The evolution of automotive air conditioning

At the turn of the century, the only way to provide comfort cooling in an automobile was by ventilation. In the earlier days of motoring with open-body automobiles, no special provisions were required. This changed in 1908 with the gradual introduction of the closed-body automobiles.

The only way to keep cool in a closed-body automobile prior to 1940 was to raise an adjustable windshield that opened vertically or to remove the side curtains. The opening of the windshield was restricted to about 13mm so that the passenger compartment was sufficiently pressurised while minimising infiltration of the hot air from the engine.

Subsequently, windows could be cranked up and down for the desired airflow. Also, vents under the dashboard facilitated air circulation. Convertible tops permitted airflow upon being lowered. These ventilation systems were rudimentary, as they did not filter dirt, dust, pollen or insects from the air. Thus, the quality of the air circulating through the passenger compartment was poor.

Beginning in 1940, there was a gradual acceptance of fresh air heaters. With this advance came an improved method of summer ventilation that was provided by cowl ventilator. Later, the car heater blower was used to increase ventilator airflow since the air inlet for the heater was located in the ventilation duct.

Early air conditioning

Perhaps the earliest attempt at developing a mechanical comfort cooling system for a vehicle is attributable to William Whiteley, who in 1884 suggested placing blocks of ice in trays under horse-drawn carriages and blowing air inside by attaching a fan to the axle. The fan and ice system was well known by that time. Such a system was used in a White House room occupied by President Garfield during his illness between July and August 1881. The room cooling required 198 kg of ice per hour.

> The total number of air-conditioned cars made by American companies reached the million mark in 1959.

By the 1930s, the mechanical comfort cooling for stores, theatres and other public buildings had become well entrenched and attention turned to comfort-cooling systems for mobile applications.

In 1930, C & C Kelvinator outfitted a customised Cadillac owned by John Hamman Jr. of Houston, Texas with 0.37 kW Kelvinator refrigeration unit powered by a 1.1 kW gasoline engine. Two flues on either side of the front seat took the air down to a fan, which circulated cool air throughout the passenger compartment. As seen in Figure 1, the unit looked like a trunk and fitted compactly on the back of the car.

Fig 1 – The first car air conditioned by C&C Kelvinator Co. for John Hamman Jr. of Houston, Texas in 1930.

The development of the automotive air conditioner began in earnest in 1930 when General Motors Research Laboratories conceived the idea of the vapor compression system with R12 refrigerant.

On September 23, 1932 a proposal was made to General Motors management to develop such a system. The Cadillac Division showed interest in the proposal. However, it was not until the summer of 1933 that work started.

The cooling capacity of the automotive air conditioning system was determined to be 1 ton, (about 3.5kW). This estimate was half of the cooling capacity of the present system. There were two reasons for the lower estimate. First, the tests to determine the cooling capacity were con-ducted in recirculation rather than in ventilation mode. Second, during the course of the tests, the in-car temperature was sought to be lowered by no more than 5.6°C. At that time, it was believed that if the difference between the outside air and the conditioned air temperature exceeded 5.6°C, the occupant of the conditioned space could experience a thermal shock upon emerging into the outside air!

During the remainder of the 1930s, the work on automotive air conditioning culminated at General Motors with the development of a prototype self-contained unit that was installed in the boot of a 1939 Cadillac(Figure 2). While General Motors was still evaluating its boot-mounted unit, Packard Motor Car developed a complete air conditioning system for summer cooling and winter heating. This all-weather air conditioning system (Figure 3) was offered at US$274.

In 1934, a joint venture between Houde Engineering of Buffalo, N.Y. and Carrier Engineering of Newark, N.J. developed the first self-contained air conditioning system for a bus.[4] The initial feasibility studies were conducted for almost a year on a Ford V8 five-passenger car (Figure 4) that was test driven for more than 12,000 miles. The condenser was mounted on top of the car. The system was compact, requiring only 0.76 cubic metre of space, and used only a moderate amount of power furnished by the bus engine.

