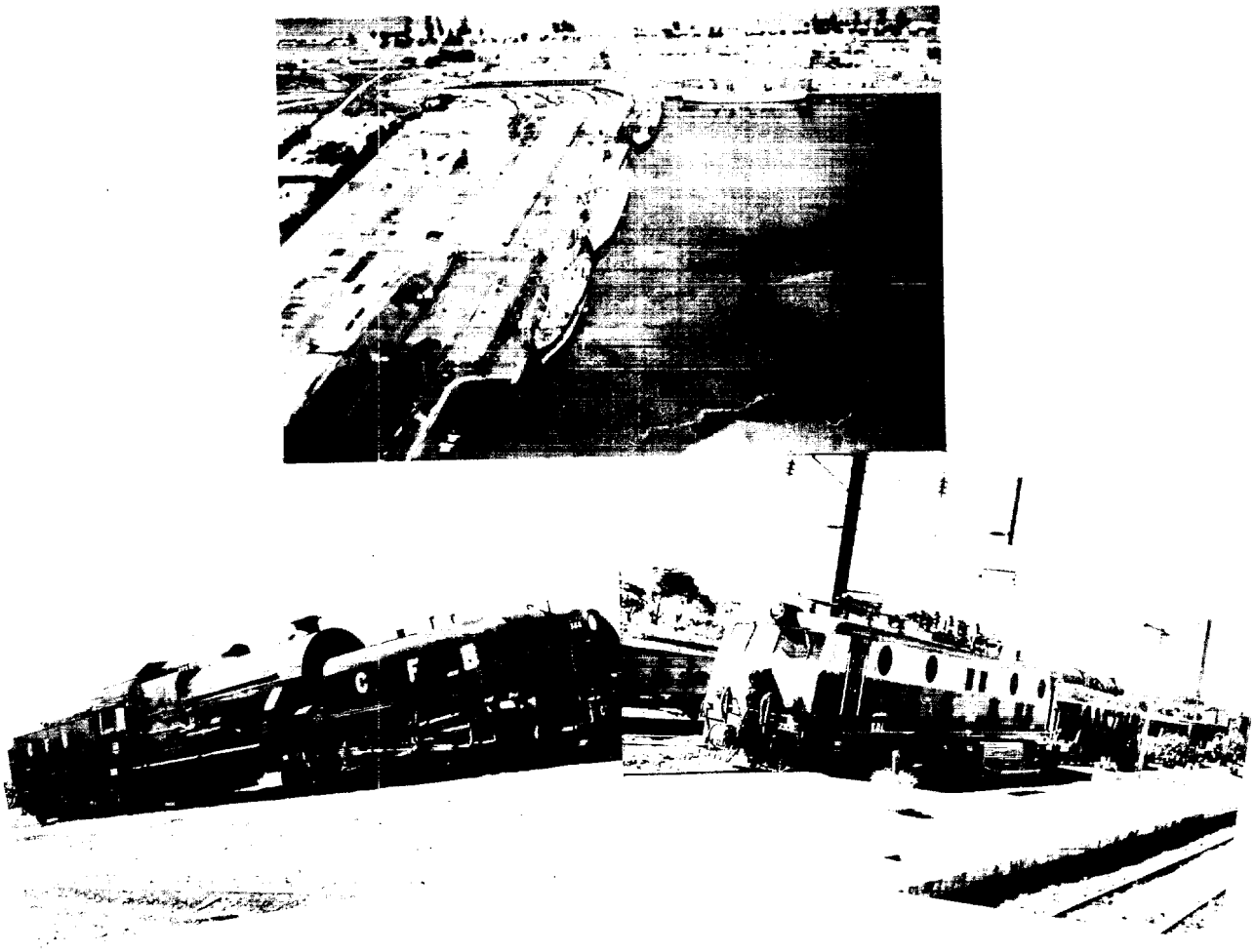
THE LOBITO ROUTE

A Survey of the Capacity of the Rail Route Between Zambia and the Port of Lobito



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[redacted]

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FOREWORD

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This report is the result of a survey of the rail route between Zambia and the Port of Lobito in Angola, undertaken between 9 November and 11 December 1965, [redacted] U.S. Department of State by [redacted] 25X1A9a Transportation Consultant. Discussions were held with directors, management, and operating personnel of the carriers involved in London, Brussels, Lisbon, Lobito, and Elisabethville as well as with key personnel in the copper companies and their traffic agents (see Appendix A). Estimates and conclusions in this report are based on published and unpublished data received from these officials as well as from on-the-spot observations. The author sincerely appreciates the kind cooperation extended by all. A special vote of thanks is due to Col. R. J. Walker, Benguela Railways consultant, for generously sharing the results of his long experience and research. Except as noted, all photographs were taken by the author.

The author acknowledges that estimating railroad capacity is not an exact science and that his brief exposure to local conditions should not necessarily be regarded as a substitute for the judgment of local management seasoned by years of experience in the area. This is to say that there are undoubtedly many practical operating problems and conditions which could not be investigated in detail and which are mentioned only superficially or not at all in this report. The estimates of both potential capacity and cost are therefore submitted only as gross approximations intended to point the direction in which to move. The opportunity was not afforded nor was it the object of this report to make a detailed cost survey.

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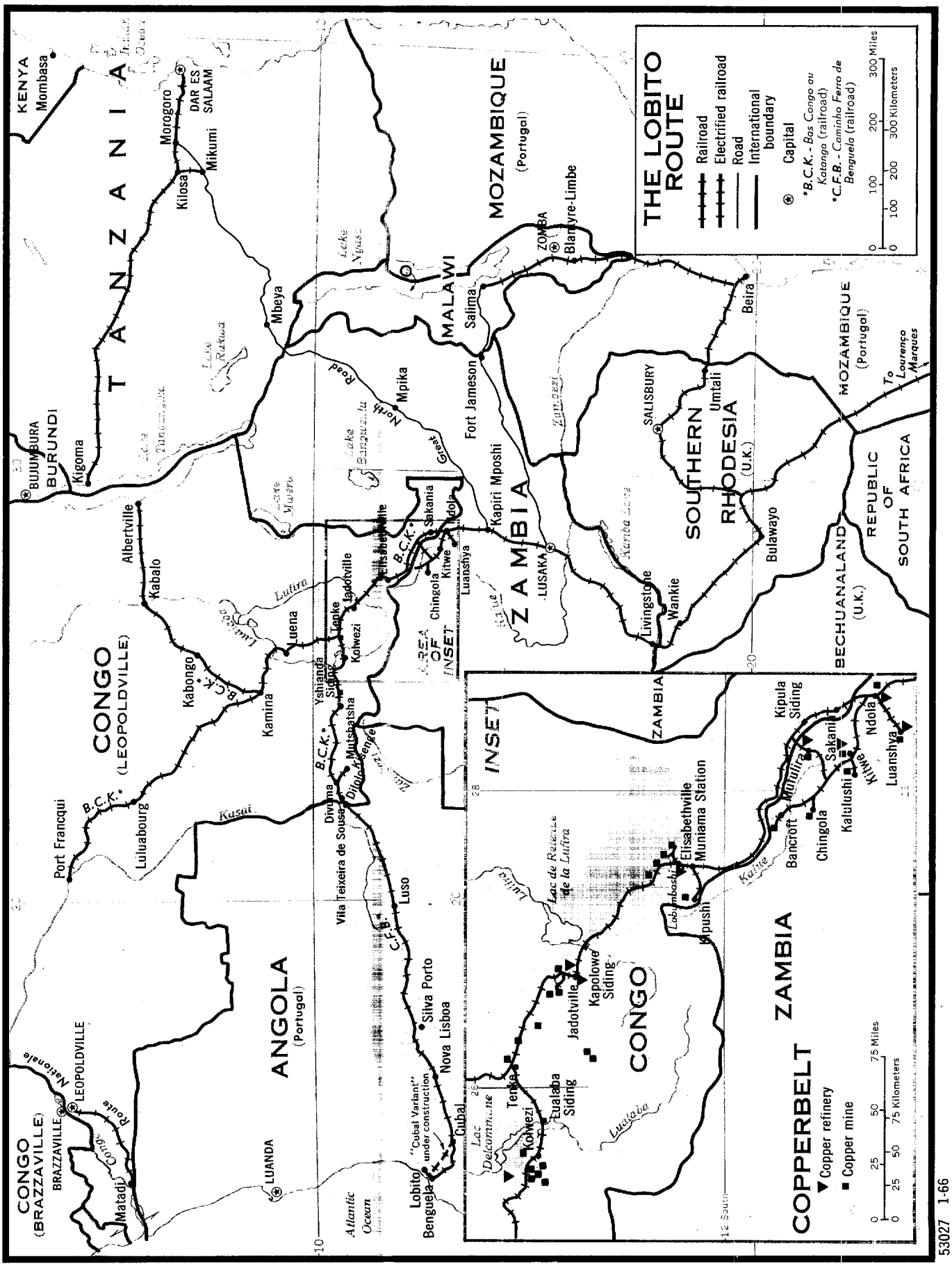
APPENDIXES



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THE LOBITO ROUTE

A Survey of the Capacity of the Rail Route Between Zambia and the Port of Lobito

SUMMARY

The alternative routing with the greatest potential capacity for handling the import and export traffic of Zambia, if the use of the rail route through Rhodesia (the Rhodesia Route) is denied, is the rail route through the Congo and Angola that connects Zambia with the Port of Lobito (the Lobito Route).* Ndola, in the Zambian Copper Belt, is virtually equidistant from Lobito and the Mozambique ports of Beira and Lourenco Marques. The gauge of the railroad lines is the same (3'6") throughout and both freight and passenger cars are interchanged without transloading. The Lobito Route, however, is not without its problems, and its immediate surplus capacity would be inadequate to handle even the imports and exports of the Congo which, in the event of a complete embargo, it is assumed would also be diverted from the Rhodesia Route to the Lobito Route. The current limitation on the capacity of the Lobito Route is primarily the lack of a sufficient number of technically competent operating personnel and the state of maintenance of electric locomotives on the Bas Congo au Katanga Railway (BCK). As a result of these inadequacies, a serious bottleneck situation exists on the electrified Elisabethville-Tenke sector of the BCK which has the heaviest density of traffic.**

It is *technically* (operationally) feasible to build up gradually (within 6 months to a year) the capacity of the Lobito Route to an annual capability to carry the requisite addition to Congolese (Katangan) traffic, some 770,000 tons*** of imports to Zambia, and over 1 million tons of Zambian exports. Realization of this potential level of performance requires the full cooperation of a flexible railway management and concurrent action on a number of projects involving the active cooperation of the Zambian, Portuguese, and Congolese governments as well as the Benguela (CFB) and the BCK railways. Several programs would, in fact, need to be undertaken simultaneously to realize the maximum potential in the minimum length of time, and any number of difficulties treated only superficially in this report or perhaps not mentioned at all could delay these programs.

I. The Lobito Route

The railroad starting at the Port of Lobito in Angola forms the sole continuous rail link which could serve as an alternate route for the import and export traffic of Zambia (currently some 4 million tons, nearly all of which moves over the

* See the map.

** Note that all freight between Zambia and Port Franqui on the Route Nationale to and from Matadi and between Zambia and Albertville on the route to and from Dar-es-Salaam via Lake Tanganyika must also pass through this same bottleneck.

*** Metric tons are used throughout this report.

railroad through Rhodesia). The gauge of the railroad lines is the same (3'6") throughout and both freight and passenger cars are interchanged without transloading. This route is known generally and referred to in this report as the "Lobito Route" comprising the Port of Lobito, the Benguela Railway (CFB) from Lobito to the Congo border near Dilolo and the Bas Congo au Katanga Railway (BCK) from Dilolo to Sakania on the Zambian border. Railroad cars are interchanged with the Rhodesia Railways at the Zambian border. The distances between Lobito and key points in Zambia, compared with the distances from these points through Rhodesia to ports in Mozambique, are as follows:

	Ndola		Lusaka		Livingstone	
	Miles	*Km*	*Miles*	*Km*	*Miles*	*Km*
Lobito	1,478	2,375	1,677	2,700	1,968	3,163
Beira	1,450	2,337	1,251	2,012	960	1,549
Lourenço Marques (via Malvérnia)	1,447	2,332	1,248	2,007	957	1,544

It may be seen from the tabulation that the Ndola area, where about 700,000 tons of copper exports originate and a roughly equivalent amount of coal imported from Rhodesia terminates (plus a significant amount of other imports), is for all practical purposes equidistant from Lobito and from both of the above ports in Mozambique. The Port of Lobito, furthermore, is far closer to European and American markets for Zambian exports and to sources of imports which could serve as substitutes for those received from or through Rhodesia.

II. The Bas Congo au Katanga Railway (BCK)

A. Management and Personnel

The BCK is managed on behalf of the Katanga-Dilolo-Leopoldville Railway Co. (KDL) by an Administrator Delegate and his staff (Belgian expatriates) with headquarters in Elisabethville. The Administrative Council of the KDL consists of a president and eight members with headquarters in Brussels. The President of the Administrative Committee and three of the members, including the one consulted during the course of this survey (see Appendix A), are designated as Members of the Permanent Committee.

Operating personnel number about 13,800 Africans and about 550 European technical assistants. All train crews, including locomotive engineers, are African. The BCK has established several training institutions for operating and maintenance personnel, staffed by a faculty of expatriate professors and technicians.

B. Extent and General Characteristics of the Network

The BCK is a single-track (3'6" gauge) railway with traffic controlled by means of a Webb-Thompson Staff Token system of manual block signals. The network consists of a total of 2,612 km of route, including 56 km of branch lines and 679 km of electrified line. The parts of the BCK network included in the Lobito Route are: Sakania-Elisabethville (242 km, steam traction), Elisabethville-Mutshatsha (489 km, electric traction) and Mutshatsha-Dilolo (268 km, steam traction). The total length of these three contiguous sectors from Sakania at the Zambian border to Dilolo at the Angolan border is about 1,000 km, nearly half electrified with steam operated sectors at either end. The steam locomotives burn either domestic wood or coal, the latter imported mostly from Wankie in Rhodesia. Hydroelectric power is available locally for the electrified sector. Single-phase, 25,000-volt, 50-cycle alternating current is supplied by 10 substations located at intervals of 70 to 80 km.

C. Locomotives and Cars

The BCK had in its mainline locomotive inventory as of December 1965 a total of 117 units including 79 steam, 36 electric (2,100 to 2,450 rated hp) and 2 diesel-electric (1,250 hp). Because of a lack of competent operating and maintenance personnel and foreign exchange for parts and equipment, only about half of the electric and diesel-electric locomotives and about 70% of the steam locomotives are operational on the average. The decrepit state of certain steam locomotives formerly assigned to hauling trains has made it necessary to downgrade them to the category of switch engines. There are in addition to the mainline locomotives listed above, 64 steam, 12 diesel, and 5 electric locomotives used for switching. The majority of the steam locomotives in train service are of the "Mikado" class (2-8-2) or the "Garratt" articulated-type locomotives (4-8-2+2-8-4) which operate on the sections with the most difficult grades and curves. The mainline locomotive inventory is listed by class and tractive effort in Table B-1, Appendix B.

