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ECONOMIC WARFARE SECTION

REPORT ON CHINESE RAILWAYS

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Economic Warfare Section
War Division
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Washington 25, D. C.

Confidential Report
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Re: Chinese Railways
Section I - The Wartime Situation;
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Section III - The Railway Situation Before the War.

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CHINESE RAILWAYS

SECTION I - THE WARTIME SITUATION

One of the basic strategical concepts of Japan in the Sino-Japanese war, has been to cut off China's transportation lifelines with the outside world. The Japanese have now succeeded in surrounding Free China on three sides, leaving only the West open, in which direction a towering mountain wall and a stretch of hundreds of miles of desert make transportation slow and uncertain. Theoretically, the strangulation of China should be complete, yet, by almost unbelievable pains, labor and ingenuity, the Chinese still continue to maintain supply lines of sorts. Driblets of materials and supplies continue to be received. China does very much with tragically little. In the aggregate, the supplies that trickle in through a thousand devious ways have been sufficient not only to enable China to maintain its present defensive lines but also to take the offensive upon occasion.

To a large extent, the result of the War in China hinges upon transportation. The entire history of the War has been inextricably bound up with the Chinese railway system, ever since Japan became the open aggressor in July 1937. The campaigns were planned with the seizure of railway lines as the principal consideration. Even today, after nearly six years of conflict, the Japanese, in many areas of China, hold only a strip of territory on each side of the railway lines, while wide stretches of territory between such lines are thinly held, if at all, by means of highway communication, constantly harassed by guerrilla activities.

Before the War, the Chinese railways were in a deplorable condition, although a vigorous and intelligent rehabilitation program had been begun. Whatever the criticism of peacetime operation, there can be nothing but praise for the daring, fortitude and skill displayed by the Chinese railwaymen in keeping these lines of transportation open during wartime under the most disturbing conditions.

This report deals with what happened to the Chinese railways during the War. It outlines as many of the physical features of the lines as are available and recounts the war damage. 1/ Later, the report will detail

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the railway development in China; 2/ the condition of the railways before the War; the difficulties in maintaining railways in China even in peacetime; and other pertinent data with regard to the railway system. 3/

On many of the railways, a wealth of engineering detail is available. Since the Japanese undoubtedly have learned from the Chinese the technique of virtually obliterating railways as they retreat, such data should prove invaluable to armies re-occupying the territory and it is therefore given in detail in all cases where it is available. It will be noted that it comes, in most cases, from former technical officers of the railways in question.

Space is also given to the various vagaries of weather, floods, etc., which affect operations on the lines.

Since there has always been a lack of machinery for railway use in China, which has now been aggravated by the diminution of supplies, considerable attention is also given in this report to the methods used through the employment of manual labor on railway jobs that would be done by machinery in the United States.

RAILWAYS ENTIRELY UNDER JAPANESE CONTROL
(NORTH CHINA)

Peiping-Suiyuan

This railway, which comprises 507 miles of main line and 37 miles of branch line (Exhibit 1) was taken over in its entirety by the Japanese on August 13, 1937, shortly after the stirring defense by the Chinese of Nankow pass on this line. In retreating, the Chinese destroyed all bridges and tunnels west from Kangchwang, 52 miles west of Peiping. However, these were eventually restored by the Japanese and service was resumed on this important railway. This line traverses extraordinarily rough country and after traversing Nankow pass (33 miles from Peiping) by means of a series of switchbacks, reaches Kalgan (124 miles from Peiping) the gateway to Mongolia. Apparently, the Japanese are completing a relocation to avoid Nankow Pass 4/ (Exhibits 2 and 3). From that point, the railway proceeds to Tatung (118 miles from Kalgan), which is a junction with a line south to Taiyuan and to Fengling on the north bank of the Yellow river. 5/ From there the line continues westward to Suiyuan, in the province of the same name, and from there to the city of Paotow on the Yellow river. A description of this line follows: 6/

The Main Line

Starting from Peiping at an elevation of 239 feet, the railway has an almost continual climb to Shihpatai, 550 kilometers from Peiping, at an altitude of 5,304 feet. From that point the railway drops to Suiyuan at 3,558 feet and to Paotow 3,420 feet. In the winter bitter cold of as much as 30 degrees below zero is encountered in the territory of the railway situated at altitudes of 4,000 feet or over. This cold has the effect of interfering with railway operations, particularly as to the steaming qualities of locomotives.

There are three branches on this railway, one being a belt line around Western Peiping. This line starts at Tsinghwayuan and runs around the city to a connection with the Peiping-Shanhaikwan line at the Tungpienmen station. There is also a 20-kilometer branch between Tatunghsien and Kowchuan, which taps a bituminous coal field. There is also a 26-kilometer branch between Hsichihmen and Mentowkow.

The ruling grades and the curvature on the main line and branches are as follows:

Main Line or Branch	Section	Length in kms.	Steepest Grade	Sharpest curvature radius in feet
Main	Fengtai to Nankow	54.96	1 in 100 or 1.00%	1000
	Nankow to Kangchwang	29.84	1 in 30 or 3.33%	600
	Kangchwang to Kalgan	116.40	1 in 100 or 1.00%	795
	Kalgan to Tatunghsien	181.95	1 in 115 or 0.87%	1000
	Tatunghsien to Pingtichuan	127.13	1 in 145 or 0.69%	1000
	Pingtichuan to Suiyuan	158.08	1 in 145 or 0.69%	1250
	Suiyuan to Paotow	147.87	1 in 400 or 0.25%	3000
Branch	Hsichihmen to Tungpienmen	12.61	1 in 300 or 0.33%	800
	Hsichihmen to Mentowkow	25.96	1 in 125 or 0.80%	987
	Tatunghsien to Kowchuan	19.81	1 in 200 or 0.50%	1000

The section between Pingtichuan and Taoputsi has been particularly subject to floods. Other places which are damaged by recurring floods are between Chaikowpu and Yungchiapu along the Yang River and also Tengkow on the Yellow River. Attempts to eliminate this flood damage have been made by facing the embankments with concrete or rubble, or by building dikes in the stream to divert the water and by building additional bridges or culverts. Where these methods were not satisfactory, considerable relocation work has been done. For example, at Ertaoho, where the line was moved several hundred feet, an unlined tunnel 163.8 feet long was built. This tunnel is 22 feet high, or much higher than the usual Chinese tunnel. Considerable flood difficulty is encountered at two bridges in this territory between Fushengchwang and Santaoying.

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In general, this line is laid with 85 lb. rails mostly of Sandberg or Hanyang sections with 60 lb. rails on the branches. There is about 60 miles of 70 and 75 lb. rail of the A.S.C.E. sections between Hungshapa and Chotzeshan. Except on the curves, the rails are approximately 30 ft. long, fastened with plain spikes three-quarters of an inch square and 5-1/2 inch long under the head. Except on the Nankow Pass the track is not tie-plated. There are about 23 kilometers of line laid with second-hand 90 lb. rails bought from the Southern Pacific Railroad. Untreated ties 6 in. by 9 in. by 8 ft. are standard, laid 13 to each 30 ft. rail length. These are Oregon pine ties and last about 8 years. The line is ballasted with gravel and broken rock. The ballast section has a top width of 10 ft. and a thickness of 6 to 8 in. under the bottom of the ties is standard, but in many places the ballast is only 3 to 5 inches thick. No. 12, No. 10, and No. 8 turnouts are used on the main line.

There are 3,334 bridges and culverts on the line, the more important of which being the following type:

Total Number of Spans	Length of each Span	Type
1	110 ft.	Half-through Warren trusses
60	100 ft.	Deck Warren trusses
16	30 ft.	Deck plate girders
171	30 ft.	Diffedange 1-beams
256	20 ft.	Deck 1-beams
4	18 ft. 4-1/2 in.	Deck 1-beams
15	5 meters	Deck 1-beams
308	12 ft.	Deck 1-beams
28	10 ft.	Deck 1-beams
11	40 ft.	Plain concrete spandrel-filled arches
3	30 ft.	Plain concrete spandrel-filled arches
20	20 ft.	Plain concrete spandrel-filled arches
193	10 ft.	Plain concrete spandrel-filled arches

In addition there are a large number of short wooden bridges reinforced with rails. Except in Nankow Pass, the bridges have a nominal carrying capacity for Cooper's E-35 loading, but before the war there was a bridge rehabilitation program to bring all bridges up to Cooper's E-50 loading.

Yards, water and coaling facilities, and track scales are situated at the following locations:

Hsichihmen	Kowchuan
Mentowkow	Fengchen
Nankow	Pingtichuan
Kangchwang	Chotzeshan
Kalgan	Suiyuan
Tatunghsien	Paotow

A large repair shop and general storehouse is located at Nankow and a smaller repair shop is at Kalgan. There are sidings at each of the smaller stations and the layout for all stations east of Fengchen is shown in Exhibit 4, while the layout west of Fengchen is shown in Exhibit 5.

Roundhouses are located on the line as follows:

Station	Type of Shed	No. of Tracks in each shed	Number of Road Engines that can be housed
Hsichihmen	Round house	12	18
Mentowkow	Rectangular house	2	2
Nankow - Old Shed	Rectangular house	4	12
- New Shed	Rectangular house	4	12
Kangchwang	Rectangular house	4	12
Kalgan	Rectangular house	2	8
Tatunghsien	Round House	11	11
Pingtichuan	Round House	6	8
Suiyuan	Round House	12	18
Paotow	Round House	12	12

The roundhouse at Tatunghsien is the only one equipped with a turntable.

Facilities for heavier repairs than ordinary roundhouse repairs are available at: Hsichihmen, Kangchwang, Tatunghsien, Suiyuan.

Steel water tanks 20 feet in diameter, holding 23,000 gallons are available at the larger stations while 13 ft. diameter tanks holding 7,700 gallons are available at 23 other places. All the stations on the main line are equipped with home and distant signals interlocked with the switches at each end of the station layout. These are semaphore signals operated from signal cabins on the station platforms.

Section gangs are responsible for 10,000 feet of track each, the ordinary gangs consisting of a foreman, four laborers, and a cook.

In general, very little track machinery is available, although there are a number of track and bridge jacks made by the Buda Company of Harvey, Illinois, available, as well as an oxyacetylene welding outfit for reconditioning rails and switches.

While comparatively heavy and costly work can be found here and there throughout the whole line, such as the bridges over the Sha River (near Peiping), over the Yung Ting River (on the Mentowkow branch) and over the Hwai Lai River (near Hwai Lai station), and the sidehill work along the Yang River in the vicinity of Sia Hwa Yuan station, the most important and difficult part of the work was to push the line through the so-called "Nankow Pass".

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The Line Through Nankow Pass

The first 28.34 miles from Fengtai (Elevation = 117.8 ft.) to Chang Pin Hsien (Elevation = 146.24 ft.) runs on a flat plain, while the next 5.8 miles from Chang Pin Hsien to Nankow (Elevation = 315.00 ft.) continues on a rising grade with a maximum grade of 1 per cent. The line from Nankow to Kangchwang, popularly known as the Nankow Pass, follows the main road up a valley, used by caravans and carts ever since the beginning of the Chinese civilization.

The elevations and distances from Fengtai to all the stations in the Pass, as well as average grades between stations are as follows:

Station Name	Elevation in feet	Distance in Miles from Fengtai	Average grade
Nankow	315.00	34.155	
Tungyuan	589.00	37.635	1 in 66.8 or + 1.5%
Chuyungkwan	1,052.68	40.450	1 in 32.1 or + 3.1%
Sanpu	1,466.55	42.848	1 in 30.6 or + 3.3%
Chinglungchiao	1,841.00	45.340	1 in 35.1 or + 2.8%
Hsipoutze	1,800.98	48.982	1 in 4,800 or - 0.2%
Kangchwang	1,635.00	52.695	1 in 118 or - 0.85%

The actual maximum grades and sharpest curvatures in the Pass are as follows:

From Station	To Station	Distance in miles	Sharpest Curvature, Radius in feet	Maximum grade, uncompensated
Nankow	Tungyuan	3.480	1000	1 in 40 or + 2.5%
Tungyuan	Chuyungkwan	2.815	700	1 in 30 or + 3.3%
Chuyungkwan	Sanpu	2.398	700	1 in 30 or + 3.3%
Sanpu	Chinglungchiao	2.492	600	1 in 30 or + 3.3%
Chinglungchiao	Hsipoutze	3.642	600	1 in 32 or + 3.1% in one direction 1 in 62 or - 1.6% in other direction
Hsipoutze	Kwangchang	3.713	5000	1 in 70 or - 1.4%

In this 18.54-mile section, there are altogether 51 curves, with an aggregate curve length of 6.51 miles. Considering only the Nankow-Hsipoutze section, there are 50 curves, with a total length of 6.03 miles in 14.83 miles of the main line, i.e. in every 1,000 feet of main line there is a curve of 406 feet. In this 18.54 mile section, there is only 5,920 feet, or 1.12 miles, which is on the level. If the level lengths in Nankow, Chinlungchiao and Kwangchang stations are excluded, the no-grade inter-station lengths have a total figure of only 1,050 feet, or 1/5 mile, in

18.54 miles of the main line. Tracks at the other stations, Tungyuan, Chuyungkwan, Sanpu and Hsipoutze, are on grades of 1 in 50, 30, 33 and 160, respectively.

The main line, after running up to Chinglungchiao station, switches back on ascending grades, while entering the long Pataling tunnel. The line reaches the highest point in the Pass (elevation = 1,959.20 ft.) in the tunnel, at a distance of one mile from the center of Chinglungchiao station, and then descends from this summit to Kwangchang.

Transition curves, 150 feet long at each end, are used on curves with radii of 800 feet or under.

Rails 30 feet long, 85 pounds per yard, Sandberg section, hardened by the Sandberg Sorbitic process, are laid on tieplates throughout the section, strengthened on curves with rail braces, and fastened with dog spikes. The joints are alternate.

Ties are of two sizes, 9 in. by 6 in. by 8 ft. and 9 in. by 7 in. by 9 ft. For each rail-length, four pieces of 9 in. by 7 in. by 9 ft. and 12 pieces of 9 in. by 6 in. by 8 ft. are used on the Nankow-Hsipoutze section, one piece less of the 9 in. by 6 in. by 8 ft. tie on the Hsipoutze-Kwangchang section. The 9 in. by 7 in. by 9 ft. size is the joint tie, two being used at each rail-joint. Treated ties were laid in the Pataling tunnel and are still in fairly good condition. When the track was first laid, all the ties in the Pass were coated with coal tar, but this practice was discontinued in the renewals of recent years. An extra fishplate is bolted and spiked on the outside of each rail at its mid-length opposite the joint in the other rail. This extra fishplate and the longer ties are used with the idea of preventing rail-creeping.

Broken stone is used as track-ballast, the thickness under the ties being from 6 in. to 8 in.

There are no bridges of any considerable size in the Nankow Pass; the larger structures are:

One open-deck bridge of single span, 100 ft. deck Warren-truss, between Nankow and Tungyuan.
One 40 ft. arch culvert, between Tungyuan and Chuyungkwan.
Three 30 ft. arch culverts, between Chuyungkwan and Sanpu.
One 40 ft. arch culvert, between Chuyungkwan and Sanpu.
Five open-deck spans of 30 ft. rolled I-beams, between Hsipoutze and Kwangchang.

All the bridges and culverts in the Pass are meant to carry a live load equivalent to Cooper's Class E-50. All the arch culverts are of plain concrete.

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Tunnels

There are four tunnels in the Nankow Pass (Exhibits 6 and 7), tabulated as below:

Names of Tunnel	Between Stations	Length in ft.	Lining	Portals
Chuyungkwan	Tungyuan and Chuyungkwan	1,204	Concrete arch Rubble side-walls	Concrete
Wukweitow	Sanpu and Chinglungchiao	150	Concrete arch Rubble side-walls	Concrete
Shihfusze	Sanpu and Chinglungchiao	463	Concrete arch Rubble side-walls	Ashlar granite back filled with concrete
Pataling	Chinglungchiao and Hsipoutze	3,580	Concrete arch and sidewalls	Ashlar granite back filled with concrete

The two short tunnels are almost entirely on curves. The Chuyungkwan tunnel has its southern end, 159 ft. long, on a spiral transition curve, while the whole of the Pataling tunnel is on a tangent.

The Chuyungkwan tunnel is on an upgrade of 1 in 30 throughout, and both of the two shorter tunnels are situated on an upgrade of 1 in 33-1/3. The grades in the Pataling tunnel are analyzed as follows: Starting from the south portal, the first 100 ft. are on upgrade of 1 in 33-1/3; the next 450 ft., on upgrade of 1 in 100; the following 1,100 ft., on upgrade of 1 in 45.45; the remaining 1,930 ft., on downgrade of 1 in 500.

There is a shaft 10 ft. in diameter directly over the center line in Pataling tunnel. This was driven during the time of construction, and is now kept open for ventilation purposes.

Unfortunately, the small clearance constitutes a great handicap in the operation of trains, especially the very poor ventilation that is found in running steam locomotives through the two long tunnels.

Refuge recesses 7 ft. long by 6 ft. deep by 7 ft. high are provided in the two long tunnels, 4 in Chuyungkwan tunnel spaced at about 200 ft. apart, 11 in Pataling tunnel spaced at about 300 ft. apart.

Operations

The stations Nankow and Kwangchang are terminals for operation of all trains running through this section. At both stations, there are engine sheds, water tanks, coaling stages, turntables, classification yards, etc.

Chinglungchiao, while being equipped for watering engines, serves mainly for reversing the directions of trains, since it is a "switch back" station. The remaining four stations, serve only for meeting trains and for catching any runaway trains or cars.

Exhibit 8 shows the track diagrams for these stations. The track arrangements at these stations differ from those found in small crossing stations in other sections of the Peiping-Suiyuan Railway or on any other Chinese Government Line. Take Tungyuan for illustration. A train from Kalgan to Peiping, running on down grade must first stop and wait in front of switch A, which is normally set for the catch siding. A train from Peiping to Kalgan, running on upgrade, should first stop between the switches A and B, then back into the passing loop and wait there. The downgrade train then gives a long whistle from the locomotive, the switch A is now set for the main line, and the downgrade train then moves on passing the switches A and B; after this, the upgrade train in the loop proceeds through B and A and continues on its journey.

It should be here noted that any downgrade train, whether meeting an upgrade train or not, must first stop in front of A and sound one long whistle from the locomotive before it is permitted to proceed on the main line. Should the engineer of the downgrade train for any reason wish to have his train brought into the catch siding, he must give two long whistles. If there is no whistle, it should be understood that the downgrade train or any runaway car is to go into the catch siding, i.e. one long whistle is the only signal for requesting to proceed on the main line.

In the case of meeting trains, before the upgrade train is brought properly to stop in the passing loop, the switch A must never be set for the main line, even if the downgrade train waiting in front of A gives one long whistle (Exhibit 9).

In addition to the catch sidings provided in the stations, there are seven more catch sidings located outside station limits. Each of the seven sidings is attended day and night by two men, one on each shift, who are carefully selected and especially trained for this purpose. The one-long-whistle rule applies also to these intermediate sidings.

In the Nankow Pass, only the stations Nankow, Hsipoutze and Kwangchang are provided with the usual distant and home semaphore signals, interlocked with the main line switches, the rest of the stations having no fixed signals whatever. As the trains in the Pass are allowed to run at 10 miles an hour only, and as all the employees working in this section, are specially trained and particularly cautioned for any carelessness, it is generally considered that fixed signals at intermediate stations are not absolutely necessary. Thanks to the faithful and vigilant efforts of the employees, very few serious accidents have occurred in the Pass.

Trains running in the Pass are under the control of Electric Staff and Tablets, while the whole of the Peiping-Suiyuan Railway still works

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under the Mechanical Link and Tablet System, with the exception of Hsichihmen--Kwanganmen section at Peiping, which is also under the Electric Staff and Tablet system.

Train Operation in the Pass

A train from Peiping, on arrival at Nankow, is generally split up and a Mallet locomotive 7/ is attached to the rear of each portion, pushing it up from behind as far as Chinglungchiao, where the direction of the train is reversed. From there on, the engine pulls the same portion up into the Pataling Tunnel and then down to Kwangchang, where the several portions are put back as one train, and an ordinary road engine is used to pull the train on to Kalgan or beyond.

A train from Kalgan or beyond, on arrival at Kwangchang, is likewise split into portions, and a Mallet engine is attached to the front of each portion, pulling it to Chinglungchiao. Here the direction of the train is reversed, and the engine is attached to the other end of the train, pulling it down to Nankow, where the portions are put back as one train and an ordinary road engine is used to pull it on to Peiping or Fengtai.

