Chilling Construction

Keeping cool means building strong alloys

BY JOHN HINCKLEY

IN THE "CORVETTE COOLING BASICS" ARTICLE IN THE SEPTEMBER 2003 ISSUE, WE REVIEWED ALL THE COMPONENTS OF THE COOLING SYSTEM AND EXPLAINED HOW THEY ALL WORK TOGETHER TO PROVIDE PEAK COOLING PERFORMANCE AND RELIABILITY. THIS MONTH, WE'LL SEE HOW THE SPECIAL CORVETTE STACKED-PLATE ALUMINUM RADIATOR WAS MADE ORIGINALLY AND HOW THE REPRODUCTION OF THAT RADIATOR IS MADE TODAY.

Thanks to Tom DeWitt for opening his Brighton, Michigan shop to us on a weekend and taking the time out of his busy schedule to walk us through the manufacturing process for his Restoration and Direct-Fit aluminum radiators and expansion tanks.

RADIATOR DESIGN: Aluminum is the material of choice for efficient radiators because it's strong enough to make wide tubes, which increases the amount of fin-to-tube contact in the core. The fin-to-tube contact area is what determines the rate of heat rejection. Copper isn't as strong as aluminum, and tubes can't be wider than 3/8 inch without "ballooning" under pressure unless they're made from very thick material, which drives weight WAY up. Aluminum radiators routinely have tubes 1-inch wide. Virtually ALL OEM radiators are now aluminum due to their efficiency and light weight.

Most conventional radiators utilize the "tube and fin" horizontal cross-flow core design, with one or two rows of tubes and coolant tanks at each end. DeWitts uses this basic design for their line of Direct-Fit radiators.

To get absolute maximum cooling capacity in a small package, the Corvette engineers adopted a much more complex and efficient design beginning in 1960 through 1972 for small-blocks, 1965 big-blocks, 1967-'69 L-88s, and small-block ZR-1s – the stacked-plate Harrison aluminum radiator.

THE STACKED-PLATE RADIATOR: The Harrison aluminum plate radiator grew from the design of aircraft oil coolers developed in the 1940s that had to have maximum heat dissipation with a small frontal area and cost as a secondary consideration.

The plate radiator is essentially "all core" from front to back, as the full depth of each individual plate element is exposed and finned, functioning as a "tube" the full thickness of the radiator, and the space between the top plate of one element and the bottom plate of

1 Several plate elements – note the raised rib around the edge which ends up brazed to the rib on the adjacent element, creating a full-depth "tube" and the embossed standoffs in the center.

2 An edge view of several plate elements, showing the folded fin insert which ends up brazed to the top and bottom plates.

3 Three plate elements nested together, ready to be loaded into the assembly fixture.

4 The plate radiator assembly fixture – it accommodates both widths, and the wheel at the top compresses the assembled "stack" to the correct height.

5 Stacking plate elements in the assembly fixture; the radiator is built upside-down and requires thirty elements.

6 A completed radiator – note the temporary top and bottom support frames and steel banding to tie the stack together.

the element above it is open to coolant circulation. These radiators have 30 individual plate elements stacked one on top of the other, and have no end tanks – they're "all core" and utilize a separate coolant expansion/supply tank instead of the end tanks that are part of a conventional radiator.

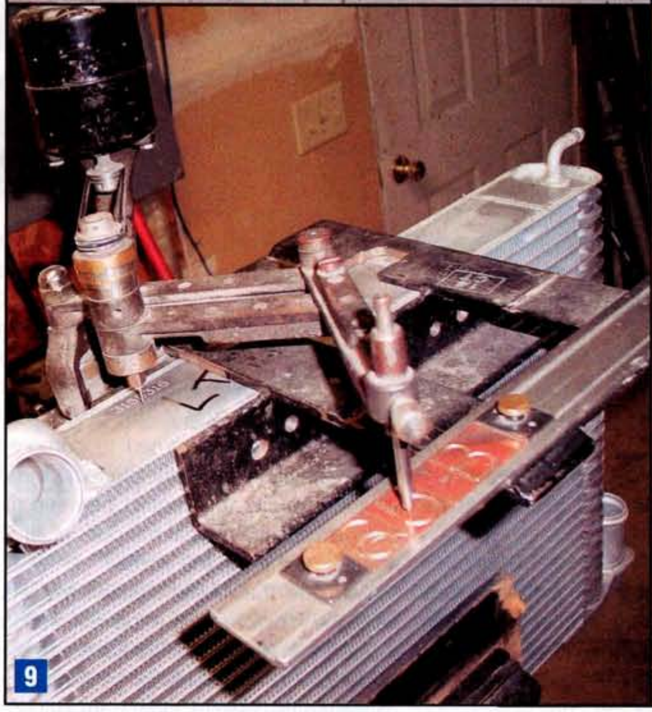
Each individual element (see photos) is made up of three pieces – a top and bottom plate crimped together at each end, and the folded fin material inserted between the two plates. The top and bottom plates have embossments that serve as standoffs where each element is in contact with the one above and below it, creating a very wide coolant flow path between each pair of adjacent plates. It's this wide flow path between plates that creates the "tubes" that are the full thickness of the radiator core, and each element also has the folded "fins" the full thickness of the core as well; it's this enormous amount of "fin-to-tube" contact area that makes the plate radiator so efficient for its size.