In 1935, another bus air conditioning system, developed by McCord Radiator & Manufacturing, was tested and it

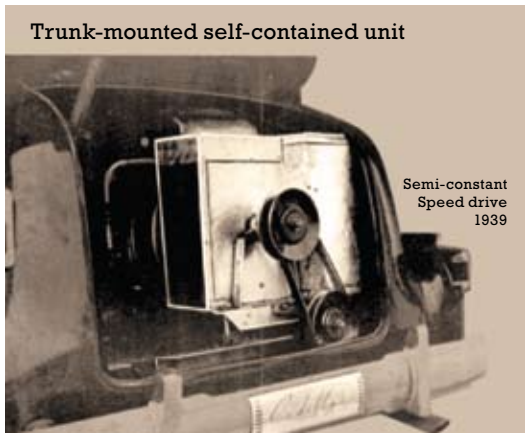

Fig 2 – The self-contained automotive air conditioner installed in the trunk of a 1939 Cadillac

worked well on a Pacific Greyhound bus run between El Centro and Los Angeles through the torrid Imperial Valley during the summer of 1935. The same year a second McCord system with a number of improvements based on the Imperial Valley experience was tested by an Eastern bus operator.

Two years later, the Kelvinator Division of Nash-Kelvinator in Detroit installed air conditioning on a White Research Coach (Figure 5). Dubbed Lord Kelvin, this air conditioned bus toured the southern portion of the United States in 1937 to determine the economics of operating a motor vehicle equipped with such a luxury item.

Automotive AC in the 1940s

Between 1940 and 1942, Packard equipped 1,500 automobiles with air conditioning. The air conditioning system was made available on the closed body models of the 120, Super-Eight 160 and Custom Super-Eight lines. Not to be outdone, the Cadillac Division of General Motors introduced air conditioning on its 1941 models, installing it on some 300 cars.

Although it was ballyhooed as a great luxury item, drivers had two major complaints. First, there was no provision for outside air. Smokers in the car made the air fetid and unbearable. Secondly, there were no interior controls. To shut off the system, the driver had to get out of the car, open the hood and remove a belt.

There were additional drawbacks. The system produced drafts in strange places and the front seat usually did not receive sufficient quantities of cool air. With the rear-mounted evaporator, sometimes the condensed water dripped over the rear seat passengers. This problem persisted into the 1950s as exemplified by a highly publicised incident when Mamie Eisenhower's dress was stained by the dripping condensation in an air-conditioned Cadillac.

Before World War II, approximately 3,000 American cars were equipped with air conditioning. Most of the units were installed in expensive luxury cars sold in the Southwest. This trend continued well into the 1950s. World War II (1941 to 1945) put a damper on automotive air conditioning growth as complete facilities were turned over to the manufacture of military vehicles, aircraft and naval vessels.

After the war ended, air conditioning growth resumed with Cadillac advertising a new, high-tech feature called air conditioning controls. However, there was still one problem. The controls were mounted nearly two metres from the driver's seat on the rear package shelf.

By 1947, independent manufacturers began installing air conditioners on all makes of cars, creating a large aftermarket business. This business was centered in Texas, although several important manufacturers were headquartered in Michigan. ARA was the first aftermarket manufacturer starting business in early 1949.

Cheap cooling aids like louvered aluminum solar screens and evaporative coolers were also marketed for those who could not afford the factory-installed or aftermarket units. The window-mounted evaporative coolers (Figure 6), known as swamp coolers, became quite popular especially in the southwest where the humidity is low. They were operated with water or ice and a fan that could be plugged into the cigarette lighter.

Automotive AC in the 1950s

The 1950s may be characterised as the decade of the comeback of automotive air conditioning. Neither the pre-war Packard nor the Cadillac system survived because of the aforementioned problems.

It was not until the 1953 model year that automotive air conditioning staged a comeback and this time it survived and flourished. That year, General Motors, Chrysler and Packard each introduced a practical system that sold for approximately US$600.

The Frigidaire system built for General Motors was available in all Cadillac and Oldsmobile lines, as well as in Super and Roadmaster Buicks. The Airtemp system built for Chrysler (Figure 7) was optional on the Imperial. For Packard, it was available only in the Cavalier and Patrician lines, as well as in the rare Derham Formal Sedan conversions. During 1953, about 29,000 cars were shipped with factory-installed air conditioning.

