthur. This branch was practically complete in 1900 but the Trans-Siberian portion was not completed till 1904. The cost of construction of the whole 1,600 miles of line was 300,000,000 roubles or about £18,700 per mile. By the terms of the concession China has the right of purchase 36 years after the opening of the line to traffic, a right not likely to be exerted if the Russian[10] valuation is to be accepted. The line reverts without payment to China after the lapse of 80 years from the opening. China should have and is now to receive by the agreement a payment of Tls. 5,000,000 on the opening of the line.

After the War with Japan the Southern portion of the Harbin-Port Arthur Railway from Changchun to Port Arthur was ceded to Japan, China agreeing in 1905, to

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[10] Cost of Vladivostok-Habarovsk Railway in same region, 716 versts, or 477 miles over £8,000 per mile (Hosie on Manchuria).

the cession on terms identical with those granted to Russia. After the Russian Revolution of 1918 the Railway was administered (until the evacuation in 1919 of the Allied Expedition) by an International Board and this has been followed by a Russo-Chinese management under Japanese tutelage.

On October 2, 1920 the following agreement between Russo-Chinese interests concerned in this railway was signed. The essential features of this document are as follows:

1.—A board of directors shall be formed of which five shall be Russian and four Chinese. The Director-General appointed by China shall be Chairman of the Board and shall have one vote, and the casting vote in a case of a tie vote.

2.—Seven votes shall constitute a majority. Seven directors shall constitute a quorum, but among the seven must be either the director-general or co-director.

3.—An additional Chinese, and an additional Russian shall be appointed deputy assistant directors-general, and the offices of general manager and other temporary high offices shall be abolished.

4.—A Chinese administrative vice-director shall be appointed, and there shall be Chinese assistant chiefs in the bureaux of accounts, traffic, engineering, and railway guards.

5.—Regarding the return of the Tls. 5,000,000[20] and interest, and the appointment of Chinese in the railway inspectorate—these shall be arranged through separate agreements.

This agreement was made with a director of the Russo-Asiatic Bank acting in the joint capacity of a bank director and also director of the Chinese Eastern Railway.

Yunnan-Hanoi Railway.

Kilometres.
859

Cost per Kilometre.
$97,000

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[20] Reduced to Tls. 3,800,000 on reorganisation of the Russo-Chinese Bank to become the Russo-Asiatic Bank. China should receive Tls. 11,200,000 or Tls. 14,000,000 according as date of opening is settled as 1903 or 1907—a matter of dispute.

Total Train Kilometre per year.
1,671,922 (1916)

Number of Locomotives.
61

Number of Goods Cars.
735

Total Capacity Tons.
8,100

Coal Kilogs. per Train Kilometre.
9.09

Maintenance per Kilometre per annum.
450 Francs

Number of Men per Kilometre.
1.86

Track.—50 lb. on steel sleepers weighing 79.2 lbs. (36 kilos) 6 feet long (1.80 M) spaced 1,253 to the kilometre (2,000 to the mile). Ballast 1,250 cubic yards to the kilometre.

Gauge metre.

Maximum grade.—One in 30 minimum curvature 330 feet (100 metres).

History.—This concession[21] (for railways in Chinese territory) was obtained in 1898 but construction did not begin till 1904 as regards the extension of the railway from Hanoi to Laokay in Tonking into China proper. The mileage in China is 289, or 460 kilometres. The construction of the line was exceptionally difficult owing to the scarcity of labour and the deadliness of the climate added to country of considerable difficulty. There are 140 tunnels on the Chinese section the longest being 600 metres. The line was opened for traffic in April 1910.

The cost of construction of the whole line was 165 million francs or $97,000 per kilometre approximately. The capital was raised by a 4% loan guaranteed by the French Government and redeemable in 65 years. France

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[21] The terms are practically those of the Chinese Eastern Railway. That is, purchase after 36 years and reversion after 80 years.

holds neither mineral nor police rights in Chinese territory. The railway pays little more than working expenses.

In addition to extension rights to the above railway, which will never be enforced on concession lines as above, France holds exclusive rights for the provision of foreign capital if required for railways in the province of Kiangsi which borders Tonking. These rights were invoked in 1916 to veto the Siems Carey Railway schemes. France also by virtue of the Chinese Central Railways Agreement of 1896 shares with Great Britain all finance business for the development of the Provinces of Szechuan and Yunnan, an agreement apparently rendered of no effect by the acquisition in 1914 by a French Company of construction rights for a railway from Yunnanfu to Suifu.

Shantung Railway.

Track.—60 lb. on steel sleepers weighing 110 lbs. spaced 1,760 to the mile. Max. Grade 0.6%.

Gauge.—4′ 8½″. Length 284 miles (455 kilometres). Goods Wagons 1,051.

Construction.—This line is a concession Railway built under conditions which have been previously noted when dealing with the Chinese Railways as a whole. Construction began in 1899 and was interrupted by the Boxer trouble. The line was completed and opened for traffic in 1904.

It connects the once German port of Tsingtau with the capital of Shantung province, Tsinanfu. The line was exceedingly costly considering the easy country traversed, but as this line probably created German standards of construction for other German ventures an analysis of the cost of line taken from German sources is worthy of some study. The details are as follows:

Land	89,700	£317 per mile.
Earthwork	148,000	Double Track.
Fencing	2,700	
Bridges, etc.	728,000	1,325 bridges. Longest bridge 1,541 feet £2,570 per mile.
Permanent way	759,000	steel sleepers £2,670 per mile.
Signals	13,200	

Stations	106,000	£374 per mile.
Repairing shops	85,000	£300 per mile.
Materials (Coal, etc.)	310,000	
Administration	203,000	
Interest on capital	200,000	
	£2,644,000	or about £9,200 [22] per mile without rolling stock.

It should be noted that the mileage given for this line includes 28 miles of branch lines whose standard of construction is inferior to that of the main line. No allowances have been given for this in the cost per mile. The price paid for land on this line was 1.1*d.* per yard or £10.10.0 per acre. This is a high initial price to pay for land, the price generally paid on the Peking-Mukden Railway for extra land required for stations being from £12 to £18 per acre at the present time, and this land has of course much appreciated in value. The original price was about £6.

The price paid for earthwork was 1.4*d.* per cubic yard or 5.2*d.* per fang of 100 cubic feet. The amount of land bought indicates an average height of bank certainly not over eight feet and for this certainly no more than 4*d.* per fang should have been paid.

The amount spent on stations is high, but the type of station adopted is far more elaborate than is usual on other lines in China.

The most mysterious item of expenditure is that on materials which appears to be very heavy indeed unless this item includes rolling Stock. The working expenses of this line is 1912 were £432 per mile. The line had paid from four to six per cent. since being opened.

Since the capture of Tsingtau in November 1914 the railway has been controlled and operated by a Japanese administration with strong militaristic tendencies. As the result of the Peace Conference award of May 1919 the rail-

[22] Convert to dollars at the rate of 12 to the £, and cents at rate of 5 to the penny.

way, with the inheritance of all German[23] concession rights in the province of Shantung was handed over to Japan. China refused to accept this condition and abstained from signing the Peace Treaty. Various attempts have been made by Japan to regularise the position but popular feeling has prevented the opening of negotiations. An agreement made in September 1919 provided for the withdrawal of Japanese garrisons with the exception of those at the termini and for their replacement by a Chinese police force officered by Japanese. Further, among the employees posts shall be given to Chinese subjects, and after it has been definitely decided to whom the railway is to belong, the railway is to be placed under the joint management of China and Japan.

South Manchuria Railway.

Kilometres. South Manchuria.

Dalny-Changchun	830 kilos.		520 miles	(practically all
Anting-Mukden	263	„	165 „	double track)
Korean Railways	1,750	„	1,092 „	
Total	2,843	„	1,777 „	

Trains per Day.
19.7
S.M.R. & Antung

Total Train Kilometre.
7,850,000
(1917) S.M.R. & Antung

Number of Locomotives.
S. M. Railway 255 (1916)
„ 323 (1919)

Number of Goods Cars.
2,903 (1916)
(1919) 4,595 of an average capacity of 62,000 lbs., and 203 other cars of caboose and brake van class.

Tons hauled per year.
6,477,325 S.M.R.

[23] Tsingtau is to be returned to China but an undefined Japanese concession is to be ceded.

Maintenance per Kilometre per annum.	*Number of Men per Kilometre.*
Yen 2,180 S.M.R.	1.5
„ 1,740 Antung Railway	—
„ 940 Korean „	1

Track.—80 and 65 lb. and 60 lb. in sidings only on the South Manchuria and Antung Railways. On the Korean Railways the weight of rail is 75, 60 and 55 lb. The 65 lb. rail is a relic of the Russian regime and is 35 feet long. Allowable axle load 80 lb. rail 20 tons. 75 lb. rail 18 tons.

The sleeper employed is 8′ 0″ × 9″ × 6″ and there are 16 to 14 to the 30 foot 80 lb. rail. Under the 65 lb. rail sleepers vary from 18 to 14 under the 35 foot rail and under the 60 lb. rail of the same length 15 sleepers are used. All joint sleepers have a four spike tie plate. American standards are general in this and in rolling stock of which the passenger stock is of the Pullman type. All stock—goods and passenger—fitted with Westinghouse brakes.

Gauge.—4′ 8½″. Formation width Antung Railway Banks 16′ 0″ cuts 24′ 0″.

Max. grade.—South Manchuria one in 100. Antung Railway one in 80. Korean Railways one in 40.

Minimum Curvature.—South Manchuria 1,320 feet. Antung and Korean Railway 990 feet.

History.—The South Manchuria originally formed part of the Russian Chinese Eastern Railway and was ceded with all the Russian rights to Japan in 1905 after the Russo-Japanese War. The gauge was originally five feet and this was first converted to the Japanese standard of 3′ 6″ during the War and on the re-organisation standard gauge was adopted, but the rolling stock is not interchangeable with the railways of the Chinese Government.[24]

The concession together with the lease of the Liaotung Peninsula was obtained by Russia in 1898 under the same

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[24] Coupling gear heights differ by 6 inches.

terms as for the rest of the Chinese Eastern Railway. That is after the lapse of 36 years purchase at cost price was possible, and after the lapse of 80 years the line reverted to China without further payment. The lease of the Liaotung Peninsula was for 25 years only. As the result of the Twenty-One Demands of 1915, the railway will not revert to China until 2,002 and in the case of the Antung Railway until 2,007 while the lease period for the territory was extended to 1997.

The South Manchuria Railway Company was formed in August 1906 with a capital of Yen 200,000,000 of which half is the property of the Japanese Government who raised £12,000,000[25] in London in 1906 to finance the re-construction. By the articles of association Chinese and Japanese subjects may hold shares, but China has never availed herself of this right acquired as the result of the Treaty of 1905, which also protected the South Manchuria Railway by forbidding the construction of railways parallel to it. The paid up capital in 1916 was 120 million Yen and on this the government guaranteed 6% interest and also a subsidy for a period of 15 years which was in no case to exceed 6% and also to form a liability of the Company to the Government.

The reconstruction of the railway was completed in April 1907. The line has been uniformly prosperous. In addition to managing the Antung-Mukden Railway since 1906 and also the Korean Railways since 1918 this Company controls the exploitation of the Japanese sphere in Manchuria and is engaged in colliery and steel undertakings, control of steamship lines and the construction of all public works in the leased area.

The Antung-Mukden Railway was originally constructed between May 1905 and October 1906 and was a 2′ 6″ gauge line solely for the prosecution of the War with Russia. On the evacuation of the country in December

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[25] Later increased to £14,000,000 5% debentures of which £2,000,000 has been repaid.

1906 the railway was handed over to the South Manchuria Railway who ran it as it stood till 1909 when the line was re-graded and re-located (the original grades were one in 30) the work being completed as a standard gauge road in November 1911. Bridges in steel 22,610 feet opening. Cost per foot Fu Chin Ling Tunnel (lined) in solid rock Yen 150 per foot. Labour only Yen 1.54. Width at rail level 12 feet.

The Korean Railways began in 1896 with an American concession which was bought up by Japanese capitalists in the following year. Railway building continued slowly by private enterprise until the war with Russia when the Government built the standard gauge line from Seoul to Antung which was opened for general traffic in 1908. Subsequently the policy of nationalisation was adopted for Korea (1906) and all the private lines bought up and the Seoul-Antung line extended to Fusan, which is only 11 hours by sea from Japan.

The profits of the South Manchuria in 1915 were Yen 8,080,000 and in 1919 Yen 24,300,000.

CHAPTER V.

THE ECONOMICS OF THE CHINESE RAILWAYS

The war in Europe has undoubtedly set back the development of China for many years unless the Government can gain the confidence of the people and foster some spirit of patriotism. China at the outbreak of the War was committed to the construction of some 6,300 miles of railways, practically all of which was to be built by foreign loans. Had this scheme been carried out the development of the country would have made great strides.

It is fairly obvious that China must still look for money abroad and there is very little doubt that it will be more costly than heretofore. Consequently the study of economy will be more of a necessity than it has been in the past. Various savings would perhaps result from variations in the present methods and standards of construction, but before entering into a discussion of this, a short summary of the railway needs, resources and present conditions of transport in the different provinces would perhaps be useful. The estimated population of the 18 provinces of China proper is as follows:—

Province.	*Area square miles.*	*Population.*	*Number to square mile.*
Anwei	48,461	20,596,000	425
Chekiang	39,150	11,589,000	296
Fukien	38,500	22,199,000	574
Honan	65,913	22,115,000	340
Hunan	74,320	21,002,000	282
Hupeh	70,450	34,244,000	486
Kansu	25,450	9,285,000	74
Kiangsi	72,176	24,534,000	340
Kwangsi	78,250	5,858,000	65

Province.	*Area square miles.*	*Population.*	*Number to square mile.*
Kiangsu	44,500	20,905,000	470
Kwangtung	79,456	29,706,00	377
Kweichow	64,554	7,669,000	118
Chihli	58,940	17,937,000	304
Szechuan	116,800	67,782,000	406
Shansi	56,258	12,211,000	221
Shantung	53,762	36,247,000	557
Shensi	67,400	8,432,000	126
Yunnan	10,706	1,721,000	108
	1,335,841	386,000,000	292

It will be seen from the above table that the bulk of the population is concentrated in the provinces of Anwei, Honan, Hupeh, Chihli, Shantung, Kiangsu and Northern Chekian. These provinces form what is known as the Great Plain of China which is shown in the double black line in the accompanying map.

Roughly the area of this plain is 210,000 square miles with a population of 132,000,000 or 625 persons to the square mile, the densest in the world. In fact the nine eastern provinces in or near the Great Plain have an area of 502,192 square miles (two-fifths of the whole 18 provinces) and an average population of 458 persons to the square mile.

The necessity of railways for the development of this area is extremely obvious when its mineral, wealth, cheap labour, and present lack of transport facilities are considered.

Practically the whole of the Western portion of this plain is one vast coal field, with smaller coal fields in central Shantung and northern Chili. Other minerals, iron stone in particular, are also present in large quantities on the eastern boundary. The mineral and other resources, agricultural and transport are as follows:—

CHIHLI, the metropolitan province, has an area of 58,949 square miles. It produces wheat, maize, oats and salt and is also responsible for a large proportion of the coal production of China. It is served by the Peking-Hankow (No. 13), Peking-Mukden (No. 5), and Peking-Kalgan (No. 8) Railways, the Peking-Mukden Railway providing its outlet to the sea *via* Tientsin and the Peiho. This river, the only one of importance is navigable for steamers drawing 15 feet of water as far as Tientsin 40 miles from its mouth. This port is kept ice free in mild winters at considerable expense, but is always liable to be closed from December to March on account of ice. The Peiho is tortuous, has a bar at its mouth, and is continually silting up. Most of the coal produced is shipped through the ice-free port of Chingwangtao the property of the[26] Chinese Engineering and Mining Company whose accommodation for shipping has been designed with a view to their own requirements only.

SHANTUNG has an area of 65,104 square miles. It is extremely fertile. Cotton, the clothing of the people, silk, straw-braid, glass, earthenware and bean oil are some of its products. It has considerable mineral wealth producing a fair quantity of coal, some gold, and copper.

This province prior to the War was the German sphere of influence and has been exploited with the usual thoroughness. It is served by the trunk line from Tientsin to Pukow No. 10 and has rail connection with the excellent port of Tsingtao. All the railways were either German owned or under German control. Internal water communication is very poor. The province is traversed by the Grand Canal, which runs from Tientsin to Hangchow, but this in some places has been allowed to silt up, is generally in poor condition and is of little use as a waterway. The Yellow River, the only one of importance, is only navigable in parts, for small steamers as far as

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[26] Now Kailan Mining Administration.

Tsinanfu, the provincial capital, 200 miles from the mouth of the river. This river, owing to its tendency to silt up and burst its banks, is of more expense than utility, costing the Government about £750,000 per annum for conservancy. A railway along its banks for efficient handling and administration of the conservancy works would appear to be one of China's most urgent needs.

HONAN has an area of 66,913 square miles and is extremely fertile. Beans are its principal agricultural product and a large amount of coal is produced. It is served by the Peking-Hankow (No. 13) Railway which provides its outlet to the sea *via* Hankow and the Yangtse River. It has also another outlet to the same river *via* the Huai river and the Tientsin-Pukow (No. 10) Railway, but this route, which would serve much of Central Honan and Northern Anwei is at present undeveloped, only junks of 80 tons maximum carrying capacity at present using this river.

ANWEI has an area of 48,461 square miles and is said to be the poorest province in China. It has never recovered from the devastating effect of the Taiping rebellion of 1866 and is in more of an arrested state of development than the other provinces of the Plain. It produces tea, hides, rice and silk and has deposits of coal and copper which have not been developed. The province is served by one line of railway, the Southern Section No. 10, of the Tientsin-Pukow Railway, which is a British built line. Water communication is poor, the only navigable rivers being the Yangtse and the Huai, the latter providing the only outlet to the sea for the northern part of the province *via* the above railway. This last river, and lack of maintenance on the Grand Canal, have been responsible for a series of most disastrous floods and their attendant famines. The conservation of this river is one of the most urgent needs of the province both for the above reason and because the usefulness of the river below its junction with the railway is very limited at present as it loses itself in the very extensive but extremely shallow Hungtse Lake.

KIANGSU and CHEKIANG have an area of 45,000 and 39,150 square miles respectively and they produce beans, silk, tea among other things agricultural. Minerally these provinces are of small value. There are practically no railways within this area except the Shanghai-Nanking (No. 20) Railway in northern Chekiang, whose usefulness is very limited as it can never compete with a magnificent waterway like the Yangtse, with which it runs practically parallel. At present this line is merely a link in the trunk system, and can only prosper when feeder lines are built. These provinces have however a most wonderful system of canals, of which there are some 50,000 miles. In addition they are traversed north and south by the Grand Canal and east and west by the Yangtse river, so that there is no very crying need for railways in this section of the country.

HUPEH has an area of 70,450 square miles and produces tea, hides, iron, and coal. It is served by the Peking-Hankow (No. 13) Railway which provides its outlet to the sea *via* the port of Hankow and the Yangtse. Water communication is indifferent the only navigable rivers being the Yangtse forming the southern boundary of the province and the Han river, a tributary flowing in a southerly direction to Hankow. This province is the centre of the modern iron industry of China, and should if properly developed be of huge importance in the opening up of the country.

From the above very summary details it is obvious that the resources of this area are enormous and that communications are extremely poor. The provinces are like watertight compartments as far as communications are concerned. At present there may be famine in one and excess in another and no attempt is made to manufacture for more than local needs.

The railway situation in China can be summarised thus. With some 6,000 miles of railway in operation, China proper has 0.3 miles of railway to each 100 square miles and 0.19 miles for each 10,000 people. For comparative purposes the United States has 238,356 miles of railway and one mile to each 3,800 people. Australia has 1 mile of railway for each 250 people and the United Kingdom 1 mile to each 11 square miles.[27]

If the length of railway is summarised for the area under consideration it will be found to amount to 2,679 miles or 1 mile for each 127 sq. miles of country.

Water transport within this area is practically confined to the Yangtse River which forms the southern boundary of the plain.

This river as far as Hankow 600 miles from the mouth is navigable for ocean-going steamers. The great drawback to the river is the enormous variation in the summer and winter levels, amounting to as much as 40 feet at Hankow and rendering navigation above this place difficult at low water. Above Hankow in addition to the lack of water between Hankow and Ichang, there is also this difficulty, coupled with that of rapids between Ichang and Chungking. However small river steamers run between Hankow and Ichang all the year and between Ichang and Chungking when water permits. Usually the river is closed from December to April. Ichang is 970 miles from the mouth of the river and Chunking about 1,400 miles. This handicap makes a railway connecting Hankow and Chengtu, the capital of the enormously populous and rich province of Szechuan one of the most urgent needs of the country.

Another railway of some urgency is a line through the province of Shansi and Shensi to the capital of the isolated province of Kansu. All these provinces are said to be very rich minerally, but owing to lack of transport have no chance of development.

South of the Yangtse the country with the exception of the province of Fukien, is less populous and much more

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India	for each mile of railway		40	square miles	and	8,000	people
Japan	"	"	16	"	"	8,000	"
U.S.A.	"	"	12	"	"	3,800	"
Korea	"	"	71	"	"	13,000	"

mountainous. Railway construction would therefore be more expensive and is less needed as the bulk of the wealth and population is concentrated either on the southern side of the Yangtse Valley or on the sea board where there is water communication. China should therefore concentrate on the Great Plain, whose development will entail least investment of much needed capital and offer more certain returns than elsewhere.

One form of transport has been altogether neglected in the above summary, namely road transport which is of very little value owing to neglected state of the roads. There are said to be 2,000 imperial roads in China, but with the exception of the courier roads these highways are mere tracks or footpaths. The chief roads radiate from Peking connecting that place with the various provincial capitals. In some places these roads are paved with stone blocks of large size and the ruins of signal towers and military posts at fixed intervals show that at one time some importance was attached to them.

