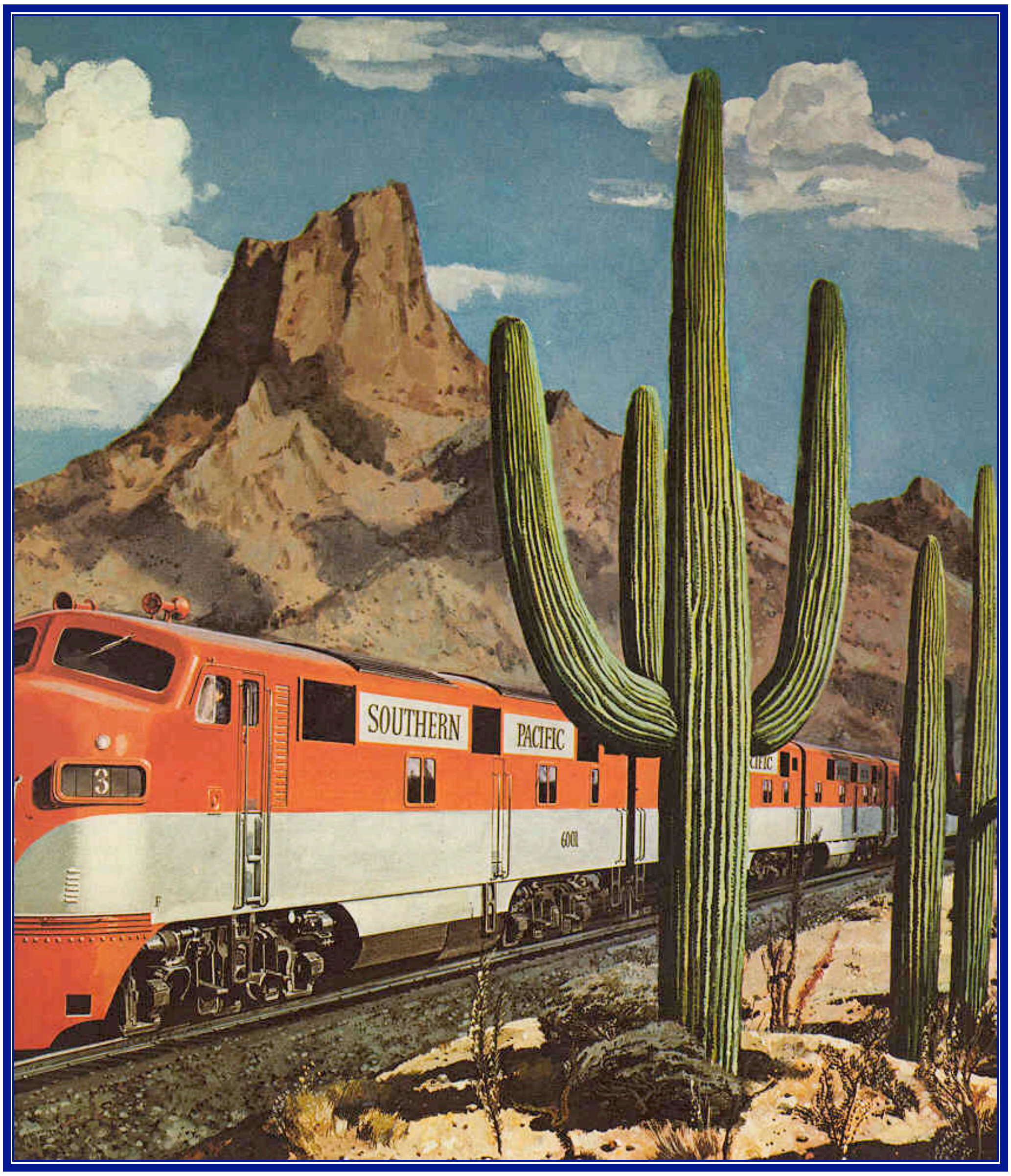
TRAIN AIR CONDITIONING



"Golden State" diesel-electric engine (Southern Pacific)
crossing the Arizona Desert

While all this was going on, Willis Carrier and his associates became interested in railroad air conditioning. Back in 1884 the Baltimore and Ohio Railroad had tried to cool a passenger car by passing air over a huge icebox built at the head end. For obvious reasons, this approach failed. In 1907, while designing a system to cool freight cars for the Santa Fe, Carrier proposed an apparatus room located below the station platform in which air would be cooled for delivery to the cars while they stood in the station. This system was never installed. In 1913 the Pullman Company, according to Carrier, "got interested in car cooling and asked us to design equipment, but we lacked suitable refrigerating machines at the time, so did nothing about it." In 1929 a representative of the B & O called on Carrier and asked him to design an air conditioning system for a passenger car, to be tested in the railroad yards at Baltimore. Carrier knew that refrigerating machines suitable for railroad car air conditioning were still in

