and environmental considerations dictate that it is the superior mode. Clearly, the trolley coach renaissance is not a passing phase; rather it will firmly establish the role for trolley coaches for the remainder of this century and a good portion of the next.

Trolley Bus Development in Brazil

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The first Brazilian trolley bus experience dates back to 1949 in the city of Sao Paulo. A 7.2-km one-way overhead wire line was built and operated with 16 vehicles. After its introductory phase and its acceptance as a convenient mode of transport, Sao Paulo experienced a rapid expansion of the system through the introduction of new lines. The principal objective was the replacement of tramway services.

Between 1953 and 1967, another 10 cities introduced trolley bus systems: Belo Horizonte, Recife, Rio de Janeiro, Salvador, Niteroi, Santos, Porto Alegre, Campos, Araraquara, and Fortaleza. In recent years, all these cities and Sao Paulo have been under common pressures that discouraged system expansion and upkeep. These pressures included the lack of spare parts for imported equipment, absence of a real program for local manufacture of components, and hesitation in the application of resources, plus the false impression that individual transport would be substituted for transit systems. Thus, in 1973, only Sao Paulo, Recife, Araraquara, and Santos continued operating trolley bus systems.

The 1974 oil crisis, as well as the concern about environmental pollution, increased the demand for public transport in the large and medium-sized cities. These were the main reasons for resuming feasibility studies to reintroduce trolley bus systems. In 1977 an Interministerial Labour Group, formed by technicians of the Planning, Transport, Power, and Mining Ministries, finished a report that gave top priority to the expansion of existing trolley bus systems as well as to the short-term introduction of new systems.

The technical specifications for vehicles, overhead hardware, and rectifying substations were developed in 1978. The aim was to use advanced technology comparable to the most modern systems in Europe and North America.

All the cities in Brazil where the trolley bus survived have devoted their efforts to rehabilitation and expansion. Ribeirao Preto started operating its new system in March 1982, and several cities have already concluded or are making technical feasibility, economical, and financial studies.

SAO PAULO UPDATE

The Sao Paulo trolley bus operation started in 1949. From 1949 to 1958, the Companhia Municipal de Transportes Coletivos (CMTC) increased its fleet from 16 to 155 vehicles--an increase totally supported by imports. In 1958 Brazil started manufacturing trolley buses. Initially this activity was carried out by private companies and thereafter by CMTC. Around 1964, CMTC had difficulties in importing vehicles and component parts required for fleet maintenance. CMTC was forced to manufacture trolley buses in its own service workshop. By 1969, 139 new vehicles were built and an additional 38 were remanufactured from the existing fleet. At the end of the 1960s, CMTC owned 233 trolley buses, 129 km of one-way overhead electric line, and 13 rectifying substations (10,500 kW), which were required to operate 12 lines.

To a large extent, these lines were projected with the idea of reaching residential quarters, without consideration for the global needs of a transit system. The routing of the trolley bus lines was the same as that used for the creation of new omnibus lines. Vehicles circulated through narrow streets in search of passengers without concern for an increase in the commercial speed or better exploitation of the trolley bus transporting capacity.

The Sistran Plan, concluded at the beginning of 1976, addressed the technical, economical, and financial feasibility of a new trolley bus system for Sao Paulo. The new system called for 280 km of two-way overhead line to be used on 400 km of individual route miles. Some 1,280 vehicles will be circulating. The installed power capacity will be 198,000 kW and the approximate transport capacity will reach 600 million passengers/year. The budget for this project, including engineering, installation, and acquisition of equipment, has been estimated at (U.S.)$830 million.

The federal government authorized CMTC to implement the plan, which is divided into five stages. CMTC is responsible for the development of technical specifications and the establishment of an operation pattern that characterizes the trolley bus as a system of high transport capacity. The first stage, which consists of 200 new biaxial trolley buses, 15 rectifying substations, almost 50 km of two-way overhead line, and 1 garage, was completed by the end of 1981. The second phase is now being built and includes 210 biaxial vehicles, 14 rectifying substations, and 59 km of wire network. The location of the corresponding garage is still under study.

CMTC is now involved in the planning for subsequent phases and in determining the equipment, installation, and necessary investments to complete the Sistran Plan, as well as the construction of a new type of articulated trolley bus. At the same time, a project for rehabilitating the vehicles, networks, substations, and garage corresponding to the old system is also being developed.

For Sao Paulo, which today has almost 9 million inhabitants and an area of 150 km², the trolley bus represents not only an option for transportation services but also provides a way of attending to transport necessities by offering an improvement in the quality of living.

RECIFE UPDATE

Recife is the capital of the Pernambuco State and is the main population center in the Brazilian Northeast. It is also the center of a metropolitan region with 2.5 million inhabitants. The trolley bus system first instituted in 1959 has 8000 kW of installed power, 100 km of wire network, and 140 vehicles. The system uses Brazilian, American, and French equipment. During the 1970s, Recife's trolley bus system started to decline, as did the remaining trolley bus systems in Brazil.

Several rationalization and public transport improvement programs are under study in the metropolitan area of Recife. The recuperation and expansion program of the trolley bus system is the subject of one study. In accordance with studies made in 1980,

six urban corridors were reserved for a trolley bus operation that would be installed in three consecutive phases. These corridors when installed and operating will result in a 2000-kW, 77-km electric network; 230 trolley buses (115 rehabilitated and 115 new); and a new garage.