The upkeep of the roads is at the present time in the hands of local officials, each village taking responsibility for its own roads. Only what are considered, according to local ideas, necessary repairs are undertaken, with the consequence that no real road maintenance has been done for some centuries. The roads as built are unmetalled, and the bridging scanty, so scanty in fact that the majority of bridges have been designed to take the dry weather flow only, with the consequence that for most of the year the approaches are flooded. In addition where country of any difficulty has been encountered the road has degenerated into a mere footpath capable of taking only wheel-barrow, coolie or mule traffic so that all cart-borne goods have to be transhipped.

On all these so-called roads in the Plain goods are circulated by mule, wheel-barrow, or carts, but transport is rendered difficult and often impossible by the state of the roads which are purely of the dry-weather order. Mule, donkey and wheel-barrow transport are universal all

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over China but the cart is only met with north of the Yangtse,[28] with the consequence that the roads in south China have degenerated into tracks of footpath width.

The cart usually seen in north China is as in Fig. 1. Into this the farmer will put a load of 1 to 1.5 tons or rather more than is put into the English cart which has a tyre width of 5 inches against 2 inches in the Chinese cart. That roads in a country with 30 or more inches of rain per annum, become impassable in the wet season is not to be wondered at when the unmetalled roads, their poor drainage, and the traffic they are supposed to carry are considered. North China has the great advantage of so severe and dry a winter that even these roads would take the heaviest traffic, but this only holds from December to March; for the rest of the year the roads are as much dependent on weather for their usefulness as the rest of the country.

In the Southern part of the Great Plain the cart is as shown in Fig. 2. It is pulled by a trace and carries the same loads as the northern cart, but has even narrower tyres in a district with about twice the rainfall of the North.

The wheel-barrow shown in Fig. 3 is even more destructive of roads as it is, often as not, unevenly loaded causing the wheel to tilt and thus present less than the normal tyre surface.

The tyre width is usually about an inch and a quarter and the barrow often carries as much as 800 lbs. The wheel-barrow is as much used for passenger traffic as anything else, it will seat four people, the charge being about 2 pence per mile. The wages of a wheel-barrow coolie vary from about 6*d.* per day in North China to 8*d.* in the Yangtse Valley.

Such ill-designed transport and abominable roads make the stagnation, ignorance, and misery which exist within 30 miles of any railway or treaty port easily understandable. The civilising influence of railways in this country needs little illustration, but it may be stated

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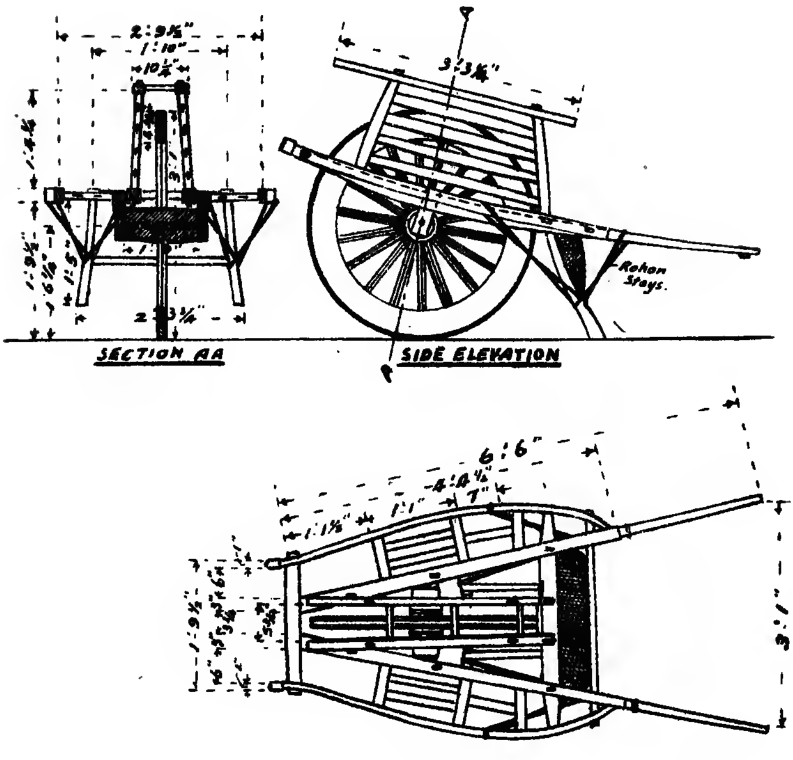
[28] Also in isolated areas near Yunnanfu and in Szechuan.

CHINESE WHEELBARROW

Scale 3/8 = 1'



PLAN

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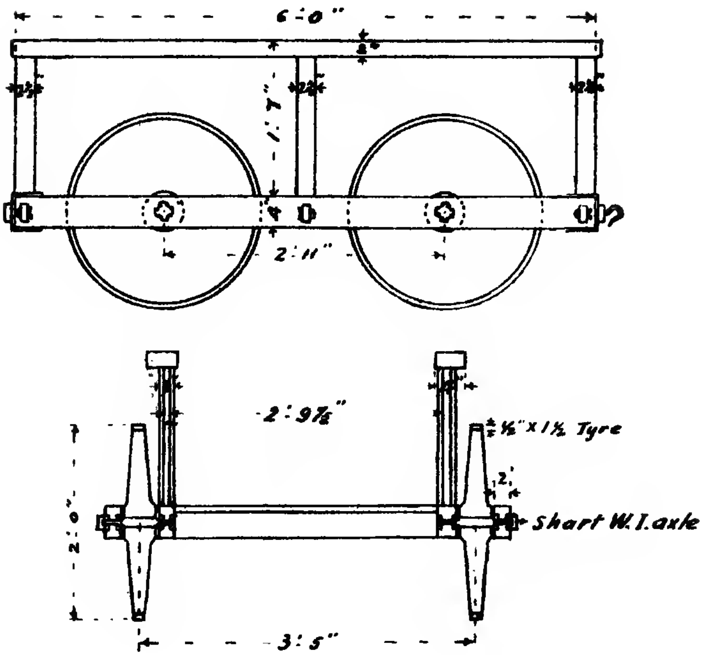
ANHWEI CART

Scale ½" = 1'



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as an instance that previous to the building of the Southern Section of the Tientsin-Pukow (No. 10 Railway) there were in existence three entirely different systems of coinage in a length of about 150 miles, the units of length and capacity varied from village to village, and most men believed their market town to be the biggest city in the world. This is typical of conditions in the closed portions of the country. It should also be stated that the roads all over the country are infested by bandits.

Finally that this, the richest part of China, has repeatedly suffered from famine is another proof of the wretchedness of communications. Thus in 1877–8 a famine in Honan, Shansi, Shantung, and Chili is estimated to have wiped out 8,000,000 people. Also in 1910-11 famine and floods in Northen Anwei and Kiangsu were responsible for thousands of deaths. Famine in Shantung and neighbouring provinces also occurred in 1921.

With regard to the cost of the various modes of transport this necessarily varies somewhat in a country where labour increases in cost from north to south, wages in the Yangtse Valley being about 50% and in Canton 100% higher than in North China. The following are fair averages:

Type.	*Cost per ton mile.*	*Remarks.*
Cart	10 cents to 20 cents (2*d.* to 4*d.*) per ton mile.	Max. load 1.5 ton. English cart 25 cwt. cost 7½*d.* per ton mile.
Water	½ cent to 1 cent (0.1*d.* to 0.2*d.*) per ton mile.	Sailing boats up to 200 tons. An extra of 4*d.* per ton for loading is charged.
Wheel-barrow	10 cents to 30 cents (2*d.* to 6*d.*)	Max. load 800 lbs.
Mule	15 cents (3*d.*)	Max. load 200 to 270 lbs.
Railway	1 cent (0.2*d.*)	Cost to Government.

It is of some interest to compare the pre-War cost of water and rail carriage in European countries.

Country.	*Water carriage per ton mile.*	*Rail carriage per ton mile.*
Russia	0.08*d.* to 0.42*d.* (Volga).	0.49*d.*
Germany	0.5*d.* to 1.315*d.*	0.055*d.* to 0.353*d.*
Austria	0.87*d.* (Danube).	
France	0.141*d.*	0.11*d.* to 0.78*d.*
Belgium		0.08*d.* to 0.78*d.*

Considering that the price paid for labour generally is about one-tenth that paid in Europe transport in China is expensive, uncertain, and under present conditions incapable of handling any large volume of traffic except on the railways which are too few.

Turning now to the question of economy the most obvious one is for the country to build the railways with the revenue of the existing lines or to induce the people themselves to invest in railways under government control and guarantee. Foreign loans increase the cost of Chinese railways owing to commission and other charges by £1,000 to £800 per mile according to the cost of the line.

It is believed that this, the greatest economy, might be to a large extent effected by the reorganisation of the road system.

The published statistics of the Government lines indicate that no railway has yet reached its maximum capacity for single line traffic. Therefore there lies in the development of the existing lines an enormous latent source of revenue.

Undoubtedly this development would be carried out most cheaply by road development and in doing this China would only be following the example of European nations in the development of their overseas possessions. In every case road construction has gone hand in hand with the construction of railways, roads being built to tap those districts not sufficiently wealthy to be able to afford a railway.

These roads could be built to connect points on the railways with large towns 100 or more miles distant. In order to save expense they could be so located as to avoid crossing the bigger rivers, the existing railway bridges serving as communication across these.

Bridges could be of reinforced concrete, old rail reinforcement being used, all maintenance would thus be avoided. The Chinese are excellent at this work which is less costly than steel-work. Piers and abutments cost about

$36 (£3) per 100 cubic feet and the reinforced slab about $60 (£5) per 100 cubic feet.

Needless to say the roads would have to be well built, not only to stand the existing abominable transport, but also to take motor tractor traffic which it is believed would develop the resources of the country most cheaply. A very well drained formation and a foundation on the Telford system would appear to be a *sine qua non,* as the southern part of the Plain suffers from an almost English winter, frost, snow and rain quickly alternating and breaking up any ill-drained road in a very short time.

The great difficulty in road construction in this region is the lack of stone, but the Government would give this transport at cost price of one cent, (0.2*d.*) per ton mile. This would add at a maximum about 10*d.* per ton to the cost of stone in cars in the quarries where rubble costs 1/8*d.* and ballast 3/4*d.* per fang of 100 cubic feet.

The following is an estimate of the cost per mile of a road of 20 feet formation width in five feet bank with a rubble foundation 12 inches deep and with six inches of two inches ballast for top dressing.

Land	£173	at £12 per acre.
Earthwork	120	
Bridges	200	openings 50 feet per mile.
Road metal	551	100 mile rail haulage.
Contingencies 10%	104	
Total	£1,148 or $13,776 [20]	

China can thus build first class roads in this part of the country at a maximum cost of $14,000 (£1,150) per mile, proximity to quarries would reduce this to $10,800

[20] Cost of unmetalled roads in Famine Areas in 1921:

Shantung	485 miles	cost per mile	$1,719
Hantan	46 ,,	,, ,,	$2,500
Pintingchow	78 ,,	,, ,,	$6,410
Pingyao	27 ,,	,, ,,	$1,200
Honan	37 ,,	,, ,,	$1,880

(£900) per mile and in districts where both Government land and stone were both available the cost might be still further reduced to $8,640 (£720). Convict labour would still further reduce the cost if properly handled.

It has lately been suggested that China should lessen the cost of her railways by adopting narrow gauge costing $9,600 (£800) to $12,000 (£1,000) per mile. A price per mile like this of necessity entails the adoption of at least 2′ 0″ gauge and 20 lb. rails. An estimate of the cost of such a line and its traffic handling capacity should be of some interest.

It will be assumed that curvature will impose no limits on the rolling stock, that is eight-coupled engines will be feasible, and that limiting grades of one in 150 will be obtainable. This implies that one of the chief money-saving qualities of narrow gauge is at once eliminated in easy country like that in the Great Plain. In other words similar routes would be followed in such country whatever the gauge. A maximum speed of 15 miles per hour will be assumed with stations five miles apart. The following is the estimated cost per mile.

	£	*Remarks.*
Land	110	4 feet deep borrow pits.
Earthwork	77	5 feet bank 10 feet formation.
Bridges	200	axle loads 4 tons as roads.
Permanent way	460	rails and sleepers at £8 per ton. 1,800 steel sleepers no ballast.
Rolling stock	500	5 ton wagons 8 coupled locos. weight 16 tons, lines or average haul not exceeding 100 miles in length.
Stations	100	
Contingencies 10%	140	
Total cost	£1,591	say £1,600 per mile.

Now the maximum capacity of this line with stations and speeds as above is certainly not more than 12 trains in the 24 hours of which two at least will be passenger trains, leaving 10 trains of a gross total weight of 2,375 tons per day. If 40% of capacity hauled is taken as paying load, then the daily capacity of this line does not exceed 570 tons.

In view of the light rail, the absence of ballast and the cost of transhipment it is extremely doubtful whether this traffic could be handled as cheaply as on the trunk lines of standard gauge, where it costs about 1 cent. (0.2*d.*) per ton mile. Also the use of mud ballast would be in the nature of an experiment; this has been successfully tried with steel sleepers in tropical Africa with a much bigger rainfall, but with a heavier rail and a lighter traffic than that proposed here.

When it is considered that the daily output of one small colliery employing 500 men is about 600 tons, the futility of narrow gauge, of 570 tons daily capacity for coping with a district of enormous population and great mineral wealth is easily recognised. There is very little doubt that breaks of gauge should be kept out of the Plain at all costs. The experience of the world is against such policy. India and Australia more especially have seriously considered converting all lines to one gauge. Indian conditions are somewhat those of China, labour is as cheap and many parts of the country are minerally rich. It has been found that narrow (metre) gauge working cost is 25% more than broad (5′ 6″) gauge, and that in spite of unlimited and cheap labour the delay caused by transhipment causes great congestion at busy times.

Roads and motor tractors would appear then to be much the cheapest and most non-committal investment for a country like China, whose resources even now are very little known, and whose present financial position owing to a long series of disturbances is deplorable. The capacity of a road for traffic handling is practically unlimited and merely a matter of maintenance. This should cost very little in a cheap labour country like China. In England it costs about £32 per mile per annum, with labour at one tenth of the cost it should not exceed $60 (£5) per mile in China. This charge could easily be met by vehicle licences. The turnpike system should be avoided if possible as it would be a loop-hole for trade-stifling abuse. A Government Road Board assisted by foreigners would of course be a necessity.

Turning to the cost of motor traction in this country the following is an estimate of the cost per ton mile of a motor tractor carrying eight tons and burning coal.

	£	s.	d.	
Wages 1 driver	0	1	8	
„ 1 helper	0	0	6	
Coal ¼ ton	0	2	10	
Oil and waste	0	1	0	
Depreciation and maintenance	0	7	0	This is at the rate of 20% per annum on £650 the cost of the tractor.
Total daily cost	0	13	0	or 156 pence ($7.80)

The average daily run would be about 60 miles, giving 480 ton miles at a cost of 156 pence, or 0.32*d.* per ton mile against an improbable cost of 0.25*d.* per ton mile on a two foot narrow gauge railway.

Should the Government adopt this road policy they will at any rate have given the people a chance of development they never had before. Easy access to the existing railway zones would be of enormous educational value, and would probably stimulate trades now stagnant or dying, while it would render easily possible the absolute suppression of the brigandage so rife everywhere at present.

The Government would of necessity encourage the idea of motor traction. There is no difficulty about the supply of drivers and mechanics. The Chinese make excellent drivers, are fair fitters and best of all have no trade unions, or eight hour days. The Chinese mechanic is a sober, quiet, and quite contented person on his magnificent wage of 10*d*. to 1/3*d*. per day.

Roads at a maximum cost of £1,200 per mile, of almost unlimited traffic handling capacity, are undoubtedly a sounder investment than 2′ 0″ gauge lines costing £1,600 per mile and with very limited capacity.

It should be stated here that the above cost of running motor tractors is deduced from Colonel Crompton's paper read to the Institute of Civil Engineers in 1908. Since then of course enormous developments in this type of traction have taken place. More recent but pre-War figures give the cost of running steam tractors at 0.1*d*. per ton mile in England and the cost of petrol tractors at 0.3*d*. per ton mile. Cheaper labour and coal would probably reduce this in China, but this indicates that the first estimate cannot be considered too sanguine. In view of the fact that experience in the War has added so much to previous knowledge motor traction afterwards should be still cheaper. Traction engines are of course about 50% cheaper than steam tractors, but 30 miles a day is their daily trip. They are also less costly in road maintenance.

The advantage of motor traction and roads against light railways in mountainous country is still more marked. In this type of country, in order to avoid expense it would be necessary to adopt limits of grade and curvature of say one in 25 and 98 feet radius, in addition to the 20 lb. rail.

Locomotives suitable for this weight of rail and curvature would not exceed 12 tons in weight and would haul a gross load of 44 tons. If 40% of capacity hauled is taken as paying load, then the earning capacity of the line per train would not exceed nine tons. It is unlikely that speeds would exceed 10 miles an hour, the maximum number of trains on this basis would be about six, giving a daily capacity of 54 tons. Further experience in China shows that the cost of working grades of this order is about twice that of lines in the plains with one in 150 grades. This would mean that this traffic would cost at least 0.4*d*. per ton mile. It is also doubtful whether this line could be built at a cost of £1,600 per mile, in spite of cheap stone and less bridging. Rock excavation would make the earthwork charge four times that in the previous estimate at least.

In the case of a road with good location, a limit of curvature of 50 feet and grades of one in 30 should ensure cheap building. Stone and land would cost very little and bridging would be reduced, enabling mountain roads to be built at a cost of £500 to £600 per mile. Grades of one in 30 would not in any way tax motor tractors which are built to negotiate hills as steep as one in eight. In this case there is no question that a road has not only an infinitely greater capacity than the cheapest possible railway, but is also much cheaper initially.

Roads should undoubtedly be built as pioneers of railways in the hill country south of the Yangtse. In this way the undoubtedly great mineral wealth of the province of Yunnan might be most cheaply developed. At present this province is dependent on mule and coolie transport over the most appalling roads for those districts away from the French metre gauge line, traffic on which is regularly interrupted in the wet season for weeks at a time.

As an indication of the value of roads in a country well supplied with railways it may be mentioned that there were in England in 1914, 50,000 commercial motor vehicles. Of these 25,000 were petrol-driven of weight not exceeding two tons unladen, 20,000 petrol-driven and 5,000 steam-driven of a greater weight than this. That the railways in England also recognise that roads are an adjunct to railways is proved by the fact that the Great Western Railway use motor vehicles as feeders to their branch lines, in South Wales in particular.

It is of great importance that the benefits (so-called) of narrow gauge should be properly appreciated. This is best shown by estimates for two feeder lines not exceeding 100 miles in length and of two feet and standard gauge following similar routes.

	2′ 0″ gauge 20 lb. rail.		4′ 8½″ gauge 40 lb. rail.	
Land	£110	16′ 0″ formation	£142	
Earthwork	77	5 feet bank	103	
Bridges	200		500	
Permanent way	460		1,000	
Rolling stock	500		800	
Stations	100		100	
Contingencies 10%	144		264	
Total cost per mile	£1,591	say £1,600	£2,909	say £3,000

This effects a saving of 46.6% on the standard gauge line. In the above estimate the 2′ 0″ gauge is as before, that is, the line is un-ballasted with steel-sleepers. 1,800 timber sleepers and 700 cubic yards ballast for the same gauge would cost practically the same money.

For the standard gauge line 1,800 sleepers and only 1,300 cubic yards of ballast (giving 4″ under sleeper), per mile have been allowed.

With respect to the vital question of the capacity of the two lines; by halving the rail weight the capacity of the two feet gauge line is halved and by reducing the gauge, speeds have been cut down from 30 to 15 miles an hour further reducing the capacity of the narrow gauge line to one quarter that of the standard line. Now on the very fair assumption, considering cost of transhipment, that costs per train mile on the two lines will be identical, charges per ton on the narrow gauge line to meet even working expenses should be twice those on the standard gauge line, assuming that the working expenses will be 50% of the gross receipts. It is therefore extremely doubtful whether the 2′ 0″ gauge would pay interest on capital if the 20 lb. rail was adopted as standard unless trade stifling rates were imposed. If the 40 lb. rail was adopted for 2′ 0″ gauge lines the capacity of the two gauges would be about two to one on account of speed restriction and the saving per mile for the two feet gauge would be as follows:

Earthwork	£ 26
Land	32
Bridges	97
Permanent Way	220
Total saving	£375 or a saving of 12.5% only.

The standard gauge line has twice the capacity of the narrow gauge line. Traffic in rich country like the Great Plain is bound to come and the railway will eventually pay. On the justifiable basis of similar costs per train mile, cost of transport should be in the ratio of two to one for the two lines. Interest therefore on twice the capital of the two feet gauge line could be paid and the same nett profit result, whereas only 12.5% extra capital is asked for. It should also be pointed out that for heavier lines, averaging say 20 feet bank throughout against five feet bank in the previous estimate, the above saving would be reduced as follows:

Land	£19
Earthwork	13
Bridges	40
Permanent way	220
Total saving	£292 or 9.75% only.

From the above figure it is sufficiently apparent that 2′ 0″ gauge has no case in a populous and potentially rich country like China and should be avoided at all costs.

Turning now to the cost of metre or 3′ 6″ gauge as compared with standard gauge lines using the 40 lb. rail, the savings that would result are as follows:

Land	£14.10	13 feet formation.
Earthwork	13.10	5 feet bank.
Bridges	49	
Permanent way	110	
Total saving	£187 or only 6.25% of cost of standard gauge line.	