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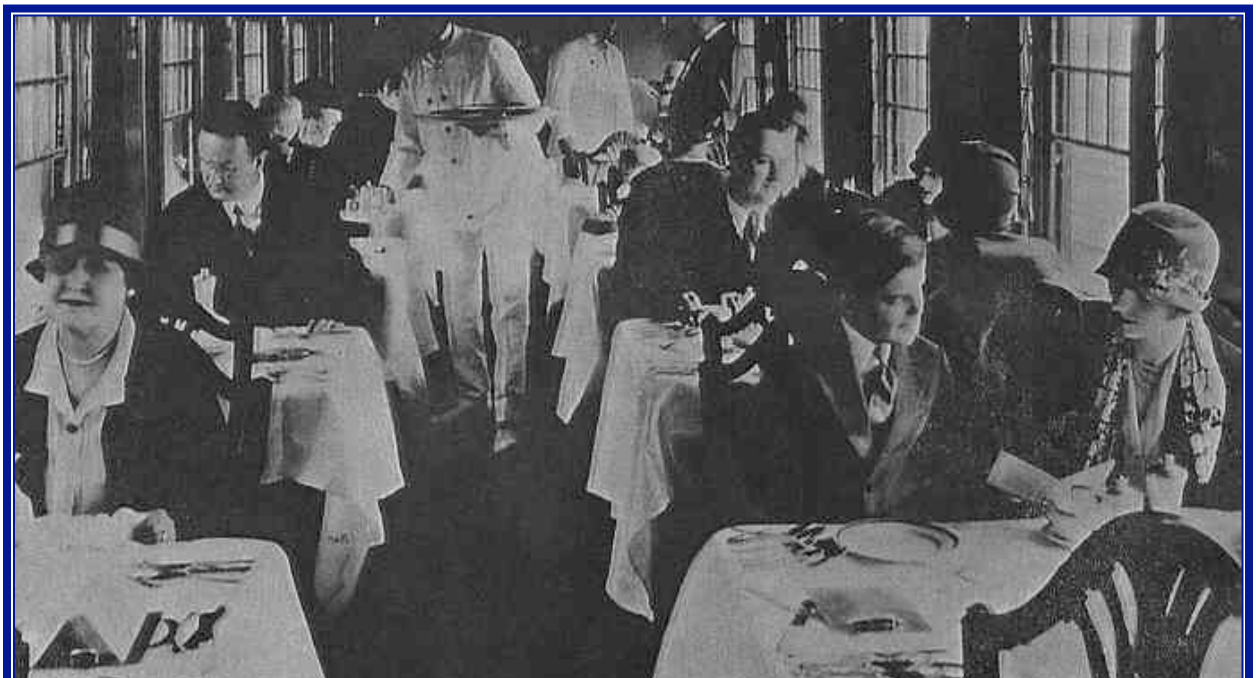


First air conditioned dining car "Martha Washington" (Carrier) 1930 the development stage, but he set out to do the best he could. He considered evaporative cooling, discarded that approach, and recommended a five-ton ammonia machine. He then laid out the first railroad car air conditioning system, which consisted of one spray-type unit to cool and dehumidify the air, a similar unit to serve as a cooling tower for the condensing water, and an ammonia refrigerating machine. In the summer of 1929, this system was installed on the B & O coach No. 5275. Carrier said:

> We also began research on railroad car air conditioning in our plant in the summer of 1929. Stacey built a mock-up of a dining car to study air distribution, which was as necessary to the success of the system as proper refrigeration was to its safety and practicability.