In pulling a train from Chinglungchiao station into the Pataling tunnel, running on steep upgrades, there is a possibility of some car or cars being detached from behind, due to a broken coupling. Such runaway cars would run into the catch siding No. 7, located between the station and the tunnel, instead of running into the station. In pulling a train from Kwangchang to Pataling tunnel, on upgrades, there is the same possibility, but the grades are comparatively more flat than on the other side of the tunnel, and moreover, the catch siding No. 8 and that in Hsipoutze station will catch any runaway car or cars.

The following statement shows the tonnages that can be safely hauled by the three classes of Mallet engines running in the Pass. Note that there is considerable decrease in tonnages when the cars making up the train have no brakes of any kind. The tonnages are diminished by 10 per cent in the winter months from November 21 to March 20.

Permissible Speed, 10 miles per hour	Loco. Nos. 21-24	Loco. Nos. 94-100	Loco. Nos. 201-207
Train with air- and hand-brakes complete	100 long tons	200 long tons	260 long tons
Train without air-brakes but with hand-brakes complete	100 long tons	180 long tons	230 long tons
Train without air- and hand-brakes	80 long tons	140 long tons	200 long tons
Train with air- and hand-brakes complete	100 long tons	300 long tons	400 long tons
Train without air-brakes but with hand-brakes complete	100 long tons	225 long tons	350 long tons
Train without air- and hand-brakes	80 long tons	100 long tons	120 long tons

Owing to the fact that most, if not all, of the freight cars now on the line have no air-brakes, and a large number of foreign line cars have lost some parts of their hand-brakes, the hauling capacities of locomotives are very much reduced. An engine of the 94-100 series very often hauls down the pass a train consisting of only one loaded 40 ton car and a caboose, and another of the 201--207 series pulls a loaded train composed of only two 40 ton cars and a caboose.

A loaded train of 600 or 700 tons from Kalgan, has to be divided into five or six portions, and hauled down successively as five or six separate trains. This not only increases unduly the operating expenses, but the cars are also used in a very uneconomical way, as they are usually held up at the terminal stations waiting for despatch and choking up the yard tracks there.

Some pertinent operating statistics follow:

Section	Locos.	Cars with or without Hand brakes	No. of Round trips Train Crew makes per day	No. of 40 ton loaded cars attached to a train	Cost of Train Operation per ton-mile	Comparative Ratio
Tatung to Kang-chwang	Mikado Series	--	--	13	$0.000895	1.0
Kangchwang to Nankow	Nos. 94--100	Without hand-brakes	One trip per day	1	0.0343	38.3
				2	0.0172	19.2
			Two trips per day	1	0.0255	28.5
				2	0.0128	14.2
		With hand-brakes	One trip per day	2	0.0172	19.2
				3	0.0114	12.7
			Two trips per day	2	0.0128	14.2
				3	0.0085	9.5
	Nos. 201--207	Without hand-brakes	One trip per day	1	0.0386	43.2
				2	0.0193	21.6
			Two trips per day	1	0.0299	33.4
				2	0.0050	16.7
		With hand-brakes	One trip per day	5	0.0077	8.6
				6	0.0064	7.1
			Two trips per day	5	0.0060	6.7
				6	0.0050	5.6

At present, there are only about 8 to 12 trains both ways running daily on the line other than the Nankow Pass, yet the number of trains running in the Pass, both ways, is already 44 to 56 per day, which is almost up to the full capacity of a single track railway.

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Track Maintenance

For a variety of reasons, the maintenance of track in this region was extremely difficult. The following data indicate in detail some of the problems encountered: 6/

The customary standard on this railway calls for rather excessive superelevations of outer rails on curves. Such superelevations do not correspond with the comparatively low train-speeds now allowed throughout various parts of the line. For example, curves of 600-foot radius in the Nankow Pass had a superelevation of 5-in., which was far too much for a train-speed of 12 or 15 miles per hour. The result is that the inner rails carrying an undue proportion of the moving load have shown hair cracks immediately under the rail-head, or the head portion of such rails has been more or less deformed, i.e., bent toward the center of the track. Again, curves on various parts of the line, other than the Nankow Pass, have been provided with superelevations as required by a train-speed of 40 miles per hour. As a matter of fact, the speeds allowed in the past ten years were only 20 to 25 miles, and it is only since October 1, 1936, that the maximum train-speed on the whole of the main line, except in the Nankow Pass, has been brought up to 30 miles per hour.

In view of the above, a general order was issued to all section engineers to reduce the excessive superelevations to those fixed by the Ministry of Railways, which are based upon the formula

$$E = 0.009864\ DV^2,$$

in which E = superelevation in millimeters,
D = degree of curve (20-meter chord)
and V = train-speed in kilometers per hour,
or, what is the same thing, in British units,

$$E' = 0.00066\ D'S^2$$

in which E' = superelevation in inches,
D' = degree of curve (100-foot chord)
and S = train-speed in miles per hour.

The train-speed assumed in arriving at the new superelevations is 35 miles per hour for all parts of the main line except the Nankow Pass. As for the sharp curves in the Nankow Pass the maximum superelevation is temporarily fixed at 2-1/2 in., which corresponds with a speed of 20 miles per hour. With the gradual increase in the number of manual applications of lubricants on such curves, it is expected further to reduce the maximum superelevation to about 2-in.

Most of the sharp curves in the Nankow Pass are situated on very steep grades of 1 in 30. The usual practice on this railway is to keep the inner rails at grade and elevate the outer rails to the full amount of superelevations as required. This constitutes a heavy task on the tractive power of the locomotives in climbing up the grade and turning around the curve.

On the numerous sharp curves in the Nankow Pass, the friction between railhead and wheel flanges causes considerable and quick wear, in spite of the fact that sorbitically heat-treated rails are used in that part of the line. To offset this, manual lubrication was used. This was commenced in April 1935, on two curves of 1,000-foot and 600-foot radii, of which the outer rails had been found very easily worn away. The result of this trial was fairly satisfactory. Beginning from July, 1935, all curves of 1,000-foot radius or less in the Nankow Pass were lubricated by the patrolling trackmen.

In the Nankow Pass where very heavy Mallet locomotives run back and forth with great frequency day and night, it has been found rather difficult to keep the track at the proper gauge. This difficulty arises mostly on curves of less than 900-foot radius, and at some places on flatter curves or even on tangents, especially where the soft-wood ties are in a more or less decayed condition.

Track gauge on curves is allowed to be widened to the extent of 3/4 in., but due to the action of the heavy locomotives, the gauge on curves of 600-foot radius often spreads to 1-1/8 or 1-1/4-in. With the use of gauge-rods, four per rail-length, at a widening of 1-in. on curves of 600-foot radius, no further spreading of gauge has been found. These gauge-rods consist of 3/8-in x 2-in. x 4-ft. 2-in. flat steel bars forged onto the tie plates and are placed on top of the wooden ties. The widening of gauge, as fixed by such rods, is 1-in. for curves of 600-foot radius, 7/8-in. for those of 700-foot radius, etc.

All of the side drains in the Pataling Tunnel are covered to prevent the water freezing and the tunnel being flooded. The rails in the tunnel corrode very badly due to the moisture in the air which comes from the smoke of the passing locomotives. In the course of time the dimensions of the rails are reduced by about 5/16-in. Rail creeping has been found throughout the main line and the branch lines. There are, however, three stretches of the main line in whic rail creeping deserves special mention. The first is in the Nankow Pass. The second stretch is one about 2-1/2 mi. long situated to the east of Tienchen (approximately midway between Kalgan and Tatunghsien). The amount of creep runs up to as much as one foot or even more. The third portion of the main line in which great trouble from rail creeping has been found is the relocated line between Chininghsien (formerly Pingtichuan) and Kisiaying, where second-hand 90 lb. rails were used in 1935.

At a great many places west of Kangchuang, tracks on the main line and on the Tatunghsien-Kowchuan branch are heaved by frost every winter. The amount of heaving varies with the quantity of water found in the cutting, with the depth of ground-water level under the roadbed, and with the atmospheric temperature of the season. In some cases the track is heaved to the extent of an inch or so while in other extreme cases the heaving sometimes runs up to over one foot.

Very bad heavings are experienced nearly every winter in the long wet cuttings, one to the south of Fengchen and another to the south of Chininghsien (formerly Pingtichuan). In the former, the poor soil has, in the past

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years, been gradually replaced with rubble or gravel down to a depth below the frost line and the heaving in the last few winters has been found greatly reduced.

The station yard at Suiyuan and nearly the whole section from Suiyuan to Paotow suffer from track-heaving every winter. Such heavings are due to the fact that the underground water level in that region is too near the ground surface, and this is especially so when there has been plenty of rainfall in the preceding autumn, and cold winter begins early before the groundwater level has any chance of being lowered by percolation or drainage.

The tracks in Shihpatai also suffer from heaving every winter, due to water coming down from a wet cutting immediately to the west of that station.

Concrete ties have been used with some success on the Nankow Pass line. (Exhibits 10 and 11)

Among other difficulties encountered at many places on the entire railway are severe sand and snowstorms. Various methods, including the planting of rows of trees along the tracks, have been used to overcome this.

Peiping-Shanhaikwan

This important railway connects Peiping with its port of Tientsin, then turns north to Shanhaikwan on the Manchurian frontier. It is the portion south of the Great Wall of the former Peiping-Mukden railway and supplies for the Japanese their principal rail connection between Manchuria and the occupied sections of North China. It comprises 262 miles of main line and 27 miles of branch line and it was taken over completely by the Japanese on August 4, 1937. The suddenness of the treacherous attack prevented the evacuation of much of the rolling stock, which, at the time of the invasion, consisted of 121 locomotives, 281 passenger cars and 2,018 freight cars. The Chinese also did not have time for much destruction along this railway, although the bridge over the Lwan river may have afforded the Japanese some difficulty. It has been condemned, its truss span showing a distinct inclination to one side and was to have been rebuilt.

The fastest train on this line prior to the invasion was operated between Peiping and Tientsin and made the 84 miles in 2 hrs. 30 min.

Operating Difficulties

The difficulties of maintaining this line are described as follows: 8/

Heavy rain in the territory traversed by this railway occurs mostly in July and August, but the yearly rainfall for any particular locality is very irregular. Most of the river channels are able to carry off a rainfall of one or two inches a day but in the cyclonic storms there may be five to seven inches a day, causing many overflows, and at intervals of, say, 25 years, when a worse typhoon than usual occurs, the rainfall may amount to 10 in. in 24 hours.

In the absence of records, the fixing of rail levels and bridge openings is a matter of difficulty and frequently the recollections of the "oldest inhabitant" about flood levels are found to be quite erroneous. Preliminary errors were thought to have been rectified but in 1930 a flood occurred completely eclipsing everything in the previous 40 years. 9/ In one instance, the river flooded the country for miles on each side of the banks and underscoured a small bridge, which led to a breach of the embankment, resulting in an enormous scour hole under the railway, 30 ft. deep and 300 ft. long. The adjacent country was all under water and repair work could only be carried on from one broken embankment end. All the quarries and shale heaps on the line were called on to supply hard material and special ballast trains were run for hundreds of miles. Five cars at a time were run to the broken embankment and unloaded and by means of floating stages, gangs of men standing in line passed the stone along and threw it into the scour hole. After a stone embankment had been brought up to water level, stacks of ties were placed on it and the slopes of the stone bank were completed by unloading from cars. Regular traffic was suspended for 12 days but in many cases traffic can be resumed with a trans-shipment; where the gap is not too great and the rails form a suspension bridge, planks are laid on the ties and the passengers walk over. Such an event is taken quite philosophically by all concerned as being unavoidable. Fortunately, these disastrous floods are rarely succeeded by another in the same year, so a deviation is often practicable. Exhibits 12 to 16, inclusive, show some of the effects of flood on bridges and tracks on this railway.

In another case, a bridge of 12 spans of 100 ft. was severely affected by the floods. For 31 years no flood had risen to the girder level but then came a new record when the water rose above the bottom boom of the truss girders. This would have caused no harm but it so happened that this abnormal flood washed away some woods far above the railway. These caught on the bridge, which of course increased the pressure of the water on the girders and broke the bedplate bolts. Most of the girders were displaced from their proper bearings but were prevented from being pushed off the piers by the concrete work of the pier top which had been made so as to act as a stop to the girders, but the force of the water was sufficient to tilt some girders weighing 60 tons each. During the dry season, a deviation was made and the bridge raised 6 ft. so that this should not occur again, but this involved some disadvantage as the grade was not as good as before.

In other cases bridge piers were carried away, the girders dropping in the river. This style of washout occurs through the overflow of larger rivers, which cause unexpected currents under the smaller bridges. The large bridges are made with deep foundations able to resist floods, but it would be financially impossible to build all bridges in that manner and so some risk has to be taken. In a somewhat similar case, a 60-ft. span plate girder, weighing 25 tons was rolled along by the current two miles from the bridge. It was thought to be sunk and lost, but to the

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surprise of the engineer making temporary repairs, a contractor turned up who offered to haul the girder back and he so did with the aid of nothing but ropes, wooden rollers, and manpower.

On another occasion an interesting example of handling a girder with limited means occurred. A washout occurred in which a pier was lost and a sixty-foot plate girder weighing twenty-five tons fell into a deep scour hole beside the bridge, the girder being twenty feet under the water surface. In such a situation cranes, steam winches, and other machinery would be used if available but none was available. A gang of river boatmen undertook to retrieve the girder and they did it as follows.

Logs of wood were available with which to form rafts. Native divers without diving apparatus fixed chains to the girder bracings. The railway lent some long capstan screws, the only modern equipment used, which were mounted on the rafts over the girder, and by means of which the girder was lifted a few feet and moved nearer the shore, this process being repeated until the girders were in shallow water. In order to pull the girder out of the pond a large capstan was made out of a tree trunk and a tripod. The tree trunk acting as the capstan barrel was set up vertically with the lower end in the ground, the top end being supported by the tripod. Capstan bars were lashed to the barrel with ropes and with this primitive arrangement the girder was hauled out of the water. Moving heavy weights without special machinery is a lost art in many countries, but not in China.

An example of simple methods of doing work without elaborate machinery was an apparatus for putting down bore holes. The boring tool was a short length of thin pipe with a flap valve on the end, which was suspended on a rope made of bamboo strips connected by simple wedges. The boring tool was raised or lowered by winding the bamboo strip round a treadmill wheel operated by a man walking on the inside. In use the tool was suspended from a "bow," the "spring" of which raised the tool a foot or so after it had been pushed down by hand. With this very simple apparatus bore holes for water supply could be sunk five hundred feet for pipes eight inches diameter. For greater depths, more modern machinery is required with a corresponding increase in expense.

Washouts occur at other places than bridges. An embankment along a river side was made twenty feet above low water level, which was thought high enough. So it was for thirty years, and then the water rose above rail level and turned the track upside down. This embankment had been well protected by stone and so it survived, which was just as well as it was a mile long in the river bed. In another place the railway was constructed several hundred feet from a river and on the convex side of a curve. A single-span bridge was made for small local drainage. A big flood came along, wiped out the several hundred feet of land and the railway, lowering the previous field level to the river bed level. The small bridge was left in the air, with the piles showing. In the same washout, instead of being on dry land clear of the river, the railway found itself right in the widened river. Another overflow from a big river near a station caused such a flood that car bodies were floated off the bogies and left strewn about the station yard.

In 1930, all flood records of 50 years were broken. At the end of July over one hundred washouts of various kinds occurred over two hundred and fifty miles. Very few materials could be forwarded except from the two ends of the damaged area and so two large gangs worked continuously from each end, advancing with the repair trains from one washout to the next. Through traffic over the part of the railway affected was not resumed for one month.

The loading gauge on this railway is unusually good, i.e., 10 ft. wide and 15 ft. high, but many of the bridges were in bad shape as far as axle load was concerned. A program of bringing them all up to Cooper's E-50 loading standard had been undertaken but was by no means complete at the time of the invasion.

The principal shops were at Tongshan, where some of these locomotives were built as well as repaired. These shops also handled car work. Everything for locomotives except axles, tires, and certain special devices for locomotives could be manufactured at Tongshan. In busy times, this work employed 2,400 men.

Most of the work for the engineering department was done at the maintenance of way shops at Shanhaikwan. This shop manufactured layouts of switches and crossings, water tanks, pumps, pipes, turntables, bridge girders up to 100-ft. span, signals of all kinds, also track tools and track scales. Plate girders and 200-ft. span truss girders have also been fabricated at this plant from imported materials. In busy times, this shop employed 800 men.

Most of the passenger cars on this line were either 57 ft. or 67 ft. over the couplers and 10 ft. wide and 14 ft. 2 in. high to the roof line. This was a highly important passenger line as it handled first-class express trains between China and Manchuria, and also one express train in each direction daily between Fusan, the port in Korea immediately opposite Shimonoseki, Japan, and Peiping. The equipment comprised first and second class coaches, sleeping and dining cars, and third class coaches and restaurant cars.

General Data

Most of the freight traffic was handled in 40-ton cars; 30-ton and 20-ton cars were also in service, and also a very few old cars of less than 20-ton capacity. A large amount of the freight traffic comprised coal from the jointly controlled Sino-British mines near Tongshan and Kuyeh operated by the Kailan Mining Administration. The total output for several years averaged 4,000,000 tons per year, most of which moved to the port of Chinwangtao over this railway for trans-shipment to other parts of China. Despite the volume of coal through this port, all trans-shipment was done by hand by coolies. The rest of this tonnage moved all-rail, mostly to Tientsin. This coal was loaded 40 tons to the car on an average and was handled in trains of about 40 cars each.

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The operating ratio on this railway was astonishingly low, having averaged well under 50 per cent for some 40 years. Just prior to the invasion it was about 60 per cent.

Passenger stations and railway office buildings in the Orient are usually quite imposing structures (Exhibits 17 and 18); however, this was not true on this railway. The general office building at Tientsin was quite an adequate building. (Most of it was destroyed during the War.) Most of the stations were small plain structures (Exhibit 19), except for the station building in Peiping. This was a large structure, the main waiting room being 130 ft. long, 65 ft. wide and 50 ft. high. The railway cuts through the city wall near this station. (Exhibit 20)

Signalling

The signalling on the railway is suitable for the conditions in China. On the single track, the electric staff is in use and on the double track, lock and block signalling. At important stations for trains arriving and departing, semaphore arm signals are used and for shunting work signals of a disc pattern which show lights both by day and night. For incoming trains, indicators are used in connection with the signals to inform engineers which platform they will enter. Track circuiting is used throughout, which as well as effecting locking, also operates an illuminated diagram in the cabin. Along the front of the levers are rows of lights showing by red and green the actual position of points and signals. There are some motor-operated signal arms and distant switches but generally speaking, mechanical operation is quite satisfactory and economical under the existing conditions. A fish-tail sign illuminated at night to distinguish the light of the Distant signal from other red lights is provided. It is customary for many people to carry lanterns giving a white or yellow light. Dust storms are prevalent and in the absence of a supply of electricity along the line to make a yellow light a distinctive light the fish-tail sign has worked quite satisfactorily.

This line includes the Peiping-Tunghsien branch, 14 miles; and the Peitaiho branch, 13 miles.

Kiaochow-Tsinan

This railway served the north-central portion of Shantung province and ran from Kiaochow on the coast to Tsinan on the Yellow river, where a connection was made with the Tientsin-Pukow line. It consisted of 256 miles of main line and 32 miles of branches.

It was captured by the Japanese on December 31, 1937. 10/ However, the retreating Chinese troops were able to destroy all the bridges and take up and remove most of the rails and ties. The railway has been rebuilt by the Japanese.

Of the 103 locomotives owned by this line, 94 were evacuated via Tsinan and the other 9 were destroyed. The majority of the 194 passenger cars and 1,783 freight cars were also removed to the south, via Tsinan, before the Japanese occupation.

Among the more important bridges on this line was that over the Tze river, 494 yards long, and another over the Mi river, 315 yards long. These bridges had just been rebuilt to comply with Cooper's E-50 loading standard a few months before the invasion.

This line includes the Changtian-Poshan branch, 28 miles, and the Kinling-Teshan branch, 4 miles.

Taokow-Chinghua

This line of 143 miles extended east and west of the Peiping-Hankow line north of the Yellow river and roughly paralleling that stream. The line was lost to the Japanese in the spring of 1938. This railway includes the important Tzuwang extension, a 41-mile line built northeast from Taokow especially for the handling of coal. This extension was constructed of old rails and other material removed from the Peiping-Hankow line while the latter was being rehabilitated.