In the Great Plain metre or 3′ 6″ gauge lines would have practically the same capacity as standard gauge as curvature would be so slight as to have no checking effect on speeds. Working expenses would be virtually the same with the exception of the extra cost of transhipment. The cost in a country like India, of this item, may be taken as a guide to probable cost[30] in this country as labour is as plentiful and as cheap. This is as follows in India:

Bulky goods	3½*d.* per ton
Grains	1½*d.* ,,
Average	1*d.* to 1½*d.*

In view therefore of the certainty of congestion at transhipment points when both lines are busy the paltry maximum saving of perhaps 7% on capital for metre gauge lines would appear to be negligible. When the enormous potential wealth, the high order of intelligence of the population, their great numbers and small wages are considered, there is very little room for doubt that at no very distant date every railway in this area will be able to work at its full capacity. Breaks of gauge should therefore on no account be tolerated here when the small savings which result are considered. The future must also be considered from a strategic point of view. In connection with this gauge question it is significant that the Japanese, at the close of the Russo-Japanese War, at once converted what is now the South Manchuria[31] Railway (No. 4 in map) from 3′ 6″ gauge to a 4′ 8½″ gauge line. The Japanese are also seriously considering altering all the lines in Japan from 3′ 6″ to 4′ 8½″ gauge. China has already to cope with the gauge question but not to any serious extent. All the lines not of standard gauge are metre, and the only one in the Plain is the Cheng Tai Railway (No. 14), but as this may be important in the future trunk system and as the country traversed is minerally rich the break of gauge

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[30] Estimated at a maximum of 10 cents or 2*d.* per ton average.

[31] Similar policy was pursued with the 2′ 6″ gauge Antung-Mukden Railway which is now 4′ 8½″ gauge.

is regrettable. This line is at present only 151 miles in length and was exceedingly costly, but the country is rather difficult. The line cost £11,500 per mile whereas the standard gauge line from Peking to Kalgan (No. 8) which is in very heavy country cost £8,200 per mile exclusive of interest and financial charges.

Other non-standard gauge lines are the French Yunnan Railway, of which 289 miles is in Chinese territory out of a total of 534 miles, and the Chinese Eastern Railway (No. 1) which is five feet gauge.

The Yunnan line is an isolated system and if ever connected up with the Burmese Railways there would be no break of gauge. Another small metre gauge line is the Tsitsihar (No. 2) Light Railway, 17 miles in length, which was built at a cost of £1,735 per mile in country similar to that in the Plain. It has 30 lb. rails and is run at a loss.

China therefore is not committed so far, at any rate in the richest part of the country, to more than one gauge and should therefore profit by the experience of the World which is undoubtedly against break of gauge in a populous and potentially wealthy country.

With regard to the question of constructional economics it would seem that something might be done by varying the present standards. At present these call for 1,000 feet radius curves, one in 100 grades, and 85 lb. rails.

These regulations in mountainous country have been very wisely departed from with the sanction of the Government. Thus in the Peking-Kalgan Railway (No. 8) one in 30 grades and 500 feet curves were permitted. In spite of these high limits the line had over a mile of tunnels; deviation from the present route at a later date is therefore impossible without abandoning an enormously costly line. It is difficult to believe that a more non-commital route could not have been found in view of the limits of grade and curvature allowed. These high limits are undoubted wisdom if a light line can be built and such expensive things as tunnels avoided, for even in China dry tunnels in rock cost £10 per foot. As things are on this particular line the Government is absolutely committed to a line which one day may be of vast importance, on which goods trains have to be halved to get over the heavy grades on which Mallet and geared locomotives are employed. The running expenses per train mile are consequently about twice those on the lines with one in 120 grades, being 5*s.* 4*d.* against 2*s.* 9*d.*, 2*s.* 10*d.* and 3*s.* 1½*d.* on the Peking-Hankow, Tientsin-Pukow and Peking-Mukden Railways. The line in spite of this even now pays handsomely, but there is no doubt that the Government will be faced with enormous expense in the future if the line extends as shown on the map.

On the Kalgan line the mountain section is about 40 miles long and the total length of the line 150 miles. The effect of this heavy section is to increase the train mileage by 40 miles per train, as each must be halved over this section, or by 25% approximately. The present (1915) annual train mileage is about 428,000 of which one quarter or 107,000 is extra, due to heavy grades. This extra mileage at 5*s.* 4*d.* per train mile costs £28,600 per annum. Foreign money at a cost to China of 13% including finance would justify an immediate expenditure of £220,000 for grade improvement. This is stating the case mildly as it neglects the very great saving in running expenses due to improved grades.

It would appear to be wise to permit limits of grades and curvature of one in 40 and 330 feet even on important lines in heavy country, but it should be a *sine qua non* that the construction on these portions should be of a character admitting of drastic deviation of the route without much loss. Bridges should be of trestle type or perhaps of ashlar in lime mortar or rubble in cement in places where stone is plentiful. For culverts reinforced concrete pipes should be used, the culverts being contoured wherever possible to save length as has been successfully done in India and tropical Africa. Back shunts should be permitted to avoid tunnels and the utmost use made of pusher engines over these heavy sections.

The cost of working pusher engines may be estimated as an additional tax per train mile, over the section entailing their use, of:

1*s*. 10*d*. per engine mile on	1 in 30	grades	300 ton train.
2*s*. 1*d*. ,, ,, ,,	1 in 50	,,	500 ,,

This rests on the assumption that the pusher engine would do a full day's work of 100 engine miles, which only means five round trips on a 10 mile section. The effect of the assistant engine is to double the motive power thus converting one in 50 into one in 100, and the one in 30 to one in 60. There is of course a limit of length of line depending on total daily train mileage at which pusher engines cease to be economical. Take the case in which the amount of one in 50 gradient is 10 miles in length. It is obvious that a pusher engine ceases to be economical when the extra cost of the engine per train mile equals the cost per train mile. On such a line as the above where the limiting grade is one in 100 except in these places where difficult country is encountered and where pusher engines are employed, traffic should cost about 3*s*. 0*d*. per train mile. Thus if the line is l miles in length and five trains per day are run, the limit at which pusher engines cease to be economical is given by the equation $5 \times l \times 36$ equals 2,500 or the cost per day of the pusher engine or l equals 14 miles.

If only two trains per day are run the daily cost of the engine is much reduced as in a 10 hour day the engine would be five hours standing in steam burning perhaps 40 lb. of coal per hour or 200 lbs. altogether costing about 1*s*. 2*d*. The total daily cost of the pusher engine would then be as follows:

	£	*s*.	*d*.
Standing charges driver and 2 firemen	0	4	5
Interest at the rate of 20% per annum on £6,000 (cost of 2 locos. and housing) to cover interest depreciation and maintenance	3	6	8

Total standing charges £3.11.1 or	853 pence	
Coal standing in steam	14	coal at 11/8*d.* per ton
Coal running 40 engine miles round trip (equivalent to 25 miles of gradient)	690	85 lbs. coal per train mile
Total daily cost of extra engine	1,557 pence	

In this case the limit l is given by the equation

$$2 \times l \times 36 \text{ equals } 1{,}557$$
$$l \quad \text{,,} \quad 22 \text{ miles}$$

It will be seen from the above that if as much as 50% of a 25 mile section is one in 50 and the remainder one in 100 or less, then it pays to run pusher engines in China even if only two trains per day are run. These figures seem to indicate that a more extended use of pusher engines might be advisable and also the sound economics of high maximum gradient in places where difficult country is encountered, provided that construction of a cheap and non-commital character is feasible. Thus on a line 600 miles in length the additional cost per train mile of working 10 miles of one in 50 grade with two trains per day is only one penny per train mile, and less of course if more trains are run. By the adoption of this grade the capital saving on this 10 miles is £60,000 (the difference between £10,000 per mile and £4,000 per mile) constituting an additional charge per mile of £6 per year at 6% interest on a 600 mile length of line. This is equivalent to 3.98 pence per mile per day or 2 pence per train mile for two trains per day.

The traffic is worked at an additional cost of one penny per train mile over the one in 50 section with pusher engine so that with two trains a day a saving of one penny per mile results from the adoption of the one in 50 grade. Moreover a railway line of similar capacity has been provided, barring the slight speed restriction which would result from this length of heavy grade.

With reference to limits of curvature the 330 feet curve should certainly be adopted as a minimum as it offers no restriction as to weight and build of engine and is safe for speeds of 35 miles an hour.

Another economy resulting from variation of standards would be the adoption of the 60 lb. rail instead of the 85 lb. for important lines.

The difference in cost per mile is as below:

85 lb. rail.		*60 lb. rail.*	
156 tons steel at £8	£1,248	112 tons steel at £8	£896
900 fang ballast (8″ under)	450	700 fang ballast (6″ under)	350
100 miles carriage on ballast 3/4*d.* in trucks at quarry.			
2,488 sleepers (14′ to 30′ rail)	358	2,112 sleepers (12′ to 30′ rail)	300
Total cost per mile	£2,056	Total cost per mile	£1,546

This results in a saving per mile of £510 or about £550 of capital paying interest since pre-War finance cost China about 8%. This constitutes an additional tax at 6% per annum of £33 per mile or 22 pence per day per mile. Now on the assumption of similar costs per train mile and axle loads proportional to rail weight, if the cost per ton mile hauled on the 85 lb. rail is one cent that on the 60 lb. rail should be 1.42 cents resulting in a saving per ton mile of 0.42 cents. On the Chinese Railways however the permissible axle loads on the two rails are 16 and 13 tons so that the cost per ton mile on the 60 lb. rail should be 1.22 cents or a saving of .22 cents per ton for 85 lb. rail. This however neglects the difference in coal consumption for the heavier trains on the 85 lb. rail, but this saving of 0.22 cents per ton implies that at least 500 [32] additional tons of paying load must pass every day over each mile of the 85 lb. track in order to pay the extra cost of the 85 lb. rail. It is a question whether any of the railways in China have this density of traffic, with the exception of the

[32] 500 ton miles per mile.

Peking-Mukden (No. 5) Railway 60% of whose goods traffic is coal; for the maximum capacity of a single line of railway in the District of the Great Plain is, for a railway equipped with a 60 lb. rail and stations at five mile intervals, about 4,300 tons daily or 1,680,000 tons yearly. This is the capacity for a length of line depending on the average haul which averaged 184 kilometres or 115 miles for the whole Government system in 1918. If the capacity of the government railways is considered from this point of view it will be found that with the single exception of the Peking-Mukden Railway, which carried more than 6 million tons in 1918, the 60 lb. rail is more than adequate to cope with the tonnage now offering. The figures for capacity are derived in the following way and rest on the assumption that grades in this district would not exceed one in 120, a very reasonable hypothesis. On this basis and with stations as above a maximum of 32 goods trains out of a possible 36 is assumed, the remainder being passenger trains. Each goods train would consist of about 62 axles with a car capacity of 370 tons of which only 37%—a distinctly low figure—is taken as paying load. This gives a daily tonnage over a length of line depending on average haul of 4,300 tons as above. The Peking-Mukden line has 376 miles of 85 lb. rail out of a total of 607 miles the remainder being 60 lb. rail, but it has traffic density of 1,680 tons per mile per day. Mineral trains on the Peking-Mukden Railway average 100 axles on the 85 lb. rail or 800 tons of paying load per full train, so that lines with a very large mineral traffic can easily afford an 85 lb. rail, but the 60 lb. rail and the use of eight coupled engines would provide all that is needed in most cases for many years. For instance the Peking-Mukden after nearly 30 years has only recently found the 85 lb. rail a necessity, relaying in the mineral district being taken in hand in 1915.

In addition no maintenance economy results from the heavier rail. Maintenance labour on the Peking-Mukden (No. 5) Railway, of which 38% is 60 lb. rail has become standard all over China, irrespective of rail weight. The cost of this is about £35 per mile per annum, in North China, working out at about three men per mile. The rainfall in the South is greater than in the North but the lines are better ballasted. Further as pointed out above the 85 lb. rail is not worked up to its full carrying capacity of 20 ton axle loads, the majority of the engines having 16 ton axle loads.

It is very doubtful whether much economy would result from the adoption of a different form of sleeper from the present untreated Japanese oak sleeper, costing at present 2/4*d.* ($1.43) each. This sleeper has a life of about eight years in well ballasted roads north of the Yangtze River. South of this the Jarrah sleeper has been adopted in most cases, at a cost of 7/6*d.* ($4.50) each, as the Japanese sleeper is said to last only five years. The life of the Jarrah sleeper expected is 20 years, but no railway using them has been operating for that length of time so no statistics are available, but Indian experience seems to indicate a life of not more than 15 years. The figures below indicate that if 25 years can be got out of the Jarrah sleeper then the Japanese sleeper with a life of five years is slightly dearer, while if only 20 years is obtained the Japanese sleeper is the cheaper investment. The following table shows this comparison:

Sleeper.		*Total value of capital invested at 5% compound interest.*		
Jarrah	20 years life	£0	18*s.*	5*d.*
Japanese	4 sleepers 5 years life	£0	17*s.*	0*d.*
Jarrah	25 years life	£1	4*s.*	2*d.*
Japanese	4 sleepers 5 years life	£1	7*s.*	2*d.*

Then for those railways already ballasted the present use of the Japanese sleeper is undoubtedly sound policy, provided that prices do not rise and that the quality does not deteriorate, which it is at present inclined to do.

The following table shows the comparison for the cast iron pot sleeper as used on the Indian Railways.

				Total value of capital invested.		
C.I. pot sleeper weight 220 lbs.	60	years	life	£19	10	0*d.*
No. 2 pressed steel sleepers—weight 140 lbs.	30	„	„	£13	15	0*d.*
No. 3 Jarrah sleepers as above	20	„	„	£10	2	0*d.*
No. 7½ Japanese sleepers	5	„	„	£ 6	4	0*d.*
No. 12 Japanese sleepers	5	„	„	£ 9	0	0*d.*

So that the pot sleeper is undoubtedly too expensive for those roads already committed to ballast. Its adoption would also entail new training for the Chinese platelayer as pot sleepers have never been tried in the country. The pot sleeper at the present price of 1.2 pence per pound has no chance of adoption in spite of the fact that rock ballast is not a necessity for its use. It is believed that the pressed steel sleeper has on the contrary a great future before it in this country unless China takes steps in the directions of re-afforestation and conservation of her present neglected forests. Japan cannot continue to supply timber for a much greater mileage of railways than she does at present, and as pointed out above the quality is by no means what it was. In what follows it will be assumed that pressed steel sleepers can be produced at £10 per ton. This is an extravagant assumption, for if China developed her steel industry properly these sleepers could be produced for at least half this amount, but at any rate it is not open to the charge of being too sanguine an estimate. The following is a comparison for the steel sleeper capital invested:

				capital invested.		
No. 1 steel sleeper wt. 140 lbs. for 85 lb. rail	30	years	life	£2	10	0*d.*
No. 1½ Jarrah sleeper	20	„	„	£2	2	0*d.*
No. 6 Japanese sleeper	5	„	„	£1	15	0*d.*
No. 1 steel sleeper wt. 100 lbs. for 60 lb. rail	30	„	„	£1	18	7

On this basis the steel sleeper has at present no chance, but the following table is of interest as showing the limit to which the price of the Japanese sleeper may rise in order to make the introduction of the steel sleeper a paying policy.

Sleeper.	*Expected life.*	*Limit of price Jap. sleeper.*
140 lb. steel	30 years	3/6*d.* for 5 years life S. China
140 „	30 „	5/0*d.* for 8 „ „ N. China
100 „	30 „	2/6*d.* for 5 „ „ S. China
100 „	30 „	3/6*d.* for 8 „ „ N. China

The present price of the Japanese sleeper is 2/4*d.* so that on the above figures a rise of only two pence would make the introduction of the steel sleeper for 60 lb. rail in South China sound policy. The initial prices of the two steel sleepers are 12/6*d.* and 8/11*d.* each. Moreover the steel sleeper is known to have a life of at least 30 years so that the case for it is under-estimated if anything. It should be pointed out that in salt or alkali impregnated soils its life is very short, from five to seven years.

If the steel sleeper were adopted as standard for new lines on the Plain rock ballast would not be required, with a resultant saving of £450 per mile to put against the extra cost of steel sleepers. With 1,800 steel sleepers to the mile the costs of the two types of track would be as follows:

85 lb. rail.

Rails as before	£1,248	
Steel sleepers	1,122	weight 140 lbs.
Cost per mile	£2,370	against £2,506 for timber sleepers.

60 lb. rail.

Rails as before	£896	
Steel sleepers	805	weight 100 lbs.
Cost per mile	£1,701	against £1,546 for timber sleepers.

From this it is obvious that the steel sleeper would at present be too costly and in all probability some additional expense would have to be incurred for carriage of proper ballast for steel sleepers (sand or gravel) as it is very doubtful whether a mud lift with material from the borrow pits would carry a minimum traffic of four trains per day, in a district with a rainfall varying from 30 to 60 inches per annum.

It is of some interest to compare practice on the Rhodesian Railways with that in China. Rhodesia has a wet season much more prolonged than that of China, but the same total annual rainfall as in South China.

These lines are of 3′ 6″ gauge, have steel sleepered 60 lb. track with a mud boxing instead of ballast. They were built at a cost of £4,500 per mile (average). In 1911 on a system of 1,392 miles 1,393,736 train miles were run at a cost of 5/4*d.* per train mile. This works out at rather more than two trains per day over the whole system. The cost of maintenance is about £45 per mile and of this practically the whole is labour. White gangers get at least £1 per day and nigger platelayers, not nearly so efficient or intelligent as Chinese, half a crown per day. It might therefore be expected that with more efficient labour at about one sixth of the cost a great reduction in maintenance labour would result from the introduction of steel sleepers in China. A saving in £10 per year on the present labour cost of £35 to £40 per mile would more than justify the extra capital cost of steel sleepers. A saving of £1 per mile would result from the abolition of spike renewals.

Further excellent ballast for steel sleepers abounds all over North China and should not cost more than six pence per fang of 100 cubic feet against 3/4*d.* paid for rock ballast in cars at the quarry.

These conclusions are borne out by experience in France, where the introduction of the steel sleeper reduced maintenance labour from £24 to £16 per mile. Similar results were experienced in Holland and on the Mexican Southern Railway where maintenance was reduced 50% on the introduction of steel sleepers and this on a line with 4% grades and 17 degree curves. At present there is only one railway (of standard gauge) in China with steel sleepers, the German-built Shantung Railway the track for which cost £2,670 per mile. The working expenses of this line in 1912 were £432 per mile, a figure not indicating any great economy, but the Germans in this country have proved themselves notoriously expensive both in the management and construction of their own and other railways, so that steel sleepers cannot be said to have been really tried in China. It should be also noted as an instance of the very extended use of steel sleepers even in countries where climatic conditions, or white ant, have not compelled their use, that there are on the Continent 12,000 and in the Argentine 4,000 miles of steel-sleepered track. Those railways on the Continent using steel sleepers carry a moderate traffic of about 14 daily trains and are gravel ballasted, while those in the Argentine are not ballasted at all in many cases.

From the above it is sufficiently obvious that there is even now a considerable case for the adoption of the steel sleeper.

Another slight economy would result from the adoption of a longer rail than 30 feet. With the flat curvature in the district of the Plain rails of practically any length could be used without bending, running would be smoother and a considerable saving in fish-plates and bolts would result. These fastenings cost nearly twice as much as rails per ton. Thus in the case of a 40 feet rail instead of a 30 feet for an 85 lb. rail a saving of three tons per mile is effected in fish plates and bolts implying an economy of about £40 per mile. In the United States and England heavy rails (85 lb. and upwards) from 45 to 60 feet in length have been found satisfactory, while a 33 feet rail can be used on a five chain curve without bending, this for a 60 lb. rail.

At present the steel-works in China can only roll rails 30 feet in length. As a closing remark in connection with track the most obvious policy for the Chinese Government is at once to make the greatest efforts to develop the steel industry, as there is very little doubt that pre-War prices for steel will be a long time coming back. China had the nucleus of a great steel industry at Hanyang near Hankow. Unfortunately this works which is said to be capable of producing 15,000 tons of pig-iron and 7,000 tons of steel rails per month is very largely mortgaged to the Japanese, who have an agreement stipulating that it shall not become a Government concern. The actual output of the works in 1914 was only 135,000 tons of pig-iron and 98,536 tons of steel so that this works is not worked up to its full capacity as it ought to be. The immediate reorganisation of the steel industry is a national necessity, for China with her cheap skilled labour should be able to produce the cheapest steel in the world.

As a summary of this discussion on variation in standards the most desirable variations appear to be introduction of the following:

60 lb. rail for main line.

40 lb. rail for feeder lines.

Five chain curve and one in 50 grades in difficult country, but no work of a very permanent nature permissible in these districts, so that deviation when warranted may be effected at small loss.

With regard to constructional economies, very little can be done in this direction, but as is pointed out in a later chapter there is some case for the more extended use of machinery on railway construction. Portable petrol-driven concrete mixers and steam pile-drivers on large bridges would undoubtedly pay, as would also crushers in quarries. The importation of timber in log instead of partly in plank would also be economical especially if circular saws were introduced for cutting.

Economy would also result from a more extended use of re-inforced concrete, using old rails as re-inforcement, for all minor bridges up to 30 feet span. Not only is the first cost of this type of work less, but the heavy maintenance charges on all paint work in China are avoided Girder trollies for fixing 20 and 30 feet spans, as is already done for the 60 feet steel spans, would result in economy as the only span which can be quickly handled with ordinary tackle is the 12 feet span. The 20 and 30 feet standard steel spans weigh four and eight tons approximately, and are very clumsy things to handle without cranes, and if sent out in halves much time is wasted in rivetting up.

A girder trolley could easily be built as an ordinary extra long bogie wagon with platforms at each end for the winches. The trolley with the suspended girder all rivetted up could then be sent out from the erecting yard, run out over the bridge on a temporary rail and sleeper stack bridge, and lowered direct into position. On the completion of the job all the material in the trolley could be re-utilised.

On the subject of economy in connection with the railways in operation something should be said on the rolling stock question. There is no doubt that compared with railways elsewhere equipped to similar standards and dealing with the same traffic conditions, the government railways are under equipped with perhaps the single exception of the Peking-Mukden Railway.

Lack of rolling stock is of course conducive of excessive empty wagon mileage which reduces the percentage freight upon wagon capacity hauled in addition to causing unnecessary wear and tear to the road and equipment and further putting an added strain on the capacity of the line. The following tables indicate the position as contrasted with the Indian Railways.

