The evolution of automotive heating

This is the second part in HVAC&R Nation®'s two-part series on conditioning automotive air. Last month we turned back the clocks and discovered how automotive air conditioning has evolved since the turn of the century. This month we look at the evolution of automotive heating. From early portable heaters to modern heating system controls, we find out how our forefathers kept their feet warm.

The early automobiles at the turn of the century were like horse-drawn carriages except that they were powered by electric batteries or petrol-burning internal combustion engines.

During the late 1800s, there were more electric cars than petrol cars. However, due to the gradual evolution of the internal combustion engines, popularity of the electric cars declined and their production ceased in the late 1920s. The early cars had only the simplest controls for operation and were aptly called horseless carriages. The driver and passengers sat on a seat and had no protection from the elements except for special clothing designed for motoring such as storm aprons made from heavy rubber cloth, lap robes, long fur coats, fur hats, mufflers, leather gloves and boots.

Figure 1 (next page) is a 1906 advertisement by the Ball-Fintze Co. of Newark, Ohio that shows a large five-passenger storm apron. Figure 2 (next page) shows some of the individual motoring apparel for winter including the lap robe that appeared in the 1908 Sears, Roebuck & Co. catalogue and the automobile gloves that appeared in a 1906 advertisement in Motor. It was necessary in the early days of motoring to wear special driving apparel for each of the four seasons.

In winter, motoring was quite unreliable in the automobile's early days. It was common practice to jack the car up on wooden or cinder blocks and store it until spring. As automobiles became more reliable, consideration was given to passenger comfort with the addition of windshields, collapsible tops and detachable side curtains.

Some electric cars used electric heating pads that were laced into the steering wheel to warm the driver's hands. Heating the steering wheel for a petrol-burning car was accomplished by bringing in exhaust gas by means of a flexible pipe around the steering wheel. Closed-body automobiles were introduced in 1908. By 1925, production of closed-body automobiles exceeded that of open-body models. Attention turned to heating devices and the need to condition the air for passenger comfort.

Early portable heaters

In the early years of motoring, attempts to provide comfort heating were largely improvisations using heating aids such as heated soapstone; hot brick and lantern (shown in Figure 3 next page) that also were used in the horse-drawn carriages. A good lap robe (Figure 2) in conjunction with one or more of these aids kept the traveler moderately comfortable. As interest in motoring increased, portable coal-burning heaters appeared on the market.

These heaters were made of galvanised iron with asbestos lining and brass handles. They were approximately 50cm long and 20 cm wide and shaped like footrests as shown in Figure 3. Some of them were covered with colored carpet that matched the carpet in the car. The coal was placed in a drawer that slid into the outer shell. The special type of coal used in these heaters was in the shape of a brick that burned without odor or smoke. Before use, the brick was placed into a brisk fire until it became thoroughly hot. It was then taken out of the fire and left standing until the flame died away. Next, the hot brick was placed in the heater drawer. When no more heat was desired, the coal could be quenched with water and used over again. A small brick was sufficient to provide heat for several hours.

Exhaust gas heaters

Since portable heating aids required special preparation prior to motoring, attention turned to the on-board sources of heat for continuous heating. With this innovation, a phalanx of heater engineers sprang into existence, mostly from the plumbing profession. Many early automobile engines were air-cooled. Engine coolant as a source of heat was not universally available. Accordingly, many different brands of exhaust gas heaters were put on the market, some of which were quite successful. Figure 4, taken from the 1907 advertisement in Motor, shows one such heater.

The early exhaust gas heaters can be broadly classified as raised type and recessed type. The raised type were like footrests that could be mounted on the rear compartment floor while the recessed type were mounted through the floor with the grating placed flush with the floor. These early exhaust gas heaters had no provision for cleaning out the dust and debris and they often leaked. They also often had an obnoxious odor.

The early exhaust gas heaters were mere radiators made of bundles of tubes through which passed the exhaust gas. The tubes usually were covered with a grating of nickel-plated iron or polished aluminum. The control usually was a valve attached to the exhaust pipe and operated by a handle or lever on the floor of the car. The heaters were not engineered for a specific car or model and required a great deal of ingenuity for installation on a specific car.

"Horseless Carriages" offered no protection from the elements.

Figure 1: Storm aprons for open-body automobiles.

There were numerous problems with these rudimentary heaters. Temperature control was difficult due to a wide variation in the exhaust gas temperature depending on the car speed. Leaks caused some deaths, although no statistics exist on the number of fatalities. Since the early closed-body automobiles were not airtight, this number was probably not too alarming. The exhaust gas heaters also created backpressure on the engine that undermined the fuel economy and reduced power. Carbon deposit on the tube interior made frequent cleaning necessary and that required dismantling the entire heater. In some cases, the heated portion of the car became excessively hot, burning occupants, robes and leather shoe soles.