The freight car inventory of the BCK as of December 1965 totaled 3,589 cars, about 11% of which (some 400 cars) are excluded from the effective operating inventory because of maintenance, repair, or service use. The effective operating inventory is, therefore, about 3,190 freight cars with a capacity per unit ranging between 30 and 39 tons (averaging 36.6 tons). The average empty weight of freight cars is 17 tons. The freight car inventory is listed by type and capacity in Table B-2.

There were in the BCK inventory as of December 1965 in addition to the freight cars, the following:

Passenger cars	133
Baggage cars	12
Dining cars	9
Crew cars and cabooses	17

Twenty-five of the passenger cars, four dining cars, and two baggage cars are of stainless steel construction, built under Budd contract in Belgium. Of the remaining passenger stock, 52 are of metal construction.

As of December 1965, equipment on order consisted of 30 tank cars (40-ton capacity) scheduled for delivery in the second half of 1966 and 5 electric locomotives (2,200 hp) scheduled for delivery in the second half of 1967.

D. Traffic

The BCK currently moves a total volume of about 4.25 million tons, about 3.2 million tons of which is revenue freight. During the peak year (1957) over 6 million tons total were moved, of which about 5 million tons was revenue freight. Nearly 60% of the total tonnage is mineral traffic, both export and local hauls between various components of the mining companies. More than 40% of the total traffic is hauled by electric traction. Traffic during 1957-64 and estimated traffic for 1965 are shown in Table B-3.

The heaviest concentrations of traffic occur on the sector between Muniama (12 km south of Elisabethville) and Tenke (249 km) through which traffic between the Zambia/Rhodesia border and Lobito, Port Franqui, or Albertville must move in addition to a heavy volume of local mine and smelter traffic. Through movements on the 105 km stretch between Jadotville and Tenke (part of the electrified Elisabethville-Tenke sector) averaged 9.9 trains each way per day in addition to considerable local mine and service traffic during the first 10 months of 1965. The extent of this traffic between mines and smelters is illustrated by movement on the short (12 km) stretch between Muniama and

Elisabethville (not yet electrified) where all movements between Elisabethville-Kipushi-Lubumbashi are intermingled. Movements (all trains and service vehicles) in this high-density sector averaged 26.39 each way per day during the first 10 months of 1965. The total dropped to only 9.13 on the contiguous sector between Sakania and Muniama, which is not involved with mine traffic between Elisabethville-Lubumbashi-Kipushi. Movements by sector of the Sakania-Dilolo Route are shown in Table B-5. The density of traffic (in terms of ton-km per km of route) on the several sectors forming the BCK portion of the Lobito Route clearly shows the concentration of traffic on the Elisabethville-Tenke, Tenke-Kolwezi, and Muniama-Elisabethville sectors (see Table 1).

TABLE 1

Congo: Bas Congo Katanga Railway (BCK) Traffic Density, by Section[a]

Section	Total, 1964	Estimated Total, 1965	Average Monthly, 1965	Peak Month, 1965
		(*Ton-km per km of route*)		
Sakania-Muniama (230 km)	475,132	545,122	45,427	55,176
Muniama-Elisabethville (12 km)	1,018,573	1,080,662	90,055	104,824
Elisabethville-Tenke (237 km)	1,241,240	1,416,358	118,030	129,092
Tenke-Kolwezi (95 km)	1,197,202	1,282,056	106,838	123,396
Kolwezi-Mutshatsha (157 km)	525,550	508,715	42,393	47,927
Mutshatsha-Dilolo (268 km)	615,400	597,522	49,794	51,573

[a] Calculated from data in Table B-4. Sections are listed in geographical order from the Congo/Zambia to the Congo/Angola borders.

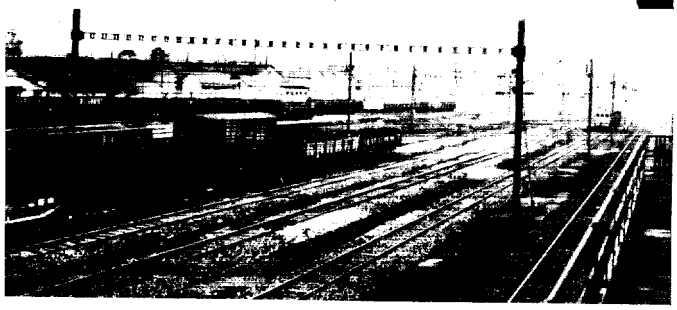
E. Operations and Line Detail

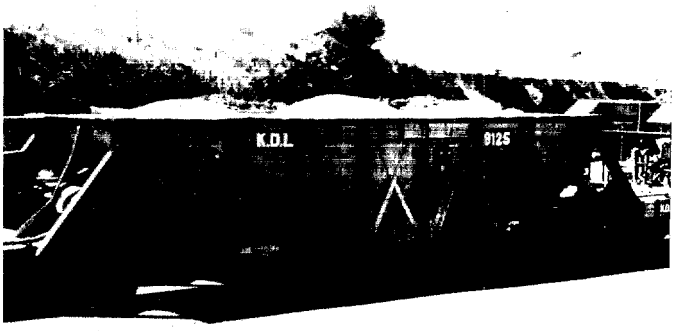
The BCK, as stated above, is a single track railway throughout, and traffic is controlled by a Webb-Thompson Staff Token system of manual block signaling. The gauge is 3'6" and the radius of curvature is generally not less than 300 meters compensated. Gradients of 1.5% to 2% are encountered at some places near Biano (between Tenke and Bukama) but do not exceed 1.25% on all sections comprising the BCK portion of the Lobito Route. Important details on these BCK sections of the Lobito Route are shown in Table B-5.

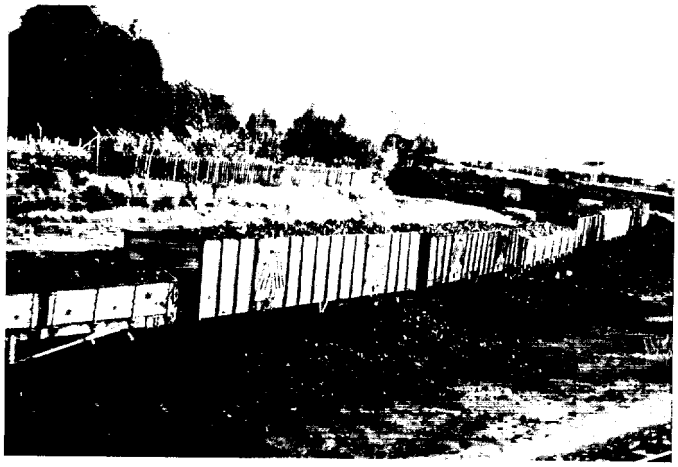
The overall average net load per freight car on the BCK system in 1964 was 29.8 tons. Experience factors for various types of freight are as follows:

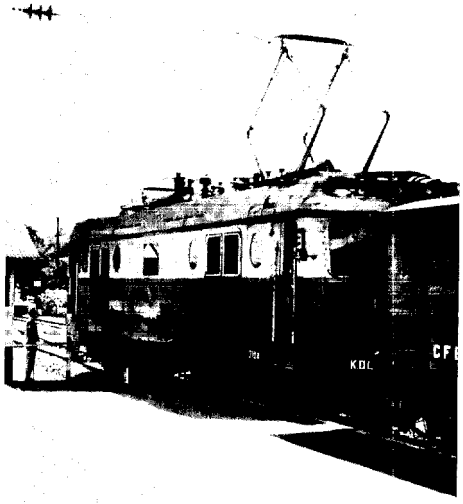
Type of Freight	Net Load per Car (Tons)
Mine products	38
Coal	30
Construction materials	25
Agricultural products	27
General freight	16

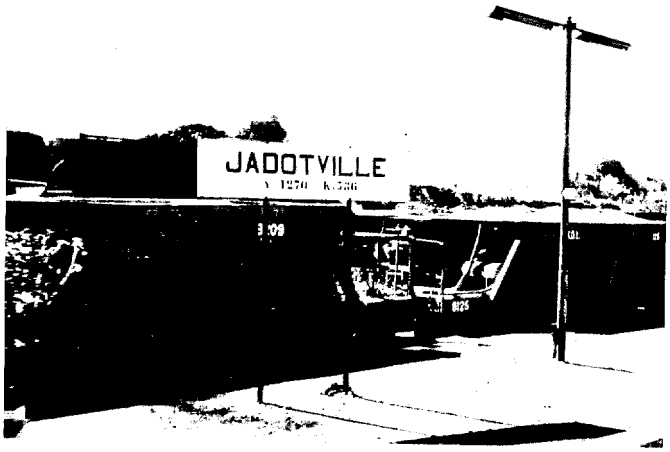
Relative availability of wood, coal, and electric power for traction has a marked effect on the operations of the BCK. Wood-burning steam locomotives are operated only on the section between Mutshatsha-Dilolo because of the lack of suitable wood along other parts of the network and because of high taxes and prices. Imported coal is used on nearly all of the remaining steam-operated sectors because what little local coal is available has a high ash content (22% to











THE BCK RAILWAY. AT THE TOP ARE VIEWS OF THE YARDS AT ELISABETHVILLE. IN THE CENTER AND LOWER RIGHT ARE CARS LOADED WITH COPPER ORE AND CONCENTRATE. AT THE LOWER LEFT IS AN ELECTRIC LOCOMOTIVE, TYPICAL OF THOSE OPERATING ON THE 679 KM OF ELECTRIFIED

25%). The abundant supply of cheap hydroelectric power and the difficulties with the supply of coal or wood explains the large-scale conversion to electrification (679 km prior to July 1963) which would no doubt be continued apace were it not for foreign exchange problems that prevent the purchase of necessary equipment. Further electrification is planned, first for the Luena-Kamina section, which has the greatest requirement for imported coal, and later for the Mutshatsha-Dilolo and Elisabethville-Kipushi sectors. A few steam locomotives have been converted to oil-burning for use on the northern sections of the network near Port Franqui, now using expensive imported coal from the United States and Mozambique. More conversions are planned. Consumption of coal and wood by the BCK during 1964 was as follows:

Imported coal	161,400 tons
Local coal	48,000 tons
Wood	437,000 cubic meters

F. Capacity and Limiting Factors

1. *The Current Situation*

The immediate surplus through-capacity of the BCK portion of the Lobito Route, assuming no interruption of the route through Rhodesia, is limited to a maximum of 120,000 tons each way per year.* This limit is set by local management principally because of the current technical level of operating personnel and the state of maintenance of electric locomotives, both required to handle high traffic densities between Elisabethville and Tenke. Thus, 10,000 tons each way per month is now available for Zambian imports and exports only if there is no embargo of the Rhodesia Route. If the closure of the rail route through Rhodesia is assumed to require the diversion of some 450,000 tons of Congo imports now moving over the Rhodesia Railway route, the diverted Congo imports alone would more than use up the existing excess capacity of the BCK.

2. *Potential Capacity after Build-up of Six Months to One Year*

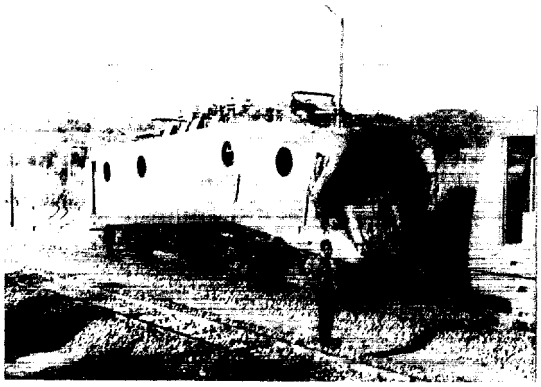
a. *Build-up with Conventional Methods of Operation*

The following method of build-up should produce an additional net capacity for handling imports to Zambia of about 400,000 tons per year (about 560,000 tons per year for exports). Build-up to this level would require a minimum of 6 months to a year after initiation (on an emergency basis) of all programs outlined in (3) below. The cost of such an effort is estimated to be approximately $11 million.

(1) *Assumed:* Normal BCK operations with build-up to an adequate supply of fuel and rolling stock having the same general characteristics of those currently in operation. The additional personnel requirement would be satisfied by a combination of training and recruiting abroad. Only minor siding construction is to be undertaken.

(2) *Discussion:* It should be possible with competent operating personnel to operate on the existing track, with minimum additional siding construction, up to 5 trains each way per day in addition to current movements (see Table B-5). "Current movements" is based on the month of October 1965 which, as may be seen from Table B-4, was a peak or near-peak month on all

* Some additional freight cars from the Rhodesia Railways (Zambia) and additional imported coal allocations are needed for this increase in BCK traffic. By January 1966, some of this surplus capacity was already being used by shipments of several thousand tons of coal into Zambia and copper out in anticipation of an embargo of the Rhodesia Route. Some petroleum was also moving into Zambia by rail from Elisabethville, after being airlifted to Elisabethville.



RESULTS OF TRAIN WRECKS ON THE BCK. THE HIGH ACCIDENT RATE IS SAID TO BE CHIEFLY THE RESULT OF PROFESSIONAL ERRORS ON THE PART OF OPERATING PERSONNEL.(BCK PHOTOS)

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sectors of the BCK part of the Lobito Route. Five inbound trains with a net weight of about 430 tons (gross weight 700 tons), double-headed on steam sectors with a maximum of 16 cars (an estimated average of 27 tons per car and the length of the train governed by siding limitations) could haul a net total of 2,150 tons per day of imports. This is equivalent to 784,750 tons of imports annually. An increase in the assured supply of rolling stock and closer supervision of operations might permit 20 cars each way per day to be added to existing trains, for an additional 200,000 tons per year of imports ($20 \times 27 \times 365 = 197{,}000$). The total import capacity for the Congo and Zambia would then be increased by about 950,000 tons per year. Subtracting the newly created Congo requirement of 450,000 tons (from the loss of access to the Rhodesia Route) and perhaps an additional 100,000 tons of coal for the BCK to meet increased traffic requirements leaves 400,000 tons per year of imports as the potential capacity available to Zambia. The estimated outbound load factor of 38 tons per car (as opposed to 27 tons inbound) yields an export capacity for these same cars ($400{,}000 \div 27 = 14{,}815 \times 38 = 562{,}970$) of about 560,000 tons per year for Zambian exports.

(3) *Requirements for Build-up:*

(a) Freight must be offered by interested importers and exporters constantly pushing the limits of the railroad's capacity to haul the freight. In addition, some guarantee may be needed that at least substantial volumes continue to move for a reasonable length of time in order to justify investment. This involves additional costs to the copper companies because more remote sources than Wankie in Rhodesia must be obtained for imported coal and because preferential rates on copper exports now granted by the Rhodesia Railways may be unavailable for the new route.