	Engines per kilometre.	*Trains.*	*per day.*	*Wagons per kilometre.*
Tientsin-Pukow	0.133	Total 9	Goods only 5.9	1.26
Kinhan	0.137	„ 13	„ 7.8	1.95
Peking-Mukden	0.242	„ 16	„ 9.1	3.52
	Indian Railways 5′ 6″ gauge.			
Bengal-Nagpur	0.17	„ 14.6	„ 10.3	5
B.B. and C. L.	0.18	„ 15	„ 8	4.42
East Indian	0.51	„ 24.7	„ 17	7.8

Trains per day are of course obtained by dividing daily train mileage by the length of the line, a more suitable name perhaps being train density.

The result of this superior equipment is seen in the following table which shows for the Indian Railways as compared with the Chinese a better average train load and without doubt a better percentage of freight upon capacity hauled.

	Freight per train.	*Percentage freight upon capacity hauled.*
Bengal-Napur	320 tons	53.9
B.B. and C.L.	312 „	47.9
East Indian	312 „	44.2

The average freight per train on the three Chinese Railways considered is 300, 291 and 282 tons respectively, the percentage freight upon capacity hauled being estimated at 36.5%, it being assumed that the average goods train on these lines should be about 800 tons capacity, a not unjustifiable assumption.

The rail weights on the above Indian Railways are 75, 80 and 90 lbs. on the Bengal Nagpur, 69 on the B.B. and C.I. and 85 lbs. on the East Indian, while rail weights on the three Chinese lines are all 85 lb. with the exception of 231 miles of the Peking-Mukden which is equipped with a 60 lb. rail in the region of lighter traffic.

The annual tonnage dealt with on the Indian lines was 7,009,872, 3,649,372 and 14,905,764 giving the following annual tonnage per kilometre: 2,300, 1,600 and 5,800.

The total tons handled on the three Chinese Railways was 2,315,832, 3,932,208 and 6,013,682 giving a tonnage per kilometre of 2,100, 3,000, and 6,100 respectively, figures indicating that with a greater tonnage per kilometre to deal with, the Chinese lines are in an infinitely inferior position to the Indian lines.

The above figures, all of which relate to the year 1918, speak for themselves and indicate the seriousness of the rolling stock shortage under present conditions. Nothing further can be got out of the existing stock the number of loads per car per year on the above three lines being 52, 72 and 83 representing practically maximum figures under existing conditions in the case of the two last lines. It must be recollected further that China is a country of long hauls and that traffic as a rule sets in one direction during the various seasons of the year giving practically no return tonnage. The average hauls per ton on the three lines considered were 310, 278 and 115 kilometres respectively in 1918.

The question of what is adequate or inadequate in the matter of rolling stock is a particularly thorny one, but it would appear that it should be considered from the following point of view. Thus take the case of a line equipped with 60 lb. rail, single track with crossing stations at five mile intervals and with a limiting grade of one in 120. Goods trains on such a line would not exceed a car capacity of 400 tons and if we assume that freight is 50 per cent. of capacity hauled, tons of freight per train should be 200. Then if the average haul is 100 miles each 100 miles of line should be equipped with a car capacity of 400, multiplied by the number of necessary trains obtained by dividing the daily tonnage available by 200 tons. This number of trains is, of course, limited by line capacity which is, say, 32 goods trains out of a daily total of 36—four being passenger trains—for a single line as above. Thus the maximum daily capacity of a single line as above is about 6,000 tons per 100 miles and for this 12,000 tons of car capacity is required or four 4/30 tons cars per mile. Passenger stock can be treated on the same basis with an assumed relation between seat mileage hauled and seats occupied, generally about 25%. The above, of course, assumes a daily motion of 100 miles per car and neglects stock not in motion. This might be true for passenger stock only on double track lines but for goods stock is incorrect for single track lines at least, and probably double track. Thus in the U.S.A. daily movement per wagon is 28.1 miles with a 30 ton load while in Japan it is 58 miles and in England about 15 miles and one ton. Figures for goods stock should thus be increased.

Efficiency in operation of goods stock is generally gauged from tons of freight per train, number of loads per year, and ton kilometres per ton of car capacity.

Tons per train is of course dependent on such factors as rail weight, grades, and gauge to a considerable extent, but is also greatly influenced by such factors as poor loading of engines and unnecessary empty wagon mileage, which may in some cases be ascribed partly to rolling stock shortage.

Number of loads per year and ton miles per ton of car capacity are entirely controlled by the efficiency of the traffic staff, due allowance being made for length of haul in the case of number of loads per year. On this account ton kilometres per ton of car capacity is the best basis for the consideration of efficiency in operation. To gauge efficiency it is necessary to establish an ideal. This ideal has been determined for coal traffic on the Peking-Mukden Railway as follows:

Load and unload and haulage to and from railway sidings—a total distance of about four miles—11 hours for each operation, 22 hours in all.

Delay in handing over to and receiving from railway before cars leave six hours in all—three hours at each end.

Running over single line with a very considerable traffic, assume a velocity of 12 miles an hour or say 19 kilometres per hour.

The bulk of the traffic of the Peking-Mukden Railway is coal which is hauled a distance of 80 miles or 136 kilometres.

With the above assumptions, and with the proviso that every car is out of action some 17 days per year for repairs about 190 loads per year should be got out of rolling stock on this traffic, and ton kilometres per annum per ton of car capacity should be about 26,000. On these assumptions and with the knowledge of average haul per ton an efficiency ratio for rolling stock can be evolved. Holidays have been neglected in the above and in China they would amount to a further 17 days reducing loads to about 180. The ideal established does not appear to be very exacting, but results show how far it is from attainment. Only a keen interest in the history of each car movement can secure efficiency in rolling stock operation.

As regards types of goods stock China has this advantage over many other countries, in the fact that average wagon capacity is high, and that the Janney coupler adopted is the best of its kind. Wagon capacity averaged 24 tons per covered car and 23.7 tons per open car in 1919. The introduction of the Westinghouse brake for goods stock is becoming increasingly necessary, especially on lines with a heavy mineral traffic, for the running of bigger trains and relieving the locomotive of strain which it should not be called upon to take.

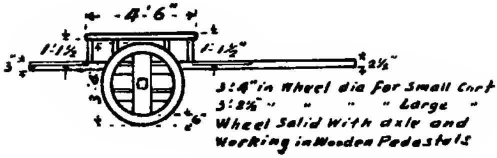
Chinese Railways 4′ 8½″ gauge.

Capacity of wagon.	*Tare of wagon.*	*Type.*
10–12 tons	Tons 5.3–5.75	4 wheeled
20 tons	Tons 11.62	High sided bogie
20 „	„ 7.64	Kin-han 4 wheeled coal
30 „	„ 12.5	Bogie ballast wagon low sided
30 „	„ 13.85	Bogie coal wagon high sided
30 „	„ 14.15	Bogie coal wagon steel sided
40 „	„ 17.59	Kin-han Bogie coal wagon
40 „	„ 17.16	Peking-Mukden Railway all steel
40 „	„ 14.17	„ wood and steel

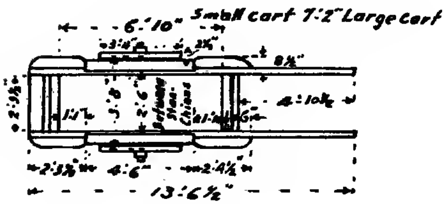
With the exception of the last all the above wagons are constructed of wood stiffened with iron.

Note.—It should be noted that throughout this chapter the rate of exchange from dollars to sterling has been five cents to a penny or 12 dollars to the pound.

NATIVE CART, NORTH CHINA.
Scale: ⅛″ to 1′



ELEVATION



PLAN

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CHAPTER VI.

PIONEER RAILWAY LOCATION.

THERE is little doubt that the first essential in railway location in all undeveloped countries is the most non-committal investment, that is the cheapest possible line. This implies getting over the natural obstacles by the use of high maximum grade and the lowest possible limit of curvature, but it should be a *sine qua non* that construction in these difficult districts should be of such a nature as to permit of drastic deviation, if ever required, without much loss. The reason for this is that traffic, as a general rule, is an unknown quantity, except in the case of mineral lines, and that the following expedients are available to increase the capacity of sections of heavy grade (should traffic ever call for it) before deviation becomes necessary. These are:

1. The use of heavier engines and if necessary a heavier rail.
2. The use of pusher engines.
3. Double tracking if work is very light.

The use of high limits of grade and curvature in difficult country are of course only a last resource after the most thorough search has been made for a better line.

Of course getting the best line in heavy country necessitates lengthening, but this is of no moment in pioneer lines and does not compare with the handicap to traffic of heavier grades on a shorter route. Further the possession of a monopoly gives the railway powers of rate fixing which will make loss on running impossible, and yet will make the railway an economic[33] advantage to the population served; for it will at least be quicker, safer, and cheaper than any other form of transport, except possibly in the

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[33] An added reason for good location for the cheaper the line the lower the haulage rates and therefore the greater the benefit to the country.

case of isolated mountain districts where feeder lines would be expensive. In this case it is questionable whether good roads (with the great scope that the much sharper curvature possible gives to good location), and motor tractors are not only the most non-committal investment, but give greater traffic handling capacity. It should also be noted that lost revenue due to delay in opening a line to traffic as a consequence of more expensive construction due to bad location is a further factor in favour of the greatest pains being taken to secure the best possible line in populous countries.

With regard to the subject of lengthening to get a light line there are two aspects of the case, that is the possibility of a more expensive shorter route of the same capacity as regards grades as the longer route, and the case of a shorter route of equal cost, but of less capacity than the longer route as regards grades.

Taking the first case in which the length from A to B is, say, 10 miles, estimated to cost £8,000 per mile, and that of the alternative route of the same capacity l miles estimated to cost say £3,000 per mile. Then there is of course a limit dependent on the capitalised cost of operating this extra mileage at which lengthening ceases to be profitable. Thus this is given by the equation.

$$80{,}000 = 3{,}000\ l + \text{capitalised operating cost of } l - 10 \text{ miles.}$$

This of course gives an indication of the area of country it would pay to investigate. With regard to estimating the last term of the above equation the only things to be estimated are maintenance cost which should be for labour only in these early years and taking no account of sleeper and rail renewals, and the added cost of fuel burnt on the longer route. Labour[34] in maintenance

[34] Assume three men per mile.

Coal consumed 100 ton train level 15 lbs. per mile.

1 in 100	32 lbs.	per mile.	Other weights of train proportional.
1 in 50	85 lbs.	”	” ” ” ”
1 in 25	160 lbs.	”	” ” ” ”

can be taken at £60 per mile for sparsely-populated countries like Africa and half this for countries with a large and cheap labour supply like India or China. Coal consumption can be estimated from the ruling grade and the weight of engine of which the weight of rail adopted will give a sufficient indication. In this last case it is of course necessary to assume a certain number of trains per day and this may be taken at one for sparsely populated countries and four for countries of the other class.

In the second case stated above the capacity for traffic handling is practically as the ratio of the ruling grades adopted on the two routes. In this the income which would result from the expenditure of the extra capital on the lengthened route (construction cost and capitalised operating expenditure) should balance the extra cost of bringing the route of heavier grades up to the same capacity as the longer route, by the use of pusher engines, etc. In the majority of cases the longest route in this case will be found the most economical, especially on a line of any length.

Another great point in favour of obtaining the lightest possible line, even if on a lengthened route, is that in countries with a heavy rainy season—60 to 100 inches—the maintenance of heavy earthwork is very expensive in the first years, and traffic may have to be restricted, if not discontinued.

With reference to the question of limits of grade and curvature, the following are those usually adopted in countries of the two classes:

Populous countries 1 in 100 grades	1,000 ft. rad. curves
Sparsely populated 1 in 40 compensated	330 ft. rad. curves

But in difficult country these limits are not adhered to if great expense is involved, in this case the utmost use is made of assistant engines and pushers over the mountain sections.

Railway location is generally carried out in three stages:

1. Reconnaissance.
2. Tacheometer traverse of the doubtful portions over alternative routes from which a paper location is made and also comparative estimates.
3. Final staking and survey.

A survey party is generally composed of the following: an engineer in charge, two men on the tacheometer traverse, one man staking the finished line, one man taking the longitudinal section, one man check levelling the previous man's work and also taking the necessary topography and cross sections, and lastly a man doing draughtsman's work, looking after transport, and other odd jobs. In addition each man will require four natives for survey while axemen will also be necessary in bush country. Further native labour will also be required for cutting pegs, messengers and looking after transport, etc., etc.

The reconnaissance survey is generally carried out by the engineer in charge and an assistant, and usually takes the form of a ride or walk in the direction to be followed by the railway, and from this a rough idea is gained of the limiting conditions for the more detailed survey. In this rapid survey distances are measured by time and direction by frequent compass readings. If riding it is useful to know that a horse covers

400 yards in 4½ minutes at a walk.
400 „ 2 „ „ trot.
400 „ 1 „ „ gallop.
China pony, fairly broken country, 6 miles an hour, average.

The levels of determining points such as passes and valley bottoms are obtained by aneroid barometer, in addition compass bearings are taken of prominent landmarks such as kopjes, peaks and pagodas, to serve as guides to the survey party following. In this way the district to be traversed is roughly mapped and the points likely to prove difficult indicated. In populated but unmapped countries like China it is wise in the reconnaissance to follow the main road, which as a rule will be found to be the shortest distance between places, and in this case distances are obtained from the natives.

This information obtained it is possible in easy country in unsettled and sparsely populated districts to lay down the final line at once for a short distance, and start the pegging and levelling, the tacheometer survey party being sent on ahead to study the difficult or doubtful portions previously located by the reconnaissance. But in thickly settled countries like China it is always necessary to traverse over the whole route to locate villages, large graveyards and other obstacles which must be avoided.

To conduct this traverse with speed and sufficient accuracy the following methods have been adopted with success, in China, where there is no bush to contend with. The party usually consists of one engineer, who runs the instrument, and two assistant engineers, one for working the plane table and the other to assist in the traversing. In the traverse all directions are referenced to the magnetic meridian and limiting points picked up by intersection. The referencing to the magnetic meridian gives a rough check on the accuracy of the work in running the main lines as of course the trough compass, except in districts where there is strong local attraction, should remain fixed in direction. The legs of the traverse are measured by the angle subtended by a fixed offset—usually a 100 feet—at the forward station, this offset being set out by means of an optical square or cross-head. In addition these distances are also chained by a party under an intelligent man and any error quickly detected in this way for the distance given by the angle method is immediately worked out and compared on the spot and re-chaining under supervision resorted to if things fail to check. These distances are then sent back by messenger to the man working the plane table whose special duty it is to pick up all villages and other nearby obstacles, vital points are also taken by intersection as stated above from the instrument so that the plane table work is checked as well as the instrument work. In addition to the above the vertical angles giving the slope of the ground from station to station are also taken and from this a knowledge of the grades feasible obtained. In this connection it is useful to remember that a

1 in 100	grade	is	a	slope	of	0° 35′
1 in 50	,,		,,		,,	1° 15′
1 in 40	,,		,,		,,	1° 26′

The levels which these angles of slope give are worked out and written on the plan. They are not of course of great value as the usual distance between stations is between two and three thousand feet but they give useful information. By this method which has the virtue of checking all native work an average of 9½ to 10 miles a day is covered—a maximum of 12 to 13 miles is possible on good days—and the cost per mile works out at rather less than 10 shillings. The scale adopted for the plane table work is 1,000 feet to the inch.

Turning to the question of location in difficult country the above method is probably the best for trial lines in open country, but it would be very expensive and slow in forest country requiring much clearing. In this class of country rough trial lines are run by prismatic compass and Abney level. Distances are measured either by chain, perambulator if possible, or pacing using a pedometer. With regard to fixing the direction of lines with reference to each other it is as well to remember, in order that curves may not exceed the usual limits, that the maximum difference in bearings between consecutive traverse legs of a length of 700[35] feet is about 98 degrees if curvature will be similar and about 90 degrees if curves will reverse. This is on the assumption of 300 foot radius curves. The stations of this rough survey should be marked as they will be a good guide if the route is found worthy of investigation by the tacheometer survey party.

The probable best route having been ascertained from these rough surveys, the elaboration of these to give the route entailing least work remains to be done. This is best carried out by traverse with the tacheometer, which is much the most suitable instrument for use in survey

[35] For 300 foot traverse legs this is 37° for reverse curvature.

work in countries where unreliable chainmen are the rule not the exception. It has the following advantages:

1. No chaining is necessary, a slow and laborious business, especially in bush country, and liable to gross error unless superintended by an engineer.
2. Adequate accuracy.
3. Economy of labour; two men being able to take all particulars for accurately mapping the route, which required four by old methods.

The adjustments of the instrument are those of the ordinary theodolite with the exception of that of the level carried on the vernier arm of the vertical circle. This requires daily adjustment and is the same as that for an ordinary level tube for perpendicularity to its axis of rotation, that is half the travel of the bubble on turning the levelled bubble through 180 degress is adjusted by the foot screws of the instrument and the remainder by the screw fixing the vertical vernier plate to the telescope "Ys."

In traversing with the tacheometer it is necessary to make the following observations at each station.

1. Measure height of telescope axis above station peg.
2. Put the telescope axis in the magnetic meridian. This is done by subtracting[36] 180 degrees from the bearing of the station now at, from the last station, clamping the upper and lower horizontal plates at the result thus given and sighting on to the last station set up at. This will set the zero graduation of the lower plate in the magnetic, or whatever meridian is chosen. The result can be checked roughly by the trough compass attached to the lower plate.
3. Read bearing on forward station.
4. Read all three wires on staff at forward station, booking central wire reading separately as this gives axis height on staff.

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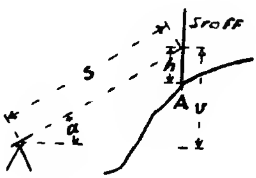
[36] Or adding 180° if the bearing is less than this.

5. Read vernier on vertical circle booking the reading minus or plus according as the inclination of the telescope is downwards or upwards.
6. Read the intermediate shots which should be so placed as to survey the ground efficiently from the point of view of getting a contour map. These intermediate shots are not read with the same care as the observations on the forward station of course, but the same procedure is followed. Each series of shots should be numbered.

In practice of course the intermediate shots would probably be taken before the forward station observation.

It should also be stated here that the traverse legs for a tacheometer survey should not exceed 700 feet in length if any degree of accuracy is aimed at.

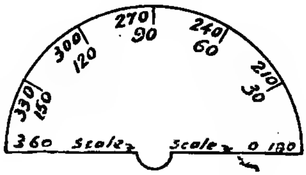
In most tacheometers the distance of any point is given by the difference of the readings on the staff, held at the point, of the top and bottom wires in the telescope. This is



then multiplied by 100 no constant being added. This gives the slope distance "*s*" only, the vertical distance "*v*" above telescope axis is obtained by multiplying the slope distance "*s*" by $\frac{\sin 2a}{2}$ where "*a*" is the vertical angle in figure. The horizontal distance from the telescope axis is given by the expression $s\ cos^2 a$, but in most cases the slope distance

"s" gives sufficiently accurate results without this correction. The above results are worked out and published in table form so that "h" and "v" can be read off straight away. Further it is obvious from the figure that if the angle "a" is positive the staff axis reading (the reading of the middle wire on the staff) must be subtracted from "v" to give the level of "A" above the axis of the instrument and added if the angle "a" is negative.

In plotting this survey the main lines are plotted either in the usual way by latitude and departure or if



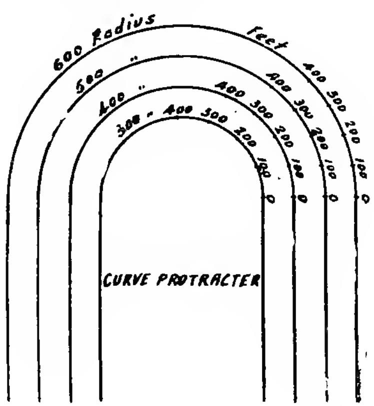
speed is necessary by plotting the bearings with a protractor without any calculation. For this purpose squared paper is very useful as it saves trouble in ruling off the meridian for each station and is also of use in sketching in the contours. The most usual scale is 400 feet to the inch, but a scale of about 1/2000 is sometimes used.

After laying down and checking the traverse lines the intermediate shots are plotted by means of the special protractor illustrated in the figure. This protractor is fixed with its centre at the point from which the shots to be plotted were taken so that it can rotate about this point. As easily seen it is so graduated that the distance and direction of each shot can be plotted in one operation by making the bearing of each shot coincide with the direction of the magnetic meridian, plotting the distance on the scale fixed to the edge. In order to fix the position of each shot it is usual to write in the level of each point the decimal point indicating the position.

In this way a rough contour plan—1,500 feet wide—of the strip of country to be traversed is made. The contours are obtained by interpolation and should be about five foot intervals. Interpolation can be done by diagram or slide rule and a good deal by sketching after the binding contours have been put in.

On this map the proposed railway is laid down, using the information gained, as to probable grades, from the previous rough survey. In conformation with the idea of getting the lightest possible line the route chosen should follow the contours as closely as possible but this of course will be governed by the controlling factors as to grades[38] previously determined. It is of course easy to see what grade will fit the ground most closely and yet conform with the lie of the land by trial with dividers set at the contour distance for a given grade. Thus in the case of a one in 50 grade with contours at five foot intervals it is obvious that the line must cut the contours at such an angle that they will be intersected every 250 feet if an approximately surface line is to be obtained.

In order to get the most suitable curve to fit the ground it is usual to draw curves of various radius on a piece of tracing cloth as shown in the figure, the lengths of such



[38] Continuous maximum grade and not the grade fitting the ground best may be necessary.

curves to be indicated from a zero point to the scale adopted for the location plan. This can then be placed over the plan and the best curve obtained by trial.

In laying down the paper location it should be remembered that it is very desirable to cut down rock excavation to its lowest limit mainly on account of the time it takes to remove and also of course on the score of expense. Further it is usual to put in a straight of not less than 170 feet between reverse curves—American practice demands a straight of 300 feet. Also as a rule curves under 500 feet radius are compensated at the rate of 0.02% for each degree of curvature (central angle subtended by 100 feet chord).