In 1953, Harrison Radiator Division of General Motors developed a revolutionary air conditioner that could be mounted in toto underhood in the engine compartment as shown in Figure 8. This was a much more efficient design and was the subject of the U.S. Patent No. 2,831,327. After much negotiation, Harrison Radiator won a contract to produce the new air conditioner for Pontiac in 1954.

In 1954, Nash joined the select group of carmakers offering factory-installed air conditioning. One of its most striking features was an all-season air-conditioning system called the All-Weather Eye (Figure 9). Nash already had what many experts considered the industry's best heating and ventilating system called the Weather Eye. Introduced in 1938, it provided summer cooling and winter heating with a single knob control and disconnected the compressor when it was not in operation. There was no need to manipulate multiple controls with All-Weather Eye. The entire Nash unit was located under the hood and weighed only 60 kg, which was just over half the weight of the Oldsmobile unit. The cost of the Nash unit was US$395, which was US$199 lower than the cost of the Oldsmobile unit. The additional savings included the cost of a heater for Oldsmobile.

For the 1954 model year, about 36,000 cars had factory-installed air conditioning. A bigger boost occurred in

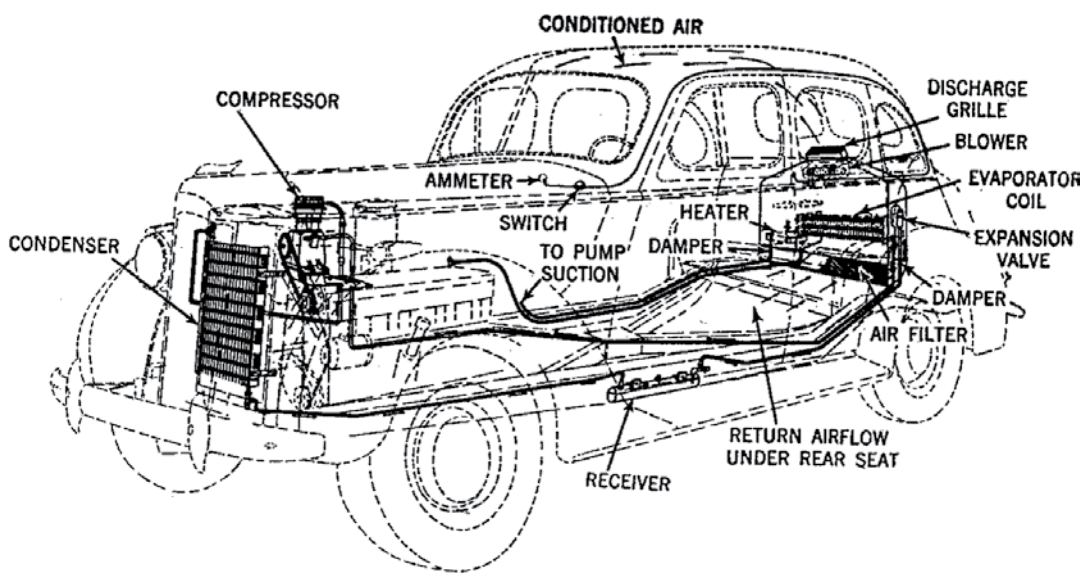

Fig 3 – The first practical automotive air-conditioning system developed by Packard in 1939.

editor's note

For those, who like I, were surprised by the mention of a cigarette lighter in a 1940's model car, I have discovered the following tidbits which may win you a pint in a pub trivia night some time.

The car cigarette lighter was originally designed as a lighter for cigars — hence its overly large size and annoyingly unheated center that make it less than ideal to light the humble cigarette.

Cigar lighters started appearing as standard equipment in automobiles in 1925 or '26. In 1928 the Connecticut Automotive Specialty Company patented the first automotive cigar lighter with cord and reel. The modern "automatic" automotive V-Coil lighter was developed by Casco in 1956.

The lighter is a cylinder containing a thin coil of nichrome wire, through which high current (15-20 amps) passes when the device is activated, usually by pushing its handle in. The lighter is held against the force of a spring by a hook attached to a bi-metallic strip. The heating element glows orange hot in seconds, causing the bimetallic strip to bend and unhook the mechanism, and the handle pops out.

Some new cars ship without the heating element (the "lighter") due to declining popularity of smoking in cars. However, the socket continues for the primary purpose of powering consumer electronics.