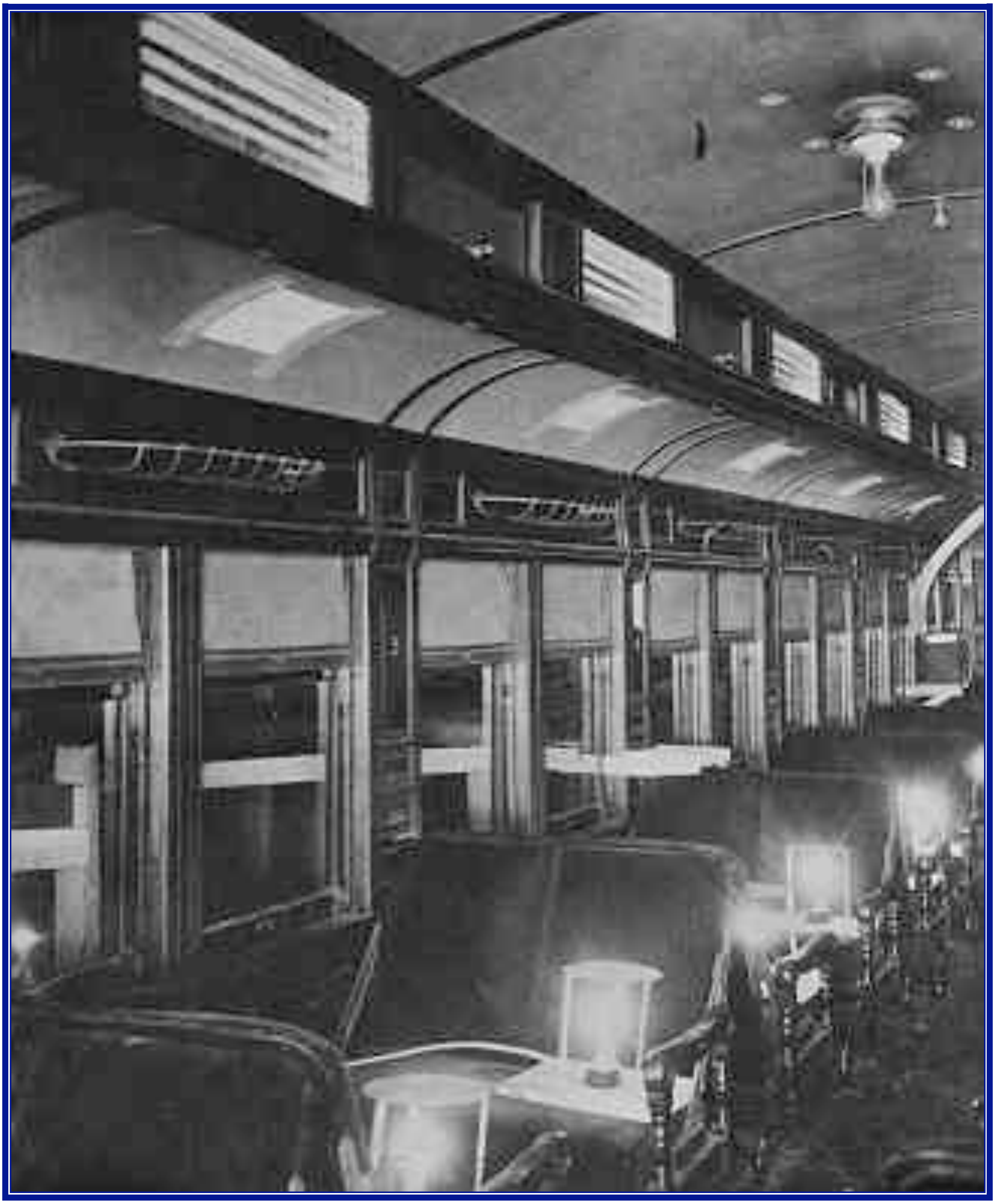
Early in 1930, after running tests on coach No. 5275, the B & O ordered an air conditioning and refrigerating system for the diner, "Martha Washington," of "The Columbian," a crack train operating between New York and Washington. The system consisted of a 2,500-cubic-feet-per-minute, horizontal air conditioning unit placed overhead at the car entrance, two air-distributing ducts located above the ceiling with diffuser-type, down-discharge outlets, an ammonia reciprocating refrigerating machine mounted under the car, and a cooling tower in a locker. On April 14, 1930, the diner was tested on a run between Baltimore and Cumberland. To obtain summer conditions for the test the heating system was turned on, the diner heated to 93 degrees F, then the heat turned off and the air conditioning system turned on. In twenty minutes the temperature dropped to 73 degrees F. The first air conditioning system in a railroad car had succeeded in producing comfort.

That summer a special train, including the diner, was organized for the journey to the Minneapolis meeting of the American Society of Heating and Ventilating Engineers. Willis Carrier was invited to be a guest of honor at a dinner in the diner where he was hailed as "The Chief of the Air Conditioning Industry," and the B & O given recognition as a "pioneer railroad." The diner was shown at the 1930 convention of the American Railway Association in Atlantic City. Some 3,000 railroad engineers observed that, while temperature in adjacent cars read 96 degrees F, it was only 73 degrees F in the "Martha Washington." Later in 1930 the Santa Fe ordered a similar system for a diner, and the Missouri, Kansas & Texas Railroad ordered systems for three of its dining cars.

By this time Carrier was far along in the development of a new type of small-tonnage refrigerating machine—the steam ejector unit—designed to revolutionize railroad car air conditioning and sweep into many other fields. Carrier began his research on the steam ejector refrigerating principle early in 1929. He was attracted to the simplicity of using a steam jet to create a vacuum in a partially-filled water tank, causing the water to boil at a low temperature, and thereby cooling the water to 40 degrees F or lower. He saw the advantages of no moving parts, an unquestionably safe refrigerant, and utilization of existing steam plants. Many steam ejector systems were operated for chilling water for industrial processes, but they had not been applied to chilling water for air conditioning when Carrier, Stacey, and associates began their research.