The line includes the Chinghua-Chenchwang branch, 8 miles.

Tientsin-Pukow

This important trunk line was captured in sections by the Japanese, the final conquest being completed on May 19, 1938. At present, its northern section (Tientsin-Pengpu, 520 miles of main line and 65 miles of branches) is operated by the Jap-controlled North China Railways and the southern section of 109 miles (Pengpu-Pukow) by the Jap-controlled Central China railways.

Pukow is on the north bank of the Yangtze river, opposite Nanking. There are no railway bridges across this mighty stream anywhere in China. There was, however, a large and well-constructed train ferry. (Exhibit 21) The shore approaches were massive and built at Middlesborough, England, in 1933, by Dorman, Long & Co. and shipped out to China after being fabricated. The bridge approaches had to make provision for a maximum variation of 25 ft. in the water level during the year and for daily variations due to the rise and fall of the tide, which comes this far up the Yangtze, of one to three feet. The train-ferry steamer for this service, the S. S. Changkiang, was built in 1933. 11/

The Chinese did a thorough job of removing all the bridge approaches to the ferry berth on both sides of the river before the Japanese occupied Pukow or Nanking. Thus the Japanese have been required to barge freight and passengers across the Yangtze at this point, which is a cumbersome

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process. They now plan 12/ to construct a tunnel under the Yangtze between Pukow and "anking to cost 70,000,000 yen and have had the engineers concerned with building the Kwammon railway tunnel under the straits between Moji and Shimonoseki in Japan on the ground to look over the possibilities.

The northern portions of this line were defended by General Han Fu-Chu, who was later executed as a traitor and he does not appear to have stripped and destroyed those portions as ruthlessly and effectively as was done elsewhere. Moreover, 271 locomotives of the Tientsin-Pukow and Lunghai railways were trapped on this line for the biggest individual rolling stock haul made by the Japanese in China.

The Japanese themselves were responsible for much destruction on this railway, as the stubborn defense, particularly of the southern section, caused them to lose 1,433 air raids on the line in 10 months resulting in the complete destruction of the following:

110 locomotives
218 cars
4 bridges.

The durability of railways under air attacks, particularly when there is plenty of daring manpower available, is indicated by the fact that trains were run every night during this period of bombardment and the total number and kind of trains that got through was as follows:

960 trains of munitions
50 trains of refugees
24 trains of government materials
17 trains of art treasures from old Imperial palaces
1,159 trains of railway materials

These were in addition to the countless troop trains.

This line originally owned 166 locomotives, 285 passenger cars, and 1,920 freight cars. Much of this equipment was evacuated. The main shops at Tsinan were dismantled, the machinery removed elsewhere, and the fixed structures dynamited.

The Yellow River Bridge

The huge bridge across the Yellow (Hwang) river at Tsinan was terrifically damaged by the retreating Chinese forces. A complete report of how the Japanese rebuilt it is available. 13/

"The famous bridge, which is said to be the finest and strongest bridge in the Orient, was completed in October, 1912. The history of the construction of the Tientsin-Pukow Railway amply shows how the German engineers taxed their brains in the building of this bridge. As a matter of fact, the construction of the railway was simultaneously set about from both ends, that is, from Tientsin and Pukow. With Han- Chwang as the center, the construction work was divided into northern and southern sections. The former was undertaken by British engineers, and the latter by Germans. Indeed it assumed an aspect of scientific and engineering competition between Germans and Britons.

"The bridge over the Hwang which was constructed by German engineers bears testimony to the high prestige of German bridge-building engineering. It is told that for this bridge-building project German authorities ordered all the firms in Germany to present plans and by combining the excellent parts of the plans thus presented, succeeded in producing the best plan conceivable.

"It was brought to perfection in three years at the cost of Y. 6,000,000. The ablest engineers in Germany were mobilized for the construction work.

"This bridge was completely destroyed by explosives last autumn by the Central Army troops of Chiang Kai-shek. Some engineers who witnessed the scene lamented that there was no immediate possibility of repairing the bridge. The Japanese Army forces, however, were determined to repair the bridge by surmounting any obstacle which might present itself.

"Immediately after Tsinan was occupied, the repair work on the demolished bridge was commenced. The plan was made by G. Inaba, engineer of the Japanese Government Railways. All the leading engineers of the South Manchuria Railway Company assisted with the repair work, which was entrusted to the Hazama-Gumi, public-works contractor, whose main office is at Aoyama, Tokyo.

"It was on January 12 that the engineers and workers of the Hazama-Gumi first arrived at Tsinan. There was no Japanese resident in the town at that time.

"Under the direction of Colonel Masuda, superintendent of the works, preparatory activities were started. Huts were constructed, and coolies were recruited. On February 4, all the necessary machinery and tools had arrived at the spot, and thus was commenced what was to be the greatest and most difficult work in the history of Japanese bridge building. It was the cold month of February. The rapid current of the river obstructed the work, but on February 11, that is, on the national holiday Kigensetsu, a temporary bridge was opened. On the following day five enemy planes came over the spot and dropped bombs killing four Japanese (two soldiers, one Hazama-Gumi employee and one South Manchuria Railway employee), six Chinese coolies, injuring over ten Japanese, and fifty Chinese. Later three enemy planes bombed the bridge, but fortunately there were no casualties among the Japanese at this time. About fifty Chinese coolies were slightly hurt. The workers were also constantly menaced by guerilla attacks, but extreme precautions taken by the

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engineering corps of Sasaki's Division, and other units held the guerillas at bay, so that they could not approach and obstruct the repair work.

"'Repairs' does not describe the real nature of the work itself, for the only spans which escaped bombing and were left standing were two at one end, and one on the other. The remaining nine spans were either destroyed or were hurled down to the dry river bed, or sunk into the water. One ordinary span is 91.5 meters in length, and weighs 530 tons. Japanese engineers have never dealt with such long and heavy spans before. Moreover, one center span and two anchor-spans which fell to the river bed weigh 3,100 tons in all.

"But these spans had to be lifted at any cost. The best jacks from 75 tons to 100 tons of the Imperial Railways were brought; and other more powerful jacks were sought. Fortunately four jacks each of 300 tons were at the broadcasting station at Saitama prefecture near Tokyo. These had been used in erecting iron towers. These jacks were brought and utilized for the lifting for the heavy spans.

"The most difficult part of the work was the question of the 'German' spans. Japanese engineers on the spot had had no experience in handling these 'German' spans, for no bridge building work of this sort had ever been done in Japan. This 'German' span is nothing but a double center span. The two most important piers at the ends of the bridge (the distance between them being 164.70 meters) had to be spanned. This spanning called for special skill, and it is called 'German' span, simply because a German engineer invented the method.

"The two spans each from one of the piers must slowly approach one another by means of load pressure on the piers, so that they meet in the center where no support is available and join together. They thus become one perfect span between the piers at both sides of the river bed. The meeting of the two 'German' spans, that is, center spans, would fail should a difference of even a few milimeters occur. Since iron is liable to contract or expand from temperature it may be that a span measuring 82.35 meters would produce a difference of a few milimeters even by atmospheric temperature.'

"The engineers by anticipating the exact time at which two spans would meet, tried to obtain the atmospheric temperature at the time in question by means of statistics and they succeeded in obtaining average figures of the iron's expansion at the time the spans came together. It took half a month for this scientific survey, and the exact lengths of the two spans had been obtained.

"When the day came Mr. Inaba, chief engineer, who had never been on the spot, arrived from Tokyo. All the engineers awaited the result with mingled feeling of expectation and uncertainty, for the completion of the strategically vital line depended on the successful meeting of the center spans. Not only that, but the prestige of Japanese bridge building engineering, nay, Japanese scientific skill was at stake. The eyes of all present were fixed upon the ends of the two gigantic iron spans. Suddenly there arose a deafening acclamation. The spans perfectly met! The eyes of Lieutenant-Colonel Masuda, superintendent of the works, were full of tears, for the brilliant accomplishment of the great task was too much for him to restrain his emotions. It was a dramatic moment.

"According to the first estimate the repair work was to have been completed on July 20, but the work progressed so smoothly that it was finished on July 1, that is, within four months. The total cost was Y1,5,000,000. The work itself was undertaken by the Hazama-Gumi under the direction of the Military and the South Manchuria Railway authorities. The Yokozawa Bridge-Building Co., did the riveting work.

"The total number of the employees were 25,000 Japanese and 63,000 Chinese. Daily wages were: Y6.00 per Japanese, Y4.00 per Korean, and Y0.70 per Chinese coolie, and Y2.00 per skilled Chinese worker. The Chinese coolies were assembled from the neighboring districts.

"The iron used for the work was manufactured by the Yokozawa Bridge-Building Co. of Tokyo and the Railway Manufacturing Co., of Osaka.

"Dependents of those killed by enemy planes' bombing attacks were provided for by the South Manchuria Railway Company. The families of Chinese victims have been granted allowances.

"The opening ceremony of the bridge was held by the Military and the South Manchuria Railway Company. Chief staff officer Okamura attended the function as deputy of General Terauchi. During the process of the work, Prince Chichibu and other princes of the blood visited the scene and inspected the work, encouraging the workers. It may be remembered that the construction of the bridge took three years by German engineers. The repairing work of the same bridge, almost tantamount to building a new bridge, was completed in four months. Although the difference of time during which science has made remarkable progress must be taken into consideration, yet this rapid completion of the work is something to be proud of, and it was due to various factors typically Japanese, including the able direction of the

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Military and the South Manchuria Railway engineers as well as the self-sacrificing spirit of the workers. In this way the emblem of the victory of Japan's modern science has been established on the Hwang River, and will long commemorate the work."

This line includes the following branches:

	Miles
Ihsien-Chochwang	20
Chochwang-Lincheng	20
Tzeyang-Tsining	20
Lokow	5

Tungpu

This was a narrow-gauge line (one-meter) extending from Tatung (on the Peiping-Suiyuan line) to Fenglin Landing on the north bank of the Yellow river. It comprised 613 miles of main line and 89 miles of branches.

It was captured on March 5, 1938, but the majority of the rolling stock was ferried across the river to the Lunghai railway on the south bank and such rolling stock as could not be removed was destroyed.

All of the main lines on this railway were converted to standard gauge by the Japanese in 1939.

The line includes the following branches:

	Miles
Chiyao	46
Pingyao-Fengyang	21
Yuanping-Yangming	22

Chengting-Taiyuan

This meter-gauge line extended from Shinkiachwang on the Peiping-Hankow line to Taiyuan on the Tungpu line, a distance of 151 miles, mostly through mountainous country.

It was captured by the Japanese on November 9, 1937, but a large portion of the rolling stock had previously been removed.

The line was converted to standard-gauge by the Japanese in 1939.

From the eastern terminus of this line, the first 16 km. are through relatively level country, but at Hwailuhsien, 123 meters above sea level, a climb begins until a summit of 1,076 meters is reached near Showyanghsien.

From this point the line drops to Yutzehsien at 798 meters. The maximum grade is 1.84 per cent and the minimum radius of curves is 100 meters.

About 1,000,000 tons of anthracite coal annually are mined in the vicinity of Yangchuan from fields situated about midway on this railway.

There are 643 curves on the main line representing 33.9 per cent of its length. The bridges are designed for Cooper's E-24 loading. There are 170 steel bridges, 249 wooden bridges, 457 stone viaducts and 483 culverts. The ties used are largely made of Siamese redwood.

A branch runs from Nanchangtsun to the Fungshan coal mine, 7 kilometers. There is another branch between Yutzehsien and Taikuhsien, 36 kilometers. A further branch runs 12 kilometers from Weishiu and a coal mine at Tsingsing, which has an annual output of 1,000,000 tons bituminous coal.

Taiyeh

This 20-mile line serves the Taiyeh mines in the province of Hupeh and runs between Tienshanpu and Huangshihkang. It was captured by the Japanese in the second half of 1938.

RAILWAYS ENTIRELY UNDER JAPANESE CONTROL (CENTRAL CHINA)

The Central China Railways Company is nowhere nearly as large an undertaking as the North China Railways. It does, however, control some extremely important lines.

Nanking-Shanghai

This important line of 193 miles was the scene of bitter fighting before it fell to the Japanese on December 13, 1937. During the course of three months fighting, it was subjected to 264 air raids and direct bomb hits were scored as follows: (Exhibit 22)

Embankments	13
Bridges and tunnels	14
Tracks	91
Station platforms	33
Train sheds	14
Ticket offices	30
Shops	10
Warehouses	13
Coal & water stations	14
Other structures	32

In addition, a Japanese raiding party destroyed two important bridges at Soochow.

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Despite all this, train operation was never stopped for as long as a single day and, in three months, the railway handled 1,346 military trains, moved 50 divisions of the Army and 50,000 tons of supplies.

This line had an allotment of 72 locomotives, 194 passenger cars and 674 freight cars. All freight and passenger cars were removed or destroyed, while 55 of the 72 locomotives were evacuated. As the Chinese retreated slowly westward, they tore up rails and ties and used them to make barricades.

The railway also comprised a belt line 14 miles long around Nanking, between the Chunghua gate and the Yaohwa gate, connecting with the Kiangnan railway. The two branches were the Woosung, 10 miles, and the Lunghwa, 10 miles.

Shanghai-Hangchow-Ningpo

This 215-mile railway was staffed by the same officers as the Nanking-Shanghai line. It was laid with rails weighing 63 lb. per yard. The line fell to the Japanese early in 1938. Between August 13, 1937 and October 31, 1937, this railway was bombed 128 times, but service was maintained throughout. On the Ningpo-Tsongo section all tracks were removed. Of the original allotment of 45 locomotives, 149 passenger cars and 482 freight cars, all but about 10 per cent were evacuated.

The bridge over the Tsongo river between Zakow and Pokwan was blown up and the huge bridge over the Chientang estuary at Hangchow was dynamited on December 13, 1937. This bridge had only been completed a few months previously. It is one of the longest and most important in China and a full account 14/ of its construction follows. It has since been reconstructed by the Japanese.

The Chientang Bridge

The bridge is located near the Zahkou station of the Shanghai-Hangchow-Ningpo Railway, and is about seven kilometers south of the business section of the city of Hangchow. Various views of the bridge are shown in Exhibits 23, 24. It crosses the river in a north-south direction, and is at the narrowest and more permanent section of Chien Tang estuary in the neighborhood of Hangchow. It has a total length of 1,400 meters consisting of (a) 16 spans of 67 meters each over the river channel, (b) 235 meters in the north approach and (c) 92 meters in the south approach. The structure has two decks, the upper one is for a six meter roadway and two 1-1/2 meter sidewalks, while the lower one is for a standard gauge single track railway. The clearance under the bridge at mean water level is nine meters, and the grades are 0.33 per cent on the railway and four per cent on the roadway. The bridge is designed to carry simultaneously standard loading (Cooper's E-50) on the railway and 15 ton truck on the roadway, with heavy crowds on the sidewalks.

The superstructure of the main spans consists of steel trusses of the Warren Type, six meters wide and 10-1/2 meters high, supporting the railway track at bottom and the roadway deck of reinforced concrete on top. Chromium copper steel is used for the important parts of the structure.

The substructure of the main spans consists of fifteen piers of reinforced concrete, each three meters by 10 meters at top and varying from 26 meters to 34 meters in height. These piers have to penetrate very great depths of fine silt and sand before reaching the bed rock which slopes downward from north to south where it is 45 meters below the river bottom. As the piers have to rest on rock, unusually deep foundations have to be executed to ensure the safety of the structure. It is of interest to note that a large number of the piers has such a great mass that the vertical depth from the surface of the roadway to the bottom of the pile foundation is no less than 70 meters--a distance even greater than the horizontal span length between two adjacent piers. In order to secure the most economical design, five piers on the north side are made to rest on rock and ten piers on piles. Timber piles of 30 meters length are used for nine piers, 160 in each, while reinforced concrete piles of shorter lengths are used for the remaining one.

The approaches on the two ends of the main spans consist of steel arches and reinforced concrete structures. The railway deck being at a low level, is carried on earth embankment which, on the north side, connects up with the present line of the Shanghai-Hangchow-Ningpo Railway after deflecting into the hills through a curve; and, on the south side, connects with the same railway and also with the Chekiang-Kiangsi Railway. Because of the high level of the roadway deck, steel arches are used as supports, so as to avoid high embankment and to save the space of land. On the north approach the roadway is carried by three steel arches, and then by separate concrete trestles onto the hillside to join up with the road to Hangchow on the right and the up-river districts on the left. Similar arrangement is adopted for the south approach, except that there is only one steel arch span and only one branch to the left for connection with the existing highway. There are altogether fifteen piers on the two approaches, two-thirds of which are on the north side. These include the two abutments which have to carry the main steel spans also.

The following principles were adhered to in building the bridge:

(1) Owing to the shallow water and the shifting sand riverbed, the piers supporting the bridge should be equally spaced, mainly for convenience of navigation.

(2) Owing to its various traffic uses, the bridge should be designed to meet heavy traffic conditions.

(3) Owing to its strategic position in national defence, the bridge should be designed with sufficient reference to military utility.

(4) Owing to its beautiful surroundings, the bridge should be designed in good proportion and size.

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The selected design gives a double course through truss bridge with 16 spans, each 220 feet long, the total length of the bridge being 3,520 feet. The depth of the truss is 35 feet. The distance between trusses is 20 feet.

The trusses are designed of Warren's type. (Exhibit 24) The top course of the bridge is designed for highway traffic with pedestrian sidewalks, all paved with reinforced concrete slab, seven inches in depth, supported on steel cross-beams, which are connected to the upper chords of the trusses by riveted joints. The bottom course is for a railroad and is composed of rails, ties, and cross beams. The upper and lower chords of the trusses are all designed to be strengthened by lateral bracings, jointed by steel rivets. The whole bridge is designed to be supported on fifteen reinforced concrete hollow piers which are practically sunk into the bottom of the river, some 70 feet below the highest water level. Near the south bank of the river, on account of the sand river-bed, the piers are designed to be supported on wooden piles, some 100 feet long, driven into the bottom, whereas, on the north bank where the rock stratum is much higher, the piers are designed to rest directly on the rock stratum, no piles being needed. At either end of the bridge, approaches are designed to connect the bridge itself with the bank.

The Foundation Work

In the foundation work of the bridge, six different processes were put into use. (1) Ordinary excavation process: Where the rock stratum is not far from the ground surface, the piers are designed to rest directly on the rock stratum by first excavating the earth to a certain depth. (2) Pile foundation process: Where the rock stratum is very low, wooden piles are first driven to the bottom to support the piers. The piers CI. C2, and I to J2 are thus supported. (3) Open caisson process: Where the rock stratum is much lower, open caissons are used. (4) Pneumatic caisson process: Where the rock stratum is very far and the deposit sand is too thick, pneumatic caissons are employed. The piers No. 1 to 6 were designed to be constructed by this process. (5) Pneumatic caisson and pile foundation processes combined: Where the rock stratum is too far to reach even by the pneumatic caisson itself, it is required to drive piles first. (6) Steel sheet-like coffer-dam and pile foundation processes combined: Where the rock stratum is very far from the surface and the liquid sand underground is very much in excess, it is required to construct a steel sheet-pile coffer-dam first; then, the liquid sand may be removed and piles be driven. This will give a very perfect foundation, and piers may be built upon it. The foundations of the two piers at the south bank are arranged by this combined process. The general arrangement of the foundation work of the bridge is shown in Exhibit 26.

Exhibits 27 to 31, inclusive, show various photographs of the bridge and the construction methods used.

The science of railway bridge building is in its infancy in China, particularly as to longer bridges. The photographs just mentioned plus the drawings which follow as Exhibits 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, and 43, are most instructive as indicating the methods used. The lessons learned in constructing this bridge have been most valuable to the Chinese in constructing the thousands of bridges on new railways in Free China, many of which are described in detail later. Actually, the methods used in building the Chien Tang bridge were unique in Chinese bridge-building up to that time (1936-37).

Soochow-Kashing

This 45-mile line was taken over by the Japanese on December 13, 1937. It supplies a cut-off between the Nangking-Shanghai and the Shanghai-Hangchow-Ningpo lines.

Weinan

This 133-mile line operated between Tinkiangan and Yukikow in the province of Anwhei. It was used almost entirely in hauling coal from the mines at Tinkiangan to Yukikow, a Yangtze port on the north bank of the river. All of its tracks were torn up and removed in December 1937.