Fig 4 – The Ford V-8 five-passenger car used in the feasibility study of bus air conditioning in 1934 by Houde Engineering of Buffalo, N.Y. and Carrier Engineering of Newark, N.J.

1955 when seven more carmakers listed air conditioning as an option. Chevrolet completed the General Motors stable of factory-installed air-conditioned cars. Chrysler made it available on DeSoto, Dodge and Plymouth.

Ford introduced it for each of its marquees. Hudson and even Rambler could be bought with factory-installed air conditioning. In all, car factories throughout 1955 installed some 118,000 air conditioners. This amounted to 1.5% of the total car production. The last American car to offer air conditioning was Studebaker with its 1956 models at a cost of US$459.

> It is remarkable that an automotive compressor the size of a bread loaf weighing about 5kg can provide 10.5 kW of cooling, which can cool an average seven-room home.

In 1957, all Cadillac Eldorado Broughams were air conditioned, making it the first model to list air conditioning as a standard item. The penetration rate for the factory-installed air conditioning reached 3.7% with 228,000 units sold at an average price of US$435. The underthehood units cost approximately US$355, while the trunk units sold for US$420.

The big slump in the automotive industry during 1958 had affected its air conditioning. Actual factory installations dropped nearly 15%. However, the penetration rate for air conditioning increased to 4.6% of all 1958 models built. At American Motors, the penetration rate dropped considerably due to discontinuation of the more luxurious Nash and Hudson lines.

Starting in 1958, American Motors concentrated on the better selling, more economical Rambler line with the total cost of the car including air conditioning of less than US$2,000. Ford produced a number of surprises during the 1959 model year. For the first time, its factory installations exceeded those of Chevrolet by a wide margin, making it the leader for that model year with 65,796 units. In the arena of luxury cars, the traditional leader Cadillac fell back to the second place with Lincoln taking over the lead and keeping it for many years to come.

The total number of air-conditioned cars made by American companies reached the million mark in 1959.

Automotive AC in the 1960s

The popularity of automotive air conditioning soared in the 1960's with the number of air conditioners installed in American cars nearly tripling from 1961 until 1964. Air conditioning for trucks was becoming a much-demanded accessory.[7]

The debut of the big three's compact cars was the most exciting news out of Detroit for the 1960 model year. However, air conditioning was not offered on them. Nonetheless, its popularity grew with the buyers of the larger cars that year. Almost 7% had factory-installed air conditioning and the total units were 422,638.

During 1961 some cars began passing the 50% penetration rate for air conditioning. Lincoln led with 64% penetration rate followed by Cadillac at 52% and Imperial at 51%. More than 8% of all the 1961 model cars had factory-installed air conditioning. Corvair introduced air conditioning to the compact class on its 1961 models. There were 2,978 built with it.

The demand for compact cars started showing signs of moving from economy to luxury. Factory-installed air conditioning on Corvair jumped in the 1962 model year to a total of 7,651. Falcon joined the "cool car club" equipping 2,900 of its 1962 models with air conditioning. An industry wide penetration rate of 11% was reached with over 750,000 air-conditioned cars. Both Chevrolet and Oldsmobile full-size models were the first to exceed the 100,000 unit air-conditioning mark pushing Cadillac from its leadership position in terms of air conditioned cars.

During the 1963 model year, Ford set the air conditioner price at US$232 for Falcon and Comet, which was the lowest list price ever for this factory-installed option. It helped both models to double their sales. In 1963, Corvette became the first sports car to feature air conditioning. For all the 1963 cars, the air-conditioning penetration rate reached 14% and the total number of air-conditioned cars exceeded the one million mark for the first time in a single model year.

Installations in 1964 increased to more than 1.4 million units. Thunderbird entered the over 50% air-conditioned group with more than 23,390 units. Also during that year, Buick factory installations surpassed those of Oldsmobile for the first time. During 1965, Buick's Riviera reached the 70% penetration mark while Lincoln hit the 90% mark.

As the demand for air conditioning grew, production increases created manufacturing economies and prices bottomed out in 1965. The range was from a low of US$252 on the Mercury Comet to a high of US$650 on the Imperial.In 1966, Oldsmobile launched the Toronado, which became the first model to pass the 50% air-conditioned mark in its first year of introduction and reached a penetration level of 74%. Other models passing the 50% air conditioned mark that year were the full-size lines of Buick and Oldsmobile.