(b) Foreign exchange must be made available to the BCK for spare parts and replacements for rolling stock, for imported coal, and for salaries of necessary foreign technical assistants. Only 18 to 20 of 36 electric locomotives are kept in operation under current conditions. Many have been damaged seriously in accidents. All of these would need to be restored to service and accelerated delivery of the 5 on order in Belgium should be assured. Steam locomotives may be leased from Zambia, and an indeterminable additional supply of rolling stock should accrue to the system were traffic through Rhodesia halted. Locomotive engineers and maintenance and operating personnel (perhaps 150) would need to be recruited abroad in addition to accelerating local training where possible. Foreign recruiting should probably concentrate on Belgium or France because of linguistic problems. Perhaps $10 million would be required for this package, over half for locomotive repair and replacement.

(c) The program of converting coal-fired locomotives to oil-fired should be accelerated for reasons of both efficiency and reducing coal requirements. Each conversion now requires $10,000 and 3 weeks; conversion of the present unconverted steam locomotive inventory would cost at least $750,000, perhaps more on a crash basis.

(d) Some minor siding construction would need to be undertaken especially to eliminate exceptionally long intervals on the sector between Mutshatsha and Dilolo. Cost should not exceed $100,000.

b. *Build-up with Special Methods of Operation*

A more extensive expansion program could produce a net transport capacity for imports to Zambia of about 770,000 tons per year (about 1 million tons per year for exports). Such a build-up would require a minimum of 6 months to a year after initiation (on an emergency basis) of all programs outlined in (3),

below. Its cost which would subsume the cost of section a, above, is estimated at approximately $20 million.

(1) *Assumed:* Normal BCK operations would be accelerated, as fuel supply and rolling stock were increased, by supplementary operation of special through trains with double-headed diesel traction. The additional personnel requirement would be satisfied by a combination of training and recruiting abroad. Only minor siding construction would be undertaken.

(2) *Discussion:* Two of the potential five additional through train paths each way per day, established in section a, above, might be utilized for the operation of two special 40-car trains each way per day. These trains would be double-headed with diesel traction and would need to be given right-of-way over all other movements because they would exceed siding limitations.* Each train would haul 1,080 tons of imports or 1,520 tons of exports for a total of about 750,000 tons of imports and over 1 million tons of exports per year.** The remaining three additional train paths each way could then be utilized by regular trains of about 430 tons each of imports and about 600 tons of exports (16 cars, double-headed on steam sectors). This amounts to a total of about 470,000 tons per year of imports (650,000 tons per year of exports) in addition to those handled by the special trains cited above. Adding to the 200,000 tons of import capacity potentially available from increased loads on other regular trains (see 2, a, (2), above), the total potential is as follows:

	Import Capacity	Export Capacity
Special trains	750,000	1,000,000
Additional regular trains	470,000	650,000
Increased loads on other regular trains	200,000	280,000
	1,420,000	1,930,000
Congo requirements (450,000 tons plus additional railroad coal and fuel oil at the increased level of traffic)	−650,000	−910,000
Net capacity available for Zambia	770,000	1,020,000

(3) *Requirements for Build-up:*

(a) The same programs covered in 2, a, above, for a total approximate cost of $11 million, would be required, to be supplemented by the following additional requirements.

(b) Expedite the delivery to the Rhodesia Railways in Zambia of 36 diesel-electric locomotives ordered in 1965 and now in production by the General Electric Co. in the United States. The total order amounts to $9 million. Deliveries are now scheduled to begin in May 1966, and shipments are to be at the rate of 4 per month. Based on an estimated 5 day turnaround time from Ndola-Dilolo-Ndola, some 22 of these locomotives might be used (20 plus 2 standbys) on this run for operating the two special trains discussed above. The balance of these diesel locomotives could be used for operating regular trains between Ndola and Elisabethville, thereby freeing badly needed steam locomotives and Congolese engineers for operation between Mutshatsha and Dilolo. Irrespective of emergency requirements, these locomotives are needed for regular operations on the Rhodesia Railways, although their use in Zambia was not what the railway management intended. Nevertheless, they could be used to

* BCK management has already proposed the handling in this manner of 30-car double-headed diesel trains between Ndola-Mutshatsha-Ndola, with the locomotives, cars, and drivers to be supplied and maintained by the Rhodesia Railways in Zambia. The increase of cars per train and distance suggested above is believed to be technically feasible.

** Allows a small margin for accidents, breakdowns, or other eventualities. Net load per car is again estimated at 27 tons for imports and 38 tons for exports.

advantage on the trunkline serving the Copper Belt, where there is a shortage of motive power. Minimum first-year maintenance could be performed at existing steam facilities. An additional requirement for foreign engineers and maintenance personnel might develop, however, if Rhodesian railroaders left Zambia en masse after a complete rupture.

c. *Effect and Feasibility of Installing Centralized Traffic Control*

It is recognized that the installation of centralized traffic control could increase the capacity of this single-track line by as much as 80%, and its installation under the present circumstances has been considered. CTC installation, however, would be supplementary to the above programs and would require lengthening of virtually every siding along the track by at least 1,200 meters, or 7/10 of a mile. At least half of these sidings would have to be electrified, including the building of additional catenary supports. The requirement for high-level maintenance and operating personnel as well as for rolling stock and maintenance facilities would be significantly increased. While the additional cost involved for the installation itself might be only a few million dollars, the time required for survey and acquisition of equipment and personnel alone might be a minimum of 9 months to a year with an additional 9 months to a year (total 18 months to 2 years) for construction and installation.* This is beyond any time-scale useful for contingency planning, and the effect of CTC has therefore not been considered in further detail.

III. The Benguela Railway Company (CFB)

A. Management and Personnel

The CFB is an Anglo-Portuguese enterprise, financed by Tanganyika Concessions, Ltd., which owns 90% of the shares and has invested approximately $145.6 million (£52 million). The railway is administered by a Portuguese company with its main office in Lisbon. Operational headquarters are at Lobito. There is also a London Committee with offices in close proximity to those of the Tanganyika Concessions, Ltd.

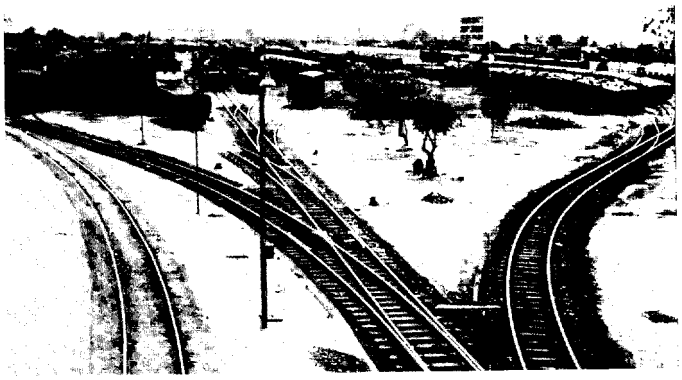
The CFB has in its service in Africa about 15,000 employees. The railroad is efficiently managed, and there are continuing programs for better employee housing and recreation facilities. Morale appears to be excellent. Training is on an apprenticeship basis and is adequate for existing requirements.

B. General Characteristics of the Network

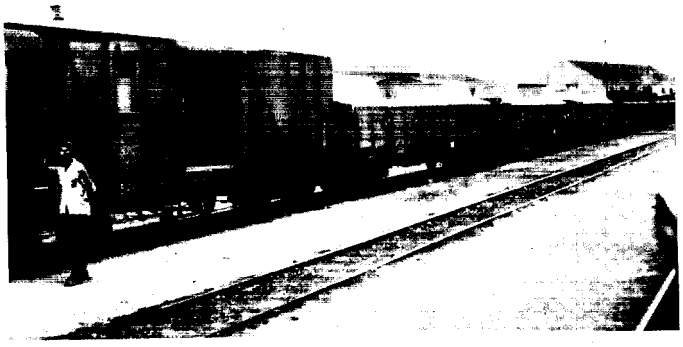
The CFB operates a total of 1,418 route km including a 70-km branch line from Robert Williams to Cuima which was opened in 1962 to serve the iron ore mines. The track is the normal African guage (3'6") and consists of 60-lb rails on steel or wooden ties with stone ballasting. Maximum gradient is 1 in 40 (2.5%) and minimum radius of curvature is 330 ft compensated. There are 164 bridges but no tunnels.

From its ocean terminal at the Port of Lobito the CFB, soon after leaving the nearby city of Benguela, begins its ascent of the coastal escarpment, rising sharply to heights between 4,000 and 5,000 ft within a comparatively short distance. It reaches its highest point of 6,082 ft near Vila Verde at a distance of 386 km (240 miles) from Lobito, and it descends gently into the Central African Plateau. (See the diagram, p. 13.) The main line of the CFB between

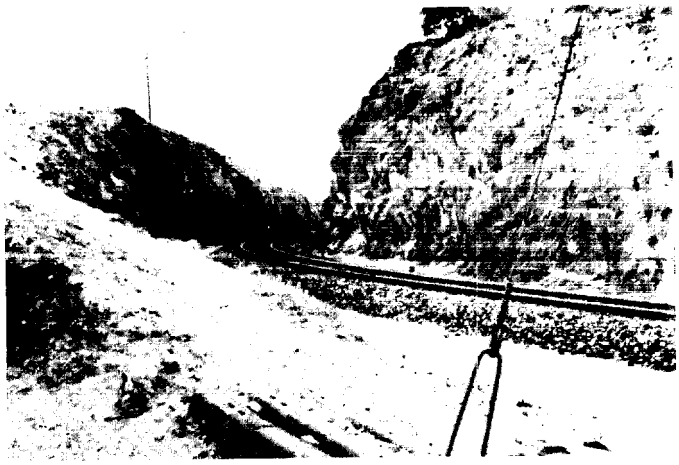
* Note also that service traffic associated with the construction and installation would interfere with capacity operations in progress during an emergency.