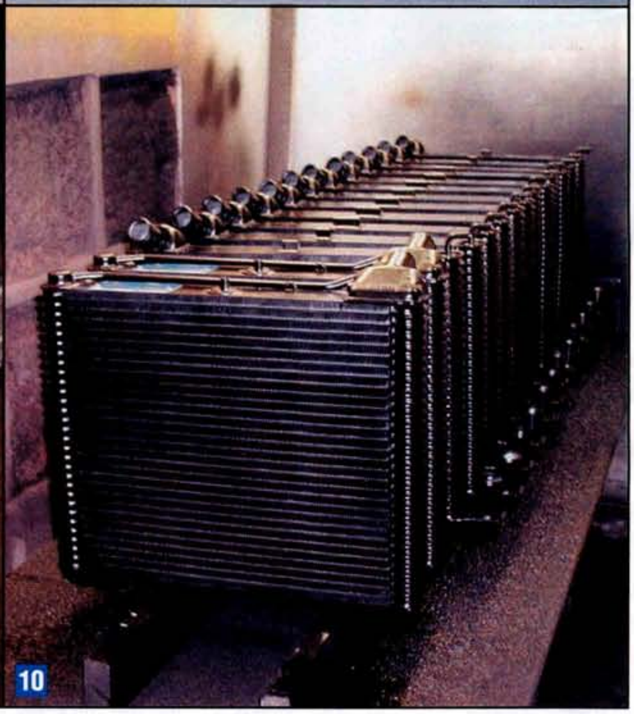
The heat from the coolant is transferred from the walls of the "tube" to the fins, and from the fins to the air passing through the radiator; the plate-type radiator typically can reject 30 percent more heat than a comparably-sized copper/brass radiator. Two different sizes of plate elements are used – one for the small-block applications and another that's two-inches wider for the big-block usages.

RADIATOR ASSEMBLY: Once each plate element is assembled and crimped with its upper and lower plates and finned insert, thirty elements are stacked in an assembly fixture, with a temporary stainless steel support frame at the top and bottom. With the elements stacked in the fixture, the wheel at the top is turned to compress the entire package to the correct overall height, ensuring full contact between the outer edges and internal standoffs of all 58 horizontal joints in the stack.

With the stack height established and held, the "stack" and the top and bottom support frames are steel-banded together as one piece, ready for brazing. Contrary to conventional wisdom, aluminum radiators aren't "soldered" together – that process is only used for conventional copper/brass radiators. Aluminum radiators are "brazed" after mechanical assembly.

The aluminum used for the plates is actually three thicknesses of material; the base is aluminum, with a cladding about .003"-.005" thick on both sides; that cladding is a brazing alloy, which melts at a lower temperature than the base aluminum, forming a metallurgical bond to the adjacent plates and fin material when it cools. The base alloy provides structural integrity for





7 The completed steel-banded radiator, ready for the oxygen-free Controlled-Atmosphere Brazing furnace. (Photo: DeWitts)

8 Plate cores fresh from the brazing operation on the left, finished plate radiators ready for packaging and shipment on the right. (Photo: DeWitts)

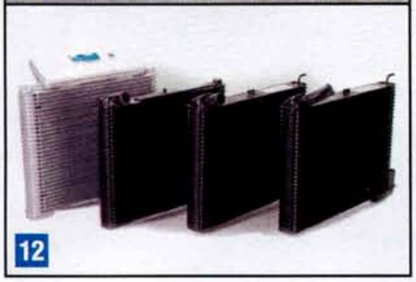
9 If the customer has specified a dated radiator, this tool is used to apply the date required just below the radiator part number.

10 A fresh batch of plate radiators in the paint booth; they're available painted or natural aluminum, depending on the customer's needs. (Photo: DeWitts)

the assembly, while the lower melting point cladding melts to form the brazed joints.

THE MOLTEN SALTS PROCESS: The brazing process used by Harrison Division in the '60s involved heating the radiator assembly to around 1100° F, then dipping it in molten salts which were at 1150° F, removing it from the molten salts, draining, cooling, and flushing out the residual salts from the radiator. When the radiator subsequently went into a new Corvette and was filled with fresh coolant, most of the remaining salt residue in the radiator was dissolved in the coolant, and with good cooling system maintenance, the radiator generally lived a long and happy life.

Such was not necessarily the case for service plate radiators which could sit for years in a box before being used; any remaining salts residue not removed in the post-brazing flushing process



11 The same plate core is used for all four 1960-'62 applications, with unique inlet casting and top-tank configurations to create each one.