Industry-wide the number of factory-installed air conditioners reached a level of 2.5 million. In addition, an estimated 575,000 aftermarket air conditioners were installed on old cars by dealers and auto shops. In 1967, almost two out of every five new cars had factory-installed air conditioning. Full-size Pontiacs exceeded the 50% air conditioned mark and so did full size Dodges and Mercurys. More than 97% of Cadillac's newly redesigned Eldorado, which debuted in 1967, had factory-installed air conditioning.

By 1968, the demand for air conditioning had reached such a crescendo that some carmakers installed it as a standard accessory on their more expensive models. That year Cadillac Fleetwood limousine became the first to feature air conditioning as the standard equipment. The same year, American Motors made air conditioning standard on the Ambassadors. Of the 7,760 Lincoln Continental Mark IIIs built in 1968, all but 88 were equipped with air conditioning.

Moving in the opposite direction was the Corvair, which removed air conditioning from its options. The first mid-size model to break the 50% air conditioned barrier was the Oldsmobile F-85 with Plymouth joining the ranks soon after.

Fig 5 – The White Research Coach Lord Kelvin air conditioned by the Kelvinator Division of Nash-Kelvinator in 1937.[6]

The percentage of new cars being equipped with air conditioning continued to increase steadily through the decade reaching more than 54% by 1969. This represents an astounding 785% increase over 1959 sales. In addition to the large number of factory-installed units sold in the 1960's, several hundred thousand car owners purchased after-market units. The majority of these units were installed in smaller cars for approximately US$200.

Throughout the 1960's, refinements continued to be made to render the air-conditioning system to be quieter and more reliable. An example of these refinements was the Chrysler Auto-Temp System that operated in response to a temperature setting selected by the driver. It provided proper velocity and temperature distribution of the air. General Motors also developed an improved air-conditioning unit in the mid-1960s. Known as the Climate Control System, it was first offered on the Cadillac. Later, modified versions of this deluxe system became available on other large General Motors cars.

Automotive AC in the 1970s

The 1970s were marked by the intense debate centered on the ozone depletion issue that threatened the continued use of the chlorofluorocarbon (CFC) compounds. Automotive air conditioners used CFC refrigerant designated R12. With the unprecedented growth of automotive air conditioning expected to reach an industry-wide penetration rate of 70% by 1980, this debate was a source of grave concern to the U.S. automotive industry.

> Faced with the prospects of an impending ban on R12, carmakers developed an alternate air-conditioning system with R-134a refrigerant.

Bemused by the scientific debate and controversy centered on the CFC issue, Harrison Radiator anticipated that the continued use of R12 in automobile air conditioning might be in jeopardy. It conducted a preliminary evaluation of alternate refrigerants in 1976. After considerable amount of screening, R134a was identified as the likely replacement in the event of a total ban on R12. In 1977, Harrison Radiator and Allied Chemicals in Buffalo, N.Y. conducted a joint evaluation of R134a for automotive air conditioning. The following year, Harrison Radiator conducted the first wind tunnel tests with R134a in a 1978 Chevrolet.

Refinements to automotive air conditioners continued to be made throughout the 1970's. Units became more efficient, more compact and lighter weight. For example, some of the compressors produced in the early 1950s weighed nearly 27 kg. Design modifications reduced the weight by 80%; they also improved the efficiency, capacity and durability of the units.

It is remarkable that an automotive compressor the size of a bread loaf weighing about 5kg can provide 10.5 kW of cooling, which can cool an average seven-room home.

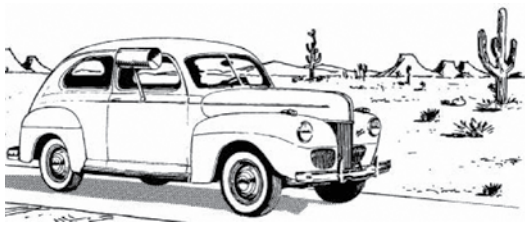

Figure 6 – Window-mounted evaporative coolers marketed during the 1940s and 1950s.