On November 3, 1930, Irvine Lyle wrote to Stacey, who was director of research, "Mr. Carrier has approved the purchase of a railroad car for test purposes." Later Stacey stated:

> We bought an old day coach from the Central of New Jersey for $400, rolled it onto tracks in the yard at our plant at 750 Frelinghuysen. Then we built a shed over it and installed equipment to maintain in the shed summer operating conditions. We made it a hot summer in the shed, holding temperatures up to 106 degrees F dry-bulb and 84 degrees F wet-bulb. We simulated the effect of a moving



Passenger car for air conditioning tests. Passenger heat is simulated by electric lamps (Carrier) 1931 train by blowing air over it at various rates. We actually had a wind tunnel, but we did not give it such a name.

Inside the car a 100-watt electric light bulb was burned in each seat to produce the heat equivalent to that given off by passengers. Later Stacey built partitions and changed the coach to resemble a sleeper to study means for air distribution in Pullmans with the berths made up. Research engineers used the car for tests to determine the best possible air conditioning system for railroad cars. By May of 1931, a five-ton steam ejector refrigerating machine was designed, completed, installed, and more tests started. On August 21, 1931, the new system of railroad air conditioning was shown to several hundred railroad men. They heard Carrier discuss the apparatus technically, stepped into the shed, got a blast of the hot, dirty, dusty air, then entered the cool clean passenger car. They got the point. In a few months the Santa Fe was ordering air conditioning apparatus with steam ejector refrigeration for twelve cars. The Union Pacific in February of 1932 ordered the system for three cars. The Milwaukee put it in its crack train, "The Hiawatha." Other railroads followed. The result was not only a new market for air conditioning, but also an expansion of old markets.

Getting into the railroads was certainly one of the industry's greatest forward steps. It not only carried air conditioning into the nooks and crannies of the land but also exposed to it people with much influence. The movies brought it to the masses, the first department stores mainly to women. Air conditioning began spreading faster than ever when businessmen began stepping out of the heat into cool Pullmans and diners—businessmen who could order it for their own plants, shops, offices, and homes.

These 4 pages of text are from "Father of Air Conditioning (Willis Haviland Carrier)," Margaret Ingels, Country Life Press, 1952

Theater just above 42nd Street. Word soon got around that the increase in the Rivoli's box office had in less than three summer months of operation fully repaid its first cost of $100,000. The owner's fears that air conditioning was a luxury for the theater almost vanished and in a year or two sales were booming.

Two related lessons were taught on both sides of the bargain. In only a few years, hundreds of thousands of movie fans learned that by patronizing this new kind of theater they could enjoy a picture during any season of the year – and for the same price. A few dozen theater owners learned that by properly air conditioning the customer, they could wipe out the costly summer slump and increase their profits tremendously. Even Hollywood soon found out that it was no longer necessary for the producer to meet the slump by slashing the cost and quality of pictures made for summer screening.

And beyond all doubts, many movie-fans began to wonder why mercantile and other establishments did not provide air conditioning.

Pullman Cars

The next step put air conditioning "on wheels" – in railroad cars. It was one of great promotional effect – and one man practically pushed us into it.

In the mid 1920's the Hunter Dryer Company was plaguing us with effective competition against our ejector system for drying crude rubber. When Hunter passed away, we bought his patents.

I was sent to Indianapolis to learn what I could about the dryer but found myself facing Oren M. Ragsdale (1884-1955: with Carrier 7/1/28 – 12/1/46). "Rags" was all steamed up over matters "of far greater importance." According to him, Carrier should be developing a system for cooling refrigerator cars by placing a centrifugal in a car next to the engine and pumping cold brine back through the train. And Carrier was also "neglecting a tremendous opportunity by concentrating on a few large systems while doing nothing about equipment that could be sold to thousands of small stores." Then, with a small system to sell, we could equip Pullman cars.

After listening for two stimulating days, I returned to Newark, N. J. Not much had been learned about the dryer but, soon thereafter, "Rags" was invited to visit us in Newark and promptly employed.

We proceeded with a rather detailed design of a "head-end" system. But no railroad ever bought one and all that came out of it were some worthless patents and some valuable contacts with railroad people.

The first concrete result of Rag's promotion came in 1925 when the B & O asked us to design a cooling system for a passenger car. Our proposition was accepted. A gasolene engine-driven ammonia compressor was attached to the underside of the floor. Chilled water was supplied to a vertical spray unit placed in one end of the car. Condenser water was obtained from a similar unit in the other end.