> Some came with installation instructions that were downright ridiculous. For example, installation of one heater called for the assistance of a ferret to crawl through the pipe and hold two screws with its teeth!

The gradual improvements of the roads allowed cars to be used more during the winter, which created demands for safer and higher performance heaters. One 1929 vintage heater, designed for Model .A. Ford, is shown in Figure 5 (next page). It consisted of an iron jacket around the manifold. The front of the heater was attached to a flexible pipe with a funnel acting as an air scoop behind the engine fan. The rear of the heater was attached to a flexible pipe running to the toe board or floorboard where a deflector directed hot air in the required direction. The deflector was later replaced with a slotted register. In summer, the register was bypassed by a butterfly valve and the heat dispersed into the engine compartment.

In 1933, Ford Motor developed a dash mounted exhaust gas heater for Ford V8 cars. It was built like a boiler with 24 flues, each 33 cm long, providing about 3250cm^2 of heat radiating surface. The hot exhaust gas from the engine passed through the flue tubes around which flowed outside air. The cold air intake consisted of a pipe with a funnel acting as an air scoop behind the engine fan. A unique feature was its double-header construction that prevented the fresh air from coming in contact with all welded joints and connections in the exhaust line. The heat register was installed in the right dash wall in front of the front-seat passenger. The heat supply was regulated by a foot-operated button controlling a valve in the intake pipe. The heater was capable of directing the hot air to any part of the front compartment.

In the mid-1930s, an unusual heater was developed by Delco using exhaust gas to generate steam. Its operation was similar to the steam house heating system. The system included a boiler at the muffler outlet. It was surrounded by exhaust gas with an average temperature of 482°C. Approximately 30mL of liquid water was placed in the boiler. Immediately upon starting the engine, the intense heat of the exhaust converted this liquid water into steam that rose to the heater core where the heat was convected into the passenger compartment by means of an electric fan. The steam returned to the boiler through the return line routed through the radiator to condense it. The pressure was automatically maintained at about 690kPa by means of a patented control chamber that governed the amount of water in circulation.

The early exhaust gas heaters were recirculation type with no provision for fresh outside air. They were essentially potbelly stoves that radiated heat to the closed passenger compartment. In 1940, a manifold type of fresh air exhaust gas heater was developed by Novi Equipment for Ford Motor. It was an integral part of the exhaust system, and once installed it required no further attention except to turn it on or off. It was capable of providing a discharge air temperature in excess of 93°C. The ability to obtain such high discharge air temperatures from the manifold type of exhaust gas heaters was why some heater engineers in the 1940s were reluctant to abandon them in favor of the hot water heaters.

Hot water heaters

The term hot water heater refers to the heater core that derives its energy from the engine coolant, which in today's automobile is a solution comprising 50% water and 50% ethylene glycol by volume. Originally, automobiles used water as the engine's coolant. They began using water-glycol solution in 1929.

Propelled by the availability of reliable water pumps and thermostats to regulate the engine coolant temperature, hot water heaters appeared in the mid-1920s. They were all dash-mounted units with an electric fan. Varying the fan speed enabled control of their heat output. They were usually purchased over the counter and installed by the owner after drilling some holes through the firewall for the core pipes and mounting bolts. They were often changed from car to car.

During the winter of 1927–28, AB Arnold, a pioneer of hot water heaters, designed and built an experimental hot water heater for an Ajax car owned by the owner of Modine Manufacturing. The heater core was of a honeycomb type and mounted in such a way that all the coolant passed through it on the way to the radiator top tank. Air was drawn by the action of the radiator fan. Subsequently, Modine built this type of heater for Bud High Compression Ring Company.

After much design work and testing in 1930, Harrison Radiator Division of General Motors joined the select group of manufacturers including Trane, Venturafin, Modine, McCord and Fedders that supplied hot water heaters for automobiles. Figure 6 shows the front views of various hot water heaters developed by Harrison Radiator.

In 1931, Harrison Radiator introduced a hot water heater for the rear passenger compartment. It was formed as

Figure 2a: Lap robe and muffler used in the early days of motoring.

a footrest and was swingably mounted on pivots at its two ends. The heater was a honeycomb structure with numerous passages and a large radiating surface. This apparently was the first attempt to provide comfort to both the front and rear passenger compartments. Around the same time, Modine Manufacturing also developed a footrest type of hot water heater for the rear passenger compartment. Its heat output was controlled by means of an adjustable air damper. This heater represented one of the earliest attempts at introducing fresh outside air with the heating system.