Automotive AC in the 1980s

The controversy centered on the linkage of CFC compounds to the ozone depletion continued through the 1980s culminating in the adoption of the Montreal Protocol in September 1987. It called for a phase out of the fully halogenated CFC compounds including R12.

Faced with the prospects of an impending ban on R12, carmakers developed an alternate air-conditioning system with R134a refrigerant. This entailed the development of new components like condensers and compressors, as well as new materials like lubricant and desiccant.

> Car air conditioning has come a long way since the first comfort cooling system was installed in a 1939 Packard.

There were many changes during the 1980s relating to cooling performance enhancement, body styling and fuel economy. One thing that did not change was the increasing popularity of automotive air conditioning. In 1980, 72% of the new cars sold in the United States had factory – installed air conditioning. By 1990, this figure jumped to 94%. Perhaps even more amazing than the new car statistics was that more than 66% of all cars and light trucks in operation in the United States in 1989 had air conditioning.

Automotive AC in the 1990s

The 1990s may be characterised as the decade of the conversion from R12 to R134a. Beginning in 1992, carmakers around the world started implementing the changes necessitated by the replacement of R12 with R134a. These changes were far from being unobtrusive.

Contrary to earlier expectations, the conversion proved to be an onerous task since it entailed replacement of not only the refrigerant, but the lubricant and desiccant as well. In addition, condenser, compressor and control switches had to be changed. The new desiccant material for the R134a system was the molecular sieve material

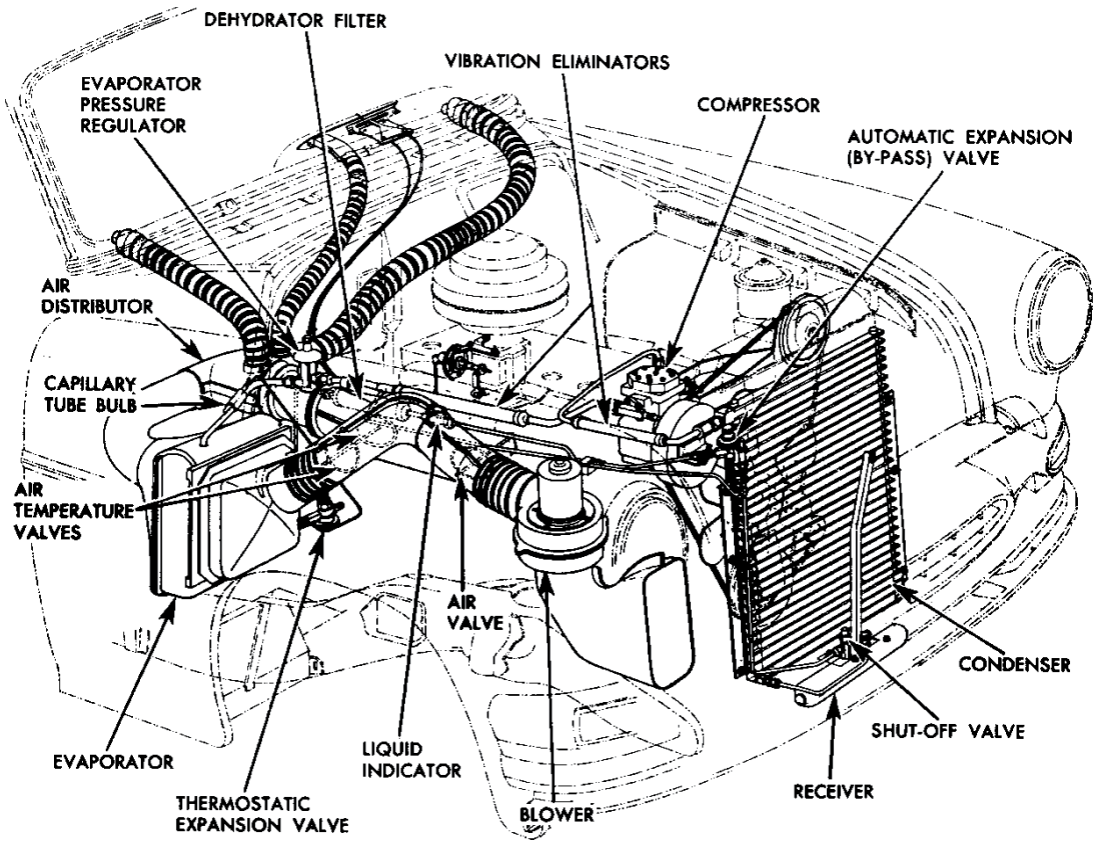

Fig 8 – Underhood disposition of the components of the automotive air-conditioning system developed by Harrison Radiator and Pontiac Divisions of General Motors in 1953 that became an industry standard.[1]