In the early part of 1930 their Pullman Diner, the Martha Washington was similarly equipped. The "Martha" was first sent on some special trips, one of which was to an American Railway Association meeting in Atlantic City – where it was seen by many railroad executives. Soon after it was put into regular service between New York and Washington.

The performance of the system was good but not good enough for us. Air distribution was faulty. Gasolene was a fire hazard and the electrical systems then in use were too puny for a motor driven compressor. And on a plunging car, open systems of water circulation presented many problems.

A steam-jet refrigerating unit, actuated by steam taken from the heating lines, looked like the answer. Carlyle Ashley, with some assistance from Willis Carrier, developed one of abnormally small size. Aerofin cooling coils were substituted for open water sprays, thereby permitting closed water circuits on both cooler and condenser – the latter becoming one of our earliest evaporative condensers.

Next, an old wooden coach was purchased for $400 and turned over to "Ned" Stacey for tests on air distribution and equipment. Electric lights equivalent to the heat of people were placed in the seats. The air conditioning and three different duct systems were installed. The entire coach was enclosed in a temporary structure that could be heated to mid-summer intensity and mugginess.

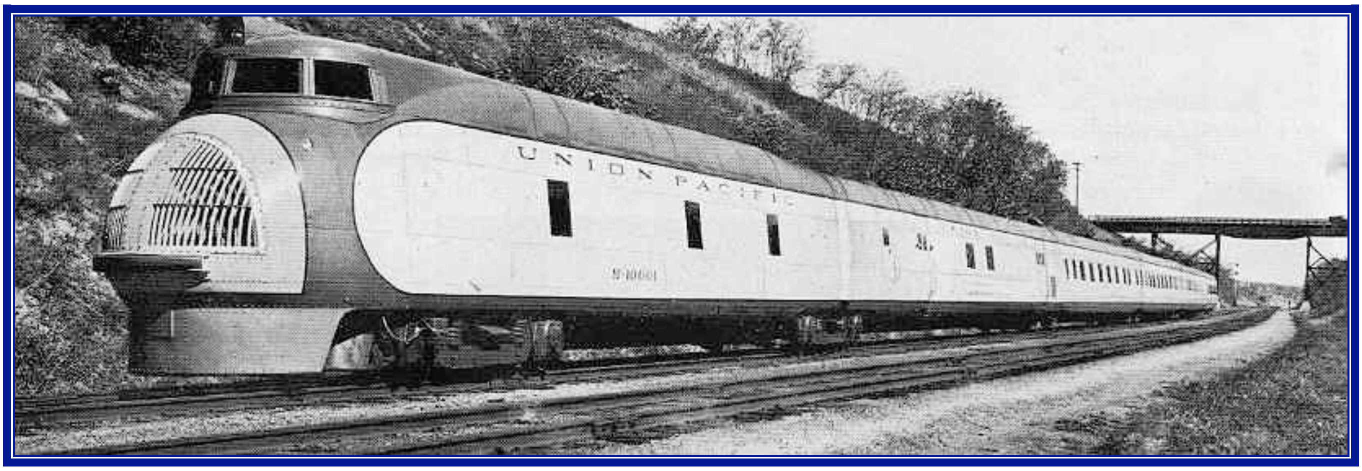
At that point, a masterpiece of sales promotion took over. When the usual bugs had been worked out, railroad men of influence were invited to witness a demonstration on August 21 and 22, 1931. More than 200, mostly top brass, came from all over the country.

After being welcomed they were put through a 3-step program. Carrier and several others outlined our objectives and described the system. Next, small groups were led into the hot, humid, dusty enclosure. Then, when they had developed a good sweat, they were led into the cool, clean car.