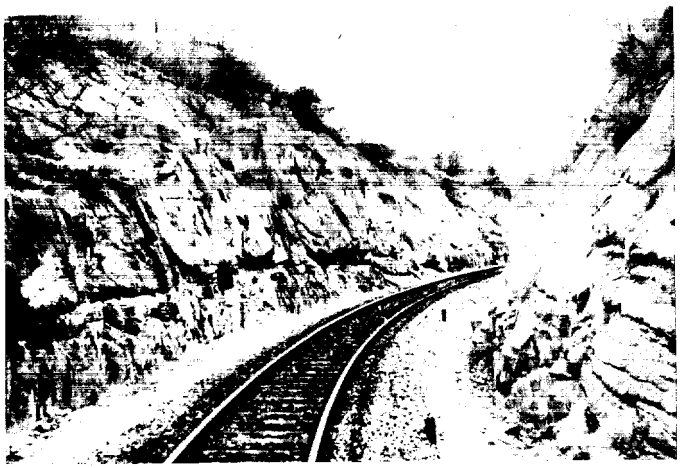
THE MARSHALING YARDS AT LOBITO



MOTOR VEHICLES FOR ZAMBIA ON A CFB TRAIN



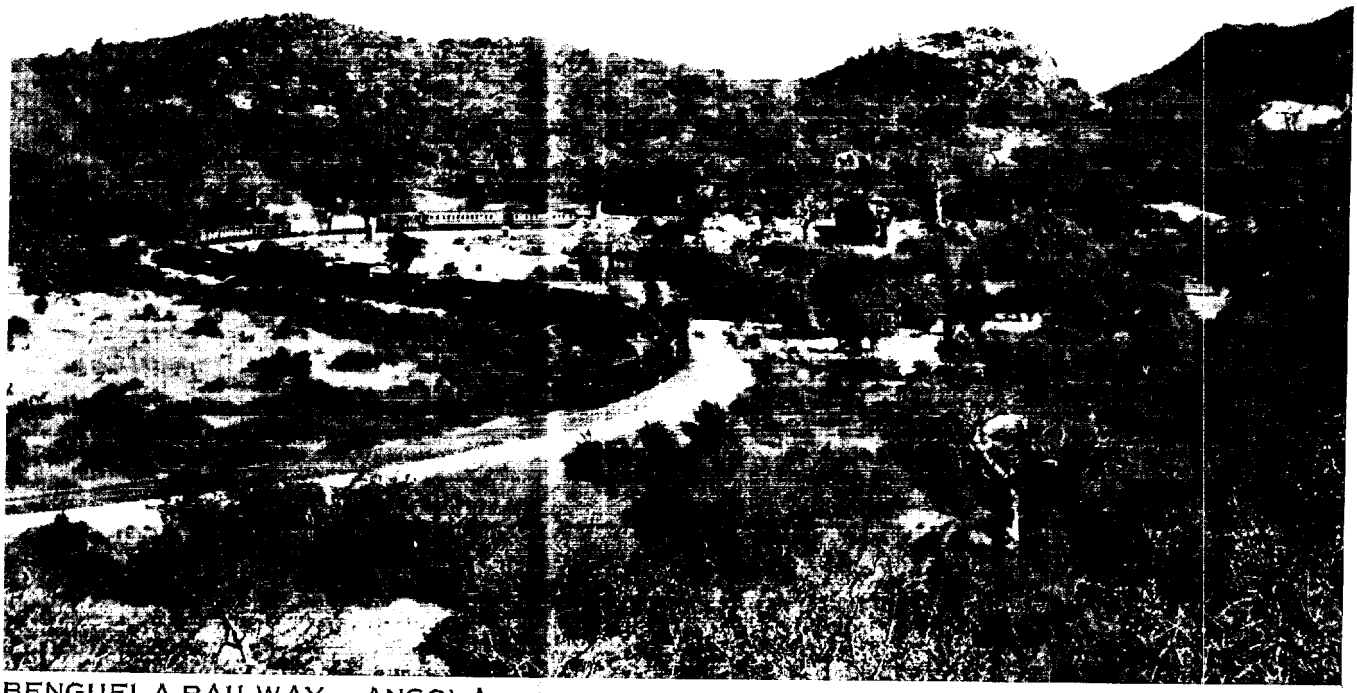
VIEW OF THE LINE BETWEEN CORUTEVA AND CUBAL



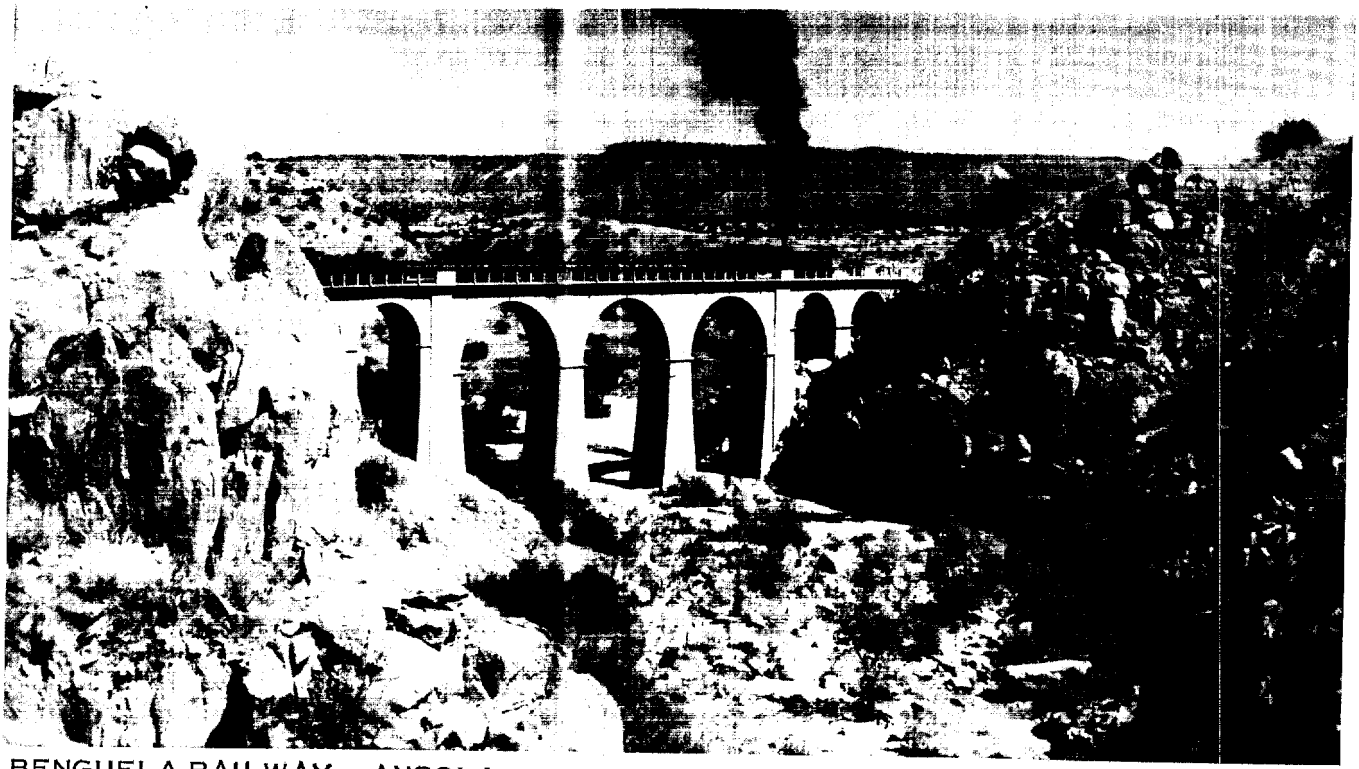
VIEW OF THE LINE BETWEEN CORUTEVA AND CUBAL

"MOUNTAIN" GARRATT LOCOMOTIVE PULLING A TRAIN ONTO A SIDING AT PORTELA AFTER CLIMBING NEARLY 300 METERS IN 12 KM. NOTE THE TYPICAL SHORT LENGTH OF THE TRAIN.

END OF THE SHARP CLIMB FROM THE EAST TO THE TOP OF THE MOUNTAIN AT PORTELA



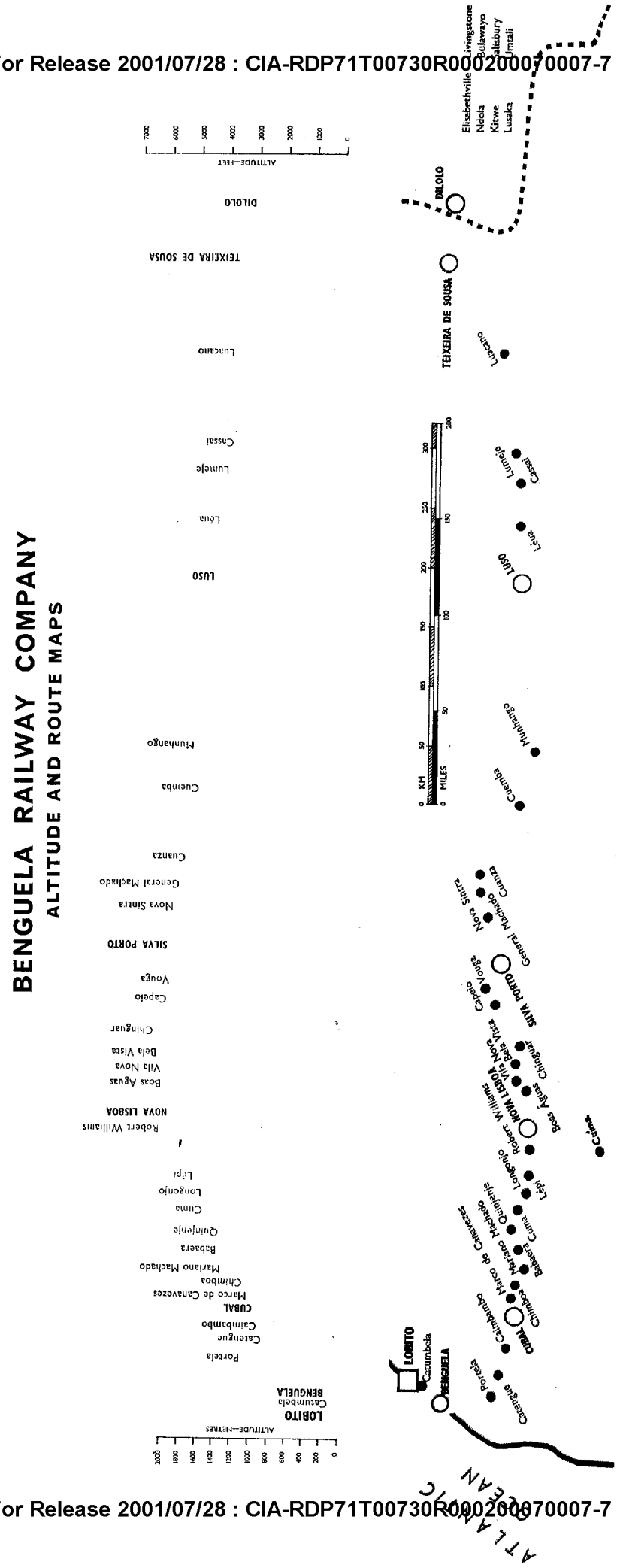
BENGUELA RAILWAY – ANGOLA . A DOUBLE TRAIN ASCENDING THE LINE NEAR LEPI (CFB PHOTO)



BENGUELA RAILWAY – ANGOLA. FREIGHT TRAIN CROSSING THE COMMANDANTE ALVARO MACHADO BRIDGE. NOTE THE BARREN COUNTRY TYPICAL OF THE COASTAL ESCARPMENT. (CFB PHOTO)

BENGUELA RAILWAY COMPANY

ALTITUDE AND ROUTE MAPS



Lobito and the Congo/Angola border near Dilolo, forming the Angolan stretch of the Lobito Route, covers 1,347 route km. Trains are hauled by steam locomotives throughout the system, and traffic control is by train order except on the difficult section between Benguela and Cubal where a Tyers Key Token system of manual block is used.

C. Locomotives and Cars

Nearly all of the rolling stock on the CFB is of British manufacture. Motive power consists of 109 steam locomotives of which 57 are Beyer-Garratts and 38 North British. In addition there are 4 North British diesel-hydraulic shunting locomotives. A detailed breakdown of the locomotive inventory may be found in Table B-1.

There are a total of 1,589 freight cars, including 1,489 open top and box cars mainly of 40 tons capacity, 45 cattle cars, 47 tanks cars, and 8 refrigerator cars plus 28 brake vans* and miscellaneous other types.** (See Table B-2 for further detail.)

There are also in the CFB inventory 18 baggage cars and a total of 50 passenger cars, of which 25 are sleeping cars, 21 are day coaches, and 4 are restaurant cars. Service stock includes 3 traveling cranes, 2 of 10-ton and 1 of 30-ton capacity, and 15 shop cars. Most petroleum oils in bulk are transported in some 130 tank cars belonging to the oil companies.

D. Traffic

Freight traffic in 1965 on the CFB was an estimated 2.85 millon tons, of which 928,000 tons was eastbound and 1,922,000 tons was westbound. Of the total 2.85 million tons carried, 1.65 million was revenue traffic—1,242,000 tons westbound and 408,000 tons eastbound. The peak year for revenue traffic occurred in 1961, when 1.8 million tons were carried—342,000 tons eastbound and 1.5 million tons westbound. Current revenue freight is therefore about 92% of the 1961 peak traffic year. Some additional locomotives and cars have been acquired, a new 70-km branch line has been built, and all existing facilities and rolling stock have been well maintained in the meantime. For freight traffic on the CFB during 1945-64, see Tables B-6 and B-7.

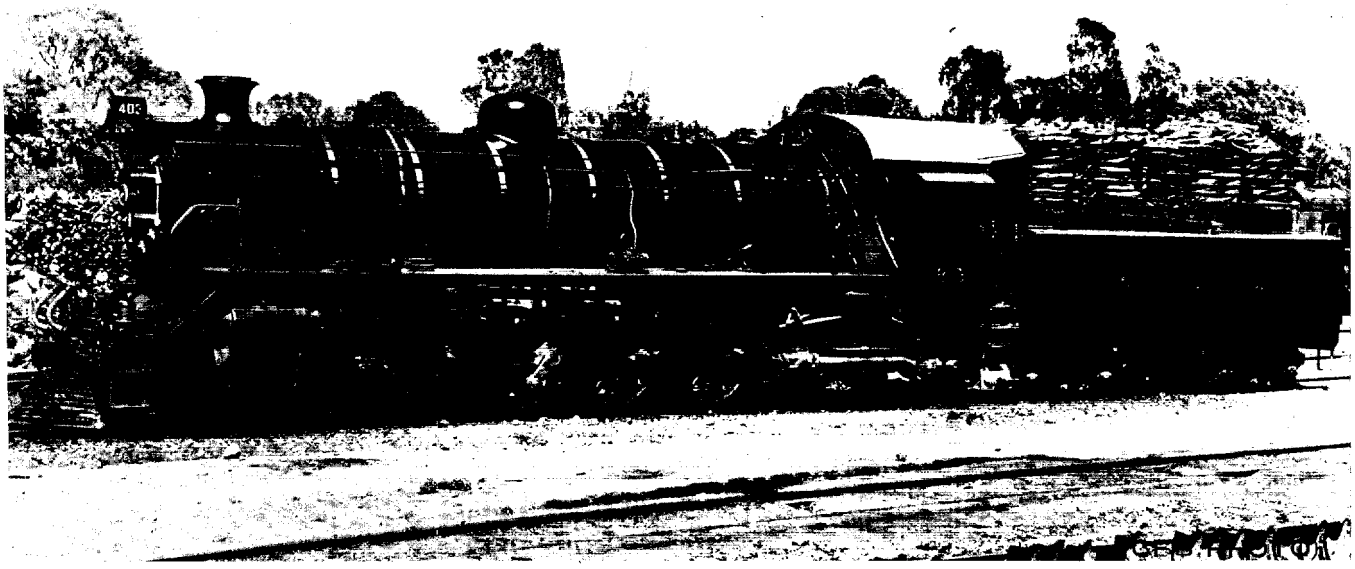
E. Operations and Line Detail

The CFB operates throughout with steam traction. There is no coal in Angola, and essential supplies are imported from South Africa. Coal is used only on the coastal plain along which the line passes on its way to Benguela. Oil-fired locomotives are employed between Benguela and Nova Lisboa to meet the severe conditions over this mountainous sector of the route. On the whole of the remainder of the line extending more than 805 km (500 miles) across the central plateau, locally grown timber provides the sole source of fuel. The consumption of wood for this purpose is now over 600,000 tons a year, and its comparative cheapness has proved a very great saving in operating costs.

The railway has its own plantations of eucalyptus which stretch for many miles alongside the line and contain about 100 million trees. The company's Forestry Department, employing over 4,000 men, is responsible for maintaining these plantations, cutting the wood, transporting it to refuelling points and for planting new trees. Eucalyptus was chosen for its suitability as fuel and also

* Cars for train crews; cabooses are not used and there is no U.S. equivalent.

** A few depressed center transporter cars of up to 50 tons capacity are available for heavy and bulky loads.

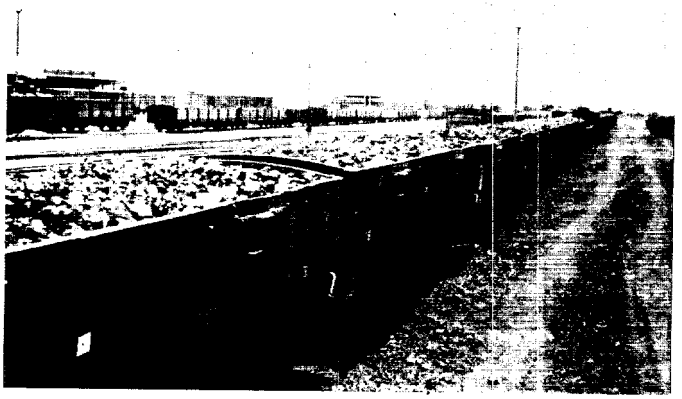


CLASS 11a STEAM LOCOMOTIVE, TRACTIVE EFFORT 12,470 LBS. THE CFB OPERATES 6 LOCOMOTIVES OF THIS TYPE.

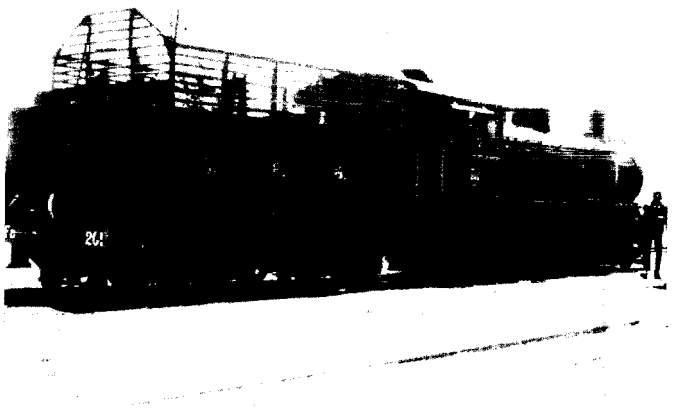
CLASS 11a STEAM LOCOMOTIVE AT LOBITO

WOOD-BURNING STEAM LOCOMOTIVE NEAR THE CONGO/ANGOLA BORDER AT TEIXEIRA DE SOUSA

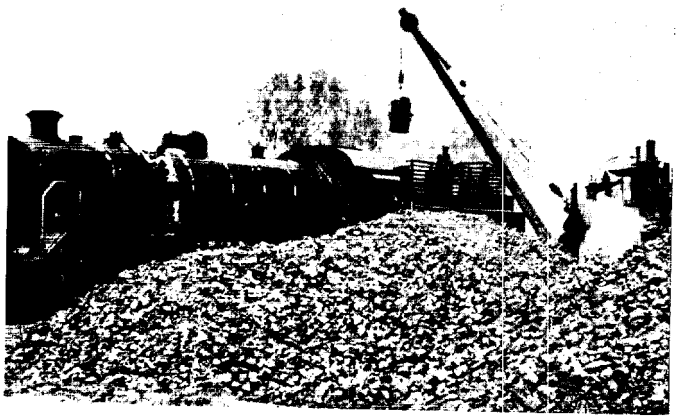
CLASS 9a B STEAM LOCOMOTIVE AT LOBITO. THE CFB OPERATES A TOTAL OF 14 CLASS 9a (A AND B) LOCOMOTIVES, EACH OF WHICH HAS A TRACTIVE EFFORT OF 9,250 LBS.