One of the first hot water heaters to successfully address ventilation and pressurisation of the passenger compartment was built in 1933 by Arnold and installed on a Ford V-8. It was comprised of a heater core that was installed behind the instrument panel and connected by ductwork to the cowl ventilator. No motor or fan was used, and the only controls consisted of a manually opening cowl ventilator and water control valve. The heater demonstrated the viability of fog elimination.

In 1937, Nash Motor pioneered the development of a heating system that recognized the importance of ventilation and pressurisation of the passenger compartment. It introduced clean, filtered and fresh air at

a comfortable temperature and created a slight positive body pressure within the passenger compartment to eliminate infiltration of cold air. This represented a major improvement over the re-circulating heating systems in use until 1937. In this early Nash heating system, temperature control was achieved manually by the operation of a water valve and the cowl ventilator. The automatic temperature control and built-in defrosters were added with the introduction of the 3900 Series Nash cars in 1939.

Harrison Radiator in 1939 released an under seat heater, it reduced the congestion in the cowl and front passenger compartment and helped distribute warm air to the front and rear compartments. All General Motors Car Divisions adopted this type of heater for the 1939-1940 model year. In the same model year, Harrison Radiator also provided an accessory package to bring in outside air to the dash heater. It was used by Oldsmobile, Pontiac and Chevrolet.

With increased awareness of the benefits of ventilation, in 1940 a gradual trend began toward the use of fresh outside air for car heaters. Ventilation provides improved quality of air and minimises window-fogging tendency since in winter the absolute humidity of the outside air is lower than that of the passenger compartment air. Also, outside air tends to keep the body pressure positive preventing infiltration of cold air. In 1941, Buick used an outside air under seat heater as well as an outside air defroster. This type of installation gave good overall heating but required separate heater cores and blowers for the defroster and heater. In the following year, the outside air heater was added to all General Motors cars and outside air dropped from the defroster. Oldsmobile adopted a dash-mounted outside air heating system that used one heater core and blower for comfort heating and defrosting.

During World War II (1941 – 1945), manufacturing facilities changed over to the making of military equipment. Several production car heaters were redesigned for use in military vehicles, aircraft and naval vessels. In 1946, all carmakers entered postwar production with the 1942 vintage heating systems.

Starting that year, Harrison Radiator began to use the cold test tunnels extensively for developing and testing the heating systems. These tunnels duplicated road conditions, which enabled the development of the complete heating system. The first system to be developed with the aid of the cold tunnels was the heating and defrosting system for 1947 Chevrolet trucks. As the new truck body was not available, the heater was tested in an old truck cab on a pair of sawhorses using an auxiliary water source and power supply. Subsequently, the actual road operation of the truck confirmed that the makeshift system simulation employed in the cold tunnel was quite satisfactory.

The 1946 Buick featured ram-driven ventilation air and an automatic temperature control. The 1946 Cadillac featured two under seat heaters and a defroster, each with its own blower-motor assembly. By contrast, the 1946 Pontiac had a single blower-motor assembly behind the radiator grill to direct the air both to the under seat heater and the dash-mounted defroster. This apparently was the first dual-zone heating system.

In 1947, Ford Motor introduced its first fresh air heating system in which temperature control was by means of a manually operated water valve. In 1948, it introduced its thermostatically controlled Magic Air heating and ventilating system that provided fresh air for year-round comfort.

1949 was the first year that all General Motors Car Divisions switched to the outside air heaters. These heating systems were developed and tested using the Harrison cold tunnels. In 1950, Harrison Radiator developed a fresh air heating system that could be employed in winter for heating and in summer for introducing fresh air into the passenger compartment for cooling and ventilating.

Figure 2b: Gloves and fur coats were a must for riding in early automobiles.

Prior to 1959, all heaters for General Motors cars were highly car-specific, requiring little or no common tooling for their manufacture. In 1959, a corporate-wide standardisation program was undertaken to reduce tooling costs, make best use of the manufacturing facilities, minimise the number of service parts and simplify the operations of the assembly plants. This resulted in a simplified arrangement of the components, which met or exceeded all previously established standards of performance.

In 1962, hot water heaters became standard on all General Motors cars. For several years, it was possible to buy a car without a heater if specified at the time of ordering. However, few cars were sold without heaters. The heater option was cancelled in 1968 with the establishment of the Federal Motor Vehicle Safety Standards (MVSS) that required that all passenger cars, trucks and buses sold in the US be equipped with windshield defrosting system, which is an integral part of the comfort heating system. Effective Jan. 1, 1969, testing procedures and performance were added to the MVSS specification.