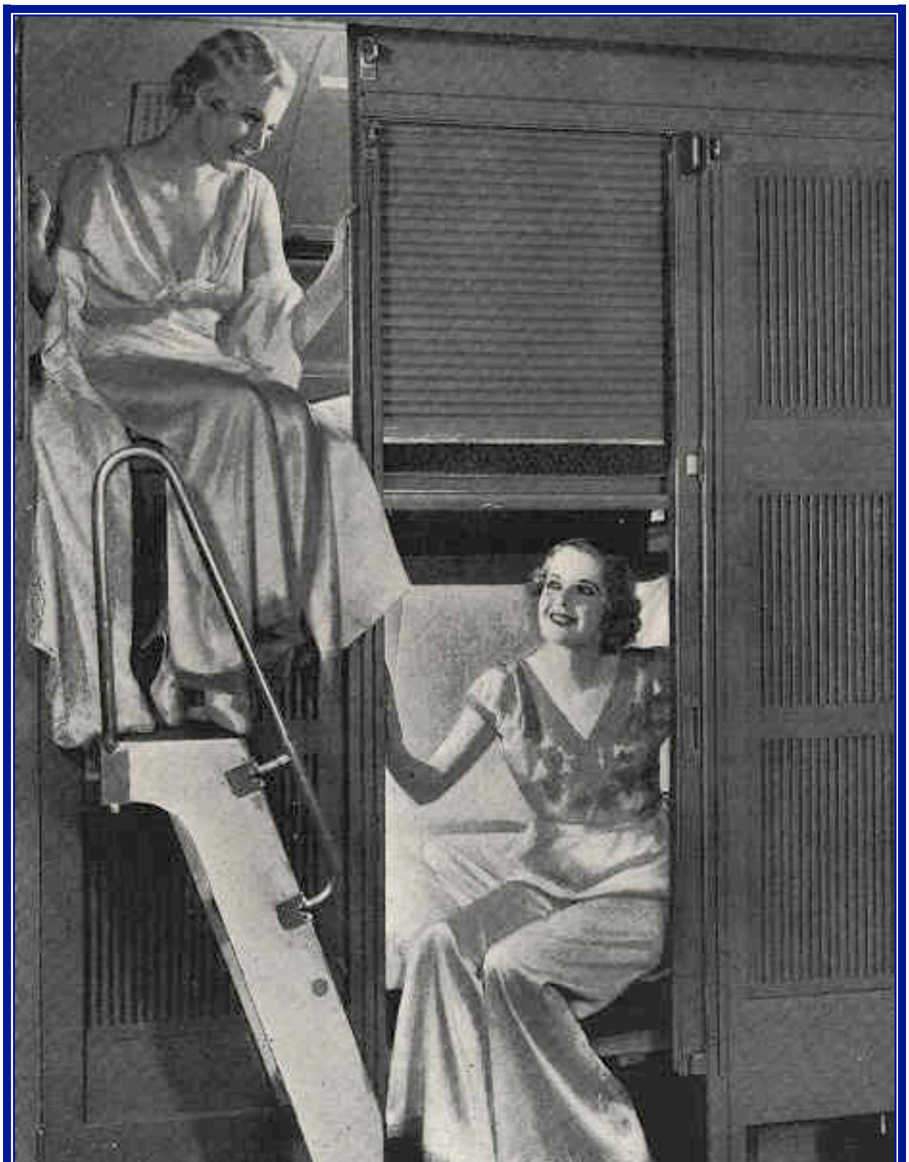
The contrast was simply unforgettable and, within a few months, Ragsdale came up with an order from the Santa Fe for equipping twelve cars. Union Pacific and others promptly followed. Soon thereafter, routine traveling was bringing to many men of broad influence first hand experience with the values of air conditioning.

The point is, that whereas the theater had introduced air conditioning to the masses, Pullman Diners and Sleepers introduced it to the man in a position at that time to buy it to attract the masses.

This extract is from "The Romance of Air Conditioning," Logan Lewis, Carrier USA, 1950's



Union Pacific aerodynamic train 1935



Air conditioned Pullman sleeping car on the Union Pacific, 1930's

51. RAILROAD PASSENGER CARS

ALTHOUGH it is only about twenty years since the first general application of air conditioning was made to railroad passenger cars, it is now considered a necessary part of the equipment of all such cars, irrespective of the service in which they will be used.

Railroad car air conditioning presents peculiar problems, particularly those of obtaining the power necessary to operate the cooling unit, and of arranging a satisfactory distribution of the conditioned air in the car. These, together with the space limitations and limited opportunities for service, create difficult problems in design. The satisfactory operation of the various types of equipment on more than 16,000 cars in U.S. and Canada is evidence that the problems have not been insurmountable.

The general **arrangement** of **equipment** is much the same on all cars. The conditioned air is supplied to the car through the air conditioning unit, which consists of the assembly of motor-driven blowers, cooling coil, heating coil, and plenum chamber, located above the ceiling of the car. The air is distributed to the car by means of ducts between the ceiling and the roof. Proper distribution throughout the car is obtained by adjustable duct outlets or by perforated ceilings.

The total **amount** of **air circulated** is from 2000 to 2400 cfm; from 30 to 50% in the latest type of equipment is outside air, and the remainder is recirculated. Some installations have adjustable air intakes so that the air circulated under suitable weather conditions may be all outside air. To prevent the infiltration of dust and uncleaned outside air, the interior of the car is maintained at a slight positive pressure.

Some sleeping cars are so equipped that the air circulated is 100 percent outside air so long as the refrigeration capacity required is below the maximum capacity of the equipment. When that capacity is reached the outside air quantity is automatically reduced to 40% of the total circulated.

The cooling capacity required varies from 8 to 10 tons, depending on the car construction and the number of passengers for which it is designed. However, there is so little difference in the capacity required for most classes of cars that the general practice is to use the same equipment on all cars except those requiring much greater capacity, such as coaches and dome observation cars.