The paper location having been completed it is sent back to the party doing the staking which pegs out the lines usually as planned, but of course deviating if any slight beneficial change is apparent.

As stated previously the line requires very little location in easy unsettled country the man in charge merely following the general directions of the engineer-in-charge and using his own discretion as to the details of location. In bush country the great difficulty is of course the clearing necessary and here the assistance of another European, in superintending clearing ahead of the pegging party and in fixing the tangents and intersections is required. In this work ahead of the pegging party the compass and Abney hand level are used as in the case of more difficult country. As a rule in this type of country the levelling party, which travels much faster than the pegging party, will assist in this work. In easy open country four miles can be pegged in a day, in bush country not more than a mile at most.

It is usual to peg curves at chain intervals except where very sharp—300 feet and under—when this should be done at half chains. This for the 100 feet chain.

In pegging long tangents the change points at about 1,000 feet intervals, should, if fixed from a back sight, be set more accurately than the intermediates, by changing the instrument face and halving any difference there may be between this and reversing the telescope direct. Further all intersections should be fully referenced as well as tangents, and precautions taken if necessary to prevent the stealing of pegs. In China this is a veritable scourge necessitating the employment of numerous peg watchmen. who are chosen for their local influence.

Behind the pegging party the following operations are carried out simultaneously, that is the levelling of the longitudinal section, the check levelling of this, and the taking of any necessary topography.

The party doing levelling should adjust instruments before starting work, but in any case every effort should be made to equalise backsights and foresights when changing stations. It is also of the utmost importance, when working with native chainmen,[39] to have the staff well swung at all important points such as turning points. It is also advisable with this class of labour to provide staffmen with a small portable peg which they can drive into the ground by hand whenever a turning point level is to be taken.

In taking longitudinal section it is important to put in bench marks at every half mile at least. These marks should be of as permanent a nature as feasible marked with an arrow head and a ring round the place where the staff is placed in black or red paint. In bush country failing rock outcrops it is best to cut a tree, leaving a short strong stump about two to three feet out of the ground. This is then trimmed and the top used as a mark, but in countries where white ant is at all prevalent such marks have very little permanency and are to be avoided as much as possible.

In taking the longitudinal section levels are taken on each peg, but these should only be taken to the first decimal for intermediate sights, change points only being booked to two places. It is of course important to bring the level bubble to the centre of its run when taking a turning point shot in addition to equalising sights as far as possible.

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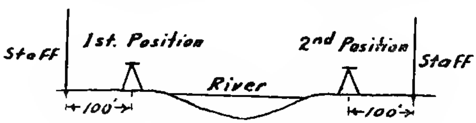
[39] Most natives have no idea of holding the staff vertical.

Sights with the ordinary level should not exceed 400 feet if of any importance.

One of the most important duties of the party taking longitudinal section is the getting of information as to flood levels, and the behaviour of rivers at flood time. It is also part of the duty of this party to make investigation and in any case to note, if beyond doubt, as to the presence or absence of rock on the route, for this will be a great factor in determining the grading of the line. Further the existence of water-logged or marshy ground should always be noted as this will be a handicap to rapid earthwork construction. The presence of such supplies,—*e.g.*, sand and stone—as are likely to be useful on construction should also be noted.

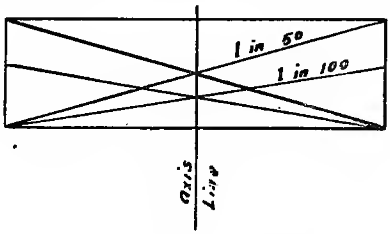
It would perhaps be as well to note here the method of transferring levels across an obstacle of some width such as a big river. In this case the work is quickest done with two staffs and two engineers in charge on each bank.



Pegs are driven on each bank and the level set up at a fixed distance say 100 feet, as shown in the sketch, from one of the pegs. The staff is then held on this near peg and the reading booked, the telescope is then sighted across the river on to the other peg the bubble levelled if required and the staff reading on the peg across the river indicated by signal and booked by the man there, as it is of course much too long a sight for clear reading. The level is then sent across the river and the same process repeated with the same pegs. Then whatever the error of the instrument the true difference in level of the two pegs is half the sum of the differences given in the two cases.

With regard to check-levelling only bench marks are picked up with the consequence that this party travels about twice as fast as the party doing the section, a very good rate of progress for which is four miles a day in fairly easy country, where many observations at distances not marked by pegs, and therefore requiring tapeing, are not required. At the close of each day's work both parties will check the accuracy of the work which should be controlled by a maximum difference given by the formula $0.04\sqrt{\text{Miles}}$.[40] This checking work is quickest done in the first place by adding up the backsights and foresights and comparing the results. If a check is not obtained the levels for each bench mark must be worked out[41] and the error thus localised and relevelling resorted to, from the nearest correct bench mark, until the mistake is found.

In laying down the gradients for the line on the longitudinal section use a piece of tracing cloth with the



various grades drawn on as in the figure. The following points are to be remembered.

1. That cuttings on the level if of any depth or length should be avoided. Very shallow cuts can easily be drained from the sides.
2. No attempt should be made to balance cut and fill, as practically all foreign work is done from borrow-pit, except in the case of the higher lifts of large banks which are sometimes built with decauville wagons where leads do not exceed five or six chains and in countries where labour is not plentiful.

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[40] On preliminary work as much as $0.1\sqrt{\text{Miles}}$ inaccuracy is permissible.

[41] The collimation method is invariably used in working out levels.

Following the levelling party comes the topographer whose duty it is to pick up all streams, survey drainage areas, make more elaborate surveys of larger river crossings and station sites and any obstacles—houses, graveyards, etc., etc. For minor surveys and drainage areas, where much accuracy would be wasted labour the instruments most largely used are the chain and prismatic compass, the pegged line being taken as the base for all small surveys. In other work, for river crossing surveys, the tacheometer should be used and for surveys with much detail either the plane table or the ordinary chain and theodolite, or a combination of both if native topographers with a knowledge of plane table work are available. In computing drainage areas and size of openings it is useful to recall the following facts.

1. One inch of rainfall per acre per hour gives approximately 24,000 gallons per hour or 400 per minute of which not more than 50% to 75% will reach the opening in the same hour. One acre is 4,840 square yards.
2. Myers' formula for waterway required for a given drainage area is square feet of waterway $= C\sqrt{\text{drainage area in acres}}$, where C is 1.5 for hilly and 4 for rocky country.

The assumption of a rainfall of an inch an hour for 12 hours is not by any means an extravagant one in most countries with a heavy rainy season. In the cases of rivers where it is impossible to get drainage area; in settled countries much information can be gained by the examination and history of the existing bridges if any. In other cases for small rivers with a hard bed, not liable to bad scour, the channel may be restricted to give a velocity through the bridge not exceeding 10 feet per second. In order to make this calculation it is necessary to know the existing velocity, preferably under flood conditions, of the river considered. This can be roughly taken by timing a floating bottle over a measured length, remembering that the mean velocity is roughly five-sixths of the surface velocity. From this and the cross-section of the stream at flood time it is possible to calculate the necessary waterway.

With regard to large rivers of much length it is safe to add that the channel should be restricted as little as possible unless local information is of such a character as to warrant it, and even then an examination should be made of the country traversed by the river with a view to finding out whether it is liable to quick flooding, etc.

Another job devolving on the topographic party is the taking of cross sections where required, that is in places where the ground is irregular or sidelong. For this the Abney hand level is the most suitable instrument. In this work the level of the centre peg previously taken by the levelling party is used as a bench mark for each cross section. The angle of slope of the ground is then read with the hand level and the distance of each shot taped from the observing station. From this the elevation of each point with reference to the centre peg is obtained by calculation. When working with the Abney level it is of course necessary to determine in the first place the eye height of the observer. This is best done failing a level to set a peg at the same level as the place where the observer stands, by choosing two spots at the water level of a pond, setting the dial of the Abney level at 90 degrees and reading the staff held at the water edge at the maximum sight distance—not over 200 feet. This eye height having been determined a target is fixed at this height on the staff and all slopes can thus be read without any correction for eye height. The simplicity, quickness, and perfectly sufficient accuracy of this method of taking cross sections for railway work does not seem to be sufficiently realised.

With regard to plotting cross sections the most usual scale is 20 feet to the inch natural. The areas are best determined by planimeter, in using which it is usually most convenient to set it to read square inches or square centimetres and to then multiply the result by the squares of the scale per inch or per centimeter. If ground surface embraced by cross-section can be sufficiently indicated by three levels, calculation of area is simple, but cross-sections should always be plotted where ground is irregular for their value in the control of earthwork, and as a check on calculation. Areas of irregular sections can be graphically computed by reduction to a triangle or by splitting up into component triangles.

For plotting longitudinal section the most usual scales are 400 feet to the inch horizontal and 40 feet to the inch vertical and for this squared paper should always be used to save ruling up—a very laborious job with ordinary paper.

As a final remark it should be stated that a locating party is, in addition to the work set out above, expected to gather all information as to local stores, their quality, quantity and cost, transport, landing facilities for stores, water supply and health conditions, and, most important of all, conditions and supply of labour and its character.

APPENDIX.

With regard to the subject of station location, these should generally be placed in situations where earthwork will be light and foundations for buildings therefore inexpensive, but in this case the question of drainage for engine and ash-pits, etc., etc., should not be over-looked as often happens. As a rule stations are located in populous countries at 10 mile intervals to begin with and in sparsely populated countries at water stations or other places of importance. In all cases with a view to unexpected developments it is wise to take a large area of land at station sites. In China for stations of the third class a length of 2,000 feet by 400 feet wide is taken and in places of importance double this area. No station should be located on a grade greater than one in 400.

On page 145 the cost of operating lengthened mileage is taken at maintenance labour only on the assumption that the railway will develop traffic to pay operating expenses in a year or two. In this case as rates are fixed on a mileage basis extra mileage pays its own way. This is not an extravagant assumption for China.

CHAPTER VII.

THE CASE FOR MACHINERY ON RAILWAY CONSTRUCTION IN CHINA.

For a discussion of this question a description of the conditions obtaining on railway construction in China is perhaps not unnecessary. Here we have the transport problem in the most acute form for China's roads are unmetalled and never repaired, with the consequence that a few hours rain renders them impassable for days at a time except for the very lightest traffic. They are purely fine weather roads and except in the North where the climate is more settled there cannot be said to be any real dry season. Even in the North the working season, owing to the winter, is confined to the months from March to November, which includes the very heavy rains[42] of June and still more July and August when damage to temporary works is certain to take place, and work is stopped for days at a time owing to the refusal of the men to work in the wet. Further the carts of the country are not built for the efficient carriage of heavy weights, and carts and cart roads are not universal, disappearing altogether South of the Yangtze River, and giving place to mule and wheel-barrow transport. In addition as every acre of ground is under cultivation and as cheap timber for corduroying soft roads is not to be had, the making of roads for transport purposes is not to be thought of.

The labour problem in China is non-existent. There is a plentiful supply of so-called skilled and unskilled labour. Labour generally is highly intelligent, not given to drinking or striking, but conservative of old methods and lazy if there is a chance. White supervision is confined to engineers, the white foreman or subcontractor being unknown. Of the skilled labourers the mason is the worst:

[42] North China 20″—40″ 60% in 3 summer months.
Yangtze Valley 40″—60″ decreasing gradually from coast inland.
South China 60″—80″ along coast; 40″—60″ inland.

his work is very showy, but he prefers small stones, badly bedded and packed with spalls, and he never improves. The carpenters are not good as a whole, but they are good enough for ordinary railway work. Fitters and blacksmiths are mediocre. The following are the average daily wages of various classes of labour in the North, in South China wages are higher.

> Coolie 23 cents or 4.6*d.*, Carpenter 30 cents or 6*d.*, Bricklayer and mason 30 cents or 6*d.*, Fitter 50 cents or 10*d.*, Blacksmith-gang, smith and 2 strikers $1.24 or 24.8*d.*

Turning to the question of supplies, good cement, lime, and bricks of poor quality are always obtainable: timber, steel, and steel tools have to be imported. There is one steel works in the country at Hanyang near Hankow, which rolls rails, but the output is uncertain and cannot cope with the requirements.

The last condition, which is perhaps peculiar to China, is the fact that it is a country of many rivers, liable to quick flooding and change of course in many cases. As a consequence the amount spent on bridge building is always heavy. There are therefore many instances in which time and labour saving machinery might possibly have effected a saving, at any rate such instances are very likely to occur. It should be said here that the standard of railway construction is high as shown by the demand for a minimum grade of one in 100 and minimum curves of 1,000 feet radius. All lines are fully ballasted. Express trains run up to 50 miles an hour.

With conditions as above it is obvious that every effort should be made to eliminate road transport as quickly as possible, and everything subordinated to pushing the rails through as quickly as possible. This implies that practically all the earthwork will be completed ahead of rails, that deviations will be put in wherever possible for the bigger bridges, and temporary bridges of sleeper stacks and rails for the smaller openings. This is the universal programme and it necessarily eliminates the steam navvy on railway work. Even if the above conditions did not compel this, the great preponderance of bank on the great plains of China would prohibit its use. The transport condition effectually forbids all thought of the use of machinery ahead of rails. Also the large use of sleeper stack bridges of height less than 20 feet implies that much of the pile driving must be done ahead of rails. This implies the sinking of some capital in the construction of hand pile-drivers and makes it doubtful whether a steam pile-driver would pay for itself. Pile-driving is a big item in China owing to the liability of most rivers to scour.

Plant Charges.—Before going further into the subject it would be as well to state that it is proposed to charge off the cost of all plant to the jobs engaged on. This is done for the following reasons: firstly because there is little or no market for special machinery when done with; secondly the amount of plant which can be utilised on maintenance is very small. For instance a steam crane is always useful in breakdowns, and by removing the jib is easily converted into a very portable steam winch and from that into a steam pile-driver by fixing a snatch block to the base of the ordinary hand machine. Portable boilers and pumps can generally be utilised in the provision of water supply to engines and staff, and portable engines in the various fitters and other shops attached to the headquarters of divisional engineers. The rest of the plant goes into store where it undergoes rapid deterioration, mainly owing to the severities of the climate, but a good deal by neglect and theft of every easily removable part, for no piece of scrap comes amiss to the Chinaman and brass is almost a precious metal to him. It should be said here that all rubber perishes very rapidly, and that pumps with rubber parts are to be avoided, also that all portable boilers should be provided with feed pump as well as injector, mainly as a stand-by. The last reason for charging off all plant is that the estimation of repairs is a difficult job owing to the varying conditions, *e.g.*, the presence or otherwise of bad water.

Excavating Machinery.

All earthwork in China is done by Chinese contractors, who thoroughly understand their business and require little or no white supervision. Banks are built from borrow pit and cuttings run to spoil, basket and shovel being the only tools employed. As a rule there is no fault to find with the organization of the work and all that the foreign engineer has to insist on is that places liable to flood are rushed up when there is a chance, for flooded borrow pits mean either extra land, train-hauled material, or pumping, at any rate extra expense. As previously stated excavating machinery is out of the question as far as railway work is concerned, but it is doubtful if it could be made to pay even in the case where the transport factor was absent, as on a dock contract. Such a job carried out in the usual way would be done by coolies loading into trains, probably about 2,000 coolies on 1,000,000 cubic yard job. An engine and wagons would be required in both cases and similar plant for dealing with the water so that the only extra plant required would be the steam navvy itself. It is estimated that a 10 H.P. Ruston Procter Steam Navvy would cost delivered in China about £1,320. The work done in the ordinary way by coolies loading into 30 ton cars would cost about 50 cents or 10*d.* per fang of 100 cubic feet. The maximum average output is taken to be 800 cubic yards per day of 10 hours for the steam navvy. The following is an estimate of the staff required to run the machine.

1 navvy driver	$1.00
3 stokers	.90
1 bucket man	.30
4 water coolies	1.00
2 cleaners and fitters	1.00
1 ton coal	7.00
Oil and waste	1.00
Total daily cost	$12.20

Incidental work round tip, etc.

2 foremen	.80
1 loco driver	1.00
2 firemen	.60
1 Roperunner	.30
2 cleaners	.60
16 waggon tippers	4.00
12 platelayers	3.00
4 coolies	1.00
4 horse drivers	2.00

Total daily cost of working 25.50 or £2.2.6

This is the cost of 800 cubic yards or a cost per cubic yard of ⅝ of a penny or 11.8 cents per fang of 100 cubic feet.

On the basis of charging off the plant it would pay to bring in a steam navvy if plant charges were run up to the figure of 38.2 cents per 100 cubic feet, this being the difference in the cost of excavation by hand and that of steam excavation at 11.8 cents per 100 cubic feet. In other words it would pay to introduce the steam navvy on a job containing 56,000 fang or 208,000 cubic yards if time were no object. This estimate is based on the assumption that no white supervision would be required. This would certainly be required at first, for the economical handling of a steam navvy necessitates considerable training. Whether the Chinese could be trained to do such work is difficult to say, but judging from their achievements in other directions there should be little doubt about it. White supervision would double the daily cost and would make it worth while to introduce two navvys on a 1,000,000 cubic yard job. The work would take about five times as long as the coolie method but would be about £8,000 cheaper. But the value of the 18 months delay in opening the dock would far outweigh this on an undertaking of large capital. In the above the staff is double that employed in England and the coal consumption also doubled on account of theft and inferior quality. In the coolie method it has been assumed that 100 cubic feet per man per day would be shifted and that about 2,000 coolies would be employed. In the one case you have a known and certain thing, in the other an experiment the cost of which may still have been under-estimated.

Pile Driving Machinery.

As previously stated a good deal of the pile-driving on railway work is necessarily done ahead of rails and for this purpose the only possible machine is the hand one on account of the transport problem. The standard type is the 26 foot which is merely a strongly strutted and braced "A" frame, with a hand winch, ¾ ton monkey, and chain. Chain is used instead of wire rope because a chain if it does break can easily be repaired in the nearest big village where there is always a blacksmith, whereas a wire rope repair would have to be sent to the nearest shops, perhaps some days away. The pile-driver described can be taken to pieces and loaded into the ordinary country cart and so presents no transport difficulties. The crew required for such a machine is as follows:

1 foreman	$0.40
10 coolies	2.50
1 carpenter	0.30
Total daily cost	3.20 or 5/4*d*.

The average daily performance of such an engine would be one pile driven 18 feet. The pile driven is a 20 feet pole 10 inches diameter at the big end, for heavier piles the 40 feet engine is employed. To drive one pile the cost is 3.20 or 5/4*d*. If steam drivers were used about four could be driven and of course more with a jet to help. One instance is on record where the speed of driving was accelerated five times by the presence of a jet.

By the use of a steam winch and boiler coupled with the already existing pile engines, the purchase of the ordinary type of steam pile-driver with its expensive monkey could be avoided. In any case the above combination is perhaps most suitable as the boiler and winch can be fixed at a convenient distance from the pile engine and the heavier staging and greater labour in shifting the usual form of machine avoided. Also by the use of a long length of wire rope coupled with a snatch-block secured to the base of the pile engine a large number of piles can be driven without moving the boiler or winch. Wire rope is necessary owing to the braking effect of chain, in the case, as here, where the monkey is dropped by pulling out the clutch on the winch, and not by the use of trip gear. As pointed out above there is always the possibility of helping matters by introducing a water jet if the ground is suitable and water is available. The cost of boiler and winch delivered in China would be about £180 and the cost of a pump suitable for a jet about £30. The estimated cost of running such a pile driver is as follows:

1 engine driver	$1.00	
1 fireman	.30	
2 water coolies	.60	for feed water
1 foreman	.40	
6 coolies	1.50	
1 carpenter	.30	
1 ton coal	7.00	
Oil and waste	1.00	

Total cost of driving 4 piles $12.10 or the cost per pile is $3.02 or 5/0*d.* It would therefore pay to introduce a steam pile driver if plant charges per pile driven were run up to the difference in driving costs by the two methods, which is 18 cents or 4*d.* per pile. Then in order to pay for itself each steam machine must drive about 12,000 piles, an altogether impossible number for one machine so that the steam machine cannot compete if plant is charged off. There is however the saving of time to be considered in the steam machine. Thus if it is assumed that the value of one day's delay in opening a section of line between potential traffic centres is the future net earnings per mile multiplied by the distance between the above centres, the value of one days delay on Chinese railways is about £3 per mile, or $36 after paying operating costs. This is of course an extreme view as a construction programme is in most cases largely influenced by supplies and weather, but it is easy to imagine a case where time-saving would be of tremendous value, in a country where the working season is limited and where failure to complete an operation in one working season means delaying the opening of the line not by days but by the interval between working seasons, and more than this, for the organisation of the work has to be done twice. This is specially true of pile-driving which is virtually impossible in the winter in the north, and where all work is shut down if possible. Another case where time-saving may be of great value is in perhaps avoiding the washouts which are unavoidable during construction in the rainy season. A saving of a few days may mean that construction need not be held up for a few weeks, besides saving the loss in repairing deviations and temporary bridges. It is of course impossible to put this into figures but there is no doubt that all railway jobs of any size could afford to convert three or four pile engines into steam drivers on account of the after utility of boilers and winches in well sinking, washout work, quarry work, and bridge renewals. Whether more should be converted would depend on circumstances, no two cases being alike. It should be said here that the steam pile-driver is if anything over-staffed and that the coal consumption has been doubled on account of theft, etc. Another very great advantage not possessed by the hand machine is its ability to keep heavy piles, such as used in the foundations of the 200 feet spans, continuously on the move.

Stone Breaking and Quarrying Machinery.

It is the custom in China to break all stone by hand. The large number of bridges and the practice of fully ballasting all roadbeds as quickly as possible make the cost of ballast a very important item. Usually a quarry site is chosen, wherever possible in close proximity to the line and a siding run in. A contract is then let to a Chinese contractor for quarrying, breaking, and loading rubble, concrete ballast and track ballast. The contractor is bound to deliver a certain amount per month or be fined. The railway supplies no plant, but sells the man explosive, drill steel and fuse at cost price. The prices usually paid for such work vary slightly with the locality, but the following are North China prices.