STRINGS OF COAL CARS IN THE LOBITO YARDS

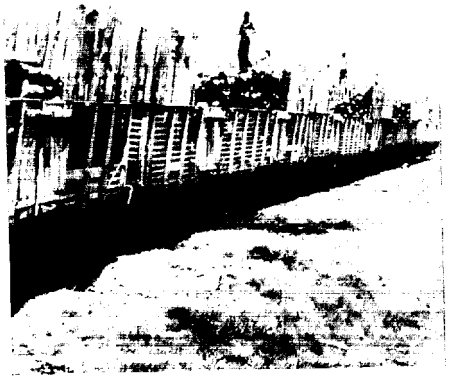


CLASS 9a A STEAM LOCOMOTIVE AND TENDER AT LOBITO. THE CFB OPERATES 12 OF THESE LOCOMOTIVES.



REFUELING A COAL-BURNING STEAM LOCOMOTIVE AT LOBITO

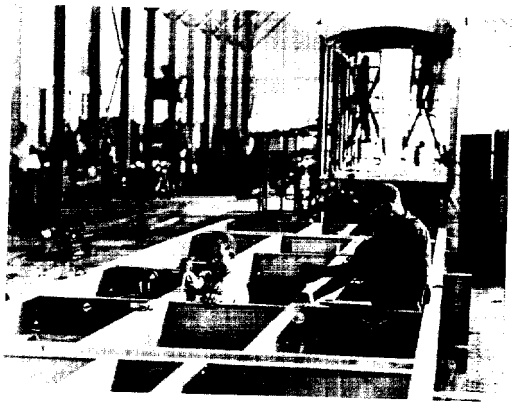
(CFB PHOTO)



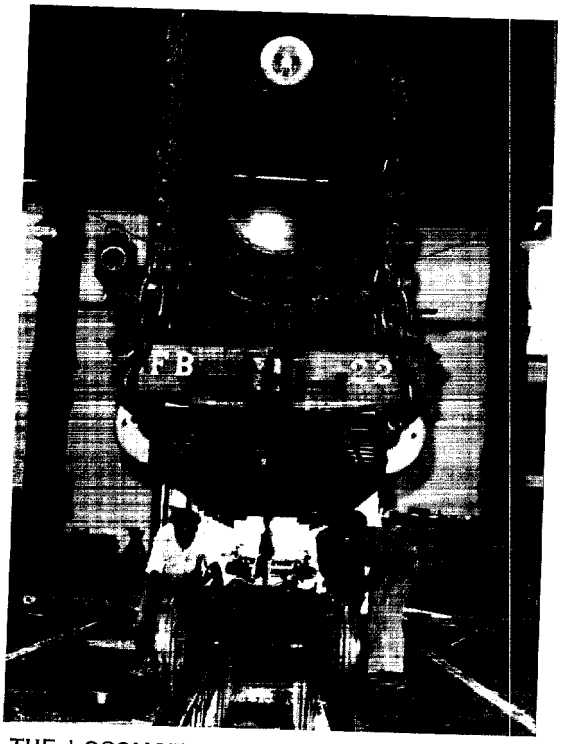
OPERATING WITH WOOD FUEL ON THE CFB. IN THE AERIAL VIEW (INSET AT TOP) THE DARK AREAS ON EITHER SIDE OF THE RAILROAD TRACK ARE EXTENSIVE EUCALYPTUS PLANTATIONS. THE PHOTO AT THE LOWER LEFT SHOWS REFUELING AND WATERING SIMULTANEOUSLY — AN OPERATION THAT AVERAGES 10 MINUTES. NOTE THE INTENSIVE USE OF MANUAL LABOR.

BENGUELA RAILWAY – ANGOLA

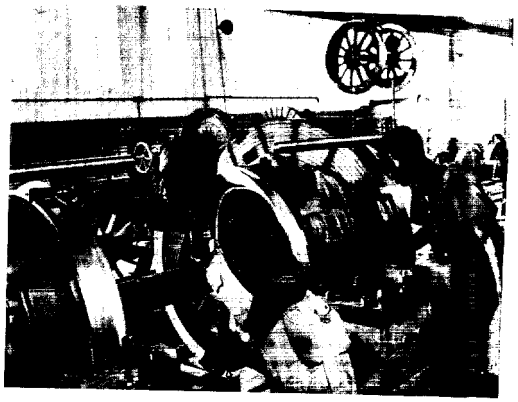
(CFB PHOTOS)



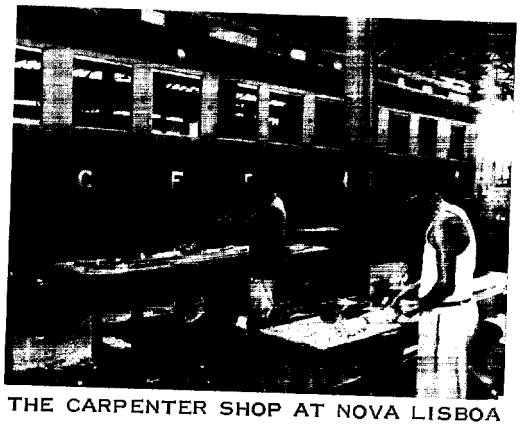
THE WAGON SHOP AT NOVA LISBOA



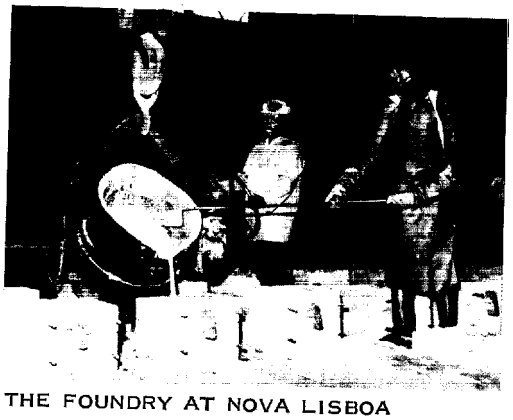
THE LOCOMOTIVE SHOP AT NOVA LISBOA



THE MACHINE SHOP AT NOVA LISBOA



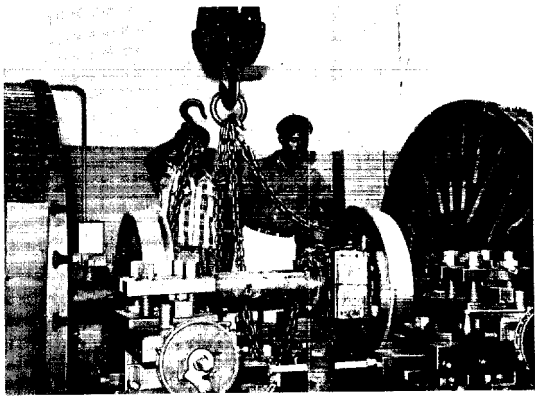
THE CARPENTER SHOP AT NOVA LISBOA



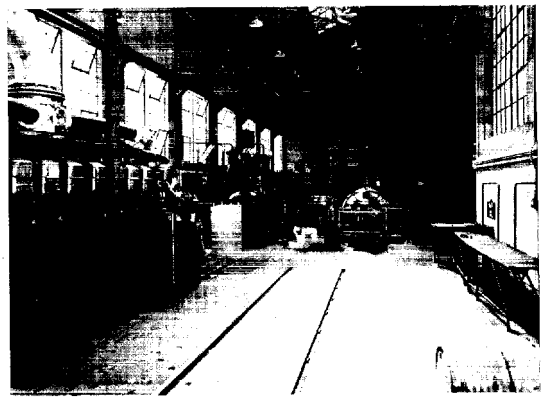
THE FOUNDRY AT NOVA LISBOA

BENGUELA RAILWAY – ANGOLA

(CFB PHOTOS)



THE WHEEL SHOP AT NOVA LISBOA



PART OF THE THERMAL POWER STATION AT NOVA LISBOA

THE GENERAL MACHINE SHOPS AT NOVA LISBOA

Table 2

ANGOLA: STATIONS AND HALTS ON THE BENGUELA RAILWAY (CFB)

Stations are shown in block capitals: others are halts

	Altitude	Distances [a] from Lobito	
	Meters	*Km.*	*Miles*
LOBITO	3	0	0
CATUMBELA	13	12	7½
Damba-Maria	11	26	16
BENGUELA	10	34	21
Chivanda	79	46	29
Monte Sàoa	374	61	38
Binga	450	72	45
CORUTEVA	634	85	53
Portela	902	97	60
Chivite	732	105	65
CATENGUE	540	123	76
Solo	799	143	89
CAIMBAMBO	779	164	102
Guerra Junqueiro	881	181	112
CUBAL	910	198	123
Marco de Canaveses	1,030	214	133
Chimboa	1,006	232	144
MARIANO MACHADO	1,253	254	158
Alto Catumbela	1,250	271	168
BABAERA	1,248	280	174
QUINJENJE	1,362	298	185
CUMA	1,438	318	198
Chenga	1,443	326	203
LONGONJO	1,421	343	213
LÉPI	1,639	368	229
VILA VERDE	1,841	386	240
ROBERT WILLIAMS	1,744	398	247
CUIMA	1,627	477	296
Dango	1,711	411	255
NOVA LISBOA	1,699	426	265
Santa Iria	1,687	430	267
Santo Amaro	1,680	445	283
Cambuio	1,738	456	293
Boas Aguas	1,768	472	299
VILA NOVA	1,851	481	313
BELA VISTA	1,807	503	323
CHINGUAR	1,811	520	340
CUTATO	1,797	547	351
Sàpinde	1,757	565	361
Capeio	1,768	582	376
VOUGA	1,756	605	390
SILVA PORTO	1,722	628	406
Chipeta	1,604	653	420
NOVA SINTRA	1,524	676	437
GENERAL MACHADO	1,476	703	451
Cuanza	1,274	726	462
Cuéli	1,291	744	475
Cuiva	1,283	765	488
CUEMBA	1,333	785	503
Chitende	1,395	809	512
Savinguila	1,355	824	526
MUNHANGO	1,426	846	537
Simoje	1,497	864	537
Cangonga	1,499	881	547
Cavimbe	1,444	907	564
Sachanga	1,412	923	577
Cangumbe	1,475	943	586
Cachipoque	1,466	963	598
Saleno	1,443	983	611
Chicala	1,410	1,001	622
Luena	1,385	1,019	633
LUSO	1,330	1,036	644
Camitongo	1,302	1,058	657
Luculo	1,266	1,078	670
Léua	1,234	1,098	682
Sandando	1,178	1,119	695
LUMEJE	1,142	1,136	706
Cassai	1,126	1,156	718
Chabaia	1,115	1,178	732
Chifumaje	1,105	1,199	745
Caifuche	1,096	1,220	758
Luacano	1,090	1,243	772
Mutuècai	1,101	1,263	785
Mucussueje	1,057	1,282	797
Cafungo	1,109	1,305	811
Camuxito	1,097	1,324	823
TEIXEIRA DE SOUSA	1,100	1,335	830
Frontier (R. Luau)	977	1,348	838

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THROUGH RAIL DISTANCES FROM LOBITO

	Altitude	Distances [a] from Lobito	
	Meters	*Km.*	*Miles*
KATANGA			
Dilolo (Angola/Katanga border)	991	1,350	838
Kolwezi	1,443	1,775	1,103
Tenke	1,169	1,870	1,162
Jadotville	1,270	1,975	1,226
Elisabethville	1,230	2,107	1,309
Sakania Frontier (Katanga/Rhodesian border)	1,258	2,362	1,468
Bukama	575	2,088	1,297
Kabongo	1,033	2,434	1,512
Kamina	1,115	2,233	1,338
Albertville	777	2,953	1,834
Kabalo	534	2,680	1,665

	Altitude	Distances [a] from Lobito	
	Meters	*Km.*	*Miles*
NORTHERN RHODESIA			
Ndola	1,486	2,375	1,478
Kitwe	1,259	2,441	1,519
Lusaka	1,295	2,700	1,677
Livingstone	907	3,163	1,968
SOUTHERN RHODESIA			
Bulawayo	1,356	3,629	2,255
Salisbury	1,477	4,110	2,554
Umtali	1,119	4,384	2,724
REPUBLIC OF SOUTH AFRICA			
Mafeking	1,277	4,420	2,747
Johannesburg	2,088	4,722	2,934

	Altitude	Distances [a] from Lobito	
	Meters	*Km.*	*Miles*
Durban	—	5,501	3,419
Port Elizabeth	—	5,910	3,673
Cape Town	—	5,810	3,610
MOZAMBIQUE			
Malvérnia	634	4,173	2,593
Beira	—	4,712	2,928
Lourenço Marques (via Malvérnia)	—	4,707	2,925
Lourenço Marques (via Johannesburg)	—	5,438	3,323
EAST AFRICA			
Kigoma	226	4,676	2,906
Dar-es-Salaam	—	4,550	2,828

[a] This table was published about 1952. Distances elsewhere in this report are taken from the current operating timetable and may differ slightly from the distances shown above.

for its regenerative powers. The first cutting is taken 7 years after planting; the stumps left in the ground are pruned to produce three shoots from which a second cutting can be obtained after another period of 7 years. About four further cuttings are possible each at 7-year intervals. The productive life of the plantations should thus exceed 40 years.

Except in one particular locality, water supplies are adequate. Nevertheless, to keep pace with increasing consumption, much work has been necessary in sinking wells and in the construction of reservoirs and pumping stations.

The main workshops of the Benguela Railway are situated at Nova Lisboa, a distance of 426 km from Lobito. They are modern and fully equipped to maintain the existing locomotive fleet which runs a total of about 11.3 million engine km per year. Erected in 1929, the workshops occupy a total floorspace of 25,000 sq yds and employ over 1,000 men. When required, the construction of passenger coaches, freight cars, and other equipment can be undertaken. Routine engine maintenance is carried out at four main depots at Lobito, Cubal, Nova Lisboa, and Luso.