Petrol heaters

Stewart-Warner developed the first successful petrol-burning passenger car heater, known as Model 781, around 1937. It was mounted on the passenger side of the firewall and the outlet of the combustion chamber was connected to the intake manifold of the engine. The engine vacuum was used to draw air and fuel into the combustion chamber where the mixture was ignited by means of a glow plug. The exhaust products were drawn into the engine where unburned fuel was consumed. A small fan circulated the air over a finned heat exchanger. The heater did not use outside fresh air and its heat output was about 84 kJ per minute, which was barely enough for a recirculation type of heater. In all, some 3.5 million units were sold.

Complications of the design and high cost of operation as well as high cost of maintenance caused a loss of interest in the gasoline heaters. At the end of World War II in 1945, a renewed interest in gasoline car heaters developed as a means of obtaining quick warm-up of the passenger compartment.

During 1956, Chrysler offered a Stewart-Warner gasoline burning fresh air heater. This design incorporated spark ignition for virtually instantaneous heat. It was equipped with its own combustion chamber blower so that the exhaust did not enter the engine intake manifold. The system provided excellent heating performance due to automatic temperature control and provision for fresh air.

In 1960 Stewart-Warner, in collaboration with Harrison Radiator, developed a petrol heater for Corvair that featured an air-cooled rather than a water-cooled engine. The heating system was a stainless steel heat exchanger, a nozzle type burner, spark ignition and separate combustion air and fresh air blowers. The system was automatic in operation and controlled by means of a duct thermostat that cycled the burner on and off depending on demand. However, the following year the petrol heater was eliminated and replaced with an exhaust gas heater that operated by forcing outside air over the engine manifold and introducing the resulting hot air into the passenger compartment when needed.

Electric car heaters

As a direct result of the 1973 Arab oil embargo, a renewed interest developed in the electric car. The U.S. Congress overrode a Presidential veto and passed the Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976. In September 1991, the U.S. Department of Energy joined forces with General

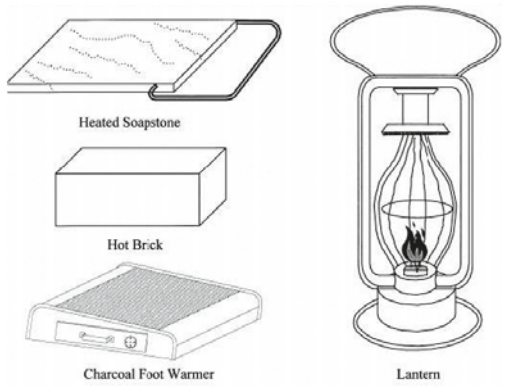

Figure 3: Heating aids were the first attempts to provide comfort.

Motors, Ford and Chrysler to develop advanced battery technologies for future electric cars. This spurred development of battery-powered electric cars, including General Motors' Impact, Ford's Ecostar and Chrysler's TEVan.

Harrison Division developed the heat pump system for comfort heating and cooling for Impact's two-passenger subcompact coupe. Although the heat pump system was used in concept cars, it apparently was the first time that it was used in a commercially produced car. Soon, other carmakers also used the heat pump system on their electric cars. The first use of a heat pump for comfort heating can be traced to T.G.N. Haldane, who in 1927 used it to heat his London office and Scottish home. There is also a record of a house in Tucson, Arizona being heated in this fashion in 1930. In 1931, a 13-story building in Los Angeles owned by an electric distribution company employed a heat pump both for heating and cooling.

Most electric cars now employ an alternate source of heat, such as a positive temperature coefficient (PTC) electric heater, to supplement the heat generation by the heat pump system. An increasing electrical resistance with increasing temperature characterises such a heater. It also features automatic power adjustment in response to ambient temperature conditions and HVAC fan speed along with self-regulation of the heater temperature. In addition, the power draw of the PTC heater is matched automatically with the available electrical power for the vehicle operation.

Figure 4: An exhaust gas heater used in open-body automobiles.