Rubble	$1.40	per	100	cub. ft.
Concrete ballast	2.50	,,	,,	,,
Track ,,	2.20	,,	,,	,,

It is suggested that the following plant might effect some saving, when rail transport is available.

2 Stone crushers 12 × 7 jaws	£240
1 10 H.P. portable engine	250
15 tons freight at £2	30
Total cost	£520

The output of this plant would be say 100 tons of stone per day of 10 hours or 2,000 cubic feet taking stone at 112 lbs. per cubic foot. The running costs would be as follows:

1 driver	$1.00
1 fireman	.30
5 coolies	1.25
½ ton coal	3.50
Waste, etc.	.50
Total cost of 2,000 cub. ft.	$6.50

The cost of crushing 100 cubic feet to any size would therefore be 32 cents or 6*d*. To this cost must be added the quarrying cost of \$1.40 per 100 cubic feet. Then the total cost of any sized ballast will be \$1.72 per 100 cubic feet. Therefore if concrete ballast be considered, it would pay to introduce a crusher if plant charges were run up to the difference in costs of the two methods or 78 cents per 100 cubic feet. In this case in view of the undoubted after-utility of the machine, and also in view of the fact that efficient supervision and proper housing will be possible, a plant charge of 20% of the cost to cover one year's repairs and depreciation would appear to be a fair estimate. That is to say that it would pay to introduce crushers if each machine crushed 160,000 cubic feet. Now with track ballast alone at least 80,000 cubic feet per mile it can be seen that this is a very small fraction of the amount required and consequently that crushers would undoubtedly pay, more especially as practically all ballasting is done after rails are available. Moreover the introduction of crushers would guarantee a fixed supply instead of the very uncertain supply given by the average Chinese ballast contractor and the quality of the ballast would be better.

It is also suggested that the Chinese might be induced to try steam or air, rock drills, at any rate the experiment might be tried with very little extra expense if rock crushers were installed in a quarry. By this means much bigger holes would be obtained and the quarrying rendered more economical of explosives, for no Chinese will make enough or big enough holes with the consequence that the full power of the charge is never obtained. The time ratios for the same work steam and hand rock drilling are about six to one where white labour is employed and at least double this for Chinese labour. This would appear to be sufficiently high to warrant the introduction of an experimental rock drill more especially as the extra plant charge per drill would not exceed £50, if the same boiler power as that used for the crushers is utilised. The difficulty is the absence of any reliable data giving the amount of drilling done per 100 cubic feet of rock excavated under present methods, also the doubt whether the Chinese would use the drills even if provided with them.

Concrete Mixing Machinery.

It is customary to mix all concrete by hand. The concrete when mixed is loaded into baskets and dumped into the forms where it is well rammed. The labour cost of such work, placing only, is about $5.00 or 8/4*d.* per 100 cubic feet. It is suggested that a belt-driven concrete mixer mounted with its engine in a 30 ton truck might at least save money on the mixing and perhaps time as well. In cases where there was a deviation, a sleeper stack and rail bridge would be built right over the site of the piers, and the mixer moved over each pier as required, shutes being used to deliver the concrete to the moulds. In cases where there was no deviation the main line itself would be used, a siding being provided off the bridge for passing trains. The estimated cost of the plant is as follows:

1 half cubic yard mixer	£150
1 4 H.P. vertical boiler and engine	£100
4 side-tip 1 cubic yard wagons and rails	£ 40
Total cost plant	£290

The running cost would be as follows:

2 foremen	1.00	
1 driver	1.00	
1 fireman	.30	
15 coolies	3.75	feeding mixer, etc.
30 coolies	7.50	erecting staging,etc.
5 cwt. coal and stores	2.25	
Total daily cost	$15.80	

This is the cost of placing 60 cubic yards or the cost of placing 100 cubic feet is 97 cents or 19.4*d*. This amounts to a saving in labour per 100 cubic feet $4.03 or 6/8*d*. per 100 cubic feet and plant charges can be run up to this figure without loss, that is if each mixer placed 870 fang of 100 cubic feet it would have paid for itself. Now it is Chinese practice to leave the bulk of the concrete work until rail-transport is available, so that there would appear to be some scope for the concrete mixer. It is realised that in many cases the capacity of the concrete forms would limit the output of the machine and that somewhat special training would be required at first to cope with the large output. On this account the petrol-driven mixer of about 6 cubic feet hopper capacity, giving an output of about 50 cubic yards per day would perhaps be the most economical machine. The petrol consumption of such a machine would be about two gallons per day and the running costs no more than for the steam plant. The cost of the machine would be about £200. Of course a specially trained driver would be required, but such men are obtainable and the extra cost has been allowed for. An additional advantage of this type of mixer is its extreme portability and the fact of its being self contained, in fact with a plentiful supply of spares and a capable driver there is no reason why it should not be used even ahead of rails in order to get ahead with the bigger bridges. It should also be remembered that a mixer saves the cost of mixing boards, shovels and baskets, quite a considerable item on a large job.

The great argument against the use of the mixer is the number of moulds required to keep it going. It is the custom to employ one mould at a bridge or at most two. These are built of 12 × 3 planks usually about 10 feet high for each lift. This type of mould is very heavy but an excellent concrete face is obtained. If a mixer is to be used at least four moulds would be required of each type of bridge. If inch and a half planks were used for moulds the extra cost of making moulds to cope with a mixer for four types of bridges would be about £70 per mixer at present timber prices. This should be added to the capital cost of the machine, as the theft of timber is too high to expect to get any credit on moulds after they are finished with.

Minor Machines.

The first of these is the steam-driven circular saw. Timber is imported in logs chiefly 12 × 12 and 14 × 14 and planks 12 × 3 and 12 × 4. The logs are sawn by hand into the required scantlings. The cost of sawing by hand in China is about $6.00 per 1,000 square feet sawn. A circular saw cuts about 3,000 square feet per day of 10 hours at a low estimate.

Plant required:

1 6 H.P. boiler and engine combined	£150
1 circular saw bench 35″ saw	50
Total cost of plant	£200

The cost of running per day would be

1 driver	$1.00	
1 fireman	.30	
2 carpenters	.60	feeding saw, etc.
5 cwt. coal and stores	2.25	
Total daily cost	$4.15	

This is the cost of sawing 3,000 square feet, or 1,000 square feet costs $1.38 or 27.6*d.* This is a saving of $4.62 per 1,000 square feet sawn or 8/8*d.* nearly. In this case a 20% plant charge would suffice as the conditions worked under would be fairly good.

Brick-making machines could be introduced with advantage, even if only hand presses, solely on account of the superior quality of the brick produced. The present brick is very porous, soft, and as often as not insufficiently burnt. Suitable clay is not common but once established there should always be a market for good bricks.

There is also very little doubt that hand paint-spraying machines would pay owing to their small initial cost, about £16 per machine, the saving in paint and brushes and the fact that they can do about 10 times the work of an ordinary painter. Also bridge painting is a very heavy item as no paint seems to last more than five years. At present the labour cost of such work is about 44 cents or 8.8*d.* per 100 square feet. It is estimated that a machine might reduce this to 18 cents per 100 square feet.

The most heavy items in plant charges have now been discussed, and while it is recognised that the above are merely estimates of machine performances in Chinese hands, they are at any rate estimates with a very large reserve margin. It should be said here that steam pile-driving somewhat on the lines suggested in this paper has been tried in North China and has proved a success saving much time and being slightly cheaper than the old method so that there would appear to be some case for at any rate experimental trial. China of course possesses the great advantage of cheap skilled labour, which makes the labour cost of running machinery very low. The white engine driver is unknown on the Chinese Railways and the work turned out by the locomotive and wagon shops of the country is excellent in quality. The white supervision at these works is very small and the only white men in the running departments are the loco-inspectors at the larger engine depôts. In this paper the wages of engine drivers are perhaps rather high and the price of coal undoubtedly so for North China, where the prices paid by the railways are as follows:

Lump coal	$5.00 or 8/4*d.*	per ton
Dust coal suitable for boilers	2.50 or 4/2*d.*	„

In this chapter it has been taken at an average of $7.00 or 13/8*d.* per ton which is perhaps high for dust coal even in South China where coal is much dearer. Throughout the Mexican dollar in use in the country has been taken at 1/8*d* or 5 cents to the penny.

The introduction of machinery would not involve an additional charge for repair shops, as these are built in any case and are not fully employed during construction.

In conclusion it would appear that the introduction of machinery into any country depends mainly on the type of line to be built, whether a light line with high grades and sharp curvature or the reverse; in other words on the amount of work. It also depends on the transport and roads available, the weather conditions and on the construction scheme which the labour supply controls. Lastly it depends on the feasibility or otherwise of reducing the white supervising element to a minimum and of making the utmost use of the cheap labour available. Thus on a heavy line in a country such as tropical Africa, where labour is difficult to obtain, the case for machinery would appear to be worth investigation even though nigger labour is cheap. Heavy lines have been avoided in such cases by high grades and sharp curvature, in the hope that later developments will pay for improvements, the expected traffic on such lines in sparsely populated countries only warranting the minimum of capital expenditure.

APPENDIX.

Since this chapter was written in 1916 the wages of railway employees in North China have been increased 10 per cent. Prices of machinery have fluctuated enormously and are still in too fluid a condition for purposes of statement.

With regard to *Pile driving* machinery in the autumn of 1920 some 153 concrete piles were driven in the reconstruction of a bridge of 18 ten foot spans on the Peking-Mukden Railway. Two of the steam cylinder type monkeys with a three way cock mounted on the head were used for this work. The piles driven weighed about two tons each and were driven 19 feet. The average performance per day was seven piles, the maximum nine. In order to handle such heavy piles 55 men were employed per machine. With wooden piles it would be at least a fair thing to assume the same crew as is considered with the winch driver, and very obviously as good a performance as was obtained with the concrete piles. The boiler and pipes were valued at $2,120 but in view of their obvious after-utility, a charge of two per cent. for repairs would be considered adequate for the month it was in use. The value of the monkey was $509.

Cost per pile-driven crew and rates as before (*see* page 167)	$12.10 / 7	or $1.70
Cost per pile driven by hand		$3.20
Saving per pile on hand driving		$1.50

Then in order to pay for monkey and all boiler depreciation each monkey would require to drive at the outside 370 piles. There is no doubt that in large bridges even ahead of rails these pile drivers would easily pay for themselves.

With reference to Chinese methods of quarrying the following information has been collected. Drilling per solid fang of rock displaced 15 feet. Depths of hole three to five feet paid at the rate of seven cents per foot in Tangshan, North China. Two pounds of native-made powder are required per fang of rock costing about 12 cents a pound. With good black powder the quantity required per fang is about 10 ounces. Drilling is done entirely by hand, about four holes being made per fang of rock. The holes are 1¼ inch diameter as a rule and the number of feet drilled per man per day is from five to six feet. Fuse is not used, joss sticks being used instead, and proving quite efficient.

CHAPTER VIII.

REINFORCED CONCRETE ON THE CHINESE RAILWAYS.

RAIL REINFORCED BEAMS.

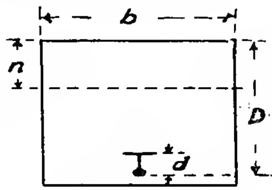
THE formulæ used for the calculation of the neutral axis and resistance moment for this reinforcement are as follows. They rest on the assumption of a linear distribution of strain in the beam

$$n = \sqrt{\frac{15A}{b}\left[2D - d + \frac{15A}{b}\right]} - \frac{15A}{b}$$

where n is distance of neutral axis below top of beam and the other symbols have the significance in the figure

$$M_c \text{ inch lbs.} = 600\left\{\frac{bn^2}{3} + \frac{15}{n}\left[A\left(D-n-\frac{d}{2}\right)^2 + I\right]\right\}$$

$$M_s \text{ inch tons} = 7.5\,\frac{\left\{\frac{bn^2}{3} + 15\left[A\left(D-n-\frac{d}{2}\right)^2 + I\right]\right\}}{15\,(D-n)}$$



Area of Rail = A
Moment of Inertia = I

where 600 is extreme fibre stress concrete in lbs. per square inch and 7.5 is that for steel in tons per square inch.

From the above two formulæ for resistance moment it is easy to deduce that $M_c = M_s$ when $n.1.86$ equals $(D\text{-}n)$, this giving the most economical proportion of reinforcement. This relation gives what appear to be rather impossible results for cases where reinforcement is concentrated, but experiment confirms these results.

Before proceeding further, a statement of the theory governing the design of such beams, would perhaps be not out of place.

Reinforcement of this type necessarily has a large perimeter and as a consequence the change per inch run in the tension transmitted to the concrete is higher than in the case of more evenly distributed reinforcement. Thus in the 60 lb. rail of the Chinese Government Railways the perimeter is 18.125 inches, and the maximum change of tension, at 75 lbs. per square inch bond stress, which can be transmitted to the concrete is consequently 18.125 $\times$ 75 or 1,360 lbs.

It is proposed to consider the case where loads are evenly distributed as reinforced concrete would only be used in situations where a good pad of ballast was available between sleeper and concrete slab.

From the principles of reinforced concrete beams the following relation is derived.

M or resistance moment is tension in reinforcement *T.jd* where *jd* is a fraction of the depth of the beam usually for ordinary cases about seven-eights.

Considering a section at any point distant x along the beam and differentiating the above equation M is $T.jd$

It follows that $\frac{dM}{dx}$ is $\frac{dT}{dx}.jd$.

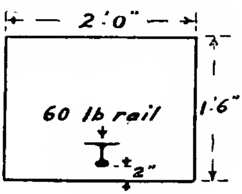
Now $\frac{dM}{dx}$ is from the principles of beams the shear at the point x and jd is a constant for any particular size of beam. Now $\frac{dM}{dx}$ is obviously a maximum at the supports and as a consequence $\frac{dT}{dx}$ or the change of tension per inch is a maximum there also. But at the supports

$$\frac{dM}{dx} \text{ is the reaction}$$

$$\text{therefore the reaction equals } \frac{dT}{dx}.jd.$$

Now the maximum value for the change in tension is as above 1,360 lbs. for the 60 lb. rail. Therefore the maximum reaction permissible with this type of reinforcement is 1,360.*jd*.

It is this relation which should determine the maximum loading on a beam, more especially short beams, and not the resistance moment. Thus in the case of the 60 lb. rail and a beam as in the sketch.



Here *jd* the arm of the resistance moment couple is 11.5 inches and therefore the maximum reaction which should occur is 11.5 × 1,360 or 7 tons. This implies that 14 tons distributed should be the maximum load on the beam. Now the maximum resistance moment of this beam as determined by the concrete is, with an extreme fibre stress of 600 lbs. per square inch, 22.2 foot tons.

Then the critical span is given by the equation

$$\frac{WL}{8} = Resistance\ moment$$

That is $\frac{14 \times L}{8} = 22.2$ or $L = 12.7$ feet

This of course implies that no web reinforcement or turning up at the ends is provided. This is to be avoided at all costs as the reinforcement should be of the simplest where native labour is employed as efficient personal supervision is not always possible. In any case such web reinforcement, using rails, would be a matter of considerable difficulty.

Then for spans less than this 12.7 feet, 14 tons distributed should be the maximum allowable load without consideration of resistance moment, while for spans over this length resistance moment is the criterion of strength.

For calculation of reinforcement spacing use a safe shear stress of 75 lbs. per square inch. For ordinary bar reinforcement, spacing (clear) should never be less than three diameters of rods.

The results given by the foregoing formulæ for resistance moment and neutral axis for 60 lb. rail reinforcement were worked out for various depths and width of concrete. In every case it is assumed that the rail is head downward and two inches from the surface of the concrete. In view of the very large use of 60 lb. rail it is thought that these results may be of some use. They are therefore tabulated below. The properties of the 60 lb. rail used are as follows:—Area 5.7280 square inches. Moment of Inertia 15.87 inch units, about horizontal axis through centre of gravity.

Perimeter	15.86 inches
Height	4.5 „
Width of base	4.0 „

Beams of 1.2.4 concrete

Width.	*D + 2 Total depth.*	*"n" inches.*	*Mft. tons concrete.*	*Mft. tons steel.*
1′ 0″	1′ 0″	5.58	5.5	8.27
1′ 0″	1′ 6″	8.59	13.1	34.0
1′ 0″	2′ 0″	11.12	24.0	46.2
1′ 0″	3′ 0″	15.31	55.12	84.3
1′ 6″	1′ 02″	4.9	7.6	13.4
1′ 6″	1′ 6″	7.65	18.0	30.6
1′ 6″	2′ 0″	9.40	33.0	45.0
2′ 0″	1′ 0″	4.62	9.0	14.5
2′ 0″	1′ 6″	6.97	22.2	32.0
2′ 0″	2′ 0″	8.75	42.0	44.0
2′ 0″	3′ 0″	11.91	89.1	89.7
2′ 6″	1′ 0″	4.3	10.75	15.0
2′ 6″	1′ 6″	6.45	26.0	32.6
2′ 6″	2′ 0″	8.16	47.0	52.0
2′ 6″	3′ 0″	10.93	103.5	91.45
3′ 0″	1′ 0″	4.15	11.88	15.73
3′ 0″	1′ 6″	6.10	29.2	33.6
3′ 0″	2′ 0″	7.60	53.3	52.6
3′ 0″	3′ 0″	10.13	116.5	92.11
4′ 0″	1′ 0″	3.77	14.44	16.30
4′ 6″	1′ 0″	3.62	15.75	16.67
5′ 0″	1′ 0″	3.49	16.95	16.95

Turning to the question of a more convenient formula for determination of the moment of resistance of the concrete of a rail reinforced beam, if the results above are plotted with resistance moment and depth as ordinate and abcissa the following empiric general formula for 60 lb. rail gives sufficiently accurate results for the conditions under which rail reinforcement is feasible (that is for depths of beam from one foot to three feet). Resistance moment concrete foot tons is $6D^2 \ (1 + 0.55(b-1))$ where D and b are both in feet—D is total depth— $= D + 2''$ in formula page 177.

Other formulæ in terms of D in feet are as follows. The position of the neutral axis of a beam one foot wide is given by the formulæ n is $\frac{3.8\,D+3.5-7.2\sqrt{D}}{\sqrt{D}}$ where n is in inches.

The limiting width at which the moments resistance for steel and concrete are equal is given by the formula:

$$b \text{ is } \frac{6.35\,D-9.91}{D^2} \text{ where } b \text{ is in feet}$$

In the case of a slab 14′ 6″ wide (the standard pier width for small spans on the Chinese Railways) the formula giving least rails is

$$\sqrt{M} \textit{ is } 6.7\,D - 0.44\,D^2$$

This is of course not necessarily the most economical arrangement. In the above M is the total estimated Bending Moment based on an assumed depth of slab.

With regard to calculation of deflection the moment of inertia of a composite beam is

$$\frac{\textit{Resistance moment of concrete} \times n}{600}$$

where all units are in inches and lbs. n being depth of neutral axis below top of beam.

The deflection of a beam under a distributed load is $\frac{5\,WL^3}{384\,E.\,I}$ where W is the load in pounds, L the span in inches, E the modulus of elasticity of 1.2.4 concrete, which varies from 2,300,000 to 3,360,000 according as the concrete is one month or six months old. This formula apparently gives sufficiently accurate results.

For purposes of calculation for other rail weights it is useful to remember that the moment of inertia of flat-footed rails increases, roughly, as the square of their weight ratios and that the sectional area in square inches is the weight per yard divided by 10. Approximately, d or height of rail in inches (any weight) $= 2'' + \frac{W}{10} \times 3/8$ approximately.

The following are suggested designs for three very usual spans and estimates showing the cost of steel work and painting in China.

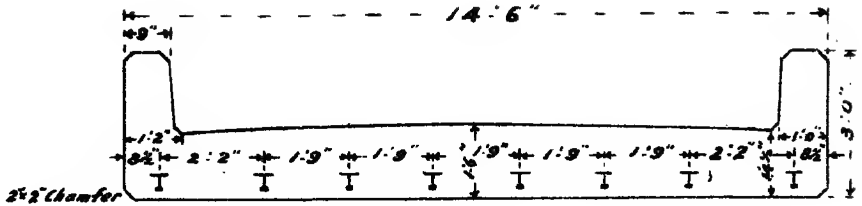
Span.	*Bending Moments Live Ft. tons.*	*Dead Ft. tons.*	*Width of slab feet.*	*Depth feet.*	*Number of 60 lb. rails.*
12 feet	80.12	34.3	15 feet	1′ 6″	8
20 feet	172.33	120	15 feet	2′ 0″	10
30 feet	342.75	380	15 feet	2′ 0″	15

The estimates below are based on a steelwork price of $150 per ton for girders, which are the Chinese Government standard for 85 lb. rail, and a price of $60 per fang of 100 cubic feet for the rail reinforced slabs. The price of the scrap rail is taken at $50 per ton. The concrete cost is based on actual experience in the re-construction of a bridge of 31 12-foot spans details of which are given below.

Span.	*Cost of steelwork.*	*Cost of concrete Wt. tons.*	*Slab.*	*Length feet.*
12 feet	$196	1.4	$180	15 feet
20 feet	$720	4.75	$360	24 feet
30 feet	$1,200	8.15	$744	34′ 6″

The rail reinforced slab is therefore not only cheaper in first cost but possesses the great advantage from a running and maintenance point of view of providing an all ballast road. Further some saving is effected by eliminating painting charges which amount to about $2, $3 and $4 annually for the three spans and in bad localities to double this. Ordinarily bridges require painting in China every four to five years. The slab design also eliminates the necessity for special sleepers thus effecting a further saving.

The attached Fig. I shows the design adopted for 12 foot spans in a bridge of 31 openings raised and re-constructed in 1916. In this case the slabs were made continuous over two spans the 30 feet rails used for reinforcing fitting in well with this arrangement. The concrete used was 1.2.4 made with ¾″ limestone quarry



—Bridge 132A Proposed Section—

Measured length When Bent 29' 8½" Average

—Bend in centre of 30 foot 60 lb. Rail—

—For Continuous Girder—

—Scale ¼" = 1'—

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Fig. I.