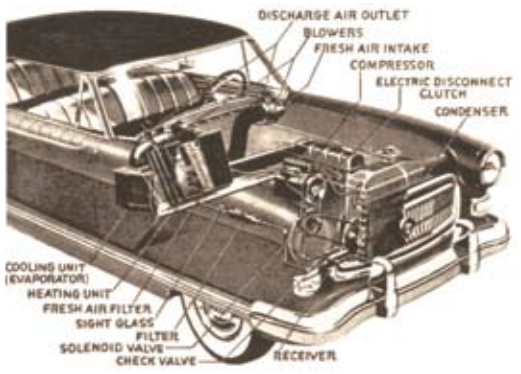

Fig 9 – The 1954 Nash All-Weather Eye automotive air-conditioning system with a single knob control that pioneered the automatic four-season controls.

4A-XH-7, replacing the similar material 4A-XH-5 used for the R12 system. The new synthetic lubricant polyalkylene glycol (PAG) replaced the mineral oil used with R12.

In addition, refrigerant containment and conservation through recycling became standard practice. In the past 50 years, this was the most dramatic change in automotive air conditioning. Replacement of R12 with R134a offered an unanticipated benefit. Unbeknownst to carmakers and others, R12 was a powerful greenhouse gas responsible for about 50% of the total equivalent warming impact of the entire vehicle. With the introduction of R134a, the total equivalent warming impact of the air conditioner was reduced to 4.5%.

The future of automotive AC

Car air conditioning has come a long way since the first comfort cooling system was installed in a 1939 Packard. Many changes have been made to accommodate new car designs, improve fuel efficiency, gain environmental acceptability, enhance passenger comfort, provide health benefits and increase passenger safety. Notwithstanding the debate over its environmental impact, the future of automotive air conditioning remains bright. ▲

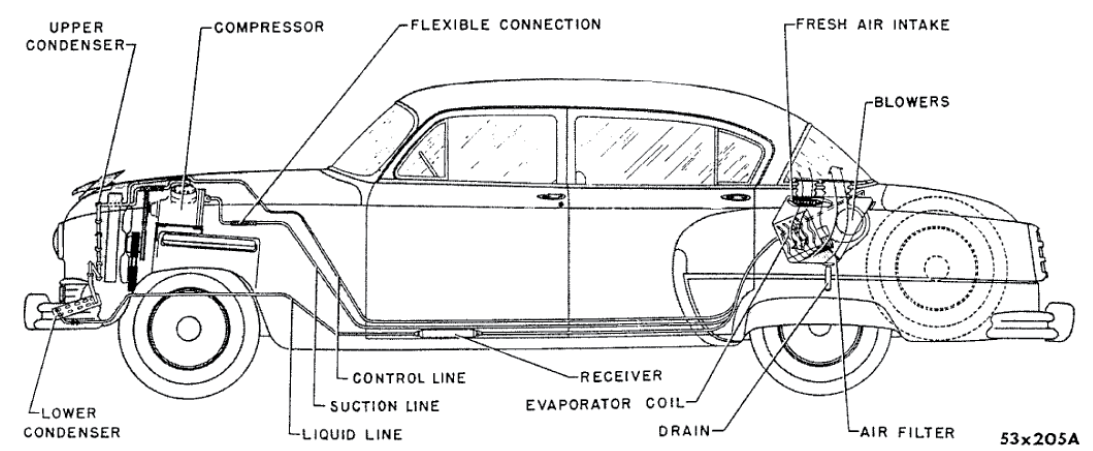

Fig 7 – The automotive air-conditioning system developed by Airtemp Division of Chrysler corporation in 1953 featuring a dual condense arrangement and R22 refrigerant.

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