On the CFB, as is often the case with young women whose vital statistics indicate the all-important matter of curvature and the heights to which they may climb, the statistics of curvature and gradient are among the predominant factors governing the railway's capacity. The limiting sector of the CFB with many steep gradients and tight curves is between Benguela and Cubal (161 km). Maximum gradients of 2.5% in both directions are encountered between Coruteva and Cubal (a distance of 113 km). The highest point on this sector is at Portela (97 km east of Lobito) and there is a constant ascending grade of 2.5% of 12 km from Coruteva to Portela.* The size of trains on this sector is limited by the length of passing sidings (minimum 330 meters) to a maximum of 19 cars and 2 locomotives for a net trainload of about 520 tons.

An alternative alignment of the track between Benguela and Cubal which would ease the now severe grades and curves and shorten the distance (now 161 tortuous km) by perhaps 25 km has already been surveyed. There are no new bridges involved, and CFB engineers estimate construction to be possible in as little as 6 months on a crash basis. The current cost estimate of about $20 million would probably be increased to at least $25 million in order to cut the routine construction time from 2 years to 6 months.

Other significant line details and operational factors are listed in Table 3, below, and in Table B-8.

TABLE 3

Angola: Significant Line Details and Operational Factors of the Benguela Railway (CFB)

(1) Maximum distance between passing sidings	26.3 km
(2) Maximum scheduled time interval between sidings	52 minutes
(3) Average interval between passing sidings (including meets)	25 minutes
(4) Minimum length of passing sidings	330 meters
(5) Average speed of freight trains	30 km/hr
(6) Average delay at various train assembly points (minutes):	
Benguela	60
Cubal	80
Nova Lisboa	90
Luso	90

* Altitudes and distances between all stations and passing sidings on the CFB between Lobito and the Congo/Angola border are shown in Table 2, page 20.

TABLE 3 (*Continued*)

(7) Average turnaround time of freight cars (Lobito-Kisenge-Lobito)[a]	12 days
(8) Estimated average net tons per car:	
eastbound	27
westbound	38
(9) Average net tons per car, by commodity:	
copper and other minerals	35 to 40
coal	30
agricultural freight	28 to 40
(10) Average annual run for mainline locomotives (1964)	81,800 km

[a] Kisenge, where some 300,000 tons of manganese per year is originated for shipment to Lobito, is actually 124 km beyond the Angola/Congo border, but freight cars are handled on a through interchange basis with the BCK, and the CFB performs 1,347 km of the total 1,471 km haul.

F. Capacity and Limiting Factors

1. *The Current Situation*

Using existing locomotives and cars on the present track, the additional capacity available for transit on the CFB to either the Congo or Zambia over and above the approximate traffic level of December 1965 was about 228,000 tons per year westward to Lobito and 210,000 tons per year eastward to the Congo or Zambia. Since December, however, in anticipation of an embargo on coal from Rhodesia, coal imports to Zambia and the Congo via the Lobito Route have increased. Thus, the eastward excess capacity as of December 1965 may be already substantially used. Some of the excess westward capacity is also used because in December 1965 copper from Zambia began to move via the Lobito Route at the rate of 5,000 to 10,000 tons per month.

Thus, the existing excess capacity of the CFB without additional locomotives, cars, and fuel would not even be adequate to carry alternative Congolese imports to those now using the Rhodesia route (about 450,000 tons per year) in the event of an embargo of the latter route. No excess capacity would exist for imports to Zambia.*

2. *Potential Capacity*

a. *Potential Capacity Without Major Line Construction*

(1) *Capacity with Maximum Effective Supply of Rolling Stock and Personnel*

It should be possible, within a minimum of 6 months to a year, to achieve a gradual increase in existing capacity for transit traffic (Zambian and Congolese combined) by 700,000 tons westbound and 800,000 tons eastbound to meet the contingency of embargo on Rhodesian rail traffic at the Rhodesia/Zambia border.** This could be accomplished without major line construction by offering to the CFB increasing volumes of transit freight to be hauled while concurrently expediting and assisting with the necessary increase in the supply

* Assuming that priority in general would be given to the movement of imports to the Congo over imports to Zambia.

** No significant diversions of traffic as a result of UDI in Rhodesia had yet occurred as of December 1965 and the 1965 traffic pattern is considered to be normal. See Appendix C for methodology on which estimates of capacity are based.

of rolling stock and the training of competent personnel.* Total capacity available for transit traffic after such augmentation would be about 1,268,000 tons westbound and 888,000 tons eastbound. Traffic for Angola at a level of 732,000 tons westbound and perhaps 300,000 tons eastbound (1965 levels), in addition to passenger and railroad service traffic, would occupy the remaining capacity of the line. A considerable movement of empty transit cars westbound (perhaps 30 percent) and of empty local cars eastbound is implied in the above traffic pattern.

Of the 800,000 tons of additional transit capacity eastbound, some 650,000 tons would probably be used by Congo imports (450,000 tons assumed to be diverted from the Rhodesia Route plus perhaps 200,000 tons of additional coal and fuel oil for the BCK to support increased operating levels). Thus, only 150,000 tons of Zambian imports and 210,000 tons of Zambian exports** could be handled if priority on the Lobito Route is given to Congo imports. This is about 620,000 tons short of the capacity necessary for the CFB to match the import potential of the BCK after a concurrent maximum build-up over a period of about a year.*** Substantial new line construction (realignment) on the CFB, discussed in section b, below, accompanied by an even greater build-up of rolling stock and personnel will be necessary to provide such matching capacity.

(2) *Requirements for Maximum Build-up Without Major Line Construction*

(a) Freight must be offered by interested importers and exporters, constantly pushing the limits of the railroad's capacity to haul the freight. In addition, some guarantee may be needed that at least substantial volumes continue to move for a reasonable length of time in order to justify investment. This involves additional costs to the copper companies because of resort to more remote sources than Wankie in Rhodesia for imported coal and because of the loss of preferential rates on copper exports now granted by the Rhodesia Railways.

(b) The CFB must be assisted through the acquisition by purchase or lease of additional locomotives. (Zambia is a potential source if traffic through Rhodesia is disrupted.) The CFB will need to expand its training programs for indigenous locomotive engineers. Language and security problems inhibit the use of engineers of other than Portuguese nationality. The management has estimated that at least 6 months are required to train a locomotive engineer. Other maintenance and operating personnel would also have to be acquired and trained.†

(c) The additional freight car requirements for transit freight could probably be supplied by Zambia if traffic through Rhodesia is disrupted.

(d) Repair and maintenance facilities for locomotives and cars would need to be gradually expanded, although for a time considerable capability could be realized by deferring maintenance on the currently well maintained stock of the CFB.

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* One of the major elements in the time requirement would be the necessity to train or recruit additional locomotive engineers. The CFB, for reasons of both language and security, may not be able to accept foreign engineers (other than those it might be possible to recruit in Portugal and Mozambique—not technically "foreign").

** The equivalent of the 150,000 tons of imports at an increased load per car.

*** See page 9.

† It may be possible to recruit some personnel in Mozambique and Portugal.

b. *Potential Capacity with Major Line Construction*

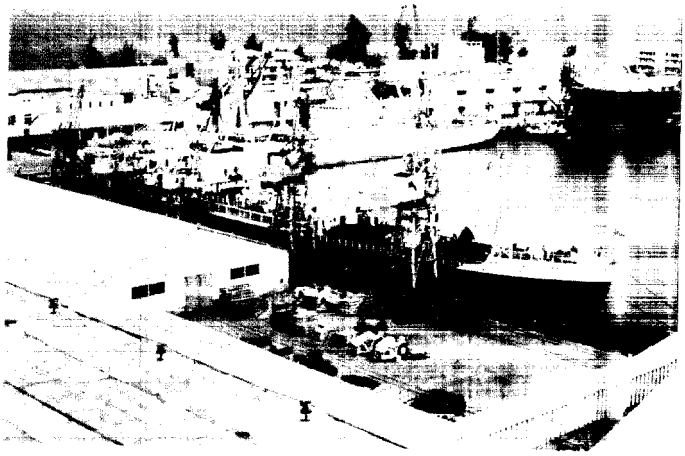
It should be possible for the CFB within 6 months to a year to match or even exceed the enlarged BCK capacity through the construction of the Cubal Variant, a new alignment of the track between Benguela and Cubal which would ease the now severe grades and curves and shorten the distance by perhaps 25 km. CFB engineers estimate that this realignment might be completed in as little as 6 months on an emergency basis. The current cost estimate of nearly $20 million (£7 million) for this construction would probably increase to at least $25 million in order to reduce construction time from 2 years (planned normal program) to 6 months. With the Cubal Variant in operation and a few additional passing tracks, the CFB could increase its carriage to a total of 3 million revenue tons westbound and over 2 milllion tons eastbound per year (allowing for the reduced average load per car of eastbound traffic).* Since current eastbound revenue traffic is only about 440,000 tons per year, eastbound capacity for additional freight of some 1.6 million tons per year would be theoretically available—more than enough to match the BCK capacity for both Congolese and Zambian imports. The total cost of the build-up, including the line construction, additional rolling stock, and expanded maintenance facilities, might reach a total of $30 million.

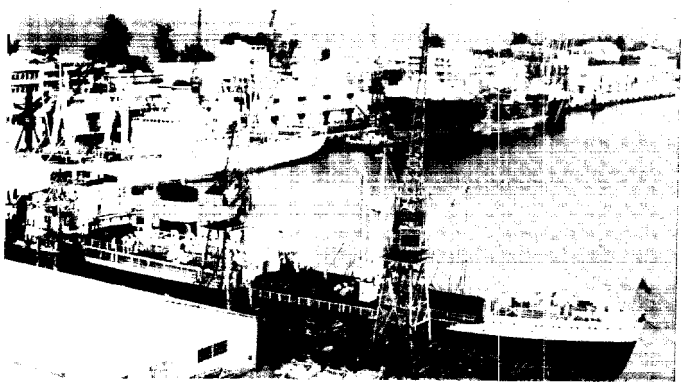
IV. The Port of Lobito

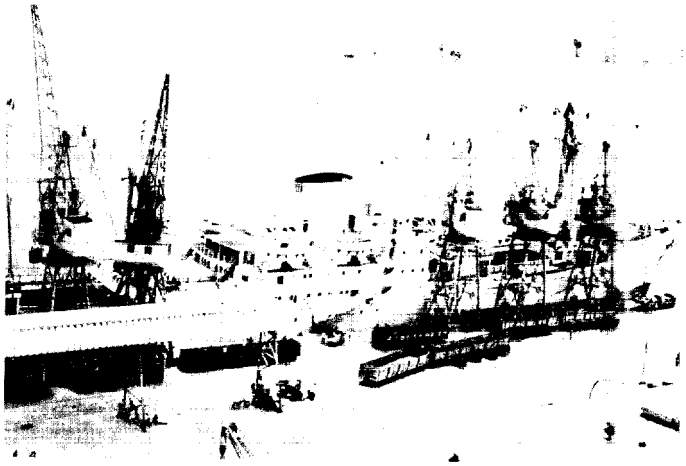
The Port of Lobito is state-owned and appears to be well managed. A natural breakwater 5 km long and 250-365 meters wide shelters a harbor of 5 square km with depths ranging from 5 to 35 meters. The 640-meter wide channel at the entrance to the bay plus the small tidal range permits vessels to proceed to the deep-water berths without pilot or tug. There are 2 main quays with alongside depths of 10 meters. Six ships that average 10,000 to 12,000 deadweight tons, or a lesser number of larger vessels, may be accommodated simultaneously. Of the six berths, one is being used for general cargo, one is used for bulk grain and for oil tankers, and the others for bulk ores and for oil tankers. Port equipment includes a mechanical ore loader with a capacity of 400 tons per hour and an installation for loading bulk grain, also at the rate of 400 tons per hour.

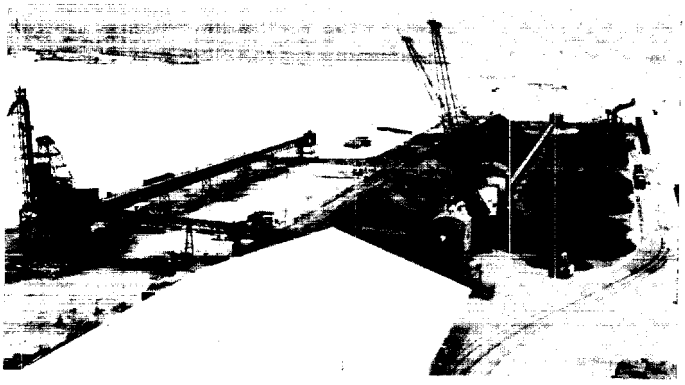
Portuguese port authorities politely declined to give a figure (even approximate) on the present capacity of the Port of Lobito. They did say, however, that they believed the port, with its present personnel and equipment, to be "near the saturation point." The points to be made here, however, are that additional contract stevedore labor is easily available, the port is not being worked around the clock or on Sundays and holidays, and, while there are some days when all or most of the berths are occupied, there are others on which there are virtually no ships being worked. Maximum working of the existing six berths would require more equipment and labor. Previous unofficial capacity estimates of 3.5 million to 4 million tons have been made by reliable civilian observers and a Portuguese military expert and these estimates appear quite reasonable. With additional berth construction, a relatively simple matter, the port capacity should have no trouble in this century keeping up with any potential traffic.

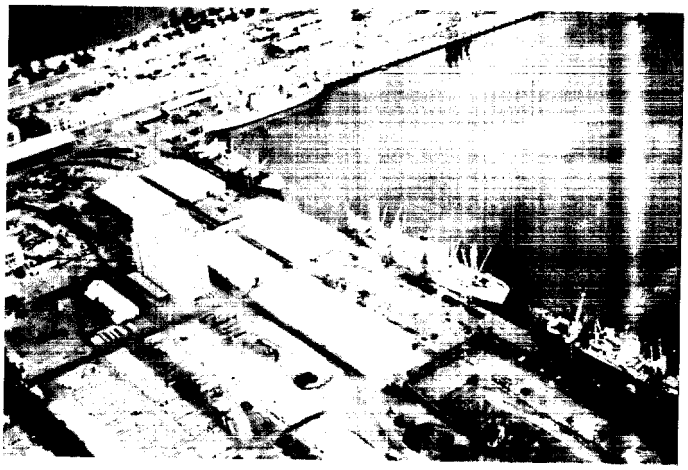
* Assuming the necessary augmentation with rolling stock and personnel, in addition to that described in F, 2, a, above.