Nanchang-Kiukiang

When it appeared that this railway would be captured, the southern section of 48 miles between Nanchang and Teian were dismantled. On June 17, 1938, destruction was begun on the northern section, 32 miles, between Teian and Kiukang, the latter a port on the Yangtze river. About 25 miles of this section had been torn up when the working parties were trapped. However, they dynamited what rolling stock was left and threw the wreckage, along with the rails, into Poyang Lake. Before this occurred, all the steel work from fourteen bridges had been removed and sent to the rear.

Nanking-Kiangsi

This section would not be complete without mention of this "ghost" railway. It was to have been an ambitious project of 292 miles. For construction purposes, it was divided in the line in Anhewi province between Hsuancheng and Tuhu, 168 miles and the line in Kiangsi province between Tuhu and Kweiki, 124 miles. Construction was started in November 1936 and earth and stonework, bridges and tunnels were all completed on the Anhwei section by late in 1937, while track had been laid for 99 miles from Hsuancheng to Sihsien. The Kiangsi section traversed more difficult terrain and only 31 miles had been completed when, in December 1937, both sections of the new railway were torn up and the materials transferred elsewhere, in view of the imminent Japanese occupation of this territory.

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RAILWAYS ENTIRELY UNDER JAPANESE CONTROL (SOUTH CHINA)

In South China, the Japanese control the territory where three railways used to be, but they have not attempted complete reconstruction of these particular lines:

Chachow-Swatow	26
Sinning	87
Changchow-Amoy	19

The only lines entirely in their control in this area which have been rebuilt are as follows:

Canton-Kowloon

This line comprised 112 miles, of which the Chinese section extended for 90 miles between Canton and Shumchun and through British leased territory for 22 miles between Shumchun and Kowloon, the port on the mainland opposite Hong Kong. The fastest train traversed the 112 miles in 2 hr. 50 min. The Chinese section of the line was captured by the Japanese on October 22, 1938, and the British section a little more than four years later. The rolling stock of the Chinese section, consisting of 14 locomotives, 43 passenger cars and 69 freight cars was largely evacuated north over the Canton-Hankow line. On the British section, however, the 14 locomotives, 44 passenger cars, 130 freight cars, and 2 rail cars 15/ had no place to go and these were captured by the Japanese. The passenger cars included two streamlined parlor railcars with Diesel-electric power (the "Taipo Belle" and the "Canton Belle") as well as the only air-conditioned car in China.

This railway was operated largely for passenger service for many years, because the business men of Canton blocked every effort to have it connected with the Canton-Hankow railway in Canton, although the terminals of the two railways were only 2-1/2 miles apart in that city. When however, the port of Shanghai was blocked and huge quantities of material were being moved through Hong Kong and Kowloon for the Chinese armies, the Cantonese rescinded their objections and a 9-mile connection was built, running practically due east from Sai Chuen, a station 4-3/4 miles north of Wongsha (Canton West) to Shek Pai, a junction 5 miles from Tai Sha Tou (Canton East). This line was completed on August 18, 1937.

The type of disaster which strikes Chinese railways upon occasion was exemplified on September 2, 1937, when a typhoon, with a maximum wind velocity of 167 miles per hour struck the British section of the line. Damage was particularly heavy in the seven miles between Shatin and Taipo Market, where the railway skirts Tolo harbor. More than 6,000 lineal feet of embankment were washed out in this section. The damage was caused by a tidal wave which swept through Tolo Channel and spent its fury against the western shore. Three embankments, each 25 ft. in height and 1,200, 500, and 300 ft. in length, composed of earth filling faced with granite blocks, were demolished by this wave, which reached a maximum height of 30 ft. above mean sea level.

During the last 2-1/2 months of 1937 and for 10 months of 1938, the Chinese section of this line was regularly bombed by the Japanese. Figures as to the 1938 bombings are not available, but from October 15, 1937, to December 31, 1937, 726 bombs were dropped on the line from 344 planes in 81 raids on 49 different days, 140 of the bombs being aimed at the two large bridges over the East river at Sheklung. Three types of bombs were used, weighing 500, 250, and 60 kilograms. While the trains lost all punctuality, traffic continued through this hail of bombs practically uninterrupted. (Exhibit 44)

Canton-Whampoa

This 15-mile line is far more important than its length indicates. Among other things, it represented a challenge of the Canton merchants, always jealous of Hong Kong, to that world port, as Whampoa harbor was to have been Hong Kong's rival in South China. The Whampoa harbor project was studied by A. G. Van Sleenborgen an engineer of the Netherlands Harbor Works and by an American engineer named E. P. Goodrich, both of whom rendered optimistic reports on the project. The railway itself was built, however, long before effective work on the harbor had progressed very far.

Canton-Samshui

This 30-mile line was captured by the Japanese on October 22, 1938.

Sunning

This line runs between Towshan and Pakkai, 80 miles, with a branch from Toishan to Paksha, 21 miles. (Exhibit 45)

The main shops are located at Kung Yik. A large bridge across the Tam river is also at this city. The bridge is 1,364 feet long and consists of eight fixed spans, each 162 feet long and one bascule span 68 feet long. In all, there are 160 bridges and 189 culverts on the main line and 53 bridges and 56 culverts on the branch. (Exhibit 46)

A map showing all the railways in the hands of the Japanese (either wholly or partially) as of January 1, 1943, is appended. (Exhibit 47)

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RAILWAYS PARTLY UNDER JAPANESE CONTROL AND PARTLY IN FREE CHINA.

Among these railways are several of the most important trunk lines in China, which are Jap-controlled at either one or both ends. All of these lines have been the scenes of bitter struggles, with the Chinese armies always retreating but always putting up a dogged battle against overwhelming odds and eventually obtaining stable defensive positions which left them in control of the west sections of some railways and of large segments in the center of some north-south lines, which latter position has prevented the Japanese from making completely effective use of some of the most important railways in the country. A map showing the railway situation, plus projected railways, as of December 31, 1942, is appended (Exhibit 48).

Lunghai

This is the most important east-west trunk line in China. By June, 1938, the Japanese had captured the eastern section of the line between the coast and Chungmow, 332 miles of main line and 19 miles of branches. However, the advance stopped there and the western section of 500 miles or more is still in Chinese hands.

This line roughly parallels the Yellow river to the south. It originally started at the port of Taipu, but when this port silted up, a new port was constructed, between 1931 and 1935, at Lienyuan, which involved building a new 23-mile line from Sinpu, on the main line, to the new port.

As the Chinese retreated, they tore up all rails and ties and destroyed water and coaling stations and bridges, All moveable equipment was evacuated from Lienyuan harbor in April 1938. This included an elaborate mechanical coaling station and car dumper, which was dismantled. Many of the fixed structures on this railway were dynamited. This railway had a supply of rolling stock amounting to 193 locomotives, 210 passenger cars and 1,547 freight cars. Some of this was evacuated, but some 80 locomotives and 1,000 cars were trapped and captured by the Japanese. A later raid by Chinese troops led to the recapture of 42 of these locomotives and 366 cars.

There is a decided gap now between the Japanese and Chinese-controlled sections of this railway. In April, 1939, rails were torn up from Chungmow west to Szeshui and, between May and August of the same year, the destruction was continued further west as far as Loyang. This included the dismantling and removal of a sizeable bridge over the Lo River at Siaoyi, 17 miles west of Szeshui.

I have described some of the effects of aerial bombardment on Chinese railways, but the Lunghai offers the interesting study of a line that was subjected to protracted enemy artillery fire at relatively close range and still kept traffic moving. 16/

Between Hweihingchen and Tungkwan this railway follows the south bank of the Yellow river quite closely. The north bank is several feet higher and, when the Japanese captured all the territory along the north side of the river, they brought up artillery to blast this section of line out of existence. To the everlasting credit of the Chinese railway workers they kept the traffic moving under the most trying conditions imaginable. At Tungkwan, for example, an important part of the railway was only 875 yards from the Japanese artillery emplacement. Constant fire destroyed the piers of a bridge (Exhibits 49, 50 and 51) at that point but the Chinese filled the chasm with earth and stones and, except for a few days, traffic was not interrupted. Even in those few days passengers and freight were detoured by highway around the break. Daylight operations in this section were, of course, impossible, but the trains went through at night with all lights out and the locomotive fire boxes screened.

In a joint air raid and artillery barrage on May 19, 1939, the roof of a tunnel at Tungkwan was breached and 70,000 cubic feet of earth fell into the tunnel near one portal. The repair gangs were subjected to a practically constant artillery barrage, but repairs were effected and trains running through the tunnel by May 26, or within a week after the damage.

On another occasion, Japanese artillery concentrated on a bridge at Wentechen, 8 miles east of Tungkwan. This bridge consisted of four spans of 33 yards each and the artillery fire destroyed two spans. Similarly a bridge of 12 spans of 33 yards each near Lingpao, 43 miles east of Tungkwan, was subjected to a withering fire and struck by 1,200 shells in all. In both cases, detours were built out of range to the south of the destroyed bridges and traffic kept on moving.

After months of such tactics, the Japanese suddenly trained their artillery on the entrance of the Tungkwan tunnel and blasted at a fixed target every time they saw a train pass that point. They destroyed 32 locomotives, 81 freight cars and 7 passenger cars before the Chinese dug a new tunnel, 568 yards long, from the inside of the existing tunnel and got the new portal out of range. (Exhibit 52)

In September, 1939, the Japanese brought up additional artillery and concentrated their fire on Puntaochen tunnel and two adjacent bridges, 16 miles east of Tungkwan. Within a short time the bridges were practically pulverized and for two months traffic had to be detoured around the break by highway while a difficult detour out of range to the south was being constructed.

Peiping-Hankow

This important north and south trunk line of 755 miles was in the process of rehabilitation immediately prior to the invasion. Because of its importance the line was desperately defended. However, by November 26, 1938, the Japanese had captured both termini. They now control the line between Peiping and the north bank of the Yellow River, a distance of 413

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miles, with 75 miles of branches. They also control the south end from Hankow north to Sinyang, 134 miles. The intervening 208 miles is either disputed territory or in the hands of the Chinese. 17/ Thus, the Japanese are compelled to use wide detours in all traffic between Peiping and Hankow.

Among the important bridges on this line are: 18/

Over Yellow River at Chenghsien. (Exhibits 53 and 54)
Over Chang River north of Anyang.
Two at Fund-Chuen, one 5 spans 44 yards each, the other 4 spans, 44 yards each.
Large bridge at Changtaikwan, 165 miles north of Hankow.

The Yellow River bridge was twice bombed from the air by the Japanese but the damage was quickly repaired. Finally, early in 1938, it was destroyed by the Chinese. However, from the outbreak of the war until its destruction, an average of 487 trains a month crossed this bridge, the record being 30 in one day.

The Yellow River bridge was built by the Compagnie D'Etude Franco-Belge, and, in view of the cheapness of construction, it was guaranteed to last for only a few years after its completion in May, 1906. Yet it stood for more than 30 years until the retreating Chinese destroyed it. The flood of 1933 resulted in such a distortion of the bridge structure (Exhibits 55, 56, and 57) that the speed of trains over the bridge had to be reduced to 10 kilometers per hour, but the bridge managed to hold together for some years after that until its destruction.

It had many vicissitudes in its history. As originally constructed, it consisted of 102 spans and was more than 3,000 meters long. Span No. 102 was destroyed in the Civil War of 1925 and was replaced by an embankment. Span No. 101 was later used to replace a more central span destroyed in the civil war of 1929, and an embankment was built to replace the removed span. Thus, at the time of its destruction, the bridge consisted of 100 spans in the following order: twenty-four pony trusses of 31.3 meters each, fifty-two 21.1 meter deck girder spans, twenty four 31.3 meter pony trusses.

The piers were made of 2 meter sections of screw piles, bolted together with the inside filled with concrete, the average depth of the piles being 14.5 meters below the river bed.

The Changtaikwan bridge was also destroyed by the Chinese as well as all bridges between Liulin and Chengchow. A tunnel at Husingkwan was also dynamited.

There were three large workshops on this line - the Kiangon Works at Hankow, and the shops at Tsiaotso and Chengchow. All machinery was removed from these works, steel beams and girders from the buildings were evacuated and fixed structures were dynamited.

The Japanese were fortunate in capturing a large stock of railway materials in the storehouse at Changsintien, as well as 120 cars of materials that had to be left behind. They also got 53 of the 434 passenger cars; 427 of the 3,477 freight cars and 40 of the 210 locomotives. The remainder of the rolling stock was evacuated by the Chinese, except for 15 locomotives which were trapped and had to be dynamited.

Kiangnan

This railway operated between Nanking and Sunkiapu, 109 miles. The Japanese now control most of this line, but at last reports they had not rebuilt several sections. In retreating, the Chinese practically obliterated this line, removing machinery from shops, materials from storehouses, then dynamiting these structures; tearing up rails and ties and dismantling bridges. Five locomotives and 65 cars were evacuated and the rest of the rolling stock was completely destroyed.

Chekiang-Kiangsi

This line originally ran between Hangchow and Yushan, 221 miles. 19/ However, just prior to the invasion, two further sections were added: Yushan-Nanchang, 182 miles; and Nanchang-Pinsiang, 162 miles (Exhibit 58). Thus, the new system of 565 miles connected the Shanghai-Hangchow-Ningpo line with the Canton-Hankow line and became an important artery of commerce. The old section, between Hangchow and Yushan had been laid with very light rails and it was completely rehabilitated in 1936-37, laid with 63-pound rails, 160,000 new ties put in while 68 of its bridges were rebuilt and 16 re-inforced.

The largest bridge on the entire railway crossed the Kan River between Changshu and Chinkiang. It consisted of nine spans of 66 yards each. This bridge was dynamited and the wreckage scattered up and down the river. The Yuan River bridge near Suki and a 64-foot steel bridge near Anwha were similarly dealt with.

The section of track between the Chientang River and Chuki was destroyed late in 1937 and all tunnels were blocked. The line between Hangchow and Chuki, 40 miles, was captured virtually intact. The damage was such, however, that it was not until April, 1943, that the Japanese were able to open the line as far west as Kinghua, 116 miles from Hangchow.

On the western section, the Chinese destroyed and rebuilt tracks and bridges as the tide of battle ebbed and flowed. The Japanese captured relatively little rolling stock on this line. However, unlike most railways, the Japanese more than once captured western pieces of the line leaving sections to the east isolated, so that the rolling stock could not be evacuated but had to be destroyed. Despite the kaleidoscopic fortunes of war which afflicted this line more perhaps than any other, in the first 15 months of the war this railway handled 1,700 military trains, carrying 1,500,000 troops and 60,000 wounded. It also handled 230,000 tons of military material and 225,000 tons of general supplies.

(OVER)

The Hangchow-Kiangshan section of this railway, extends between Kiang Pien, the station opposite Hangchow at the southern end of the Chien Tang River bridge, to Yushan. For the first 70 kilometers the many streams were generally crossed by wooden trestles, or stone culverts for the smaller streams (Exhibits 59 and 60). There are many other structures, however, including large diameter concrete pipes, often in a series up to four, concrete arches up to 16-ft. span, stone abutments with steel girders and masonry piers and abutments designed for steel girders but crossed by wooden stringers (Exhibit 61). At Chien Shuan, 31 kilometers from Kiang Pien, the Pu Yang river is crossed by the longest bridge on this section (Exhibit 62), consisting of steel plate girders on cluster-pile piers. The railway followed this river for some distance (Exhibit 63).

The Yushan-Nanchang section of the line is 185 miles long and crosses a 500-meter bridge over the Fu river at Liangchatu, 30 miles from Nanchang (Exhibits 64 and 65). In addition, the line comprises 18 bridges of between 20 and 80 meters in length, including the Teng Chia Kiang (Exhibits 66, 67, 68, and 69) and the Yih Ho San bridges, and 15 bridges under 20 meters long. It contains also hundreds of fills and cuts, many of the latter through solid rock. Whereas the Hangchow-Kiangshan section was originally of light, cheap construction with many temporary structures, the Yusan-Nanchang section was well built in accordance with the Chinese standards of railway construction prevailing at the time (1936). (Exhibit 70, 71, 72, 73 and 74)

Canton-Hankow

This line has had a most chequered history. Actually, it begins at Wuchang, on the south bank of the Yangtze River, opposite Hankow on the north bank (Exhibit 75). Its conception was founded on both an economic and political basis. It was felt, and rightly so, that the establishment of a railway connection between North and Central China and the chronically disaffected southeastern province of Kwantung would be of great value in cementing friendly relations between the various provinces and of the utmost importance in the plans for progress in New China. However, so many adverse factors were encountered that while a line was built south for 259 miles from Wuchang to Changsa and eventually to nearby Chuchow, and another line was built north from Canton to Lochang, 169 miles, by the time the central connecting link was built between Lochang and Chuchow, 252 miles, the earlier northern and southern sections were practically worn out. The central section itself, while new, had also been built hastily and was not up to the standard of railway construction of Chinese railways as a whole. Thus, a complete rehabilitation of the entire line was necessary. This work was largely done in 1936 and the early part of 1937 and comprised, among other things, the relaying of all light rail sections with 63-pound per yard rail and the strengthening of all bridges (numbering 164 in all) to the Cooper E-50 loading standard.

At various periods, the Japanese captured both the north and south ends of this line. On the south end, they got the Canton-Yuentan section of 39 miles virtually intact. The Chinese were, however, able to take up rails and ties and dismantle bridges on the next section, from Yuentan to Kukong, 96 miles.

On the northern section, the rapid advance of the Japanese resulted in their capture of the Wuchang-Huangsiaje section with only minor destruction having been accomplished. However, the next section to the south, between Huangsiaje and Chuchow, 93 miles, was virtually obliterated by the Chinese in their customary thorough fashion, by the removal of rails and ties, dismantling of bridges and dynamiting of fixed structures.

At Chuchow, a large locomotive and car shop was being constructed, which was intended to serve as the principal rolling stock repair and rebuilding point for all railway lines in China south of the Yangtze River. Most of the buildings had been erected and one section of the shop had been supplied with the necessary machinery and was actually in operation, when, late in 1937, the threat of Japanese occupation became imminent. In their customary realistic and ruthless fashion 20/ the Chinese removed the machinery and many of the steel beams and dynamited the rest of the buildings.

As the Japanese advance continued, the Chinese tore up a further 10 miles of railway between Chuchow and Lukow and were dismantling the line for a further 25 miles to Chuting, which would have included the dynamiting of an important bridge at Lukow. However, the Japanese were repulsed and the Lukow-Chuting line was rebuilt. In the next two years, this line was dismantled and rebuilt three times.

Today, while the Japanese hold the north and south sections, the Chinese remain in control of about 250 miles of line in the center.

This line was subjected to a terrific bombing by the Japanese. Every month it was raided between 60 and 145 times a day and for months on end raids were of daily occurrence. In all, 3,200 tons of bombs were dropped on this line. For a time, Japanese bombers concentrated on a bridge at Yinchanow, 35 miles north of Canton and, for weeks, this bridge was damaged more or less every day. Still traffic was kept moving at night, without serious interruption.

As stated, the central section of this line was built several years after the northern and southern sections and was not opened for through traffic until September 1, 1936. Some of the engineering features of the line follow: 21/

The central section presented engineering problems of great variety as the territory traversed included flat country where long, level tangents were possible; hilly country where it was necessary to put 65 per cent of the line on curves; wide rivers with sandy beds and deep gorges with rock foundations. The line between Lochang and Chenchow, 150 kilometers, was the most difficult to construct. After several surveys a line was laid out along the upper part of the North River, thence through the mountain watershed, which required 14 tunnels (the longest 300 meters) in this section. (Exhibits 76, 77, 78, 79, 80, 81, 82) The quantity of stonework amounted to 3,000,000 cubic meters and over 2,000 tons of dynamite were used in blasting out the right-of-way, while, at one time, 184,000 workmen were employed on this construction job. (Exhibits 83, 84, 85 and 86).

(OVER)

The bridges in this section are mostly over shallow streams with rock beds and high banks, requiring short, but high bridges, piers of 30 to 40 meters high being of frequent occurrence (Exhibit 87). Between Chuchow and Hengchow, 130 k.m., rolling country is encountered, involving much lighter construction, but involving three major bridges, as follows:

Over the Lo River (Exhibits 88 and 89), four through trusses of 45 meters each and seven 18 meter deck-plate girders;
Over Mi River, two 45 meter through trusses and fourteen 18 meter deck plate girders; (Exhibit 90)
Over the Lei River, with four 60 meter through trusses and eight 18 meter deck plate girders.