The distribution of conditioned air in multi-room cars, such as sleepers and some types of parlor cars presents a problem as occupants of rooms on the shady side of the car are likely to reduce the supply of conditioned air to their rooms, forcing an oversupply to the other rooms if the total air is kept at a constant volume. An arrangement to overcome this condition, which has produced considerable improvement, is the use of heating coils in the delivery ducts to the individual rooms with a damper in the main supply duct for modulating the air supply when the amount required is changed by the operation of the individual room controls. This damper is controlled by the static pressure in the main supply duct.

The dome observation cars are presenting a problem, particularly those now being constructed with the dome the full length of the car, as they require a large refrigerating capacity and the design presents difficulties in obtaining room for the air supply ducts to the dome and in placing

the air outlets where they will not deliver the conditioned air directly on the passenger.

Filters are provided for both the outside and recirculated air. As the outside air contains particles varying in size from large cinders to fly ash, the design of a satisfactory filter is a problem. Present practice is the use of filters 4 in. thick for outside air and 2 in. thick for recirculated air.

Activated carbon filters are being used to some extent to adsorb odors from the recirculated air, lessening the amount of outside air required.

Electric precipitation has been applied to a limited extent to remove the finer particles, the coarser material being taken out by mechanical separation.

The refrigerating apparatus is located outside the passenger space—in most instances, under the car body.

The **cooling system** used will be in one of the following classes: Ice bunker, mechanical compression, or steam ejector. However, most new applications are of the mechanical compression type.

GEORGE E. HULSE, Author, Chapter 51. Born 1/21/77 in Bellport, N.Y. Educated at Stevens Inst. of Technology, ME, 1902. Formerly, Assistant Engineer, Safety Car Heating and Lighting Co.; Engineer of Tests, 1903; Chief Engineer, 1907 to retirement, 1946. In charge of design and quality control of equipment for lighting railway cars by gas and electricity, heating by steam and air conditioning. Developed a mechanical system for cooling refrigerator cars.

Fellow, Amer. Soc. of Refrig. Engrs., President, 1940; Fellow, ASME; member, AIEE.

From ASRE Data Book, 1954-55

TRAIN AIR CONDITIONING

One of the earliest mentions of ventilating apparatus is in "The Royal Trains" by C. Hamilton Ellis (1975) which on page 22 refers to an installation in 1843 for Queen Victoria's carriage:

> "In the middle of the saloon roof there was quite sophisticated ventilating apparatus, covered outside by a very large and ornate crown. The inside of the carriage was quilted to deaden the racket, to which end, also, there were wooden wheels with iron tyres. There was as yet no water-closet; indeed it is recorded that even in the Royal Palaces, the progressive Prince Albert had had some difficulty in persuading the Queen that such apparatus really worked without unmentionable accidents. Wonder of wonders, however, there was real heating apparatus; first travelling advance on the hot-brick or hot-water bottle. It was an invention of Jacob Perkins ... Perkin's carriage heater was under the floor and comprised a little oil-fired flash boiler and a cistern, feeding a closed-circuit pipe set inside the double flooring and warming the carriage through a grating." (A)

In India blocks of ice below overhead fans, and water sprayed filters were used to ameliorate conditions inside railway coaches. (A.I.).

But it was not until 1928 that Carrier experimented with specially designed air conditioning equipment in the Martha Washington Dining Saloon for the Ohio and Baltimore Railway. It was so successful that it was early the object of world-wide interest.

By arrangement with Carrier Engineering Company of London, J. Stone & Company of Deptford, the train lighting experts, were put in touch with Carrier, the friendship of Stanley Groom (of CEC London) with Willis H. Carrier was extended by his friendship with Kenneth Preston (of J. Stone). (B)

The first exploit of Stones was for Australia, the Dining Car on the "Spirit of Progress" for the Victorian Government Railways in 1936. The first air conditioned train in South Africa was "The Blue Train" built in 1938. After the war when the South African Railways decided to build a Royal train for the visit of the Royal Family in 1947, the contract was awarded to the Metropolitan Cammell and Wagon Company Limited and Stone-Carrier were again entrusted with the air conditioning. (C)

Up to 1939, there had only been minor progress to the development of railway air-conditioning in India, circulating fans had been used with spray type evaporative cooling. The Nizam of Hyderabad had a fully air conditioned coach. After the war, however, in 1947, Stone's received an order for 36 equipments for Indian railways. The increase of tourists to India has also promoted the application of air-conditioning to railway travel in India. (D)

The accommodation in each of the new ~~"Ghandi"~~ "Gandhi" trains - as they became known - consists of one sleeping car, three "chair" cars and a restaurant car. The sleeping car carries 20 passengers and the "chair" cars each carries 80 passengers, a total of 260 persons - great increase in air - conditioned accommodation, even if the restaurant only handles 32 persons at one sitting. (E)

In 1954, the Queen visited Australia and a special installation was made for the Royal Saloon. This was a particular project but in general the Government-owned railway systems in Australia had pro - gressed the application of air-conditioning from 1936 in considerable degree especially after the war. At the end of 1949, the seven systems had 98 equipments but by thw end of 1956, there were 298 equipments. This attitude to air conditioning has continued through the years with increasing acceptance. (F)

In these notes there are repeated references to the fact that often Royal visits prompted the application of air conditioning to railways. This was true in regard to Egypt and Ethiopia.