Reinforced Concrete Pile

Scale ½″=1′.

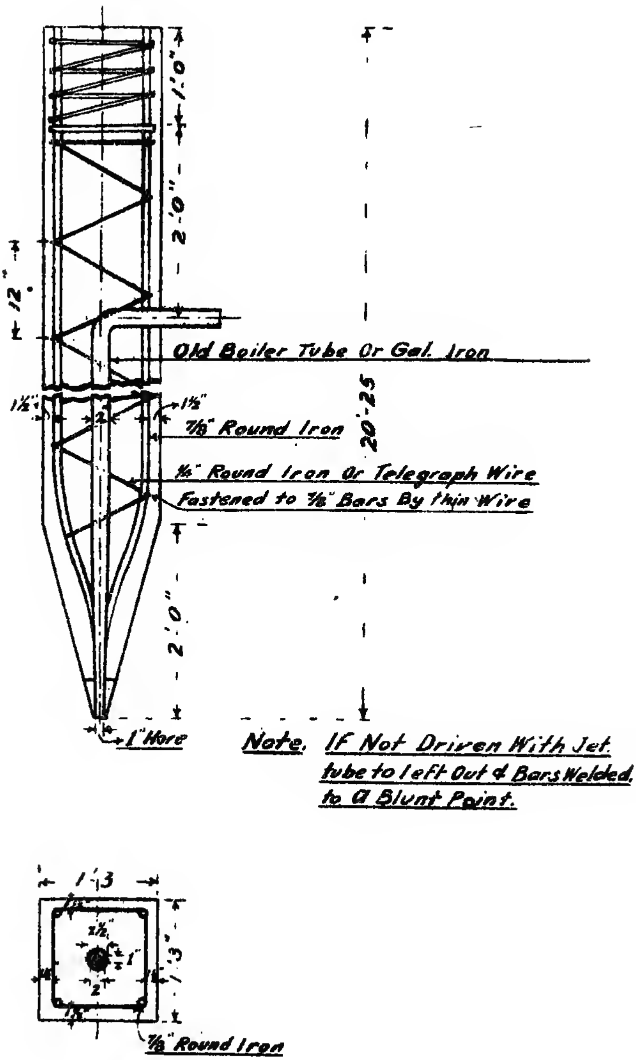


Fig. IA.

To face page 183.

chippings and coarse river sand. An expansion joint one inch wide was put in every 30 feet. The width of this is excessive as from observations made in the following winter the total contraction amounted to only ¼″. The total variation in temperature was 76° Fah. This bridge has been satisfactory with the exception of a crack which developed when the winter had set in, in one of the raised piers. This crack in the centre of the pier and about 3′ 6″ depth is thought to be due to contraction of the slabs as it occurred at the coldest time of the year. The only provision made for the sliding of the slabs on the piers was to float the top surface of the pier and allow it to set before casting the slab. This is apparently insufficient and paper or grease should have been used to prevent any bond.

With regard to forms used in casting the slabs, these were of three inch planks carried on sleeper stacks. The planks were planed only and not greased, the joints being caulked with oakum at first, but this was dispensed with later, an overlapping strip of thin sheet iron—old cement drum—3″ wide being nailed to one side of each plank. These planks ran at right angles to the length of the bridge and were sufficiently long to carry small triangular frames of 4″ × 3″ timber spaced 3′ 6″ centres, which were bolted to these and thus provided the stiffening for the side planks of the slab.

The cement used in this bridge and elsewhere is of Chinese manufacture and of first class quality.

With regard to concrete piles Fig. IA shows the standard 20 feet pile, but piles are moulded for a given job to the length required, previously ascertained by driving a timber pile. The piles are all cast with a central jet pipe 1½ to 2″ diameter made with old boiler tube, or failing that old galvanised sheet iron, or corrugated iron beaten flat. The shoe of the pile is iron bored for the jet pipe. These piles are driven by the ordinary 40 feet hand pile driver, but with a two ton monkey. A steam winch and boiler on an independent mounting are used for hauling up the monkey, which is tripped and falls free in the ordinary way. It would appear that much greater speed in driving would result from dispensing with the trip gear and heavy chain and substituting wire rope. The monkey could then be shackled to the rope and dropped by taking out the winch clutch. The fact that bridge work is now of infrequent occurrence, and the necessity for using old plant, has prevented the adoption of this method which has been used with success elsewhere. The heads of the concrete piles are protected by a special cap as in Fig. II when being driven. When driving is completed the heads are chipped to expose the reinforcement and then moulded into caps. Concrete pile trestles are extremely useful in low-lying situations where restriction of the water course is inadvisable.

Minor Applications of Reinforced Concrete.

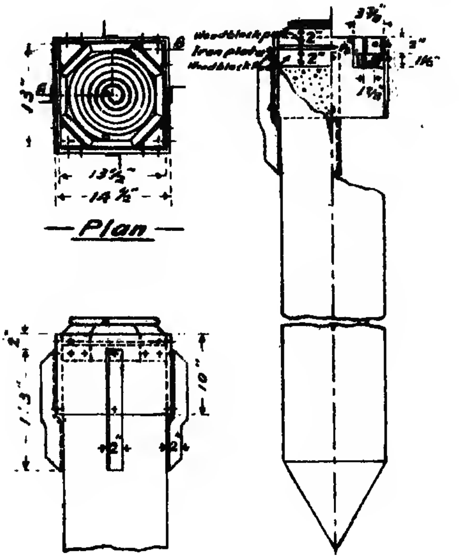
Figure III shows the standard station name board of the Peking-Mukden Railway, the head of which varies in length to accomodate the name.

The concrete signal post for a semaphore 25 feet above ground is made 32 feet long and is 11 inches square at base and 7 inches at the top. It is reinforced with eight ½ inch square bars for a length of 22 feet, the remainder with four bars of the same size. Double and triple arm posts are also made, the post being forked to carry a timber platform which carries the doll posts. The concrete lamp post is 11 feet long, 7 inches square at base 4 inches at top. It is reinforced with old boiler tube, to which is clamped a ladder rest of two plates of 1½ × ½ inch iron 10 feet above base. Post fixed 3 feet in ground.

The 50 foot concrete post for electric light is 15 inches square at base 7 inches at top. The reinforcement consists of 1″ × 1″ angle iron at the corners set 1½ inches inside the concrete and four ½ inch bars at 6 inch centres at centre of post. There are also four ½ inch bars fixed midway between the angle irons for the bottom 25 feet of post. Post fixed 5 feet in ground.

Cap for Reinforced Concrete Pile

Scale ½" = 1'



Elevation — Section A. B.

Fig. II.

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Reinforced Concrete Station Name Board

Scale 1″=6′.

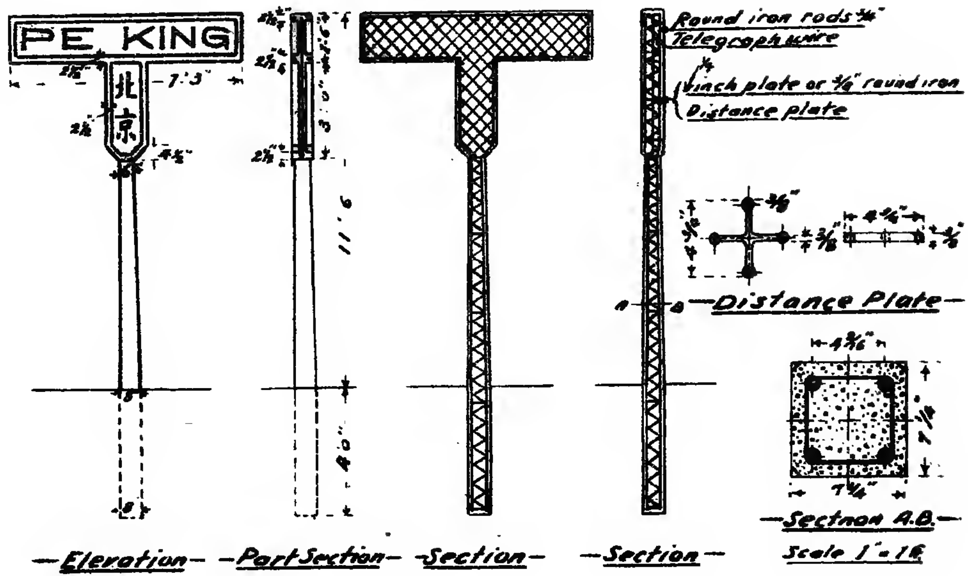

Fig. III.

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The reinforcement is very heavy throughout but in spite of this breakages have occurred through bad handling. Posts should be erected in all cases in a wooden casing of considerable length.

With regard to concrete sleepers experiments have been and are being made. No attempt has been made to use these for main line but a few experimental sleepers have been tried in sidings and a concrete sleeper reinforced with old boiler tube has been adopted in sidings under cover as in repair shops where axle loads are light. In this case the rail-fastening consists of ordinary spikes cast in the concrete the rails being pushed into position from the end when fixing these sleepers—that is the rail must be taken out.

Concrete is also being used to replace timbers, as they rot out, in engine pits, ash-pits, etc. It is also used instead of wood for rod-carrier stools, crank stools, etc., and also for signal wire pegs, gate posts, well curbs, etc. In those articles subjected to light stresses, tubes of old galvanised iron, beaten flat if corrugated, have been tried as reinforcement with success.

Turning to the question of concrete pipes, a good many experiments have been made on various types of 8″ pipes designed to stand a head of at least 45 lbs. per square inch. At first a pipe 8′ 0″ long was tried in order to reduce the number of joints as much as possible. Telegraph wire, in spiral form was tried at first as reinforcement but all the wire wound pipes leaked at low pressures and so a sheet of galvanised iron was tried. The joint in the sheet was soldered as otherwise the pipe leaked. It was also found that placing the reinforcement in the centre of the concrete caused the pipes to crack.

Although these pipes cost rather less than one-third of that of similar pipe in cast iron, it was considered that a shorter pipe would give better results. Eventually the pipe adopted had a length of 3′ 3″ and a thickness of two inches and was reinforced with 13 rings of one-eighth inch diameter wire which were inserted during moulding. Only

¾ inch stone was used and the mixture adopted was 1.1.2, sand being a mixture, half fine, half coarse. After moulding the pipes were immersed in water for 7 days and then buried in damp sand and tested at 2 weeks. The mixture used for jointing was 2 to 1, the sand being half fine, half coarse. This jointing was not a success and a pitch joint is in process of trial. All joints were spigot and socket. An extended trial of these pipes proved them unsuitable for pressure use.

Ordinary concrete pipes have been used for 18 inch and 1′ 0″ diameter culverts. The 18 inch pipe is cast in 3′ 0″ lengths moulded 3 inches thick and reinforced with rings of ⅛ inch diameter wire spaced 6 inch centres. These wire rings are placed central in the concrete and are kept in position longitudinally by four evenly spaced lengths of the same wire which is wired to the rings.

The 12 inch pipe is cast in 3′ lengths 3″ thick without any reinforcement. The concrete in these pipes is 1.2.4 and the stone ¾ inch. The cost of the 8 inch pipe is 90 cents per piece and the 18 inch pipe $1.00 per foot.

CHAPTER IX.

CONSTRUCTION MEMORANDA PECULIAR TO CHINA.

EARTHWORK.

Standards.—These vary considerably for no apparent reason. Thus the Antung-Mukden Railway has a 16 foot formation, while the Peking-Mukden Railway which traverses country of similar climatic conditions, has a rather lighter rail and similar speeds, has a formation of 20 feet. Similarly the Canton-Kowloon Railway, with 85 lb. rails and built to first class standards generally, has a formation width of 17 feet, whereas the rainfall is about 100 inches compared with 30 inches for North China. A usual double-track formation width is 30 feet, but 33 feet is quite usual with track centres at 13′ 6″.

All banks are built from borrow pit and the usual berm width is 10 feet, 6 feet being a minimum. Cess widths at boundary are from 2 to 3 feet.

The following is a formula for land widths required, the assumption being that borrow pits will be 4 feet deep, a fair average owing to probable water troubles at greater depths. Borrow pit slopes are 1½ to 1 as in the case of banks

$$\textit{Land width} = C + 3\,H + 0.25\,A - 12$$

where C is sum of formation berm and cess widths, A is cross sectional area of bank, and H height of bank.

As banks built in such a manner have a large shrinkage, the following extra heights must be added to the nett heights.

SHRINKAGE HEIGHTS FOR BANKS.

Height of bank.	*Sand.*	*Loam.*	*Clay.*	
0 to 2′ 6″	10%	20%	30%	of nett height
2′ 6″ to 5′ 0″	8%	16%	25%	„ „
5′ 0″ to 10′ 0″	6%	14%	20%	„ „
10′ 0″ to 16′ 0″	5%	10%	15%	„ „
16′ 0″ to 20′ 0″ and over	4%	7%	10%	„ „

The standards for cuttings generally allow for an increased formation width of 4 feet over banks to allow for side drains. Cuttings should never be on the level and should be well drained especially in North China where frost lift is always liable to occur. Land widths for cuttings are as for banks as spoil must be stacked.

Construction.—This is universally carried out by contract, the Chinese earthwork contractor, if a man of any standing and experience, needing little or no supervision, and in the matter of organisation no hints whatever. The following precautions should be taken. Banks situated in marshy or other ground liable to flood should be rushed up when opportunity offers and the engineer will often require to insist on this. Levels should of course be run over the work before final payment and slopes measured.

Earthwork prices.—The following formula believed to be due to Mr. T. J. Bourne, M.I.C.E. is given as a guide, but 18 cents may be taken as a minimum price per fang of 110 c. feet.

Get, fill, and unload: 12 cents.

Add 4 cents for each 100 feet horizontal lead, measured from centre line to centre of borrow pit and convert vertical lift into horizontal lead at the rate of 1 feet vertical lift to 12 feet horizontal.

Rock prices.—These vary from 90 cents where pick-work only is required to $2.50 for hard rock requiring blasting, in which case the contractor supplies all powder and fuse, drills only being provided which he is required to sharpen. Fifty per cent. over the local price for small rubble is a fair indication of the proper local price for rock excavation of this class. The great difficulty with rock excavation is to ensure that there is no wasted effort on the side slopes until a gullet has been pushed right through a cutting capable of accommodating the track.

Train-hauled mud.—A fair price for this: get, fill, and unload, and spread up to distances of 200 ft. from track is 40 cents. per fang. Similar prices have been paid for earthwork loaded into decauville wagons and hauled by hand for distances up to 1,000 feet.

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BRIDGE AND CULVERT CONSTRUCTION.

Estimation of openings.—For this see the chapter on Railway Location, but make careful examination of all native bridges and err on the side of excess. Native information as to flood levels is eminently unreliable. Pile all openings where there is any tendency for bed to scour.

Design.—For the smaller openings make the utmost use of re-inforced concrete pipes which can be used up to a diameter of 4 feet. For larger culverts the design giving greatest economy is that throwing most of the structure into arch, and therefore a parabolic or elliptic section is best, but this is hardly suitable for conditions prevailing, and the utmost use should be made of the semi-circular arch. There is very little to be gained in increased opening by reducing the rise of an arch for spans up to 20 feet, the class of structure considered here. It is not economical to shorten a culvert by increasing its height as this throws more quantity into wings.

It should also be an axiom to avoid light spans of the 10 to 20 feet type, arches being used where there is headway and failing this reinforced concrete slabs, preferably of the rail reinforced type, or failing this light steel sections for reinforcement.

With regard to abutments, wherever possible splay wings should be used as giving far less quantity than "U" abutments with straight wings. In all larger bridges where the adequate provision of opening is doubtful, use a pier abutment with pitched slopes.

Choice of materials.—This lies between concrete, ashlar and coursed rubble which may be used for all spans up to 30 feet. On the score of economy of cement the following figures are worthy of consideration. Cement in 100 cub. feet of following materials built in place: 1.2.4 concrete 5.9 barrels cement; 1.3.6 concrete 4.2 barrels; 1.4.8 concrete 3 barrels; Ashlar masonry 6 to 1 mortar one third barrel; Ashlar masonry 3 to 1 mortar ¾ of a barrel. Coursed rubble 6 to 1 mortar 1 barrel;

„ „ 3 to 1 mortar 1.6 barrels;

„ „ 1 cement 4 lime 12 sand mortar ½ barrel.

There is also this consideration in favour of masonry. No forms are required, a great consideration in a country where there is much theft of timber. Moreover, the time factor in a country with China's labour supply is largely eliminated. The utmost use should be made of coursed rubble where good quality stone is obtainable. If ashlar is employed an excellent job, which avoids the handling of heavy blocks, is given by using a uniform stone 2′ 0″ long by 1 ft. square in section. All piers and bearing surfaces in coursed rubble should be capped with a 2′ 0″ thick slab of 1.2.4 concrete. The use of lime mortar in bridge work is not advocated, an admixture of cement is essential.

Excavation of foundations.—Foundations should never be sheeted if this is avoidable. It is infinitely cheaper to batter the sides. For unwatering foundations baling is best for small quantities of water, but if hand pumps must be employed, avoid the use of pumps with rubber diaphragms, and this remark applies to steam pumps, the best of which for constructional purposes in China is unquestionably the centrifugal pump. This is usually a day work job as there are so many unforeseen contingencies.

Piling.—It is of course essential that timber piles should be below saturation level so as to be always wet. This job is essentially a day work one. The returns made of the set of piles under last blows should as far as possible be checked by a responsible person. Use the Engineering News formula for calculating set $P = \frac{2\,WH}{S + 1}$, where P = safe load on pile in tons, H = distance free fall of monkey in feet, s = penetration or set of pile in inches.

Contract prices.—For coursed rubble pay $5 a fang for arched culverts up to 8 feet span this including all work on arch. For spans over this pay $6 under similar conditions. These prices would apply to ordinary bridge work.

A common price for heavy ashlar built in place is $8 a fang but this is for bridges of a height above ground of

Wooden Chain Pump

Scale ¼″ = 1′

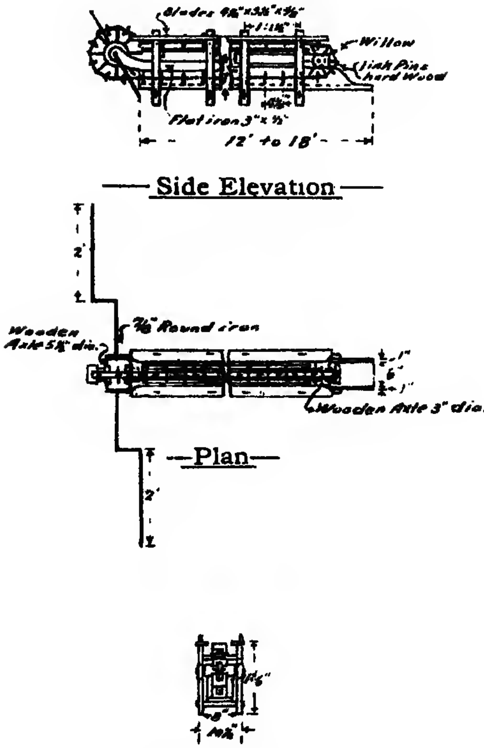

Fig. IIIA.

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from 16 to 20 feet. Placing mass concrete is usually done by daywork. For low bridges up to 12 feet high estimate by this method $1.50 per fang, and this should be ample for contract work including carpenter work.

For bridges requiring much staging $3 a fang should be ample, including work on forms, for which 2 inch plank should be always used, stiffened at intervals not exceeding 4 feet. Washing ballast should be severely discouraged, it is hardly ever necessary, and does not make for economy in cement.

Quantities for concrete.—Rule to obtain quantities: divide total cub. ft. concrete by numbers below.

Mixture.	*Cement barrels.*	*Sand cub. yards.*	*Stone cub. yards.*
1.2.4	17	61	31
1.2.5	20	59	30
1.3.6	24	57	29
1.4.8	34	55	28

Salt Mixture for Winter Work in North China.—2 lbs. salt per Kerosene tin of water (3 gallons). Boil the mixture and use hot in the mix. Cover work with straw.

TRACK.

As regards construction this needs little comment for features peculiar to China. As in most countries in the initial stages of development, track-laying by machine is unknown, the usual method being to carry forward from a train pushed up as the track advances. It is essential that this train should not be too long and it should never carry more than a half day's supply of materials. A rigid check should be kept on unloading as, if done without consideration, this entails added labour for re-handling and is conducive of stealing. Decauville track has been used to push forward sleepers as unloaded from the wagons ¾ mile being about the length required. Before track-laying begins the centre line should be re-pegged without fail. All hardwood sleepers should be bored with an auger ⅛ inch less than diameter of spike. Joints should be staggered and the use of shims for the expansion space insisted on. The thread of all fish bolts should be burred to prevent theft.

This work can be carried out very well by contract, 150 dollars a mile being a fair price. Where daywork is employed a gang of 150 men should lay in an average of at least half a mile per day. Extra labour will be required if there is much sleeper stacking.

For laying in sidings including all ballasting and surfacing a contract price of 10 cents a foot is a fair thing with an extra of $8 for each crossing; crossing leads being deducted from the length. Ballasting alone carried out by daywork has cost as much as 10.7 cents a foot.

Screening ballast can be done by contract at the rate of $1 per 30 feet rail length.

Prices for 2 inch ring ballast will vary from $1.90 to $2.50 according to locality. This is on car in quarry.

Unloading ballast. No unnecessary delay to trains should result, and for this allow 8 men per 20 ton car, who should complete the job in 25 minutes.

TYPE TOOLS GANGER AND FIVE MEN.