Between Chuchow and Chenchow, the ruling grade is 0.7 per cent, with a 300 meter minimum radius for curves. The Chenchow-Lochang section has a ruling grade of one per cent, uncompensated.

Because of climatic conditions and termites, about 120,000 treated Canadian pine ties were purchased for this section. However, most of the ties were of the Australian hardwood type (Jarrah wood) of 5 inches by 9 inches by 8 feet. Some 60,000 ties cut in the vicinity, of local pine and San wood, were used for sidings.

Three bridges on the railway were blown up during the Chinese Civil War - a 45 meter truss at Tien Tou Shui, a 30 meter truss at Chiu Feng Shui, and a steel girder span at Hiu Kang. Another important bridge at Pu Tang Kow was not harmed.

The rolling stock on this line consisted of 105 locomotives, 261 passenger cars and 1,516 freight cars, and practically all of this was evacuated safely from the Japanese-occupied sections. The locomotives included 24 locomotives, purchased in 1936-37 that were of the 4-8-4 type, having a tractive effort of 17,500 kilograms each and capable of 80 kilometers per hour on the level and of hauling a 1,000-ton train up a one per cent grade at 25 k.m. per hour.

Four switch engines were purchased at the same time.

The stations on the line were well-constructed although small (Exhibit 91) except at important ciries. The station at Hengyang, which became the junction for the new Hunan-Kwangsi Railway, is quite an imposing structure. (Exhibit 92)

The northern section of the southern end of the line, between Shaochow and Lochang, 51 kilometers, involved difficult construction. A bridge at Shaochow crosses the Nan Hsiung river and consists of one 60-meter through truss span and five 30-meter, one 18-meter and one 10-meter girder span.

The railway is situated in the canyon of the upper North river and much cutting and tunneling was necessary. The type of terrain traversed is indicated in Exhibits 93, 94 and 95.

The cuts on this line are difficult to maintain as they are all on mountainsides and usually are through loose earth, loose rock and occasionally coal and are subject to landslides and falling rocks. There is a 1,400 foot tunnel in this section through soft rock strata. The tunnel is fully lined with concrete throughout. (Exhibit 96) The North River in this canyon is a swift mountain stream and it has been necessary to build numerous retaining walls to avoid wash-outs. (Exhibit 97)

The line consists of more than 60 per cent of curved track, with a maximum curvature of 7 degrees 30 minutes, but it ascends on a fairly easy grade, considering the type of country traversed, of 0.7 per cent.

SECTION II - NEW CONSTRUCTION

Under this head is given, first, the construction that the Japanese have completed, are building, and have proposed in occupied China, insofar as this information is available. The organization set up to handle the railways in occupied China is also described. Secondly, the description of the railways in occupied China is given under this heading, since, in almost every case, a great deal of construction has taken place on these railways.

JAPANESE CONSTRUCTION

Tunghsien-Kupeikow

A Chinese railway project to link Peiping directly with the railways of Manchuria has been completed by the Japanese. The Chinese proposed to build a railway from Peiping to Kupeikow and had, in fact, completed a line from Peiping to Tunghsien, 14 miles, with this in view. The Japanese built a further section of 64 miles from Tunghsien to Kupeikow, connecting at the latter point with the Manchurian railways. Kupeikow is a town on the Mongolian frontier and a line has been built through Mongolia to Jehol, the capital of the province. This line facilitates overland movements of troops and military supplies between China and Manchuria, which, until its completion, had only one railway route available, the Peiping-Shanhaikwan line. Construction of the main line was started in September 1937 and completed in April 1938.

Sinsiang-Kaifeng

Because of the dynamiting of the Yellow River dikes, the Japanese were unable to use the normal connection at Chenchow between the portions of the Peiping-Hankow and the Lunghai railways in their possession. Accordingly, they built a new line from a point on the Yellow river opposite Kaifeng (a station on the Lunghai railway) to Sinsiang (a station on the Peiping-Hankow railway). This 64-mile line, together with a barge and

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ferry service across the Yellow river at Kaifeng, gave them the desired connection between the two lines, although, of course, it is not as effective as was the former direct interchange of cars, without transfer of lading, at Chenchow. The line was completed in May 1939.

Shihkiachwang-Techow

The purpose of this line of 124 miles was to supply an east-west line connecting the Tientsin-Pukow line at Techow with the Peiping-Hankow and Chengting-Taiyuan railways at Shihkiachwang. Since the Chengting-Taiyuan line had been converted from meter-gauge to standard-gauge in 1939, it supplied, in connection with the new railway, an important line across northern China, which linked the through railways mentioned above with the Tungpu line to the West and, via this line, which was also converted to standard-gauge in 1939, with the Peiping-Suiyan line to the north. This established a system of integrated standard-gauge line in Hopeh province which enormously facilitated military movements. It should be noted also that this gives the Japanese a choice of several alternate routes in case of destruction or interruption of traffic on any one line, a condition that did not prevail before. Construction of this line was begun in June 1940 and completed in November 1940.

Tunghsien-Tangshan

This line is, in effect, a cut-off for the Peiping-Shanhaikwan railway and it permits the operation of trains direct between Peiping and Manchuria without the necessity of following the old line south via Tientsin before proceeding to Peiping. Construction of this line was begun in February 1941, and finished in April 1941.

Paotow-Shilachi

This line is an extension of the Peiping-Suiyang line from its western terminus at Paotow to the mines at Shilachi and it was built to facilitate the transportation of coal.

Liutung-Tunghai

This is a narrow-gauge line, 6 miles long, built to transport coal from the Liutung mines to the seacoast.

Siaokan-Yangtze

This is a 20-mile line built by the Japanese from Siaokan (a station on the southern section of the Peiping-Hankow line) south to the north bank of the Yangtze river.

Tatung-Tangku

This line would comprise 342 miles and is intended to supply an alternate route to the Peiping-Suiyan line for hauling coal from Shansi province to the seacoast at Tangku (a few miles from Tientsin) where the coal will be supplied to the Japanese navy. Apparently, the new line is intended to avoid the difficult operating conditions over Nankow Pass and certain other portions of the Peiping-Suiyang line. The new line was to connect with the Peiping-Shanhaikwan line at Fengtai, from which point the line is to be double-tracked into Tangku.

The line also served another purpose, in that it enabled the Japanese to penetrate the Chungtiao mountains in southern Shansi provinces, where Chinese guerrillas had been operating for years until the better communications supplied by the new line forced them to evacuate.

As of Janaury 1, 1943, 106 miles of this line had been completed. The line runs largely through very difficult mountain terrain, where construction problems are formidable. However, the line has probably been completed by this time.

As originally surveyed, this line was to have followed the course of the Yungting river from Fengtai into southern Chahar province. From Chencheng in the southeastern corner of Shansi province, the line follows the highway into Peikweichen, on the Tungpu railway, and thence into Tatung.

Suanha-Lungyin

This line is planned to serve the iron mines at Lungyin and will be used almost entirely for the transportation of ore. As of January 1, 1943, the line had been completed from Suanha to Chaochuen and the entire line is believed to be in service now.

Fungyang-Chaikow

This line is being built between Chaikow, a port on the north bank of the Yellow river to Fungyang and the Japanese plan to extend it to Pingyao on the Tungpu line. While certain economic considerations are involved, the line would never have been built except for the desire to facilitate troop movements, particularly to the northern sections of Shansi province.

Hainan Island

The Japanese are building a railway which will completely encircle this southern Chinese island and this project is undoubtedly nearing completion.

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LINES PROJECTED BY THE JAPANESE

The railways previously referred to have all either been completed or are approaching completion. According to Dr. Chang, 10/ the following lines are also projected in Jap-occupied China:

Sinsiang-Tungming

Sinsiang is the station on the Peiping-Hankow line, north of the Yellow river to which the line from Kaifeng has just been built. Tungming is a port on the north bank of the Yellow river.

Hanton-Tsinan

Tsinan is the most important junction point in Shantung province, situated on the south bank of the Yellow river where the Tientsin-Pukow line crosses that stream.

Kiaomi-Hsuchow

This line is to be built in Kiangsu province.

Kalgan-Chengteh

This is to supply a more direct line between the capitals of the two Mongolian provinces of Chahar and Jehol than now exists and give an additional rail link between Manchuria and the rest of China.

Paotow-Anpei

This would be an extension of the Peiping-Suiyan line at its western end.

Wuyi-Sinyang

This line would strengthen the Japanese hold on southern Honan province.

Hangchow-Sunkiapu

This line would supply a more direct route, through Chekiang province, between Hangchow and Nanking, via Wushing, Kwangteh, and Suancheng.

Yuko-Tunghai

This line would cross northern Kiangsu province, from Yuko, via Tunghai, Yencheng, Puming, and Kwanyuan to the coast.

RAILWAY MANAGEMENT IN OCCUPIED TERRITORIES

Two companies have been established by the Japanese for railway operation and construction in the occupied areas of China. They are largely staffed by former South Manchurian Railway officers and are, in effect, subsidiaries of the S.M.R. There is a somewhat complicated set-up of interlocking companies involved. The over-all supervision of the two sections is under the North China Development Company and the Central China Development Company. Under these, the North China Transport Company and the Central China Transport Company operate and, finally, in actual control of the operation and construction of the railways, are the North China Railways Company and the Central China Railways Company.

The North China Railways Company controls by far the greater proportion of the mileage in occupied China. Since its formation in 1939, the route mileage of this company is said 22/ to have increased from 5,000 km. (3,100 miles) to 6,000 km. (3,725 miles). Passenger traffic is stated to have trebled since 1939, and freight traffic to have increased more than 50 percent.

The total route mileage under control of the Central China Railways Company is stated to be 1,200 miles. The only through rail connection with the North China lines is the Tientsin-Pukow railway and, of course, since the destruction of the train ferry approaches on the Yangtze river between Nanking and Pukow, there is no actual physical connection even via this line, over which the Central China company exercises jurisdiction as far north as Pengpu.

The Central China Railways Company has a total capital stock issue of 64,000,000 yen, of which the Central China Development Company holds a majority interest, the rest being divided among 20 other Japanese companies and the puppet government at Nanking.

To assist in the management of the railways in occupied China, the Japanese have set up divisional control offices at Peiping, Tsinan, Kalgan, Tientsin, Taiyuan, Kaifeng, and Hsuchow.

RAILWAY SABOTAGE

The Japanese have been in control of many of the Chinese railways for more than six years now, but they have never been able to eliminate entirely the daring and highly annoying (to the Japanese) sabotage and guerrilla tactics of the Chinese. 23/ Railway garrisons and railway patrols are frequently attacked or ambushed and trains are frequently blown up by dynamite, even deep in Jap-occupied territory. The Japanese have adopted vicious and ruthless methods, such as punishing a whole village if sabotage takes place in the vicinity. They have built trenches along the right-of-way and established concrete pill boxes at intervals for long distances, but still the sabotage goes on. Even after years of oppression, the spirit of the majority of the Chinese remains unquenchable.

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RAILWAYS IN FREE CHINA

As is described in detail later, the Chinese have accomplished wonders in railway construction in the area still in Chinese hands. This is largely western and southern China, where the terrain is extremely mountainous and railway construction would be an arduous task at best, while today it is further complicated by the virtual shutting off of supplies for building railways. Most of the supplies used have been evacuated from rail lines in occupied China, snatched from under the very noses of the advancing Japanese, or have been purloined by daring raiding parties since the occupation.

At first glance, it might seem a colossal, if not impossible, task to steal a railway, yet the Chinese have been doing just that. Railway laborers, disguised as peasants, have filtered through the Japanese lines to assist the guerrillas in the destruction of railway lines and they have brought back large quantities of railway materials. Smuggling an object the size of a bridge girder through the Japanese lines is no light undertaking, but it has been done. These men have, upon occasion, not only destroyed railway bridges within Japanese lines, but have brought the bridge steel back with them. With such materials as are available, the Chinese have been accomplishing miracles in railway construction.

THE RAILWAY MILITARY TRANSPORT CORPS

One of the most effective military bodies in China has been the Railway Military Transport Corps, which was organized on July 24, 1937. All railway employees were made jointly responsible to the civilian railway supervisors and to the officers of the Corps. That this arrangement worked satisfactorily is indicated by the fact that, despite the somewhat dilapidated condition of the Chinese railways at the beginning of the war and the bombardment of the lines from the air and by artillery during the war, in the first five-and-a-half years of the struggle, under the auspices of the Railway Military Transport Corps, 21,582,000 Chinese soldiers and 4,433,000 tons of military supplies were transported. This was accomplished in spite of a steadily dwindling railway mileage in the first phase of the war. A breakdown into periods shows the following:

	Troops	Tons of Military Supplies
July-December 1937	4,460,000	1,230,000
December 1937-June 1938	4,330,000	1,140,000
June-December 1938	2,600,000	480,000
Year 1939	2,830,000	350,000
Year 1940	2,280,000	470,000
Year 1941	3,182,000	413,000
Year 1942	1,900,000	350,000

To accomplish this task, regional railway transport corps were established on each railway 24/ and the civilian and military command of each railway was unified, either by appointing the civilian managing director to an equivalent military rank in the Transport Corps or by making the Corps officer in charge an assistant managing director.

CHINESE LABOR

A great deal of the success in building railways was due to the patient labors of the coolie. Much credit is also due to the more skilled railway workers. As described later, only a few years before the war, they were a demoralized lot, yet the war welded them into a daring, determined and efficient corps, and, on the whole, they worked admirably as a team and assisted in performing what were virtually miracles.

The new railways herein described were built by coolies conscripted locally and each man was required to work for 45 days. On the Dongdang-Nanning section of the Hunan-Kwangsi line, for example, 220,000 conscript laborers were used for a total of 317,800,000 cubic feet of earthwork.

The coolies are formed into units of 60 men each and 10 such units comprise a company. In each camp there are men especially charged with carrying water, cooking, and policing the camp. The elders of each village were conscripted to serve as sergeants of the units or as captains of the companies. The discipline in camps and on the job is on a strictly military basis.

The conscripted coolies are paid on a basis equivalent to about 6¢ (U.S.A.) per day. Certain bonuses are also paid for particularly difficult or dangerous work. The scope of this labor conscription is indicated by the fact that in performing earthwork amounting to 20,000,000 cubic yards on the Hunan-Kwangsi construction, more than 500,000 coolies were employed at one time or another. Chinese railway labor at work is illustrated in Exhibits 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109 and 110.

BUILDING NEW LINES IN FREE CHINA

In evaluating the following achievements in railway building on the part of the Chinese, it should be taken into account that almost all of the mileage built was through extraordinarily difficult country (Exhibits 111 and 112) and that the Chinese had to build almost entirely with makeshift materials.

Lunghai

This line was extended on west beyond its former western terminus of Paoki to Tienshui, a distance of 103 miles. This was an extremely difficult line to build, as it follows a winding course through the Chen mountains, in a region of high peaks and deep gorges. There is not a single stretch of level land in the entire distance. The line follows a mountain stream known as the Wei river and 520 bridges and culverts were built, or more than five to the mile.

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There are 105 tunnels having a total length of 13 miles; the longest being 656 yards long.

An important branch line for the Lunghai was also built. This line normally obtains its coal from the mines at Hanan, east of Tungkwan. When it appeared likely that this source of coal would be cut off by the Japanese, prospectors were sent out to find other coal fields in less-disputed territory. Sizeable mines were found at Tungkwanhsien, where small private "one-man" mines had been operated for many years. Accordingly, an 86-mile branch was hastily constructed. This branch leaves the main line at Sienyang, 14 miles west of Sian and it was built to Tungkwanhsien via Sanyuan, Fuping and Yaohsien. From the latter point, the line traverses mountains and two tunnels aggregating 400 yards were built. All bridges on the line are built of wood and there are 141 culverts. In all, 6,000,000 cubic meters of earthwork were involved for the entire line. The coal fields tapped by the new line are 30 miles in length from east to west and about 18 miles from north to south. The seams vary from one to seven feet in thickness.

Chengtu-Tienshui

This projected line is closely tied in with the completion of the Paoki-Tienshui extension of the Lunghai. While this line is still in the planning stage, it is to be built as soon as possible and the detailed surveys show the following data:

The line will be 469 miles long, with a ruling grade of 1.5 percent. Between Chengtu and Kiangyu--112 miles--the country is level but the line would have to cross many rivers which would require a total of 2,200 yards of bridges. Earth and stonework in this section would amount to 247,000,000 cubic feet. Rolling to rough country is encountered between Kiangyu and Kwangyuan, 104 miles, involving 602,000,000 cubic feet of earth and stonework, 2,400 yards of bridges and 2,500 yards of tunnels.

Between Kwangyuan and Hingling, 230 miles, wildly mountainous country would be traversed, requiring a tunnel 1,072 yards long, and total tunnels of 2,962 yards. Also 1,200 yards of bridges would be required, while the earth and stonework would reach the formidable figure of 1,410,000,000 cubic feet.

The last stretch of this line, between Hingling and Tienshui, 23 miles, is in relatively flat country, requiring 141,000,000 cubic feet of earth and stonework, 995 yards of bridges, and 1,000 yards of tunnels. The length of tunnels on the entire line would be 18 miles.

Hunan-Kweichow

This was an ambitious project intended to link up the Canton-Hankow Railway with the Southwestern provinces. As originally laid out, it was to run 623 miles from Chuchow to Kweiyang. The surveys had been completed by the Chinese and much of the foundation work had been completed, including the sinking of piers for large bridges over the Siang, Chi and Yuan rivers in Hunan province. Also, 109 miles of this line had actually been completed when, because of imminent Japanese encroachment, the completed section was torn up and removed in March 1939, and the entire project was temporarily abandoned.

Hunan-Kwangsi

This is one of the major projects in China's plan of rail communications in unoccupied territory. The first construction was begun in August 1937, and the line from Hengyang (on the Canton-Hankow line) to Kweilin was completed in August 1938, 224 miles of line having been built, under the stress of wartime conditions, in 365 days. Among other things, the new line afforded a haven and means of escape for rolling stock which would otherwise have been destroyed or would have fallen into the hands of the Japanese. In the first ten months, this line handled 480 military trains carrying 360,000 troops; also 235,000 tons of freight and 640,000 civilian passengers.

An extension was completed from Kweilin to Liuchow, 108 miles, on December 16, 1939. From that point it was intended to complete this line south to Nanning and thence to the Indo-Chinese border at Chennankwan, both to provide another route via which supplies from the outside world might reach China and also to bring about a closer link between Kwangsi province and the rest of China.

Work was started on the southern section beginning at the Indo-Chinese town of Dongdan, 2-1/2 miles south of the border. The line crossed Chennangkwan pass through high mountains at the border, and, on the northern side, a number of tunnels were built. At Ningming, a temporary wooden bridge, 220 yards long, was built across the Ming river. North of that point the line follows a series of narrow valleys between high mountains, with a tunnel 120 yards long in this section. The line comprised 700 bridges of over 22 yards each and was to have included a huge bridge over the Yung river at Nanning. The earthwork amounted to 317,800,000 cubic feet and the stonework 42,370,000 cubic feet.

When the Japanese landed at Yamchow and threatened to capture Nanning, all earth and stonework had been completed and 45 of the total of 75 miles of rails had been laid. The piers for the Ming river bridge were also complete. With the approach of the Japanese, all wooden bridges were burned and work ceased. The Japanese captured Nanning in April 1939, and, while the Chinese eventually drove them out, it was apparent that, because of the encroachment of the Japanese into Indo-China, no help could be expected from that direction, the rails were torn up and the project abandoned.

Work had also been done on the northern section which was to have connected Liuchow with Nanning. The line had actually been completed from Liuchow to Laiping, but it was halted there when the Japanese captured Nanning. The completed line is still operating, however, as the Japanese did not menace the northern section and Laiping is the site of coal mines.

(OVER)

The Liuchow-Nanning line, if completed, would have involved 283,000,000 cubic feet of earth and stonework. The largest bridge, 330 yards long, was to have been constructed over the Hung river. It was to have comprised nine spans of 33 yards each and a central span of 98 yards. There were 15 other bridges of 137 yards each to be built and many smaller bridges totaling 880 yards, as well as 760 culverts. When work was stopped, 82.5 percent of the earth and stonework was completed; also 30 percent of the bridges (but not the large Hung river bridge); 73 percent of the culverts; and 71 percent of the drainage.

When it became apparent that no help could be expected through Indo-China, the Chinese decided to build this line westward instead of southward from Liuchow, with the idea of reaching Kunming eventually and there to connect with the Yunnan-Burma line.