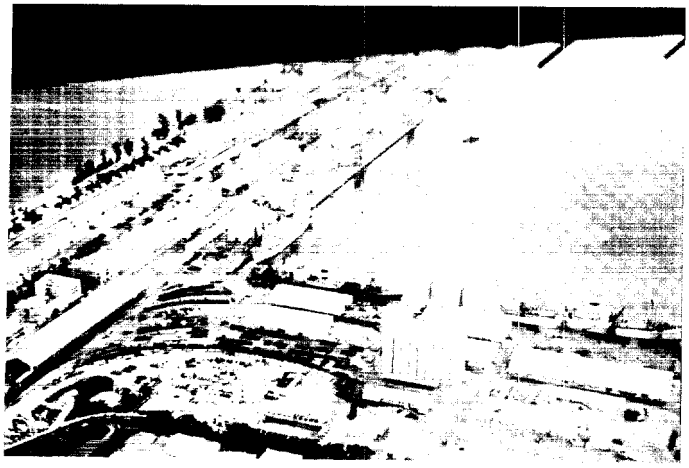












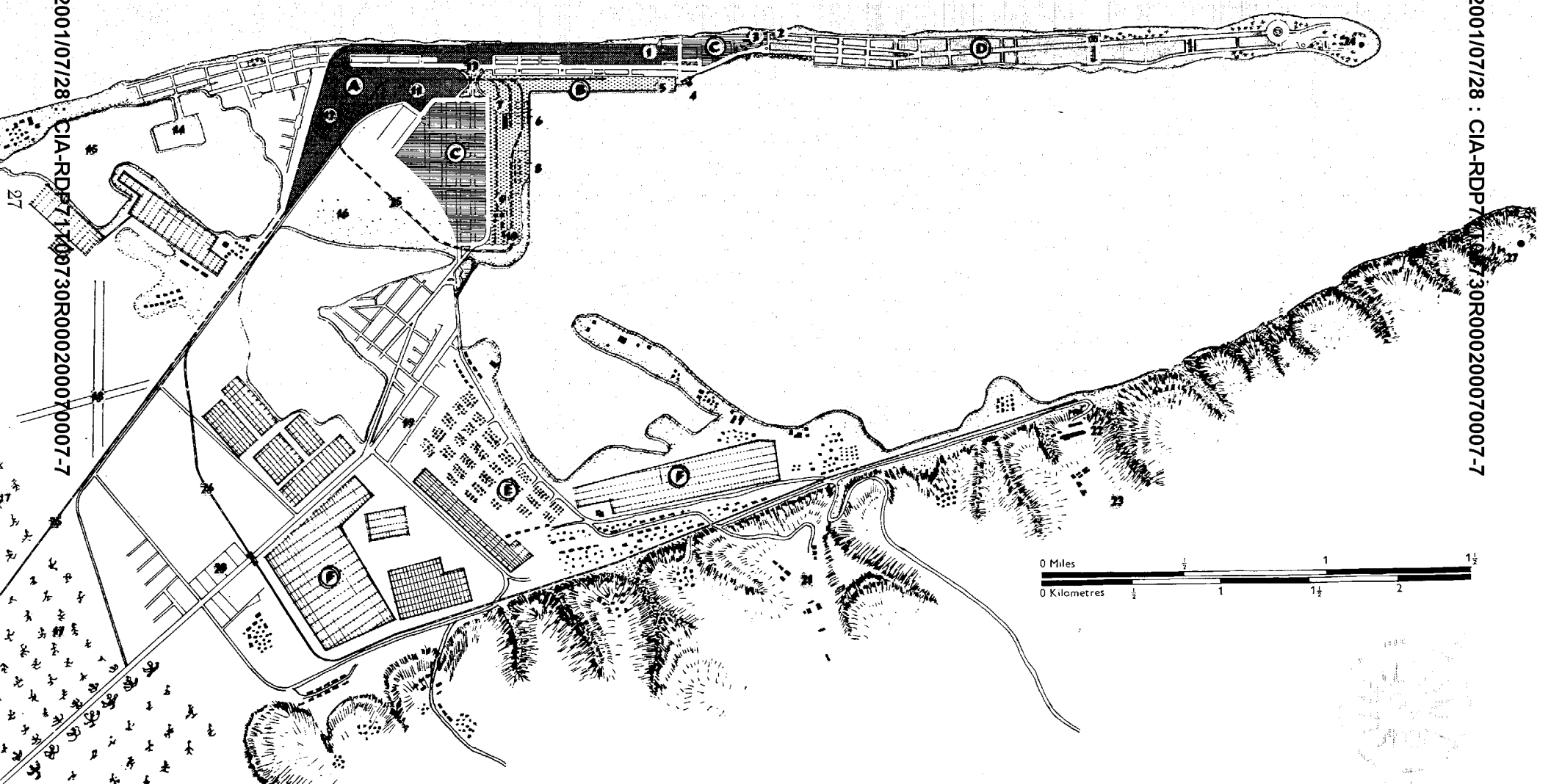
VIEWS OF THE PORT OF LOBITO SHOWING THE DEEP-WATER BERTHS AND CRANES, THE MECHANICAL ORE LOADER, THE GRAIN ELEVATOR, COVERED STORAGE, AND RAILROAD ACCESS TRACKS

PLAN OF LOBITO HARBOUR

KEY TO MAP REFERENCES

- A Railway Area
- B Port Area
- C Business Area
- D Residential Area
- E African Town
- F Salt Pans

1. Railway Station
2. Railway Offices
3. Hotel Terminus
4. Quay for Coastal Shipping
5. Vegetable Oil Tanks
6. Cargo Sheds
7. Grain Silos
8. New Ore Loader
9. Coal Yards
10. Oil Terminal
11. Mineral Yards
12. Marshalling Yards
13. New Road Bridge
14. Government Hospital Site
15. Tidal Mudflats
16. Reclaimed Land
17. Sugar Cane
18. Airport
19. Light Industrial Site
20. Warehouses
21. Barracks
22. Cement Works
23. Golf Course
24. Restinga Light
25. Railway Lines
26. Railway Line to Cement Works
27. Lobito Lighthouse



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The highest level of traffic ever handled at Lobito occurred in 1964 when almost 1.8 million tons were handled, as tabulated below:

Outbound	
Mineral ore	761,252
Other minerals	176,154
General cargo	318,131
Ship supplies	89,811
Subtotal	1,345,348
Inbound	
POL	163,388
General cargo	267,521
Subtotal	430,909
Coastal	
Inbound and outbound	4,078
Grand total	1,780,335

There has been only a slight variation in traffic for the past five years. Traffic in 1965 is expected to be slightly below the 1964 record.

V. Conclusions

The Lobito Route, in the event of an embargo on the use of the Rhodesia Route in the immediate or near future, would have no capacity available for the shipment of Zambian imports or exports if it is assumed that the existing excess capacity would be used by the diversion to the Lobito Route of Congolese (Katangan) freight now moving via the Rhodesia Railways. Over a period of 6 months to a year at a cost of about $20 million, mostly for the rehabilitation and augmentation of motive power on the BCK, it should be possible to build up gradually the combined throughput capabilities of the BCK and the CFB to a level where all of the diverted Congolese freight could be handled plus some 150,000 tons per year of imports and 210,000 tons per year of exports for Zambia. Recruitment of skilled personnel and an adequate supply of foreign exchange would be critical requirements. Throughput to Zambia at this point would be limited by conditions on the CFB.

If construction of the Cubal Variant on the CFB were accelerated concurrently and some additional passing tracks were built on other parts of the route in the meantime, it should be possible to build up the Lobito Route over a period of perhaps 6 months to a year to a level where some 770,000 tons of imports and perhaps a million tons of exports could be handled for Zambia over and above Congolese (Katangan) requirements. The Cubal Variant and associated construction would cost $30 million. The total expenditure on both BCK and CFB would be about $50 million (including additional rolling stock and maintenance facilities). Many problems, however, involving politics, costs to shippers, consideration of return on investment by railway management, and attitudes of railway labor would impose considerable delay on the technically (operationally) possible time-scale suggested above.

APPENDIX A

Key Personnel Interviewed During the Survey of the Lobito Route, 9 November–13 December 1965

Location	Organization	Names and Titles of Officials
London	The Benguela Railway Co., Ltd.	Mr. Howard Easby, Member London Committee
		Mr. S. Graeme Watts, Member London Committee
		Col. R. J. Walker, O.B.E., R.E. (Ret'd), Consultant
	Tanganyika Concessions, Ltd.	Mr. P. H. Waterhouse, Chairman
	Roan Selection Trust Group of Companies	Mr. R. H. Finn, Executive Ass't to the President
Brussels	The Katanga-Dilolo-Leopoldville Railway Co., Ltd.	M. Gustave Wenes, Member Permanent Committee, KDL; President, Nouvelle Co. BCK; Managing Director, Ancien Co. BCK
		M. Wautelet, Executive Ass't to the President, Nouvelle Co. BCK
Lisbon	The Benguela Railway Co., Ltd.	Sr. D. Antonio d'Almeida (Lavradio), Ass't Managing Director
Lobito	The Benguela Railway Co., Ltd.	Sr. Aguiar Silva, Acting General Manager
		Sr. J. Martins Lopes, Ass't for Public Relations
		Sr. F. Melo de Sampaio, Chief, Forestry Service
	Leopold Walford Shipping, Ltd.	Mr. R. F. Norman, Chairman (Home office, London)
	Port Service, Province of Angola	Various Port Operating Personnel
	Manubito S.A.R.L.	Sr. Mario de Abreu, Freight Agent
Nova Lisboa	Benguela Railway Co., Ltd.	Sr. Nozolino de Azevedo, Workshops Manager
Elisabethville	Bas Congo au Katanga Railway Co.	M. Yanz, Administrator Delegate
		M. Philippot, General Manager
		M. Le Blanc, Operations Manager
		M. Aimeblanc, Chief, Commercial Service
		M. Frans Leys-Wendeler, Chief, Traffic Movement
Ndola	Leopold Walford (CA) Ltd.	Mr. Mitsford
		Mr. Paton
	Roan Selection Trust	Mr. Ralph Cable
Lusaka	Anglo-American Corp. (Zambia)	Mr. George Relly, Chairman
		Mr. Mike McCrumm, Special Ass't to the Chairman
	American Metal Climax, Inc. (Associate of Roan Selection Trust)	Mr. F. Taylor Ostrander (Home office, New York)
	Roan Selection Trust (Zambia)	Mr. B. D. Napper, Chairman
	Zambia Ministry of Transport and Works	Mr. Ewen Thompson, Administrative Officer, Transportation
		Mr. Glyn G. Davis, Undersecretary for Railways
		Mr. J. M. Kesson, Railways Advisor

APPENDIX B

STATISTICAL TABLES

Table B–1

Angola and the Congo

Selected Data on Locomotives as of December 1965

Angola: Benguela Railway Co. (CFB)				
Series	Inventory (*Units*)	Tractive Effort (*Kg*)	Wheel Arrangement	Weight (*Kg*)
		Steam		
1–A [a]	1	1,030	0–4–0	6,500
2–A	1	1,690	0–4–0	11,600
4–A	2	4,400	0–6–0	23,500
5–A	4	7,080	0–6–2	36,200
6–A	6	6,410	4–6–0	43,314
9–A	2	9,250	4–8–0	60,858
9–A	10	9,250	4–8–0	62,428
9–B	2	9,250	4–8–0	55,386
9–C	18	10,940	4–8–0	62,938
10–A [b]	6	18,000	4–8–2+2–8–4	122,390
10–B [b]	14	18,000	4–8–2+2–8–4	133,602
10–C [b]	18	18,000	4–8–2+2–8–4	141,618
10–D [b]	10	18,000	4–8–2+2–8–4	143,789
10–E [b]	9	N.A.	2–8–2+2–8–2	N.A.
11–A [b]	6	12,470	4–8–2	73,810
Total	109			
Diesel				
D	[c] 4	N.A.	0–6–0	N.A.
Total locomotives	113			

Congo: Bas Congo Katanga Railway Co. (BCK)				
Series	Inventory (*Units*)	Tractive Effort (*Kg*)	Wheel Arrangement	Weight (*Kg*)
		Steam		
200	18	11,920	2–8–2	N.A.
400	22	12,187	2–8–2	N.A.
700	24	11,760	2–8–2	N.A.
800	3	14,577	2–8–2	N.A.
[b] 900	12	20,000	4–8–4+2–8–4	N.A.
Total	79			
Diesel				
1,250	2	18,200	C–C	N.A.
Total	2			
Electric				
2,100	11	24,420	B–B	75,000
2,200	8	25,000	B–B	75,000
2,300	11	25,000	B–B	75,000
2,400	2	23,000	B–B	75,000
2,450	4	23,000	B–B	75,000
Total	[d] 36			
Total locomotives	117			

[a] Museum piece not in use.

[b] Beyer-Garratt Mountain types.

[c] Switching locomotives not suitable for mainline service.

[d] Seventeen out of service awaiting repair in December 1965 and five new locomotives on order in December 1965.

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Table B–2

Angola and the Congo

Selected Data on Railroads as of December 1965

	Angola: Benguela Railway Co. (CFB)	Congo: Bas Congo Katanga Railway Co. (BCK)
Length of route (kilometers)	1,418 (1,347 mainline)	2,612 (999 from the Rhodesia/Zambia border to the Zambia/Angola border)
Of which: Steam operation	1,418	1,933
Electric operation	0	679
Maximum grade (percent)	2.5	2.0
Signaling (type)	Train order and manual block (Tyers Key Token)	Manual block (Webb-Thompson Staff Token)
Weight of rail (pounds)	60	60–85
Maximum axle load (metric tons)	13½ to 15	15–19 [a]
Locomotives (units)	113	117
Of which: Steam	109	79
Diesel	4 (switchers)	2
Electric	0	36 (5 new locomotives on order and 17 awaiting repair)
Freight cars (units)	1,589	3,589
Of which: Box	432	1,436
Open	1,057	1,571
Tank	47	32 (30 new cars on order)
Other	53	550 (505 special ore hoppers and 45 cattle cars)

[a] See detail by sector on Table B–5.

Table B–3

Congo: Railroad Freight Traffic

Bas Congo Katanga Railway Co. (BCK) 1957 and 1961–65

	1957 [a]	1961 [b]	1962 [b]	1963 [a]	1964 [a]	1965 [a c]
	Thousand Metric Tons Carried					
Total Traffic	6,007	3,864	3,636	3,357	3,963	4,250
Of which:						
Service	1,002	414	383	407	434	1,002
Revenue	5,005	3,450	3,253	2,950	3,529	3,248
	Million Metric Ton Kilometers					
Total Traffic	1,833	1,003	896	879	1,207	1,358
Of which:						
Service	184	90	70	111	167	170
Revenue	1,649	913	826	768	1,040	1,188

[a] Data supplied by the staff of the BCK in response to a questionnaire by the author of this report.

[b] International Union of Railways, Paris (International Railway Statistics, 1961–1962).

[c] Data for 1965 estimated on the basis of actual data for the first 10 months of the year.