1 Track lever.
4 Iron claw bars.
6 Shovels.
6 Beater picks.
1 Spanner $\frac{7}{8}$″.
1 Spiking hammer.
2 Ballast hammers 6 lbs.
1 Track gauge.
1 Spirit level.
1 Straight edge.
2 Red flags.
2 Green flags.
2 Platelayer lamps
2 Ballast forks.
1 Name board.
10 Fog signals.
4 Fish plates 60 lbs.
20 Fish bolts „
10 Jap. sleepers, New
4 27′ rail 60 lbs. Two spare rails is the usual number in most countries.
3 gangs under Section Foreman who has:—
  1 Jimcrow.
  1 Ratchet brace.
  2 Drills.
  Cold sets.
  1 $\frac{3}{4}$″ & $\frac{5}{8}$″ Spanner.
  Platelayer trolley, Wt. $\frac{3}{4}$ ton & 1 box.

NOTES.

NOTES.

1 ½″ Auger.
6 Fog signals.
50 Dog spikes.
1 Rule book.

Kerosene.

Each gang allowed 20 cents per month.

Gang length 2 miles.

BUILDING CONSTRUCTION.

Excavation of foundations.—For ordinary depths 15 cents a fang is a fair price by contract.

In made ground unless of great height use a footing of 6 to 1 lime and mud concrete rammed in 6 inch layers, this work costing about 60 cents per cubic fang by contract. Safe load about 3 tons per square foot.

Rock excavation $2.50 per fang.

Piling 10 cents per foot driven for 10 inch pile requiring a pile driver.

Trenching for pipes, 4 feet deep, 5 cents a foot including back fill and ramming.

Masonry.—For the soft native brick a rubble footing to all brick walls is essential for at least a foot above ground level.

For *random rubble* up to 10 feet high above ground $2.40 per fang should be paid for labour. Such walls should not be less than 18 inches thick and through stones should be insisted on at least 3 foot centres, staggered in alternate courses.

Coursed rubble labour cost should be $3 per fang as in platform and turntable walls.

Ashlar.—For heights up to 6 feet pay $5 per fang for labour.

Dressing stone.—From observation of day labour, the performance per man, was about 10 square feet per day in hard limestone. On contract at least twice the work would be put in.

Pointing.—Labour 40 cents per fang. The day labour performance is about 25 square feet per man per day.

Compound walls 8 feet above ground. Labour 40 cents per foot all charges except pointing. Random rubble 1′ 6″ below ground on 1′ 0″ lime and mud, excavation included.

Brick coping. Pointing if in lime and sand mortar 30 cents per fang, if not price as above.

Quantities for masonry.—For rubble add 25% to the net quantity. Rubble price per fang should be about half the rock excavation price. Price in North China $1.50 per fang on car at quarry.

For *rubble masonry mortar* estimate one-third of the net quantity as mortar. If ashes are available use 4 to 1 lime and ash mortar, ashes screened for this work. If sand is used 3 to 1 mortar should be used. For pointing use a 2 to 1 mixture with screened ashes if these are used.

Lime.—50 lbs. per cubic foot or 38 catties. 3,750 catties lime equal 1 fang. 16.8 piculs equal 1 ton. In China it is a matter of the greatest difficulty to get lime properly slaked and only the threat of heavy fines will ensure this. Estimate 300 catties lime per fang of masonry. Theoretically 1 ton lime will make 2½ fang 3 to 1 mortar.

Ashlar.—For this estimate the net quantity and for the mortar which should be 3 to 1 estimate one barrel of cement per fang of masonry. Pointing should be of 2 to 1 mortar.

Ashlar is usually priced per chang of 10 Chinese feet the following prices obtaining in North China.

$1.65 per chang	2′ 0″ wide	6″ thick
$3.00 ,,	2′ 0″ ,,	12″ ,,

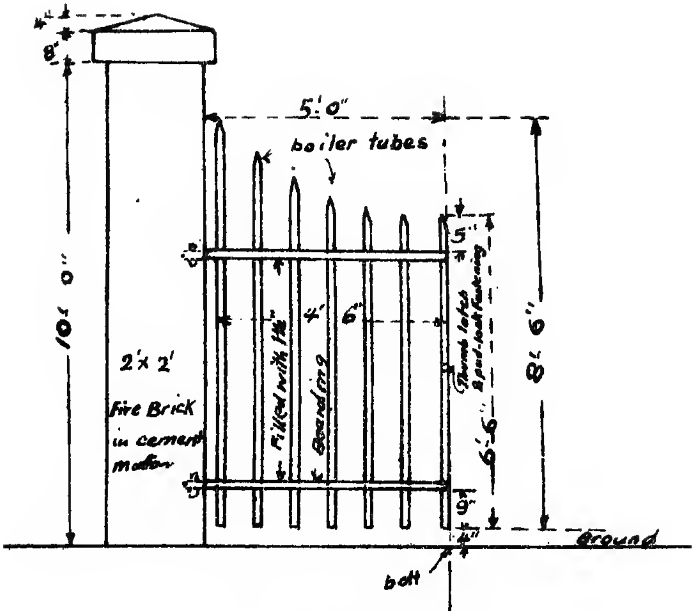
A satisfactory mortar for ashlar is a mixture of lime and cement in either of the following proportions.

1 cement	5 lime	18 sand or screened ashes
1 ,,	4 ,,	12 ,, ,, ,,

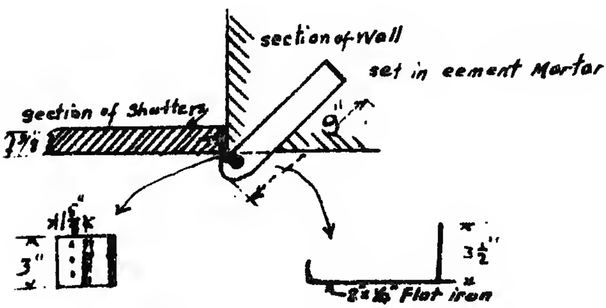
Brickwork.—This work is best done by contract wherever possible.

North China prices as follows.—Two storied buildings that is for heights up to 35 feet $3 per fang. This price

Note.—1 fang = 110 cubic feet.
1 catty = 1⅓ lb.
1 picul = 133⅓ lb.



Compound Gate & its Pillar



—Detail of Shutter Hinge—

—3 to every large window—

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Russian Stove

Scale 1/4" = 1'

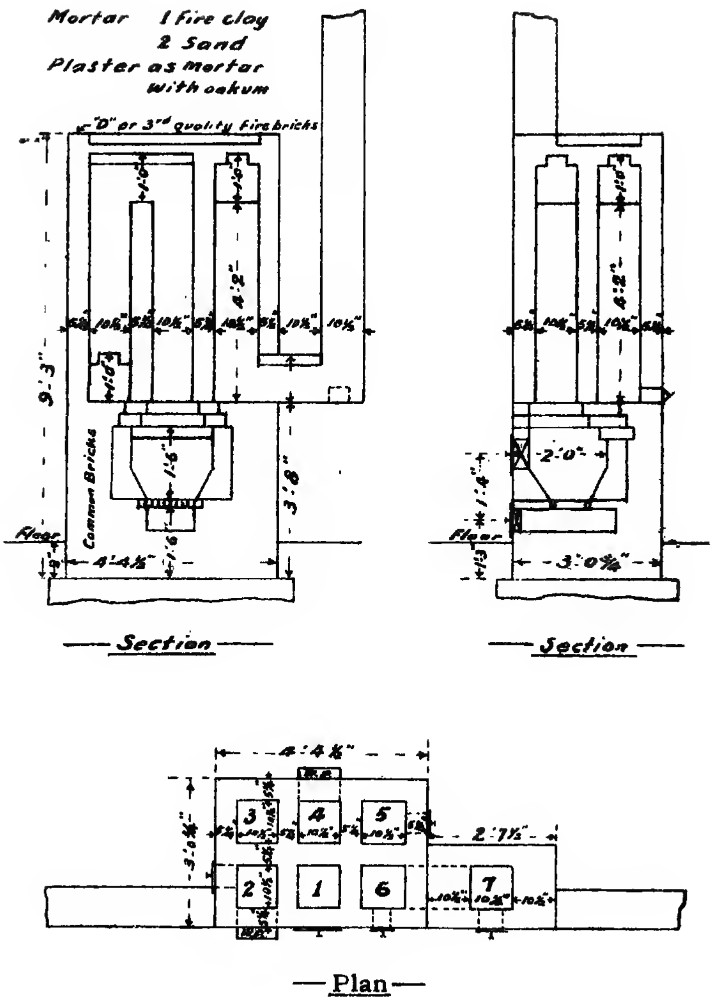

Fig. IV.

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includes all labour charges scaffolding included. The contractor is provided with all materials except such perishable stores as ropes and carry baskets. No deduction made for openings, and casting lintels[43] included in price.

For heights up to 10 feet \$2.50 is a usual price for labour. Conditions as above.

Plastering walls.—This is often necessary to protect a wall from the effects of damp, especially if built in the porous native brick. Day labour cost including all scaffolding \$2.50 per fang.

Tiling Walls.—This is essentially a day labour job. The following performance has been obtained. 9 square feet per man per day including all necessary cutting on floor tiles 7″ × 7″. On wall tiling 2 square feet is the daily performance. On wall tiling use 2 to 1 cement mortar.

Quantities for Brickwork.—No wall for outside work should be less than 14 inch or brick and a half work, and north walls should be not less than 18 inches thick.

For the native brick estimate 1,750 bricks 9″ × 4½″ × 2″ per fang.

For the standard brick estimate 1,300 bricks 9″ × 4½″ × 3″ per fang.

For mortar use a 3 to 1 mixture of lime and fine sand and estimate 25% of the net quantity as mortar. For lime estimate 300 catties to the fang. For mortar estimate 6 catties per square yard of brickwork for pointing.

The use of wood bricks in walls should be avoided and breeze bricks of half size, made as follows, used: 1 cement, 2 lime, 4 screened ashes.

Flues should not be less than 8″ × 8″ and flue linings of earthenware of not less than this size should be insisted on, as pargetting is very badly done in China as a rule. Where *Russian or wall stoves* are built fire brick and fireclay mortar are of course essential. Further extra strength should be given to the brickwork by wire or hoop iron binding at about 15 inch centres. Fig. IV shows the construction of these for a bungalow, with greater

[43] Lintels assumed to be reinforced concrete.

height additional flues may be provided. Fire-clay plaster is essential for the walls of these stoves, the plaster being further strengthened by rubbing in a layer of native mosquito netting with each coat of plaster. Plastering should be done while the stove is hot and plaster continuously rubbed until dry.

Fire grates.—Fig. V shows a cheap form of this. The weight of the casting about 50 lbs. The opening should be 17 inches by 2′ 6″ high and lined with firebrick. The chimney breast should be not less than 4′ 6″ wide by 9 inch projection.

Concrete.—Reinforced work on lintels and other small jobs $3 per cubic fang for labour, and the same price for floors if no excavation. If excavation is necessary pay $4 per fang including all loading and unloading and spreading of earth removed.

For placing mass concrete as in low bridges pay $1.50 per fang or estimate 8 labourers per fang per day.

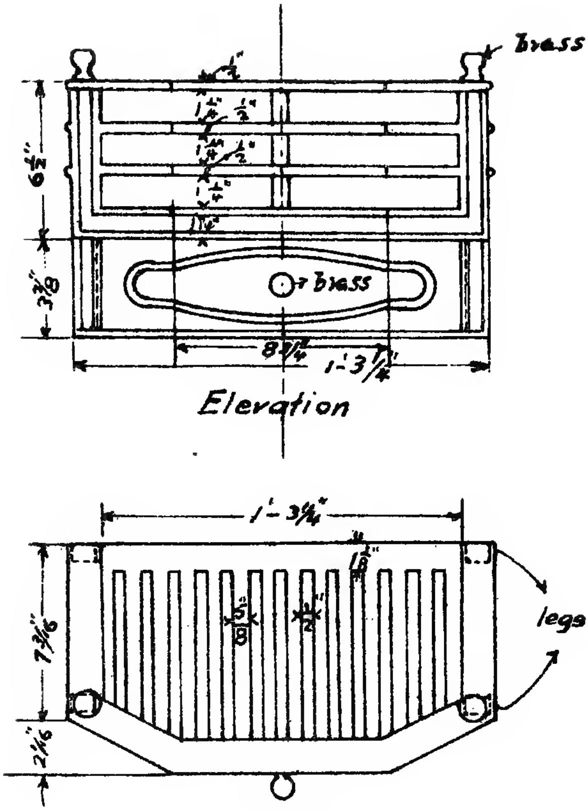
The above prices include all labour, except carpenter work in fixing forms for which allow one carpenter per 5 concrete coolies.

Quantities for concrete.—Use 1.2.4 mixture for reinforced work and 1.3.6 for floors. For quantities see under bridgework in North China, estimate at 30 dollars a fang if stone and sand handy.

For *lintels* estimate 6 inches thick for 3 feet openings and 9 inches for 4 feet. Reinforcement is unnecessary. For openings over this the following dimensions have been adopted.

Span.	*Depth of beam.*	*Reinforcement.*
10 feet	1′ 3″	30 lb. scrap rail
8 „	1′ 0″	2 old boiler tubes
6 „	9″	1 sheet No. 10 expanded metal

Verandah and all other posts should be of concrete if possible. These need reinforcement for handling only, that for 8″×8″ posts carrying an upstairs wooden verandah being No. 4¼″ bars. These posts were 22 feet long and



Plan

Fire Grate

Scale ⅛" = 1"

Fig. V.

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Varendah Post & Rail

1 : 2 : 4 Cement Concrete

Scale 1/8″ = 1′

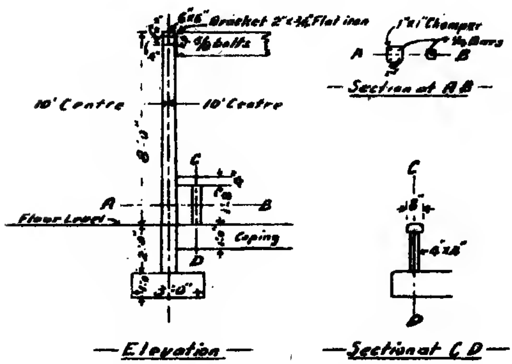

Fig. VI.

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fixed 10 to 12 feet centres. They should be erected in a wooden casing.

Verandah rails should also be of concrete if for a bungalow verandah. Fig. VI shows a type.

Plastering.—For labour 60 cents per fang for three coat plaster is a fair price by contract. This does not include lath nailing for ceilings. The following day labour performances have been obtained.

Wall plaster 3 coats 33 square feet per man per day.

Nailing laths 160 square feet per man per day on ceilings.

Quantities for plastering. Straw paper plaster for walls. Quantities per 100 square feet. 350 catties lime, 100 catties straw, 3 catties straw paper, 7 cubic feet sand. This is for three coat work as follows:—

1st coat, 1 straw, 2 lime, 3 sand.
2nd coat, 1 paper, 9 lime.
3rd coat, 1 lime, 1½ sand.

Lime and oakum plaster.—Quantities per 100 square feet. 400 catties lime, 40 catties oakum. This is for three coat work. A cheaper plaster is as follows:—

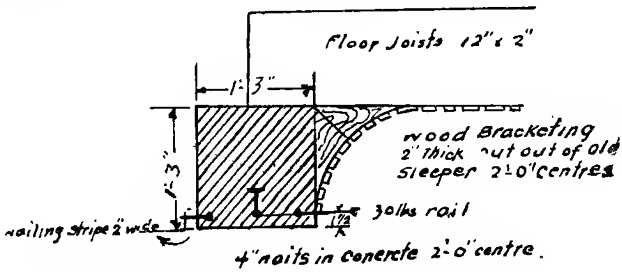
1st coat, 2 sand, 1 lime. No oakum.
2nd coat, 1 sand, 1 lime. „
3rd coat, neat lime with 1 lb. oakum to every 3 cubic feet lime.

For ground floor ceilings add cement to the ceiling plaster. In North China a double ceiling of 2 to 1 sand and lime plaster is advisable.

Ceiling joists should be of 3 × 2 scantling and fixed 1′ 0″ centres if ceilings are double. For single ceiling 2′ 0″ centres suffices. Bearings of such ceiling joists should not exceed 6′ 0″. Weight of single ceiling 9 lbs. per square foot.

Ceiling laths.—Estimate that one bundle of 400 feet run will cover 45 square feet.

Cornicing and ornamental plaster work should be avoided as it only harbours dust and is as a general rule clumsily done. A good finish is given to a ceiling by moulding the corners to 1 foot radius as shown in the figure below.



Over 10' Opening Bay Window

ROUGH CAST.

Cleansing brickwork.—All loose pointing or decayed bricks to be cut away and the whole front brushed down and wetted with clean water and before the wall is dry the first coat of plaster is to be applied.

The plaster and rough cast when finished will be about *one inch thick.* Plaster for cornice (if any) to be one part cement and two parts clean sand.

Rough Casting to be executed as follows:—

First coat one part cement to four parts clean sand: while the first coat is wet, it is to be well scratched over with pointed laths, to form key for next coat.

Second coat.—10 parts of lime, (bushels) 15 lbs. of fibre and one bushel of cement. To be laid on with a trowel and before it is set, it is to be immediately followed by the—

Third coat.—Gravel well washed and passed through ½" mesh seive and the larger stones thrown out. Mixture being 4 bushels of above stones, half bushel of cement, and 2 bushels of lime.

This last coat or Rough Cast as it is called must be ready in a tub, and is then thrown or dashed on the walls with slightly turned up flat trowels. This dashing must

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be done with considerable force. Any that does not adhere must be taken up and used over again.

1 bushel = $1\frac{1}{4}$ cubic feet.
1 „ cement = 114 lbs. about.

A cheaper mixture which has given satisfactory results is one cement, ten sharp sand, the final coat being made with a mixture of fine and coarse sand, no stone being used, the last coat as above being thrown at the wall. For giving walls a smooth finish, the following mixture can be used for wall plaster, one cement, two well slaked lime and twelve well graded sand.

Painter's Work.—In China it is advisable to cut down outside painted surfaces to a minimum as all paintwork rapidly fades and looks shabby and for this reason a cheaper covering such as solignum or microlineum, which has in addition a much greater covering power than paint, is advocated for this purpose.

Labour on painting.—For inside work pay 32 cents a fang which includes properly washing down and painting one coat. For outside work pay 20 cents for two coat work and properly cleansing before painting. On large painted surfaces such as girders 200 square feet per man has been recorded as the daily performance in China. In England, the expected work of a painter on such is 45 square feet per hour. The usual expected cost of labour in painting steelwork is 44 cents a fang, indicating that the above performance is above the average.

Labour in colour washing.—For this work 38 cents a fang for two coat work and thoroughly washing down is a fair price.

The day labour performance is not more than 54 square feet per man per day under the above circumstances.

The *covering power of paint* varies with the mixture of ingredients and also with the type of paint. Thus iron paints, greens and yellows have a greater covering power than lead paints. Iron paints, greens and yellows require the presence of driers to ensure quick drying, a very desirable quality in countries subject to dust storms; lead paints do not require such treatment.

For a paint to dry in 20 hours the following mixture has been used with success. 15 lbs. paint paste, 6 lbs. boiled oil, 1 lb. turpentine, 12 ounces of driers, which are omitted for lead paints as above. The covering power of the above mixture on an old painted surface was as follows for the following paints:

White lead	4 lbs. per 100 square feet	1 coat
Red Oxide	2.4 ,,	,,
Green	3.57 ,,	,,

For new wood a priming coat is usual and this is mixed as follows. 2 lbs. red lead, 18 lbs. white lead, 2½ raw linseed oil, 2½ boiled linseed oil, 2 ounces driers. The covering power of this mixture is about 8 lbs. per 100 square feet. New wood will generally require three coats, two finishing and the priming. It should be remembered that white zinc paint requires special pale oil for its mixture or it will appear yellow. Old painted surfaces should be thoroughly washed with as strong a mixture of soda as is feasible before re-painting. All surfaces to be painted should be rubbed down with sandpaper.

The following data is derived from various authorities.

Paint:—One gallon of paint will cover 50 square yards 1st coat.

One gallon of paint will cover 60 square yards 2nd coat.
,, ,, ,, 75 ,, ,, 3rd ,,

A gallon of paint requires 14 lbs. dry paint, 6 lbs. linseed oil, one pint boiled oil, one pint turpentine.

A gallon of paint by weight for inside work requires, 15 lbs. paint, 8 lbs. linseed oil, 1 lb. turpentine. If for outside work use 7 lbs. linseed oil and add 1 lb. of boiled oil.

Knotting, which is used for painting over knots in wood before applying the paint is a mixture of red lead and size in equal parts.

Putty is a mixture made of the following ingredients and proportion, 10 lbs. whiting, 1 lb. white lead and oil.

Five pounds of putty and two of white lead should be allowed for stopping each 100 square yards of new deal.

Varnish has about twice the covering power of paint, but costs about twice the money.

1 pint varnish will cover 14 square yards.

1 lb. white paint covers 4½ square yards for 1st coat, 6½ second, 6¾ 3rd coat on wood.

1 lb. red lead cover 5¼ square yards on iron (1 coat).

1 lb. oxide of iron covers 8 to 12 square yards on iron (1 coat).

1 gallon tar with 1 lb. pitch covers 12 square yards on wood, and 17 each additional coat.

The following quantity data is taken from Hurst and is for work in England, and in all probability will be found under the mark for foreign work, with, probably, inferior materials and workmanship.

Lime-Whiting once done requires 1 cubic foot, about 15 lbs, of slaked lime per 100 square yards and ¾ lb. of tallow, if twice done 1.66 cubic foot of lime and 1¼ lb. of tallow.

Whitening once done requires 12 lbs. whiting, ½ lb. ultramarine and 1¾ gallon size or 1¾ lb. of glue per 100 square yards. Twice done 21 lbs., ¾ lb. and 2¾ gallons of the above materials are required per 100 square yards. 1 lb. glue makes about 1 gallon size.

Ceilings should be washed previous to whitening with a coarse sponge and cold water.

An experiment on the Chinese Railways with the following mixture gave a covering power of 50 square feet for one coat work, 1 lb. whiting, 3 oz. glue, 6 lbs. water. This is a very good result and in general it is as well to estimate 4 lbs. of whiting per 100 square feet for 2 coat work. Similar results have been obtained with Hall's Distemper.

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