12 The full line of Restoration plate radiator configurations, covering all 1960-1972 applications. (Photo: DeWitts)

continued to eat away at the radiator from the inside, and many of those 10- to 20-year old "NOS" radiators leaked like a sieve when they were finally installed in a car, and they can't be repaired.

GM discontinued all plate-type radiators in 1984, with list prices as high as $855. Buying an "NOS" Harrison plate radiator isn't a good idea; they were discontinued in 1984, so any "NOS" radiator has been sitting in a box for at least 22 years with some level of salts residue in it, and it would likely have a service part date code.

These days, the premium process for brazing aluminum radiators, used by DeWitts, is non-corrosive Controlled-Atmosphere Brazing. In this flux-brazing process, the mechanically assembled radiator is heated in a special furnace whose nitrogen atmosphere is essentially free of oxygen (less than 100 parts per million of oxygen), to a temperature slightly above 1100° F, just a few degrees below the melting point of the base aluminum, but above the melting point of the cladding alloy. The cladding alloy melts, forming the metallurgical bond between the aluminum elements

13 The 1955-1960 aluminum Direct-Fit radiator with a Spal electric fan and aluminum shroud with pressure-relief flaps for additional highway-speed ram airflow.

14 The 1966-1968 big-block aluminum Direct-Fit radiator with stamped end tanks, corner hood relief depression, and the original "dent" in the outlet for stabilizer bar clearance.

15 Part of the Direct-Fit aluminum radiator line; the total range covers all Corvette applications from 1955-2006. (Photo: DeWitts)

16 The two deep-drawn halves of the expansion tank, stamped in the original Harrison progressive dies; four configurations cover all applications from 1961-1972.

17 Expansion tanks are available dated or undated based on customer requirements; this fixture permits dating a fully assembled tank.

when it cools; a flux used in the process dissolves the oxide layer on the aluminum surfaces and prevents further oxidation and remains on the surface as a thin film.

After cooling and annealing to relieve stresses, the steel bands and temporary upper and lower stainless steel support frames are removed, and the radiator is ready for assembly of inlets and outlets, leak-testing, and whatever level of final detailing, dating, and painting the customer has specified.

WHAT STARTED THIS PROJECT: Reproducing this unique high-performance radiator obviously took a great deal of research and a major expenditure for dies, tooling, and facilities. In 1985, Tom DeWitt was in the process of restoring his '63 Corvette to NCRS standards and couldn't locate a replacement for the original radiator after they were discontinued by GM. He decided to try and reproduce it, as it was obvious that there would be a continuing market for the product.

Tom worked with Harrison Radiator Division to get the product and process information he needed, and went through numerous suppliers from Venezuela to Canada trying to find one that could successfully produce the parts and braze aluminum. Finally, he moved the tooling to the U.S., refined it, and located suppliers with the facilities required for the precise Controlled-Atmosphere Brazing process required by the design.

DeWitt's entire line of Restoration plate radiators are licensed GM Restoration parts, and are reproduced to appear 100 percent original in every detail to the originals, with improved cooling performance due to advances in materials and a more modern brazing process.

THE DIRECT-FIT RADIATOR LINE: In recent years, DeWitts has expanded their line to include high-performance aluminum radiators for 1955-2006 Corvettes, engineered to be an exact fit without any modifications to the original mountings or hose connections.

These competitively priced radiators have cores with a double row of extra-wide tubes, special louvered fin material, press-formed end tanks, and all are Controlled-Atmosphere Brazed like their plate radiators to provide high-quality leak-free cores without the use of any epoxy. The Direct-Fit line covers virtually every Corvette application since 1955, with many options for shrouds, electric fans, and controls to suit any usage. Although most people only associate the DeWitts name with the Restoration plate radiators, over 75 percent of their total volume comes from the Direct-Fit line, which covers a much wider range of potential applications.

EXPANSION TANKS: The Restoration plate radiators don't have end tanks, so each one requires a companion expansion/supply tank. DeWitts has the original tooling from Harrison Division and produces four different configurations of tanks that cover all applications from 1961-1972.

The deep-drawn tank halves are stamped in progressive dies, the fittings and filler neck are either welded from the inside or heliarc welded from the outside, depending on the application, the halves are fused together, and the tanks are available either dated or undated. As with the Restoration plate radiators, the tanks are reproduced to appear 100 percent correct in every detail.

SUMMARY: After GM discontinued the Harrison stacked-plate aluminum radiator in 1984, there was great concern in the Corvette restoration community that the plate radiator was gone forever, which gave rise to a number of "look-alike" drop-in copper/brass replacements with 30 percent less cooling capacity than the original. These radiators were inadequate, and "overheating" Corvettes became common, especially with air conditioning or big-block applications.

When you consider that the DeWitts Restoration plate radiators are priced the same or lower today than the originals were when GM discontinued them 22 years ago, that's a bargain! Add to that, the expanding line of Direct-Fit high-performance aluminum radiators and the strong reputation DeWitts has earned and we've all got a winner, no matter what Corvette we own. ■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