Table B–4

Congo: Monthly Railroad Freight Traffic by Sections of Route
Bas Congo Katanga Railway Co. (BCK), 1964–65 [a]

(*Ton-Kilometers*)

	Sakania/ Elisabeth-ville (242 km)	Kipushi/ Lubumbashi-Elisabeth-ville (48 km)	Elisabeth-ville/ Tenke (237 km)	Tenke/ Kolwezi (95 km)	Kolwezi/ Mutshatcha (157 km)	Mutshatcha/ Dilolo (268 km)
1964						
January	8,206,428	2,256,541	23,723,639	9,472,960	7,115,512	13,893,568
February	8,796,943	2,265,419	21,141,615	8,866,811	7,490,118	14,251,604
March	8,605,924	2,366,651	21,582,045	8,439,600	5,612,571	12,384,206
April	9,196,128	1,840,902	21,061,007	7,467,831	5,091,770	12,166,370
May	9,562,080	2,266,403	22,667,939	8,718,983	6,359,325	13,412,979
June	11,224,538	2,382,790	24,887,638	9,621,892	6,063,832	12,358,164
July	11,566,225	2,110,494	26,925,024	10,637,627	6,557,216	12,659,569
August	6,735,407	2,239,766	26,295,543	9,797,091	8,243,602	15,050,025
September	10,745,203	1,963,041	25,331,091	9,508,936	8,232,256	15,408,426
October	10,252,762	2,013,764	27,779,312	10,703,052	7,652,711	14,582,178
November	9,965,936	2,222,991	25,930,165	10,320,479	7,219,891	14,088,894
December	10,124,396	2,156,429	26,848,930	10,179,005	6,872,583	14,671,285
Total	114,981,970	26,085,191	294,173,948	113,734,267	82,511,387	164,927,268
1965						
January	11,055,110	1,995,839	27,531,300	9,817,510	6,778,184	13,524,225
February	9,749,761	2,009,223	25,772,314	8,814,629	5,816,223	12,422,621
March	12,859,320	2,247,140	27,946,840	8,618,099	6,134,956	13,647,004
April	8,874,670	2,203,684	24,987,020	8,481,400	5,550,658	12,942,728
May	9,832,803	2,141,046	27,387,814	9,968,814	6,779,779	[b] 13,821,616
June	9,946,947	2,012,693	27,202,183	10,585,342	6,672,604	13,300,072
July	11,317,269	2,113,735	29,129,461	11,492,577	[b] 7,524,593	13,470,336
August	12,844,414	2,177,599	30,436,104	11,703,289	7,496,668	13,373,211
September	10,100,097	2,137,555	[b] 30,594,771	[b] 11,722,601	6,898,068	13,445,254
October	[b] 13,352,661	[b] 2,383,090	28,742,833	10,287,850	6,905,165	13,499,545
Total	109,933,052	21,421,604	279,730,640	101,492,111	66,556,898	133,446,612
Estimated 12-month total	131,919,660	25,705,920	335,676,768	121,790,532	79,868,278	160,135,934

[a] Route sections are in geographical sequence from the Rhodesia/Zambia border to the Zambia/Angola border.

[b] Denotes peak traffic during 1965.

Table B–5

Congo: Selected Line Characteristics and Operational Data on the Bas Congo Katanga Railway (BCK) Part of the Lobito Route as of December 1965

Item	Section of the BCK Railway					
	Sakania-Elisabethville	Elisabethville-Jadotville	Jadotville-Tenke	Tenke-Kolwezi	Kolwezi-Mutshatcha	Mutshatcha-Dilolo
	(242 km)	(132 km)	(105 km)	(95 km)	(157 km)	(268 km)
Traction	Steam (coal-burning).	Electric	Electric	Electric	Electric	Steam (wood-burning)
Maximum permissible axle loading (tons/axle).	15 [a]	19	19	19	19	15 [a]
Weight of rail (kg/meter)	29	40	40	40	40	29
Weight of metal ties (kg/tie)	42	50	50	50	50	42
Number of ties per km	1,500	1,500	1,500	1,500	1,500	1,500
Average speed of freight trains (kms/hr).	20–24	30	30	30	30	20–24
Average tons per freight train [a] [b]						
Gross	405	480	472	508	491	447
Net	201	219	255	254	220	200
Maximum number of 4-axle cars and gross tons per locomotive (cars/tons) [c]						
Maximizing tonnage	11/600	11/510 to 15/900 [d]	11/510 to 15/900 [d]	11/510 to 15/900 [d]	11/510 to 15/900 [d]	11/573
Maximizing cars (for return of empties).	25/500	23/390 to 30/750	23/390 to 30/750	23/390 to 30/750	23/390 to 30/750	25/475

See footnotes at end of table.

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Table B–5

Congo: Selected Line Characteristics and Operational Data on the Bas Congo Katanga Railway (BCK) Part of the Lobito Route as of December 1965

Item	Section of the BCK Railway					
	Sakania-Elisabethville	Elisabethville-Jadotville	Jadotville-Tenke	Tenke-Kolwezi	Kolwezi-Mutshatcha	Mutshatcha-Dilolo
	(242 km)	(132 km)	(105 km)	(95 km)	(157 km)	(268 km)
Minimum length of passing sidings (meters/cars). [e]	280/18 (Kipula)	376/23 (Kapolowe)	288/18 (Katusembe)	338/21 (Lualaba)	367/23 (Tshianda)	320/20 [f] (Mangoa)
Number of through movements each way per day possible with existing sidings and train speeds.	9–10 [g]	12	15	12	9–10	7–10 [h]
Average number of through movements each way per day during October 1965. [i]	5	7.7	9.9	7.3	3.4	4–5.2

[a] BCK management has stated that axle weights up to at least 16½ tons are acceptable on these sectors under special circumstances.

[b] All statistics on tons per train are based on the use of a single locomotive. Averages are from current typical samples.

[c] Traction limitation with one locomotive taking no account of the length of passing sidings. Figure varies with starting tractive effort of locomotives and friction of additional axles.

[d] Depending on the type of electric locomotive, as follows:

Rated horsepower	(4-axle cars/tons) Maximizing tons	Maximizing cars
2,100	11/510	23/390
2,200	11/610	27/450
2,300	15/900	30/750
2,400	13/720	30/550
2,450	13/720	30/600

[e] In addition to one locomotive.

[f] The passing siding at Kawayongo will also take only 20 cars with one locomotive and is only 330 meters long.

[g] Additional short-distance movements can be accommodated on short stretches where passing sidings are more closely spaced. Good examples are the Elizabethville-Triangle stretch (about 2½ km) where there were during 10 mos of 1965 an average of 26.39 movements each way per day and the Triangle-Muniama stretch (about 9½ km) where movements during the same period reached an average of 17.11 each way per day.

[h] The 7 movements are governed by a distance of 38 km between sidings at only one point between Mutshatcha and Divuma. The management says that this could rather easily be remedied if the need arises. Between Divuma and Dilolo, it is possible to accommodate 9 to 10 movements each way per day.

[i] October is a peak or near-peak month for traffic on nearly all sectors of the route (see Table B-4).

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Table B–6

Angola: Railroad Freight Traffic on the Benguela Railway Company (CFB) 1959–64

	Thousand Metric Tons Carried			Service and Revenue Traffic as a Percent of Total
	Total	Eastbound	Westbound	
Total traffic, 1959	2,732	752	1,980	100
Service traffic	1,263	491	772	[a] 46
Revenue traffic	1,469	261	1,208	54
Angola local	31	11	20	
Angola import-export	818	157	661	
Katanga transit	519	74	445	
Zambia transit	101	19	82	
Total traffic, 1960	3,608	1,059	2,549	100
Service traffic	1,790	784	1,006	[a] 50
Revenue traffic	1,818	275	1,543	50
Angola local	37	12	25	
Angola import-export	1,028	167	861	
Katanga transit	675	81	594	
Zambia transit	78	15	63	
Total traffic, 1961	3,524	1,076	2,448	100
Service traffic	1,698	734	964	[a] 51
Revenue traffic	1,826	342	1,484	49
Angola local	67	30	37	
Angola import-export	995	174	821	
Katanga transit	733	128	605	
Zambia transit	31	10	21	
Total traffic, 1962	3,227	1,139	2,088	100
Service traffic	1,593	776	817	[a] 49
Revenue traffic	1,634	363	1,271	51
Angola local	48	13	35	
Angola import-export	833	209	624	
Katanga transit	751	139	612	
Zambia transit	2	2	0	
Total traffic, 1963	2,792	931	1,861	100
Service traffic	1,125	502	623	40
Revenue traffic	1,667	429	1,238	60
Angola local	47	14	33	
Angola import-export	950	252	698	
Katanga transit	668	161	507	
Zambia transit	2	2	0	
Total traffic, 1964 [b]	2,853	963	1,890	100
Service traffic	1,045	516	529	37
Revenue traffic	1,808	447	1,361	63
Angola local	73	36	37	
Angola import-export	1,034	246	788	
Katanga transit	695	159	536	
Zambia transit	6	6	0	

[a] The percentage of service traffic was at an abnormally high level during 1959–62 because of an extensive reballasting program. Service freight tonnage is high, but it accounts for only about 6% of the movement in ton-kilometers because of its short length of haul.

[b] Later totals (shown on p. 28) broken down by category of freight were furnished by the Lobito Port authorities. They differ slightly but not significantly from these totals.

Table B–7

Angola: Traffic Movement and Working Receipts and Expenses of the Benguela Railway Co. (CFB), 1945–64

Year	Kilometers (thousand)	Ton-Kilometers (thousands)		Passenger-Kilometers (thousands)	Receipts (thousand escudos) [c]	Expenses (thousand escudos) [c]	Net Receipts (thousand escudos) [c]
		Gross [a]	Net (Commercial) [b]				
1945	1,703	584,112	224,720	40,004	58,076	46,462	11,614
1946	2,220	719,113	273,154	45,338	71,849	58,588	13,261
1947	2,258	800,329	348,432	45,021	124,119	90,582	33,537
1948	2,722	989,012	428,739	49,236	172,909	79,051	93,858
1949	2,982	1,019,897	448,432	47,956	189,042	108,032	81,010
1950	3,229	1,172,111	504,235	55,045	189,784	116,350	73,434
1951	3,655	1,378,917	614,027	62,935	251,503	146,981	104,522
1952	4,065	1,602,066	754,841	52,461	320,970	179,157	141,813
1953	4,721	1,779,536	787,947	54,908	320,825	227,006	93,819
1954	5,253	2,147,150	984,536	53,839	360,976	220,224	140,752
1955	5,555	2,319,463	1,067,379	55,939	392,191	235,014	157,177
1956	5,949	2,572,823	1,226,140	58,787	474,331	240,588	233,743
1957	5,992	2,569,634	1,128,457	59,776	463,918	255,745	208,173
1958	6,095	2,586,092	1,094,746	58,320	428,645	260,941	167,704
1959	6,518	2,752,937	1,204,187	60,263	450,209	274,870	175,339
1960	7,913	3,370,170	1,487,497	58,344	592,229	325,019	267,210
1961	8,061	3,395,581	1,518,354	50,038	598,178	357,456	240,722
1962	7,639	3,217,305	1,434,012	58,967	595,565	365,005	230,560
1963	6,925	3,019,921	1,380,660	69,642	550,974	356,805	194,169
1964	7,358	3,220,359 [d]	1,475,891	74,977	561,742	374,825	186,917

[a] Includes service traffic and tare weight of trains.

[b] Revenue traffic only.

[c] A nominal rate of exchange is 30 Escudos to $1.

[d] Estimated gross ton kilometers for 1965 is 3,230,614,000.

Table B–8

Angola: Selected Data on Sectors on the Benguela Railway (CFB) Part of the Lobito Route as of December 1965

Items	Sections											
	Lobito Catumbela (13.8 km)	Catumbela Benguela (22.2 km)	Benguela Coruteva (47.3 km)	Coruteva Cubal (113.3 km)	Cubal Cuma (120.3 km)	Cuma Nova Lisboa (108.2 km)	Nova Lisboa Chinguar (93.8 km)	Chinguar Silva Porto (108 km)	Silva Porto G. Machado (74.8 km)	G. Machado Munhango (142.8 km)	Munhango Luso (190.4 km)	Luso T. de Sousa (299.2 km)
Maximum distance between passing tracks (km)	8.4	14.4	12.9	11.3	18.0	15.1	21.8	26.3	22.8	24.2	26.2	22.7
Maximum scheduled time interval between passing tracks, including meets (minutes)	18	26	34	28	36	42	42	42	50	44	52	39
Maximum potential number of trains each way per day limited by intervals between passing tracks [a]	40	27	21	25	20	17	17	17	14	16	13	17
Current number of trains each way per day [b]	11	11	10	15	11	9	9	9	7	9	7	7

[a] A further limitation to about 8 or 9 freight trains each way per day of 19 cars each is imposed by the time required to form and reform trains at Benguela and Cubal for the trip over the escarpment (now averages about 60 and 80 minutes, respectively).

[b] From typical daily train diagrams for November 1965.

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APPENDIX C

Methodology for Estimate of Potential Capacity on the CFB

Method 1:

Estimated theoretical line capacity of the CFB is 2,219,200 revenue tons each way per year.* This is equivalent to 2,108,240 tons at a practical average load factor of 38 tons per car westbound. Capacity is therefore estimated at a little over 2 million tons. Deducting for estimated traffic for 1965 (when no significant diversion as a result of UDI in Rhodesia had yet occurred) produces the following:

CFB Capacity and Estimated 1965 Traffic

CFB Capacity and Estimated 1965 Traffic	Thousand Tons
Westbound:	
Estimated capacity	2,000
Traffic for Angola	−732
Total available for transit	1,268
Transit traffic from the Congo and Zambia	−613
Excess available for transit westbound after build-up to maximum potential on present track	655
Eastbound:	
Capacity available for transit	888 [a]
Transit traffic to the Congo and Zambia	−140
Excess available for transit eastbound after build-up to maximum potential on present track	748

[a] The same cars used for the westward transit of 1,268,000 tons loaded for eastward transit to the Congo or Zambia at an average estimated load of 27 tons per car.

Method 2:

The theoretical line capacity of the CFB estimated in Method 1 above is 2,219,200 tons each way per year. This is equivalent to 55,480 cars of 40-ton capacity. Deducting 19,263 cars to be allocated for local traffic which was heaviest westbound at an annual rate of about 732,000 tons in 1965 (732,000 tons at an estimated average load per car of 38 tons) produces the following:

55,480 cars available at theoretical line capacity*
−19,263 cars allocated to Angolan traffic
36,217 cars available for transit

At an estimated average westbound load of 38 tons per car, the transit capacity of these 36,217 cars is 1,376,246 tons westward; at an estimated aver-

* Assumes an adequate supply of locomotives and freight cars. An estimated potential of 8 freight trains each way per day (after allowance for service and passenger traffic) with a maximum of 19 cars (siding limitation) at a theoretical capacity of 40 tons per car calculates to 2,219,200 tons per year (8×19×40×365). Current movements are compared to potential on Table B-8, page 37.

age eastbound load of 27 tons per car, the transit capacity of these same cars is 977,859 tons eastbound. Deducting for transit traffic at the estimated traffic level during 1965 produces the following:

	Thousand tons	
	Westbound	Eastbound
Potential total transit capacity	1,376	978
Transit traffic (1965)	−613	−140
Excess transit capacity after build-up to maximum potential on present track	763	838

APPENDIX D

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