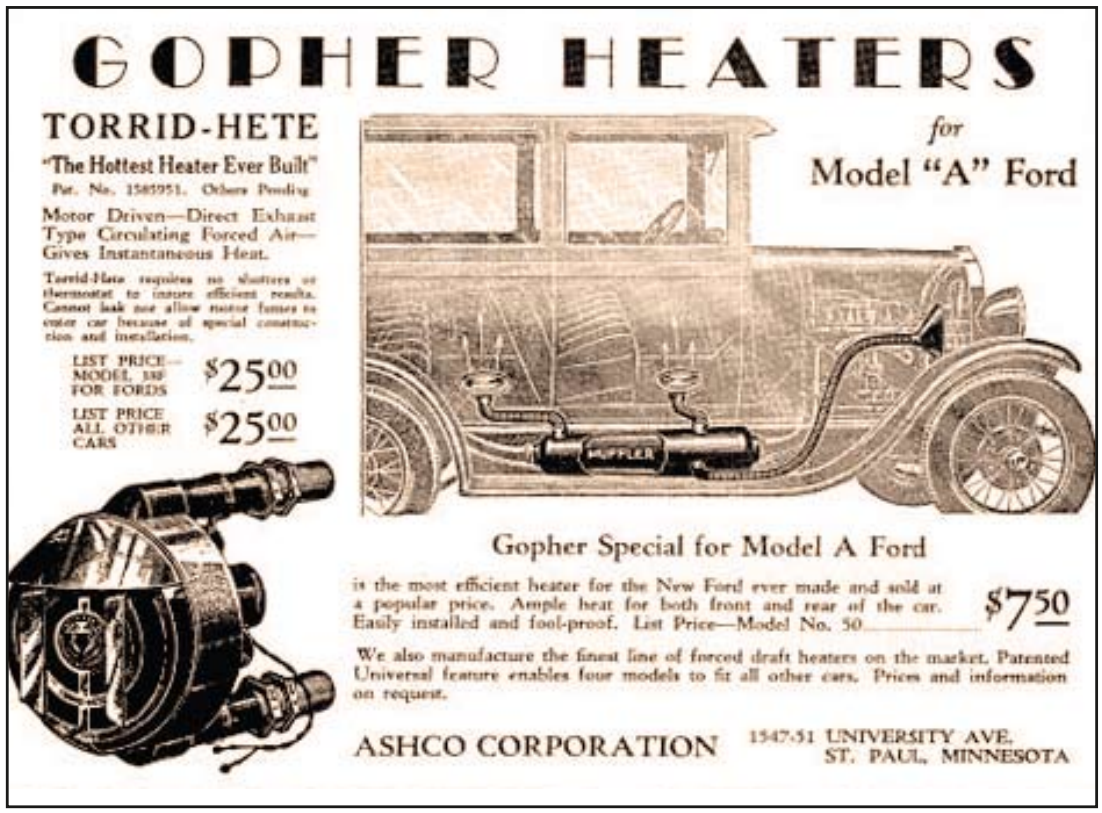

Figure 5: A high-performance exhaust gas heater used in 1929.

Heating system controls

Prior to 1938, no automatic temperature controls existed for the airside of the heating system. Nash Motor Company in 1939 championed them. Nash's Weather Eye control system was comprised of a thermostat that sensed samples of the incoming outside air, discharge air and inside air. Any change in any of these three samples resulted in an automatic adjustment of the Weather Eye control to maintain passenger comfort.

The model year 1941 marked the introduction of automatic temperature controls in the car heating system. The control was achieved by means of temperature sensing elements such as liquid – filled bellows or capillaries that were placed to sense in-car temperature. Location of the temperature-sensing element was critical and often was mounted on the outlet core face. This development was fostered by Harrison Radiator and first used in the 1941 Buick, Oldsmobile and Cadillac heating systems.

In 1942, Ford Motor offered factory-installed fresh air hot water heaters for their car line. They were integrated with the standard ventilation system and included a thermostatic valve manufactured by Ranco of Columbus, Ohio. The capillary of the valve was positioned to sense in-car temperature. However, this arrangement proved unsatisfactory. For example, if the control valve were repositioned for less heat, it would completely shut off the water supply to the heater core causing a cold blow. This deficiency was overcome in 1950 by redesigning the control in such a way that a certain reduction in the temperature lever setting produced a pro rata reduction in the discharge air temperature.

The heating system controls prior to 1953 were simple because there were no comfort cooling system controls to contend with. With the large-scale introduction of the comfort cooling systems starting in 1953, the heating system controls became intertwined with the comfort cooling system controls. In 1954, Nash Motors announced its new All-Weather Eye, a self – contained automotive air conditioner with all components located forward of the instrument panel. The unique features of the All-Weather Eye included a single knob control that operated both the heating and cooling units.

Figure 6: Front views of the hot water heaters manufactured by Harrison Radiator starting 1930.

In 1964, Cadillac introduced the first automatic air-conditioning control enabling a motorist to drive from Northern Maine to Southern California without adjusting controls or lowering a window. In many respects, it was the automatic version of the Nash All-Weather Eye single knob control. Although it has undergone some design changes centered on the use of electronics in place of thermo-mechanical elements, it is today the standard equipment on most luxury cars and also an optional accessory on many other cars. ▲

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