The extension of the line westward to Kweiyang was to be completed late in 1943 and this section of the line is known as the Kweichow-Kwangsi and is described under that heading later.

The rails used in constructing these lines were taken from the dismantled Hunan-Kweichow railway. The ties were also salvaged from dismantled lines and consist of hardwood ties, some imported Oregon pine ties and fir ties produced locally.

The traffic capacity of the Hengyang-Liuchow section is 31,000 tons per month. The Kweilin-Liuchow portion of this section follows the Loching river through rugged, mountainous territory and, as a matter of fact, as in nearly all of western China, mountainous territory is encountered throughout the line.

The bridge over the Siang river on this line is 460 yards long, on cement-concrete piers, with steel trusses. Many of the bridges on this line have combination trusses, using pine timber for the body, iron rods for the vertical tension members, and sheet steel piling for the bottom chords.

The Liu river bridge is 635 yards long, and 22 yards high. (Exhibit 113). Its 18 spans are supported by 17 piers and 2 abutments. This is a peculiar but apparently adequate structure with the piers (above the water level) built entirely from rails salvaged from other lines. In all, 18,600 yards of 85-lb. rail were used in its construction, also 500 yards of 35-lb. rail and 4,160 yards of 12-lb. rail. One-half a ton of other steel was used.

There are also many timber trestles on the line, but regardless of construction, all bridges on the line are built to at least a Cooper E-35 loading rating.

There are literally hundreds of tunnels on the line, totaling 5,900 yards in length. They are mostly quite short tunnels and, in view of the shortage of cement, they are lined with stones and lime mortar.

Kweichow-Kwangsi

This extension of the Hunan-Kwangsi line from Liuchow to Kweiyang involved difficult construction. The difference in elevation between the latter two points is 3,018 feet and rugged mountain ranges must be crossed en route. There are 12 miles of 2 percent grades on the line and the bridges and frequently the embankments are 230 feet high. Between Taksing and Lungli, both the Fungyang and Yunwu mountains are crossed by means of switchbacks and another portion of the Yunwu range is penetrated by means of a mile long tunnel at Tungshanping.

The railway has a ruling grade of 2.7 percent. It has an initial traffic capacity of 1,500 tons per day. Most of this is handled over the heaviest grades by a 2-8-0 and a 2-8-2 locomotive. These two engines have been specially equipped with Westinghouse ET-6 automatic air brakes. Other smaller locomotives have also been specially equipped for this line. All passenger and freight cars used on the line have either K-2 triple-valve automatic air brakes or straight air braking. All of this rolling stock represents equipment selected from equipment evacuated from other railways now in the hands of the Japanese.

Between the summits of Liuchow and Kinchenkiang passes, 100 miles, the line is on a fairly level plateau, but, between Kinchenkiang and Tushan, 147 miles, the worst country is encountered.

The line includes 20 large bridges, with a total span of 1,968 yards. Most of these have piers of concrete under water and old rails above the water level. The 24 tunnels on the line have an aggregate length of 5,468 yards.

Peh-Chuang

For many years, this 10-mile line, of 2 ft. gauge, was the only railway in western China. It is situated in the Kiang Peh district of Szechuen province, and brings between 400 and 500 tons of coal per day down from the mountains (Exhibit 114). It leaves the Kailing river bank and shortly makes an abrupt climb on a five percent grade to Bei-Miao (Exhibit 115). From this point to the mines in the vicinity of Tai-Chia-Gou, the grade is about two percent for most of the distance. The line owns four locomotives. Two of these are of English make and are 40 years old. Two Orenstein-Koppel locomotives about ten years old do most of the work. One of these of 110-h.p. is used on the five percent grade. A 70-h.p. locomotive is used on the less steep sections.

Yunnan-Burma

This proposed line between Kunming (formerly called Yunnanfu) and Lashio, in Burma, involved elaborate negotiations with the Burmese government; first, because it necessitated the building of a new railway in Burma from the existing northern terminus of the line at Lashio to the frontier, a distançe of approximately 120 miles, and, second, because the frontier in the region the railway was to traverse had never been definitely established and this involved political considerations.

(OVER)

China was in dire need of this outlet with the outside world, to supplement the Burma Road, for, as against the minimum needs of 200,000 tons of military supplies and 100,000 tons of other goods, the Burma Road had a capacity of only 180,000 tons a year.

It seemed essential to the Chinese that the Burmese section should be built first, in order that railway materials could be shipped over it for the construction of the Chinese section of the line, thus not overburdening the already jammed Burma Road. However, they did not wait, but began construction on their side of the border.

The line traverses territory that offers about as difficult engineering problems to railway construction as may be found anywhere in the world. As finally surveyed, the line comprised two sections. The 244-mile section between Kunming and Siangyun roughly parallels the Burma Road, via Anning, Lufeng, Ipinlong, Kuangtung, Chuhsiung, Chennan, and Yunnanyi.

The second section of 248 miles proceeds in a southerly direction from Siangyun to Kunlong, via Mitu, Mankien, Chilung, Kunglang, Yunhsien, Menglai, and Mengchien. The ruling grade on the first section is 2-1/2 percent, and 3 percent on the second section, with a minimum radius of curves of 110 yards on the entire line. The route crosses the Mekong river at Kunglang, necessitating a 175-yard bridge. Other large rivers to be crossed are the Menghua, the Hanting, and the Yangpi.

The one-meter gauge was chosen for this line to conform with that in use on the Burmese railways. Even so, it was estimated that a traffic capacity of from 30,000 to 50,000 tons per month could be attained.

Prior to the invasion of Burma, little progress had been made in that country, but, in China, the railway was completed between Kunming and Changpo, 15 miles. It was 80 percent complete between Changpo and Ipinlong, a further 62 miles; 20 percent between Ipinlong and Siangyun, 157 miles. The second section was about 10 percent complete between Siangyun and the Burmese frontier. Construction scenes on this line are shown in Exhibits 116, 117, 118, 119, 120, and 121.

Work was halted when the Japanese occupied Burma. Obviously, however, it could be begun again and the railway rushed to completion shortly after Lord Mountbatten runs the Japanese out of Burma.

Suifu-Kunming

This railway was projected as a means of giving the Yunnan-Burma railway an outlet north to important cities and also to the Yangtze river. Complete surveys were made and a great deal of work has been done. The 528-mile line would run from Kunming, via Kutsing, Suanwei, Weining, Chaotun and Yentsing to Suifu.

Between Kunming and Suanwei, the work is difficult for 30 percent of the distance, although no long bridges or tunnels are involved. Between Suanwei and Weining, the highway is paralleled over the mountains, requiring many cuts and fills.

The territory to be traversed by this line is rich in minerals, the principal mines being as follows:

Mingliang	Coal
Suicheng	Iron
Iliang	Copper
Taiwenchi	Copper
Chaotung	Low-grade bituminous coal
Tentsing	Bituminous coal

Considerable work has been done on this line. The Kunming-Kutsing section of 99 miles was opened for traffic in March 1941. The roadbed between Kutsing and Suanwei (62 miles) is completed. Some work has been done on bridges and culverts between Suanwei and Weining (106 miles) and also for 12 miles south from Suifu.

Kunming-Indo China

The recent history of this road has been characterized by destruction rather than construction. Originally, this meter-gauge line ran from Haiphong, a port in northeastern Indo China to Kunming in the Chinese province of Yunnan.

In peacetime, the freight handled over this line only amounted to 3,000 tons per month. However, with very little cooperation from the French, the Chinese had stepped this up to about 7,000 tons per month in 1939. In January of that year, Japanese bombers destroyed two important bridges on this line south of Kaiyuan. These were repaired promptly, but, when the Japanese landed in Indo China, the Chinese blew up the bridge at Hokow on the frontier and dismantled a 93-mile section of the line between Hokow and Chechun.

This railway leaves Laokay the last Indo-Chinese station at an elevation of 230 ft. and crosses into China within a few kilometers. For a time it ascends gradual slopes, then it enters the gorges of the mountain torrents of Namti, Pa Ta and Ta Chan. Sometimes the railway is just above the level of the river, but, at other times, it rises to heights of as much as 1,000 ft. above the stream and the crossings of the rivers are frequent. The bridges are exceedingly numerous and there are some 107 viaducts and bridges of over 65 ft. in length on the Chinese side, as well as 172 tunnels, with a combined length of more than 15 miles. Eventually, the line reaches the Kunming plateau, at an elevation of 6,600 feet. The profile of this line is shown in Exhibit 122.

A description of the line before it was partly destroyed follows:

Beginning at kilometer 20, north of the frontier, the line ascends 1,700 meters in the next 120 kilometers, with an average grade of 1.4 percent and a ruling grade of 3 percent. The line crosses the Red river on a long steel bridge between Lao Kay in Indo-China and Hokow, in China. The Red river is again crossed on a short girder bridge at kilometer 42, and the line enters the gorge of the Nam Ti river. At kilometer 65, a steel trestle 200 feet high and 400 feet long, with almost a right angle

(OVER)

curve, is crossed and a tunnel is entered at the opposite side. On this climb there are more than 100 tunnels ranging from a few yards to half a mile in length. At kilometer 83, the railway crosses the Nam Ti again on one of the world's most remarkable bridges. The gorge is a vertical cut more than 1,000 feet deep, with sheer walls 400 feet apart. The bridge consists of a braced girder supported by two unsymmetrical girders which meet in an inverted V. There are two tunnels on 90 degree curves at both ends of the bridge (Exhibit 123).

From Mong Tze summit the line drops on a 1 in 40 grade to Ta Ko plain, reaching Mong Tze Junction at kilometer 148. From here a 0.60 meter gauge line branches off to Mong Tze, 30 kilometers. This branch is principally used for hauling tin from the mines in the district.

At kilometer 240, the line enters the Lah Ti gorge and is characterized by many tunnels and retaining walls to guard against rock slides. The summit is finally reached at 2,170 meters and the line drops down on a 1 in 40 descent to the Kunming plateau.

The difficult terrain is illustrated in Exhibits 122, 123, 124, 125 and 126.

SECTION III - PRE-WAR RAILWAY CONDITION

In order to understand the transportation picture of China, a certain amount of background material is vitally essential. An expert on the subject 25/ gave a most detailed account of the situation immediately prior to the outbreak of the Sino-Japanese war (June 1937) as follows:

History

China's first railway, if we agree to exclude the short-lived Shanghai-Woosung Railway, was built by a mining concern and later worked as a private railway company. It was found, however, that the difficulty of raising private Chinese capital made it desirable for the Chinese Imperial Government to intervene in order to complete an extension of the line to the capital (Peking). As Chinese capitalists were still reluctant to invest in railways, even under the government aegis, the Chinese Government obtained a foreign loan by an issue of bonds through the Hongkong and Shanghai Bank under certain stipulations by the bank which took the form of a "Loan Agreement." These conditions stipulated that, through the appointment of Britons to key posts on the railway, a large measure of financial and administrative control should be in their hands. The arrangement might be considered a modification of the system of foreign railway companies such as was, and is, successfully operated in South America and other countries, and was created to meet the natural desire of the Chinese to have at least nominal control of the only modern means of communication in the Empire.

The refusal to entertain the idea of foreign-controlled private railway companies under strict Government inspection was also caused by the system of legal extra-territoriality then and now in force under which the subjects of important nations were under Consular, and not Chinese, jurisdiction. This system, which was a modification of that adopted in the Turkish Empire in the sixteenth century, though excellent in theory, has not, for various reasons, had good results in China, and in practice has sometimes hampered progress, as in the present case.

The original loan agreement concluded between the Chinese Government and the Hongkong and Shanghai Bank, as the agents for foreign bondholders, was regarded as a model, and was imitated to a greater or less extent by later loan agreements.

The ensuing period in China's history was an unsavory one. China had been so greatly weakened by the Sino-Japanese War that it seemed to the world that the break-up of the Empire was at hand, and each great power maneuvered to prevent any other powers from seizing part or all of it. These maneuvers often took the form of forestalling other nations in their attempts to secure railway and other concessions and also of enhancing as much as possible their trade with China. In consequence there followed what has been called the "Battle of Concessions." In so far as railways are concerned, the powers saw that railway concessions were not only politically desirable, but economically profitable; competition in this sphere was keen, and several of China's major railways came into existance as a result.

The Boxer Rising called a halt to these politico-economic maneuvers, and after the Russo-Japanese War the enhanced comparative strength of Britain and the United States in China causing a relaxation of the expectation that China was shortly to be divided up by the powers, the clamor for political railway concessions died. Thereafter loans for railway construction were made upon a business basis, though as the lenders were still supported by their governments this often resulted in political pressure being put upon the Chinese government. Many Chinese as a consequence not unnaturally failed to note the fundamental difference in the basis of the loans, and could see little improvement in China's position.

In justice to all parties it might be pointed out that, though political pressure was frequently used to procure further advantages for foreign syndicates, it was also much used to overcome obscurantism, petty restrictions, and favoritism on the part of some of the officials. Nevertheless, though the results may often have been good, pressure of this kind could not fail to cause resentment in such a proud nation as the Chinese.

The scrupulous care with which payment was made on the railway bonds as they fell due improved China's credit rapidly, and the terms on which railway bonds could be sold on foreign markets became progressively easier. As a result, loan agreement safeguarding clauses (employment of foreign staff, deposition of funds, etc.) became less and less stringent.

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In 1911 the Chinese imperial government decided to take back direct control of the trunk railways from the provincial governments, and this was the immediate cause of the revolution which caused the displacement of the Manchu dynasty. The effect of the revolution on the railways was not great, and after a short pause the flow of foreign money and materials to China for railway construction was actually accelerated.

World War I, however, caused an absolute cessation of foreign lending, and its aftermath of financial confusion prevented any renewal of interest in Chinese railways. In the meantime China had commenced that long period of civil wars which, reminiscent as they were of England's Wars of the Roses, were extremely confusing to outsiders, and caused conservative foreign financial interests to await tranquillity before re-entering the investment field.

Railways, being the sole modern means of transport, naturally suffered severely during this period, and the foreign railway officers, whose dual duties under the Loan Agreements were to safeguard not only the rights of the central government, but also the interests of the foreign bondholders, were placed in an invidious position, and had to endeavor to withstand the requirements of the various war lords and governors in whose territories they chanced to be. In consequence, a large majority of the foreign staff, and also many of the experienced Chinese staff, on the various railways were removed and their substitutes were frequently military or political appointees whose knowledge of railway matters was sometimes small.

Internal Complications

The rise of the Nationalists in 1926 was followed by their split with the Communists in 1927. Prior to the split, much communist propaganda had been spread, and this had caused a large fall in the efficiency of the various railways, especially in shops and sheds, due to decay of discipline. It became, consequently, less and less possible to repair the damage to the railways done in the civil wars.

To the heavy damage to rolling-stock resulting from the wars there was added the wholesale removal of locomotives, passenger and freight cars by the "Old Marshal" Chang Tso-lin when he retreated to "the three Eastern Provinces" (as the Chinese call Manchuria), and this equipment was used by him on the new railways which he built in Manchuria, and little of this stock ever returned to the owning railways (mainly the Peiping-Hankow, Tientsin-Pukow, Peiping-Suiyuan, and Lunghai).

In 1929 the National Government occupied Peking (the name of which was changed from "Peking," Northern Capital, to "Peiping," Northern Peace), and there came a period of peace. A Ministry of Railways was then established (formerly the railways had been under the Ministry of Communications) in Nanking, the new national capital, to endeavor to rehabilitate the railways, which by then were in a deplorable condition. On some lines as many as 60 percent of the locomotives were out of service, and the condition of rolling-stock was almost as bad. Interest on bonds was in arrears on almost all lines, and repayment of, or even interest payments on, the large material loans, which during the wars had been made on increasingly onerous terms, was also impossible.

Before palliatives were possible, yet another war broke out, led by certain discontented leaders then in the north. For six months the struggle continued along the Peiping-Hankow, Tientsin-Pukow, and the Lunghai lines, and still more damage was done.

The ensuing peace found the majority of the railways in a condition little short of chaotic, with but a small proportion of serviceable rolling-stock, over-aged and rotten sleepers, patched and weakened bridges, a shortage of spares of all kinds, an insubordinate staff heavily in arrears with salaries and wages, and an enormous mass of both long-term and short-term indebtedness which increased inexorably year by year, much of it at heavy compound interest.

That was the problem confronting the Ministry of Railways in 1931.

Conditions in 1931

It is no exaggeration to say that the task facing the Ministry of Railways in 1931 was one of the most complex and difficult railway problems which has ever been faced.

The railways were in ruins, large expenditure was necessary to keep them at work at all, and yet money could only be borrowed on almost prohibitive terms which still further increased the load of debt, already so great that the ability of the railways to pay it off at all was already questioned. Any railway official might be forgiven, therefore, who regarded the task as impossible.

The form of capitalization of the railways was a handicap, as, being a bond and not a share indebtedness, it was inflexible and allowed no margin for the bad times which the railways were now experiencing. Fortunately the bondholders, to their credit, realized the difficulties and did not adopt an intransigent attitude, which would still further have complicated the position. The foundation of the subsequent improvement in the railways was, therefore, the desire of the Government and Ministry of Railways to honor its indebtedness and the willingness of the bondholders to take a broad view of the situation. The fact that tacit cooperation existed between them almost from the beginning should never be forgotten.

The stoicism of the Chinese was well exemplified by the attitude of the general public towards the Chinese railways at this period. Trains were few, crowded, slow, and grossly unpunctual. The coaches were dirty and damaged, engine failures were frequent, and the unpaid railway staff frequently obtained money by illegal charges. All these troubles were faced by railway users with a cheerful equanimity which would be met with in no other country.

The movement of freight which had been awaiting the restoration of train services was considerable, and called for the utilization of every serviceable wagon. Revenues, therefore, soon reached substantial figures. The railways, however, were in far too serious a condition for this revenue to have any immediate effect on their general position. Their credit was strained to the utmost to provide the wherewithal to continue operation, while the result of years of neglect may be seen in the enormously enhanced operating ratios. Furthermore, unproductive transport and taxation were still at a high level.

It should be remembered that it is the average of the railways which is being considered. Some railways in the coastal areas were in much better condition than those inland for several reasons. The Loan Agreements of these railways prevented them from giving much assistance to less fortunate lines.

At the outset, therefore, there was little opportunity for creating a detailed program of rehabilitation, such as the Russian Five-Year Plan. The Ministry and the railways found that the only possible course was to use the available revenues to pay off the most urgent creditors, and thus secure sufficient new credit to continue operation. To do this, coal, oil, consumable stores, ~~and a~~ few vital spares were essential, and equally urgent was the purchase of new ties. The renewal programs were all in serious arrears, and on some lines the state of the track was so weak that it was dangerous to run at any greater speed than twenty miles per hour and sometimes even less. At least two million ties were required as soon as possible.

In September 1931, the Mukden incident occurred which led immediately to the occupation of Manchuria. The occupation of Manchuria and the subsequent creation of a new state in that area reduced the lines under the aegis of the Ministry of Railways by about 3,500 kilometers, and at the same time rendered permanent the loss of the locomotives and rolling-stock taken away by Chang Tso-lin.

In January 1932 the Shanghai affair occurred, which caused an estimated damage of $30,000,000 to the Nanking-Shanghai railway, including a serious loss of revenues due to complete cessation for three months and a restricted service for several months afterwards and the partial destruction of the shops and stores. Not only the Nanking-Shanghai, but also the connecting lines suffered through loss of traffic.

These events naturally caused a sharp drop in revenue, and it was not until 1935 that the revenue rose above the 1931 level. Despite this setback, however, the reorganization of the other lines was proceeding. It must not, however, be assumed that this reorganization could be effected in an atmosphere of calm consideration. Interruptions and emergencies continued throughout, while varying subsidies to military expenses and local contributions caused financial uncertainty.

Efforts were made to create a long-term system or a plan to improve the railways, but this had to be varied with changing circumstances. Furthermore, the reduction of operating expenses by an increase in the efficiency and a decrease in the number of the staff, as would be done in an industrial undertaking, could be carried through only to a very minor extent owing to political reasons. These reasons are simple: in a democracy, political power is often dependent on popularity. A high official who created unemployment by reducing staff would not be likely to increase his popularity, to say the least, and there was, therefore, an inevitable tendency to retain surplus staff until they could be given posts on the new railways which, everyone anticipated, would shortly be built.