In 1982 two corridors (12 km and 11.5 km) were operating. Some 23 vehicles were built in a workshop especially designed for that purpose, and 12 new trolley buses with chopper command were purchased. This system transports 66,500 passengers daily and each corridor has its own interconnection terminal with diesel bus feeder lines. The trolley bus system fare is 25 percent lower than the diesel one.

SANTOS UPDATE

The city of Santos is the most important port in Brazil and is in an important metropolitan region with more than 1 million inhabitants. The Santos Mass Transit Company started operating at the beginning of this century with an efficient tramway system. Diesel buses were introduced in the 1950s, and the trolley buses came in 1963 with the aim of replacing the tramway system.

The Santos trolley bus system is of Italian origin, obtained through a turnkey installation operation. The system made use of two old substations (2600 kW), which belonged to the tramway station. The initial system owned 50 vehicles, 7 substations (one of which was mobile) with a capacity of 4600 kW, 60 km of electric network, and 5 operating lines. Difficulties with the supply of spare parts and maintenance problems, together with the lack of new investments, resulted in a fast deterioration of the system. In 1979, at the beginning of the recuperation and expansion program, the system had only two lines operating with 15 vehicles. The system was in poor condition.

During the period 1979-1982, a workshop was set up to reconstruct trolley buses, and 25 vehicles were rebuilt. Simultaneously, five new trolley buses were bought with electronically activated contactors. Seven substations were built, and the oldest equipment was replaced with state-of-the-art equipment. Some parts of the electrical network were rebuilt in order to allow a more reliable operation of the system, which is transporting 30,000 passengers/day.

ARARAQUARA UPDATE

In 1958 Araraquara, located in Sao Paulo State, decided to reorganize its transport system and to reintroduce trolley buses as a means of public transport.

At the time several steps allowed for the continuous development of an efficient and cheap system for public transport. It should be emphasized that although the system (vehicles, electrical network, substations, and garage) belongs to the city, its administration and operation have been entrusted to a private concern. The Araraquara Trolley Bus Company (ATC) owns a 50-year concession for the exclusive running of the public transport of the city.

From 1959 to 1976, ATC experienced a period of continuous expansion--from 7 vehicles, 1 substation, 18 km of electrical network, 2 operating lines, and 3.1 million passengers/year to 28 vehicles, 3 substations, 84 km of electrical network, 6 operating lines, and 15 million passengers/year. This expansion was made possible from the resources generated by the operation of the system, without any outside financial aid. With a competent administration, ATC was able to purchase equipment from trolley bus companies that were being deactivated all over the country, thus enabling ATC to expand its system with reduced investments.

The expansion of the system had been restricted by the investment capability of the company. When an expansion program was started within the context of the National Trolley Bus Program, 80 percent of the project costs were available from the federal government. The goals of the expansion program during the period 1979-1982 were the purchase of 11 vehicles, installation of 3 substations (1200 kW), 14 km of electrical network, and the rebuilding and expansion of the garage. New technologies were introduced (vehicles that had a traction system based on electronically actuated contactors and choppers) as part of the expansion program.

Today, Araraquara is the only city in Brazil with a public transport system that is totally electrified. It operates 8 lines and transports 55,000 passengers/day.

RIBEIRAO PRETO UPDATE

The city of Ribeirao Preto is an important commercial and education area in the northcentral portion of the state of Sao Paulo. Due to its sociological and economical characteristics, it was selected by the federal government as a representative medium-sized city for the installation of a pilot trolley bus program. This program, the first to be implemented in the last 15 years, employs all available technology.

In 1979 the pilot program started with the organization of TRANSERP (Ribeirao Preto Mass Transit Company) owned by the municipality. This agency is responsible for the development, installation, and operation of the trolley bus system. Until that time, public transport services had been operated by a company whose service level was very low.

Initially a planning study of the transport system was made with the purpose of nationalizing and integrating the diesel and electrical systems. As a result of this study, the corridors with high density were selected for trolley bus operation.

The trolley bus system started its commercial operation in July 1982 with one line operating 8 vehicles and transporting 11,000 passengers/day. This system is the first one in Brazil to use only one operator (driver). Passengers purchase their tickets at designated places and the trolley buses are equipped with two automatic turnstiles close to the driver. The fare price is 25 percent lower than that in the diesel bus.

The funds for the installation of this system were provided by the federal government (50 percent) and the municipality (50 percent).

FUTURE PROSPECTS

The rehabilitation and expansion programs of the trolley bus system for Sao Paulo, Recife, Santos, and Araraquara and the installation of the new system in Ribeirao Preto allowed the development and consolidation of new and modern technology in Brazil. The level of technological development reached by the Brazilian industry, specifically in the manufacture of vehicles, can be compared with that in the United States and Western Europe.

Substitution of petroleum-derived combustibles by alternative energy sources such as electric traction, alcohol, vegetable oils, and solar energy has gained ground. Petroleum represents 40 percent of total Brazilian imports, whereas hydroelectric power is cheap and abundant. There are sufficient reserves to last until the end of the 21st century.

In the major metropolitan areas and medium-sized cities, public transport accounts for more than 50 percent of the daily trips. Brazil has a population of 120 million inhabitants, 70 percent of whom live in urban areas, creating a large number of trips for urban transport systems. The short-term tendency is, therefore, the continuation of trolley bus programs and the installation of new systems in other cities where the technical-economical viability of the undertaking is justified.

Simultaneously the operating companies are trying to modernize and rationalize their services, and industries are trying to procure new technology and modernize subsystems. In 1983 trolley buses with alternate current propulsion systems and an electrical network with polyester supports will be tested.