The Egyptian Royal Train was constructed by the Fiat Company of Turin for King Farouk with Stone-Carrier Air Conditioning. Naturally this obtained more publicity than the many equipments installed for Argentine State Railways. (G)

Again it was Air Conditioning for the Emperor that highlighted the application in Ethiopia. The French firm Deccauville built the pair of coaches, sleeper consisting of 2 state rooms, bathrooms, the Emporor's study and a compartment for the secretary, the other is a lounge/dining car fitted out with kitchen and pantry. The journey from Addis Ababa to Djibouti covers 487 miles. (H)

The development of Air Conditioning for Railways is now considered just as standard as air conditioning for other purposes. Stone-Carrier eqiupment, used on railways throughout the world, is now available for road passenger vehicles. (I)

In the States, air conditioned cars and other motor vehicles are fairly general, still a prestigue facility in many other countries, the application of air conditioning to all means of transport is becoming daily more common throughout the world.

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LIST OF REFERENCES

A. Extract from "The Royal Trains" by C. Hamilton Ellis (1975)

B. Article "Stone's of Deptford" - a brief history from 1831 up to 1956

C. Article "The Development of Railway Air-Conditioning by A. H. Chilton covering the period 1931-1951.

D. Article "Cooperation in Sales" by W. J. Rushton

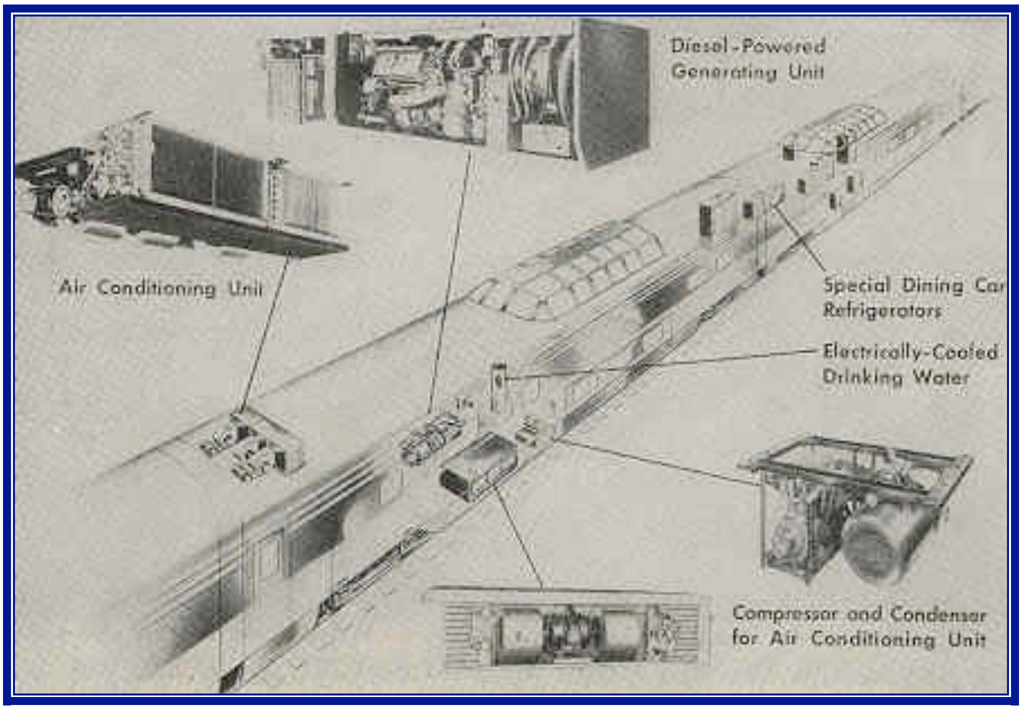
E. Article "India's New Fully Air Conditioned Trains"

F. Article "Air Conditioned Rail Travel in Australia"

G. Article "The Egyptian Royal Train" by C. E. P. Hall

H. Article "Air Conditioning for the Emperor" by J. K. Brident

I. Article "One for the Road".



Passenger train air conditioning (General Motors-Frigidaire) 1956