Revenues continued to mount. Payment was made of wages and salaries, and a start made on catching up on the arrears of back pay, thus causing more content among the staff. Sums became available not only for sleepers, but for the purchase of fire-box steel, tires, drills, tool-steel, and other necessary items, and also some spares in quantities sufficient to permit the shops to cease robbing unserviceable locomotives and rolling-stock of spare parts in order to keep the remainder in repair.

The workshops of the railways were choked with unserviceable and wrecked locomotives and rolling-stock. Many of these would have been uneconomic to repair had new capital been cheaper, but as it was repairs had to be done as opportunity offered. The general shortage of locomotives and rolling-stock was limiting the earnings of the railways very considerably, and in addition, many wagons were under military control; the turn-round of the wagons was often tardy; and the engines were, on the average, unable to pull more than about 50 to 60 percent of what they should. A vicious circle had been formed. Shortage of rolling-stock and higher operating expenses were preventing payment of external debts, and until these were paid capital could not be borrowed to buy new rolling-stock or reduce operating expenses.

It may, of course, be argued that the government as a whole might have come to the assistance of the Ministry of Railways, but this had not hitherto been the custom, and, though the Ministry had large claims against other government departments for military transport, etc., those departments had large counter-claims. The only method at that time possible for the Ministry of Railways was, consequently, to proceed independently, and, while endeavoring to sustain the credit of the lines whose bonds had not sunk to hopelessly low values, to devote as much revenue as possible to material improvements in the railways, including the purchase of new locomotives and rolling-stock which, by increasing the speed and number of the trains running, would considerably augment the revenue.

The Locomotives and Rolling-Stock

Repair of existing locomotives and rolling-stock had naturally become of prime importance, and as the growth of the shops had failed in past years to keep pace with the increase in locomotives and rolling-stock, the heavy damages of the war years had put them seriously in arrears. Furthermore, the changes in personnel and the spread of discontent among the staff during the disturbed years had lowered the efficiency and output of almost all the shops.

To overtake the arrears, some shops worked as many as four hours of overtime per day, while others adopted the two-shift system. Neither of these schemes was wholly successful in its object, as shortage of spare parts, stores, and extra skilled staff prevented the output from increasing in proportion to the extra hours worked.

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Typical of the small but vital difficulties besetting the mechanical officials was the impossibility of transferring staff from roundhouses to shops, as the staff, being in arrears with their salaries, were owing such large sums to local tradesmen as to make transfer impossible. Furthermore, the shop staff objected to sending "their" engines for repair to the shops of other railways, as they feared reduction of staff as an ultimate consequence.

As the months passed, the accumulation of locomotives and rolling-stock awaiting repairs at the various shops actually increased to a considerable extent, due to the resumption of heavy mileage entailing breakages of worn-out parts and for another important cause. This was the large number of tires of minimum thickness extant, many of which became loose. They were kept running either by fastening the tires to the wheel-spokes by clamps or by putting liners between them. In either case it was impossible to use the brake-blocks on these tires, and these were removed. In consequence the braking power of engines and trains was seriously diminished and frequent collisions occurred as a result.

The condition of the shops had serious repercussions on the roundhouses. It became impossible for either shops or roundhouses to maintain stocks of finished parts, and to relieve the shops rough castings instead of finished parts were sent out to each roundhouse which possessed suitable machine tools. The system, however, did not work out well, as not only was the skilled staff at the roundhouses of a very low quality, but as large numbers of castings could not be sent from shops it was usually impossible for the roundhouses to machine for stock, and engines had to be held up while parts were finished.

The foregoing difficulties were intensified by the fact that locomotives and rolling-stock of different lines, which had become mingled during the troubled periods, had not as yet been sorted out to any great extent, due to the competition of all the lines for the least damaged cars irrespective of ownership. Each railway feared exchanging a good vehicle for a bad one, and in consequence, interchange of cars entirely ceased for a period, and only recommenced after many cars had been repainted in the using line's colors. Before the cars were sorted out some years elapsed, and during this time, as may be imagined, the multiplicity of equipment on each railway was a serious handicap to the car repair shops.

Locomotive boilers were, perhaps, the most difficult feature of this difficult period. A very large proportion of the boilers in China were, and are, over-age according to the usual computation, and fire-boxes were in extremely poor condition. As only the cheapest materials could be afforded for repairs, they gave constant trouble, which was accentuated by the fact that the shortage of good boilermakers, and even more of competent boiler-inspectors, was, and always has been, acute. Careless washing out of boilers frequently caused scorched plates through accumulations of scale, while unskillful repair work caused grooved tube-ends, cracked tube-plate bridges, and bulged tube-sheets. Inasmuch as spare boilers did not exist on many of the railways, the delays to engines waiting for boilers were, as can be imagined, very great.

Welding here came to the rescue. Some good welders had been obtained on some of the lines, and some extraordinary feats of welding were attempted, often with some success. Tube holes in tube-plates had often been brought back to size by welding, and cracked tube-plate bridges repaired, but more ambitious repairs were now carried out, such as welding new flanges to tube-plates, or even welding two halves of a tube-plate together. Superheater flues had rings welded on, while superheater elements had had their return bends, elbows, and ball-joints welded to such a degree that the extent of the steam passage through them was a matter of doubt. On some engines the entire superheater had been short-circuited at the header owing to shortage of elements. Much welding of pitted sheets and foundation rings was done, though not always with success. Despite these efforts the condition of the boilers was, it will be easily understood, very bad indeed, and hydraulic tests revealed such multitudinous small leaks, which nothing but new materials would rectify, that steam pressures had to be reduced, sometimes very materially.

The purchase of spare boilers and fire-boxes, and also of good quality sheeting and stay-bolt material, soon caused an improvement, though it will be long before the boiler position is what it should be. One of the main obstacles to rapid improvement was the lack of standard classes of boiler. In China the average number of boilers of each type is less than five, and the fittings and connections are almost as diverse. An attempt to provide standard boilers for several similar classes of existing engines is to be made, and with clever designing much may be done.

The state of the engines apart from the boilers was also the cause of grave anxiety. Loose tires have been already mentioned and their corollary of collisions, but another result of the rough treatment the engines had undergone was that of cracked frames, which were a very common feature. Both bar and plate frames cracked, but whereas the former cracked generally as the ultimate result of a collision, cracks in the latter were usually the result of a derailment. Plate frames had formerly an advantage over bar frames in that in a collision they bent rather than broke, but the advent of welding had largely nullified this advantage, and as the number of plate frames which cracked due to wear and tear was rather higher in China than elsewhere, there was little to choose in efficiency between the two types.

Cracked spokes were to be found in almost every engine, and welding was here of little permanent value. A large number of axles were of minimum diameter. Some of these had to be built up by welding, but in some cases leading and trailing coupled axles could be transposed without upsetting the balance of the wheels, and as the axle-wear took place mainly on the trailing axle, a new lease of life for it was thus provided at no cost. Bearing springs had been broken and replaced so often that the plates were latterly of very poor quality steel which required yet more frequent replacement, while cracked and loose buckles were an additional trouble.

The walls of cylinders had in many cases become dangerously thin, but only too frequently neither new cylinders nor new liners could be afforded. Where new and larger piston-heads to fit the worn cylinders were unobtainable, bronze or iron junk rings were cast on to the original heads.

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Poor quality brass was a great handicap. On many of the lines the brass which was used for the best quality work had greatly declined in quality as a result of being repeatedly remelted and reused. Crown brasses and side-rod brasses made of this brass wore out very rapidly, while boiler fittings soon leaked and required replacement.

In addition to these main causes, a great many minor points caused extra trouble and work. One may be cited as an example. This was the worn-out and scorched condition of many smoke-box doors, which had ceased to be air-tight, and thus impeded the steamraising capabilities of the engines to which they were fitted. Replacement of these doors was essential, but could not be afforded, and instead fire-clay had to be used in large quantities to stop the leaks before the engines left the roundhouse.

In the matter of passenger cars the condition was as bad as that of the locomotives and boilers. A large proportion of the up-to-date coaches, especially from the Peiping-Hankow line, had, as stated, been removed by Chang Tso-lin, and had never returned or been replaced further than by the conversion of cars to lower-class passenger stock. Also the various campaigns had reduced all cars to a common level of dirt, decay, and wreckage. Apart from the many cars which had been burned out or smashed in collision, all mechanical parts, such as tires, couplers, brake-gear, and lighting, were badly worn, while the upholstery, etc., was in a very bad state.

Most of the bodies were of wood, and as Chinese people have a genius for working in this material, new bodies were built on the old frames, and if the design of these was sometimes imperfect, the workmanship was adequate, though as softwood had to be used the life of these bodies was short. Interior fittings were repaired as far as supplies permitted.

At the end of 1931 wrecked and disabled freight cars were scattered all over the war zone. Slowly they were moved to shops, and a certain amount of repair done by transferring sound parts. From that time onwards steady work has been done in repairing the remainder. Cars have gone out containing little but the original sole-bars, and even these have been laboriously straightened and reshaped.

It should again be pointed out that the only justification for some of the repairs carried out was the high cost of capital. Had it been possible to borrow new capital on reasonable terms, the cars referred to would certainly have been scrapped, but with the then condition of the money market, the interest and amortization rates on capital borrowed to purchase new wagons would have more than swallowed up the savings made by the reduction in repairs and maintenance.

The Permanent Way

In our survey of the railways at that period, we can now turn to the permanent way. The main need, as already mentioned, was for new ties. Shortage and cost of capital again entered into the problem and made the higher cost of hardwood or creosoted softwood not only difficult to afford, but financially unprofitable, and softwood was accordingly used in the majority of cases, though it was known that its life could not exceed about eight years, and in some districts less than three. The cleanliness of the ballast had a considerable effect on the life of the ties, but, though the gangs were adequate, it was frequently impossible to clean the ballast unless complete sections were relaid with new ties throughout, as so rotten were the old ties that had the ballast been dug out for cleaning, the ties would have fallen to pieces. Ballast cleaning was, therefore, in many cases impossible, and ties, both old and new, lay in damp mud and their life was but short.

As to the rails, these were in almost all cases the identical ones that were laid when the line was first built, and they had suffered badly during their long life. The running surface of the rail, instead of being a curve, was too often worn completely flat; the rail-ends were battered and frequently had a permanent set, having low joints and high centers, which refused to yield to treatment. Their fish-plates were in still worse case, for they were so worn that they could no longer span the web of the rail and hold the joint solid by wedging themselves between the head and foot.

The repair and renewal of ties and bridges was more urgent than renewal of rails, for, apart from the flat rail-top, it could not be maintained that the state of the rails was actually dangerous. But when funds became availabe, albeit in limited amounts, a start was made in shimmying the fish-plates and raising the rail-joint. Cropping the rail-ends in order to improve the joints was often suggested, but it had the cardinal objection that it means buying a certain amount of new rail.

The Bridges

During the wars many of the bridges had been destroyed, the broken spans jacked up and mounted on tie stacks, and frequently destroyed again. Many bent and damaged girders were removed and laboriously straightened and patched. Others had to be replaced. To provide material, bridges over watercourses normally dry were replaced by tracks laid across the bed of the watercourse with stone dressing. In this way a number of extra spans were obtained which were used either whole or in parts. Old rails or timber bents were used to support, either temporarily or semi-permanently, spans which had been permanently weakened as a result of multiple damage. It need not be emphasized that had capital been cheaper a large proportion of this work would not have been undertaken, as it would have been better in every way, and more economical, to replace the broken spans with new and stronger bridges.

It had been noted that welding has been widely used in locomotive rolling-stock repair, and it was natural that the use of welding for strengthening the older and weaker bridges should have been mooted. Despite some reports of failure due to inability to anneal the weld after completion, many welded bridges in other countries have given no trouble, and in the present case the attempt is well worth while and is being carried out.

China is unusual in that the rails have on most lines always been stronger than the bridges, and in consequence the limit to locomotive size is not axle-load, but its effect on a bridge of certain strength.

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The Other Departments

This survey of the various railway departments to obtain a bird's-eye view of what they were doing to overcome the difficulties of the position must include the operating department. This was naturally put to great difficulties to maintain the traffic by the difficulties already mentioned, and also by the fact that with two minor exceptions all the main lines in China are single track. In consequence the crossing of trains without delay depends on the punctual arrival of both. If one train going north is late, the south-bound train which meets it at a certain station will also be made late. Unless the latter train can make up lost time, it will delay all north-bound trains which it meets, and so on. With engines in bad condition, delays were frequent; furthermore, with a strict speed limit to avoid danger on rotten ties it was impossible for trains, once late, to make up more than a trifling amount of time, even if the engine happened to be in good order. In consequence the on-time performance of trains was very poor, and on some lines became so bad that trains of the previous day delayed trains on the following day, preventing any fresh start being made each morning. As the railways in China do not observe Sunday as a time of rest, and as exactly the same service is run, it thus became impossible to correct matters without a wholesale cancelling of trains or the conversion of certain regular trains to specials. The result of this late running was that it was impossible to roster engines or crews for return working, especially on lines without telephonic train-control, as the arrival of the engines was often a matter of conjecture. The shortage of rolling-stock was also accentuated by these troubles, especially in the case of passenger rolling-stock, and trains had sometimes to be cancelled as there was no rolling-stock available.

The foregoing was a condition brought on by several separate but inter-locking circumstances, and it seemed impossible to avoid one without incurring another. To slow all trains down in an endeavor to insure better punctuality sounds simple, but to do so would have accentuated the shortage of rolling-stock, as the miles per passenger car per day would have been decreased, and consequently more overcrowding would have resulted. To reduce the loads of the engines would have had the same effect. To raise the speed of the trains required new ties, and to improve the reliability of the engines required new boilers and equipment. It was a position which had no outlet except cleverness in scheming the timetable in order to allow the more important trains clearer movement and less possibility of delay by less important trains.

The Operating Department quite early after the Civil Wars reduced the unloading time of a car (even the standard 40-ton car) to six hours, and applied stiff penalties if this time was exceeded. This improved to some extent the turn-round time of cars, and the plan of running freight trains by night instead of by day improved it still further. The "car-ton-miles per car-day, per car in service," which is one of the most vital statistics in railway work, had, therefore, correspondingly improved, and this did something to alleviate the shortage of cars, which is, however, a chronic condition on the average Chinese railway. There is no doubt, nevertheless, that the utilization of freight cars can be still further improved, and this applies with equal force to locomotives and passenger cars.

The general situation, therefore, was that the railways were being gradually rehabilitated from their own revenues, despite a great many adverse factors which have already been touched upon. In doing so, however, it had been inevitable that no money was available for the payment of many of the material debts and of the bond amortization, and sometimes even the interest. This was regrettable, not only because it depressed China's credit, but also because the unpaid debts were steadily increasing in amount, many of them at heavy compound interest. Unless some agreement could be reached, therefore, it was only a matter of time before the sum of indebtedness rose beyond the maximum that the railways could pay, despite the most efficient management. Had this been allowed to happen, repudiation of some sort would have been hard to avoid, as the only alternative would have been a foreign loan on such onerous terms that its full observance would have been difficult.

The Boxer Indemnity Fund

Fortunately at this time the Trustees of the British Boxer Indemnity Fund commenced to invest on a large scale in Chinese railways. The return of the British share of what is commonly called the Boxer Indemnity took place in 1931 and took the form of the creation of a revolving fund in China, the principal of which was to be invested in productive enterprises, the interest to go to educative and cultural enterprises. To administer this fund a board of trustees was created. The agreement further provided that the accumulated funds and half the future instalments should be expended in the British Isles, while the other half of the instalments should be expended in China or Britain. To conduct the expenditure on goods in Britain a purchasing commission was set up with wide powers.

The Chinese Government made an allocation of the funds to the various government departments, the lion's share going to the railways. It should be noted, however, that though the various sums were earmarked for various government departments and other enterprises, the investment of the funds remained strictly at the discretion of the board.

A considerable number of rehabilitation loans for the railway were made, including new locomotives and cars for the Tientsin-Pukow, new rails and locomotives for the Kiaochow-Tsinan line, new bridges for the Peiping-Mukden, etc. A train-ferry across the Yangtze River was also installed, and this increased the revenues of the adjoining railways, especially of the Nanking-Shanghai, very materially. These rehabilitation loans were, however, subsidiary to the main venture, which was to complete the building of the Canton-Hankow line, which had been building for almost forty years, but had never been finished.

It may have been noted that the Indemnity Fund arrangement, while it provided goods in England, did not provide cash in China beyond the future annual instalments of the indemnity. As railway construction requires both cash and material, the problem was to turn the materials from England rapidly into cash. This was effected by the above-mentioned material loans to other railways.

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The actual assistance given by the board to the Chinese railways was great, but perhaps a still more valuable service was the fillip given to public confidence in railway investment. For the first time the Chinese banks began to consider long-term railway investment in a favorable light, especially when they were in partnership with the board of trustees. At the same time the gradual emergence of the world from the financial depression caused renewed interest in China as a field for investment, despite the constant pressure from the north, where the loss of Jehol and Chahar provinces was followed by the partial divorce of the northern provinces, including the cities of Peiping and Tientsin, from the Chinese national authority. The Fukien revolt, however, made capital extremely cautious for a time, despite its dramatic collapse. The independent attitude of Canton and the so-called Communists in Kiangsi had likewise a chilling effect. Later the clearing of the Communists out of Kiangsi had an excellent effect on public opinion.

The Ministry of Railways throughout the whole of the time from 1931 had before it several cardinal rules. The first of these was that there was no hope of obtaining a rehabilitation loan from foreign sources which would be in any way acceptable to the Chinese; until the railways could show the world that they were a sound investment, investors, both Chinese and foreign, would be shy of investing money in anything but short-term loans with personal security.

The second principle was that the offer of any foreign syndicate to take over and operate one or more of the national lines, paying surplus profits to the government, would not be acceptable, partly owing to the feeling that such an arrangement would be derogatory to China's dignity, and partly to the difficulty of protecting the railway from interference by military on transfer, and also by bandits, who would be certain to gather round a company-owned line in the hope of being bought off. (It should be noted that this opinion dated from some years ago.)

The employment of foreign railway officers on the various lines was also not considered with much favor except by a few. It was not always fully appreciated that the foreign officer being free from politics could often be friendly with everyone, whereas few, if any, Chinese officers could be so independent. Those few foreign officers who remained on the lines had in some measure been short-circuited, and the change in the official language from English or French to Chinese had greatly restricted their capacity, as few of them had had the time to learn Chinese characters, and this placed them in the hands of their translators.

Standards

In the work of adopting standards, the Ministry had continued the work of its predecessor, the Ministry of Communications. The standards adopted by the latter organization were of rather a general character, with some exceptions, notably the standard 40-ton wagons which had been designed and adopted complete. The Ministry of Railways endeavored to avoid adopting too rigid a standard, and for a start at least endeavored to standardize essential parts such as tires, trucks, brasses, etc., while for locomotives in place of standard engines the endeavor was to adopt standard boilers, wheel centers, tires, axle-boxes, axles, piston-valves, pistons, etc., which in time would approach nearer and nearer to a standard engine. Factors which directed this policy included that of avoidance of obsolescence of design owing to the rapid progress in locomotive design which was and is being made throughout the world. Secondly, the large variation in conditions, climate, grades, etc., in such an immense area as China made it essential to vary the type to suit each case, as well as to suit the loads to be hauled and the speed. A large number of standard types would therefore be essential, and these types would be split up in small quantities on the existing railways amid locomotives of similar but non-standard design for which different spare parts would be needed.

Unless, therefore, a very large number of engines of the same type were required, the advantages of the standardization of whole locomotives would be lost, and the lesser method of standardizing details was consequently advisable.

Improvement of Railroad Administration

When Dr. Chang 10/ was appointed Minister of Railways, he inaugurated a vigorous campaign for improving conditions and rehabilitating the railways. He was a banker and not a railway man, but he was a fearless and capable administrator and under his leadership, great strides had been made at the time of the Japanese invasion. Dr. Chang describes his efforts as follows:

> In 1935 the Chinese government invited Brigadier General F. D. Hammond, a British railroad expert, to give his advice on the matter of China's railroads. In his report General Hammond made many pertinent suggestions for improvements, including the following three basic principles:
>
> (1) The railroads should be operated as business enterprises, that is, to secure the maximum returns with the minimum expenditure so that loan obligations could be fulfilled and additional foreign investments attracted; (2) the railroads should be administered on a rational basis, that is, all matters relating to personnel, engineering, supplies, operation, and car service should be based on a rational standard of performance so that every staff member should be able to contribute his best; (3) the railroads should be operated in accordance with the fundamental policies of national economy, that is, they should be operated not only on the most economical basis but should also be made to assist in the development of industry and commerce in the regions they serve.

These three broad principles serve admirably as the guiding rules in the administration of railroads in general. In their application to a particular country or to a particular line, however, attention must be given to historical background. In the case of China, for example, most of the railroads were built with foreign loans which placed certain restrictions on operation and administration. The restricting conditions in one line

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might not be identical with those in another. Attempts to apply a uniform and detailed measure of improvements to all the railroads often met with practical difficulties. Hence improvement must be made by general measures applicable to all the railroads. The goal would be attained if the best possible use were made of railroad finance, materials, and personnel. During the one and a half years before the war, special emphasis was laid on centralization of control in the Ministry of Railways and on the replenishment of equipment for the individual railroads. To inaugurate an effective centralization of control, the problem was approached from three angles: In finance by the introduction of accounting and statistical control; in the matter of materials by centralized purchasing; and as to personnel by the reduction of railroad staff.

Introduction of a New System of Accounts and Statistics

With the resumption of the service on all railroad loans, the most important financial problem was to increase earnings without a corresponding increase in expenditures, so that the surplus might be applied to the payment of obligations. The total earnings of all the railroads at that time was about CN$15,000,000 per month or CN$180,000,000 per annum. If in the administration of railroad finance a saving of, say, 5 percent could be effected, it would amount to CN$9,000,000 per annum. To this end a rigid centralized control would be necessary, and the key to centralized control lies in accurate accounting with quick and reliable financial reports.

Until this time each railroad had handled its own finances and serviced its own foreign loans, and during the period of internal strife local militarists were able to interfere with the administration and to appropriate the revenues of the railroads for military and political expenditures. Aside from their regular contributions for the support of the Ministry of Railways and for other designated purposes, the railroad administrations did not submit their financial accounts to central control. After the resumption of the debt service on old loans it was necessary to handle all railroad funds through the Ministry of Railways, especially since materials available in one railroad had often to be diverted to another line against payment in cash. In general, financing became more complex as time went on, and centralization of the railroad finance in the Ministry was therefore inevitable.

Without appropriate accounting control it was impossible to maintain adequate supervision. The general ledger which had been in use up to that time did not meet the requirements of the new conditions. The General Railway Fund Ledger was adopted on January 1, 1937 and marked the first step toward centralization of railroad finance. The old ledger was duly audited and closed, and the balances were brought over to the appropriate items in the new ledger.

Speedy and detailed reports on the cash position of each line were required to permit the transfer of funds from one railroad to another, so that all available funds might always be used to the best advantage. For this reason, daily and monthly reports and monthly cash budgets were introduced with instructions that all railroads should submit the required information to the Accountant General's Office for compilation and analysis.

The rules governing railroad budgets were revised, and budgetary control was made the key to centralization. Hitherto, budgets in different shapes had been submitted by individual railroads and the result was a lack of coordinated policy. Beginning in 1937, standard regulations were prescribed to govern all railroad budgets, including a cash budget, a material budget, and a budget for miscellaneous expenses, all of which had to be drawn up according to detailed schedules covering all important items so as to facilitate thorough analysis. Aside from the operating accounts, income accounts, and anticipated profit and loss accounts, there was a statement of anticipated surplus appropriations to show the trend of prospective changes in the financial position of each line.

The accounts of all railroads were audited and adjusted. Formerly the accounts of most railroads failed to reveal an accurate picture of their assets and liabilities, and for a long time there had not even been any detailed audits and adjustments in accordance with the changing financial circumstances. To this end detailed explanations were required covering the history of each account, and all suspense accounts were to be cleared off as much as possible and to be adjusted so that the financial status of each railroad would be accurately represented in its statements.

The property accounts called for special consideration. Since the first railroad was built in China seventy years ago, no attempt had been made to evaluate railroad properties and no rules were promulgated governing railroad valuation. The bookkeeping values of the railroad properties differ widely from the physical values. Detailed rules were therefore issued for the valuation of railroad properties, and a committee was set up to take charge of it.

To obtain at any time a bird's-eye view of the prevailing railroad conditions, speedy and accurate statistical reports were needed. To this end several experts were appointed to study the question of statistical control. After four months of preparation the "Rules Governing Railroad Statistics" were promulgated on December 5, 1936. They contained eight chapters and an appendix, covering general principles, traffic, operation, locomotives, engineering, stores, finance, and administration statistics. There were sixty-nine articles and one hundred and thirty forms and schedules to be used. This marked the first attempt at complete statistical control. Before the rules became effective on January 1, 1937, a conference was called in which the spirit and purpose of statistical control was explained to all attending statisticians.

Among the statistical reports prescribed for the railroads, the daily revenue report was one of the most important. This report, compiled by the chief accountant of each railroad from the daily telegraphic reports on station revenue, was to reach the Ministry before noon on the third day. On the basis of these reports from the different railroads the statistical department of the Ministry compiled a daily as well as a ten-

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day summary. In this way the Ministry was kept informed of the current revenue situation of the entire railroad system, making possible a comparison of actual with expected earnings.

Next in importance were carloading statistics and statistics of cargoes awaiting transportation. As the earnings of the Chinese railroads depend largely upon freight traffic, any change in carloadings must directly affect the railroad revenue. Fourteen major commodities were selected to give an indication of the volume of traffic, i.e. bituminous and anthracite coal, wheat, flour, beans, peanuts, sesame seeds, raw cotton, cotton yarn, piece goods, sheepskins, tobacco, salt, and petroleum products. The reports from the railroads gave the respective volumes of traffic in each of these commodities and the volume of goods awaiting transportation at each important station. In this way the volume of freight held up at the stations served as an indication of the shortage of freight cars on which action would have to be taken.

New Methods for the Administration and Purchase of Materials

One of the largest items of railroad expense is that for materials. Their cost amounted to CN$30,000,000 per annum or about 30 percent of the total operating expenses. In addition to materials for maintenance purposes, new construction work called for additional supplies. The management of the stores of materials, therefore, had an important bearing upon railroad finance and administration. Inspectors were sent to all the railroads to study the condition of stores. They reported three major defects: the lack of an adequate accounting system for materials; an overabundance of materials; and a lack of uniformity in their classification. The lack of an adequate material accounting system made effective control impossible, the large volume of surplus materials on hand tied up a large portion of railroad capital, and the lack of uniform classification made it impossible either to purchase materials on a large scale at a lower unit cost or to transfer surplus stocks from one railroad to another.

These topics were first brought up for discussion in 1936, and in the following a conference was called of all storekeepers, which came to the following conclusions:

The procedure of store accounting as adopted in 1921 contained no provision for material budgets nor for centralization. Requisition, valuation, and accounting were done in a haphazard manner, making centralized control impossible. It was therefore decided to enforce a material budget, a centralized system of material accounting, perpetual inventories, and a uniform valuation of materials. In March 1937 the necessary rules were printed for distribution to all the railroads. They were required to set every unit of the store organization in motion by May or June, in preparation for the adoption of the new system on July 1, 1937.

The standardization and uniform classification of materials are starting points of centralized control. They form the basis for approving requisitions, purchases, transfers, and for uniform accounting and statistics. The technical terms and the classification of materials used by different railroads up to that time varied not only from one railroad to another but also between different sections of the same railroad. Work on the standardization of technical terms and a uniform classification for all materials was started in March 1936 and completed after three months of arduous labor. Rules and regulations were finally promulgated on July 1, 1937, to take effect three months later.

The total value of materials stored by all railroads in June 1936 was estimated at CN$50,000,000, of which a large part had been purchased on credit. The enormous inventory involved not only a waste in interest but also considerable losses due to deterioration and obsolescence. A perpetual inventory was instituted of all railroad materials, and each line was to organize a committee for that purpose. The rules were especially designed to determine whether the actual stocks corresponded with the bookkeeping records and to find out the volume of slow-moving and obsolete materials. The result of the investigation revealed that of the total inventory of CN$50,000,000 slow-moving and obsolete materials represented no less than CN$8,706,000. The obsolete materials were listed, and most of them were sent to the nearest locomotive works to be used to the best advantage, while some were sold to the highest bidder. No centralization of purchases had been possible in the past because each railroad controlled its own finances and the Ministry was without an adequate circulating fund to undertake the work. As a result of this practice, the prices paid by the individual railroads were unnecessarily high, the total stocks held by the entire railroad system were excessive, and some sections suffered from acute shortage. Furthermore, the financing of all purchases was handled separately and bank guarantees had to be provided in each case, which made the practice unduly cumbersome. A system of bonds was instituted for the payment of railroad materials, guaranteed by a consortium of Chinese banks composed of the Central Trust of China, the Kincheng Banking Corporation, the National Commercial Bank, and the China and South Sea Bank. Beginning in June 1937, bonds of CN$800,000 per month or a total of CN$9,600,000 per annum were issued for the payment of purchases, each series to mature within one year from the date of issue and to carry interest at 7 percent per annum. In case the remittances of the railroads should be insufficient to retire the bonds as they matured, the difference was to be made up by the banks of the consortium, up to the limit of CN$3,000,000. This system had many advantages. Purchases of all railroad supplies could thus be centralized in the hands of the Ministry of Railways by means of paying suppliers with bonds. The Chinese suppliers whose financial strength was limited and who were unable to compete with foreign firms in selling on credit could now discount the bonds in any bank for the cash they needed. In this way it was possible to encourage the development of home industries.

It must be noted in this connection that the system of discounting commercial paper had never developed in the Chinese money market. With the introduction of the new system of bonds it was hoped to encourage the development of a discount market and thus to attract idle capital into productive channels.

The system of centralized purchasing was instituted and the Central Stores were organized to be situated at Puchen, Loyang, and Chuchow.

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Railroad ties formed an important item of expense. According to General Hammond's estimation, ties of untreated Oregon pine lasted 5 to 6 years in North China while ties of creosote-treated pine lasted 15 years. The cost of untreated ties was CN$3.00 each in 1935 and of treated ties CN$4.50. On the basis of life expectation the cost of one untreated tie was CN$0.60 per year and that of the one treated tie CN$0.30. There being 3,992 miles of Chinese government railroads north of the Yangtze in 1935 and about 2,240 ties to a mile of railroad, there must be 8,942,080 ties in use north of the Yangtze alone, so that the use of treated ties would mean an annual saving of CN$2,682,624. South of the Yangtze, where ants and insects abound, the life expectation of non-treated ties was 2 to 3 years while that of treated ties was 5 to 6 years. On this basis, the cost per tie per year in this region would be CN$1.00 for one non-treated tie and CN$0.75 for one treated tie. There being 1,744 miles of Chinese government railroads south of the Yangtze, the annual saving would be CN$976,640. The total saving in the whole of China would therefore be CN$3,659,264. This saving would be further increased when the new program of construction was put into effect. In accordance with General Hammond's recommendation two creosoting plants were put up, one in Wuchang and another in Shanghai. The original Tsinan plant of the Tientsin-Pukow Railway having fallen into disuse for some time, its machinery was dismantled and removed to Wuchang, where it arrived on December 3, 1936. The Sino-Japanese War interrupted the project and the plant was not put up. The land for the Shanghai plant was acquired, but its construction was also prevented by the war.

In the provinces of Fukien, Chekiang, Hunan, and Kiangsi, timber is produced in large quantities. Fukien alone exports lumber to an annual value of CN$20,000,000, and Chekiang to an annual total of CN$5,000,000 to CN$6,000,000. Part of this export timber is suitable for making railroad ties. In the past, little was done to secure ties from these sources for lack of suitable sawmills; the quantities of ties offered were not sufficiently large, deliveries were not made according to schedule, quality was not uniform, and sizes were not cut according to specifications. To remedy the situation it was necessary to establish suitable sawmills and promotion agencies.

Forestry experts were sent to different provinces to investigate possibilities and persuade the provincial governments to set up suitable organizations to undertake the work. In Hunan, Anhwei, and Kiangsi, lumber industry promotion associations were organized, and under a cooperative arrangement with the Ministry of Railways these local associations undertook to collect railroad ties from local producers. In localities where there were no local associations, the Ministry canvassed mill owners through its own representatives.

Reform of Personnel

The political unrest that existed for many years was reflected in the railroad administration in the frequent changes of managing directors. At each appointment of a managing director, a number of new officials was added to the staff, and since no rigid limit was placed on the number of staff members in each railroad, the total increased from year to year.

General Hammond in his report brought out the fact that the increase in staff had been out of all proportion to the increase in revenue. Especially the departments of general affairs of the different railroad had large numbers of employes with no specialized training or with training that had no direct relation to railroading. In the traffic and locomotive departments the increase of personnel also went on at a greater rate than that of revenue. For example, in the Peiping-Hankow, Tientsin-Pukow, Taokow-Chinghua, Lunghai, and Chengting-Taiyuan Railways, the percentage of increase of personnel was three to four times greater over a period of years than that of revenue. The Peiping-Mukden Railway had been cut in half by the Japanese occupation of Manchuria in 1931, but its traffic staff inside the Great Wall, instead of decreasing, grew by 3.5 percent, and its locomotive staff showed a similar increase.

In order to raise working efficiency and reduce operating expenses it was therefore absolutely necessary to cut down the staff. On the other hand, any hasty measures of this kind would probably retard railroad operation, increase unemployment, and even cause social unrest. General Hammond pointed out in his report that if the number of superfluous employes reached several thousand, the problem of reduction would be rendered even more difficult because the government organizations could not very well reduce the number of their employes by such numbers without disturbing social stability.

The course of gradual reduction was adopted and a special training course was introduced for part of the surplus staff to prepare them to take up work in the new railroads under construction; for in a few years the railroad mileage would be doubled and the surplus staff of the old lines could usefully be diverted to the new lines.

Maximum limits were placed on the number of employes and wage bills in all railroads. The maximum number of office workers in the Shanghai-Nanking, Shanghai-Hangchow-Ningpo, Tientsin-Pukow, Kiaochow-Tsinan, and Lunghai Railways was fixed, and it was found that these railroads had excess staff totaling 1,400 on November 1, 1936. These lines were instructed to reduce to the designated number within three years. Restrictions were also placed on the enlistment of new staff members. Beginning with 1937 any vacancies for employes receiving over CN$60. a month had to be filled by the Ministry. A new committee to determine the fitness of candidates was created. Detailed rules governing the registration and employment of all railroad employes were promulgated. The managing directors of all railroads and the department heads of the ministry were given power to recommend eligible persons as candidates for registration, and any vacancy was to be filled from the registered candidates, but if the vacancy could not be filled from them, selection was to be made in an open competitive examination. This system was to eliminate any possible favoritism or patronage.

The New Spirit

The spirit of New China and its importance to railways was well described by Marshal Chiang Kai-shek, in his address in 1936 at the graduation of the Railway Training Class of the military academy at Loyang, as follows:

"Whether the system of railway communication is good or bad, has a great bearing on the economic and cultural conditions of the country. The reasons why our country has been so weak are many, but the most important one is the meagre development of her railways. Even in operating her mere ten thousand or more kilometers of lines, darkness and corruption prevail. No reforms are attempted, and no efforts made to increase operating results. Not only are they incomparable with the railways of other countries, but the very state of their corruption makes our foreign friends slight us saying: China is not a modern nation and not hesitating to invade and oppress us at will. It should be noted that whenever a foreigner wants to find out whether the organization of our state is efficient or otherwise, whether our government is strong or weak, and whether our people are intelligent or ignorant, it is not easy for him to find this out; but as soon as he sees our railways he can make an immediate, accurate judgment as to the real conditions of things. From our railways, he can easily see whether our railway staffs from station-masters, trainmasters, booking clerks down to railway police and workmen, are energetic, orderly, polite in speech and deportment, and have enough intelligence to perform their duties . . . and whether the furniture and fixtures in the trains and on the stations are clean and well arranged."

NOTES

1/ The amazing details of the manner in which the Chinese railways stood up under merciless bombing and how they were repaired and kept in service under the most adverse conditions supplies an interesting side-light on why the German railways have not collapsed under the terrific punishment that has been meted out to them.

2/ For a complete and unprejudiced account of the exploitation of China by the European powers through railway concessions see "China's Struggle for Railroad Development," by Dr. Chang Kiangau, former Minister of Communications in China.

3/ While the Manchurian railways were once an integral part of China's railway system and doubtless will be again, they are being dealth with in detail in a separate report and will not be dealt with here.

4/ One informant, Rev. H. S. Williams of Chicago, who lived in Kalgan for many years and left there in June 1942, to return on the S.S. Gripsholm, after having been interned for several months, states that the Japanese have completed a line west of the original line that supplies a detour and avoids the difficulties of operation over Nankow pass. He states that the new line leaves the old main line at Shacheng, a station south-east of Kalgan. This is undoubtedly the line referred to later as a proposed relocation.

5/ This is the narrow-gauge Tatung-Pucheng railway, commonly referred to as the "Tungpu", which has been converted to standard-gauge by the Japs.

6/ Data supplied by T. King, former chief engineer, Peiping-Suiyuan Railway.

7/ For a description of the rolling stock on this railway and other railways, see a forthcoming report on Chinese Rolling Stock.

8/ Data supplied by W. O. Leitch, formerly Chief Engineer and General Manager, Peiping-Shanhaikwan railway.

9/ Railway work in a primitive country such as China is perfomred in a different manner than elsewhere. Ingenuity in the use of primitive tools and above all in the use of manpower is a prime requisite. To the railway civil engineer the following examples will portray the situation graphically.

10/ Most of the data as to what happened to the Chinese railways during the War were supplied by Dr. Chang Kia-ngau. Dr. Chang is undoubtedly the foremost authority on this subject, as he was Minister of Railways and Minister of Communications from the beginning of the Sino-Japanese war until very recently. He is now in New York.

11/ See my report on Railway Train Ferries, CHI-117, #3161, August 13, 1943.

12/ Japanese radio intercepts in July and August, 1943.

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13/ A translation of an official report issued on September 25, 1938, by the Intelligence Department, Staff Quarters, Japanese Army, Suematsu division.

14/ Data from T. E. Mao, engineering director, who was in charge of this work.

15/ Data from R. D. Walker, manager and Chief Engineer, British Section, Canton-Kowloon Ry.

16/ This was observed by Dr. Chang (see Note 10) personally on several occasions and the description is his.

17/ M. C. Ford, now of Chicago, returned on the Gripsholm after 14 years in China as a newspaper correspondent. He points out that there are really no hard and fast lines of demarcation on the fringes of the territory in China controlled by the Japanese. He refers to these fringes as "gray areas." He describes this as follows:

> "For five years the Sino-Japanese struggle, on the whole, has been a stalemate, with vast gray areas where there has been a semblance of an armed truce. There has been an apparent desire in these districts not to upset the status quo. Japanese troops keep to their barracks and guerrillas or bandits roam outside. It works in well with Chinese strategy. No bullets or men are wasted and the Japs are limited to their railway patrols and outposts."

18/ Details supplied by Jick G. Wong, former chief engineer, Peiping-Hankow Railway.

19/ Details supplied by Arthur M. Shaw, formerly consulting engineer in China.

20/ For contrast between the desperately effective delaying tactics of the Chinese in the face of Japanese invasion and what the British did in their Oriental Colonies, compare this whole account with certain chapters of Clyde Brown's book "From Suez to Singapore," dealing with the Japanese invasion of Malaya. Brown's account is tinctured by petty indignation and by what seems an inbred dislike of everything British, which destroys the factual contents of his book. Nonetheless, it is true that the modern, well-equipped railway workshops at Kuala Lumpur in the Federated Malay States were permitted to fall into the hands of the Japanese intact and the all-important viaduct between Singapore island and Johore, although over a mile long, was only destroyed for approximately 30 yards. The lessons so tragically learned by the Chinese that stark realism was essential were not taken to heart in the first months of the Japanese advance into British possessions.

21/ Data from H. H. Ling, managing director and chief engineer, Canton-Hankow Railway and from F. K. Sah, engineer on Ling's staff.

22/ According to an intercept of a Japanese broadcast in August 1943.

23/ According to advices from missionaries and others who traveled from concentration camps in various interior points to the sea to be put on the Gripsholm; also from other corroborative testimony.

24/ The somewhat peculiar breakdown into individual railways of the Chinese national railway system was brought about by the necessity, because of the widely varying methods used in financing, of keeping separate accounting records on each railway. This led to the establishment of a complete staff for each railway and led to the preservation of each line as a unit, rather than as integral parts of the national system.

25/ Kenneth Cantlie, Technical Advisor to the Chinese Ministry of Railways.

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