Fleetline CAST IRON AXLE Restoration

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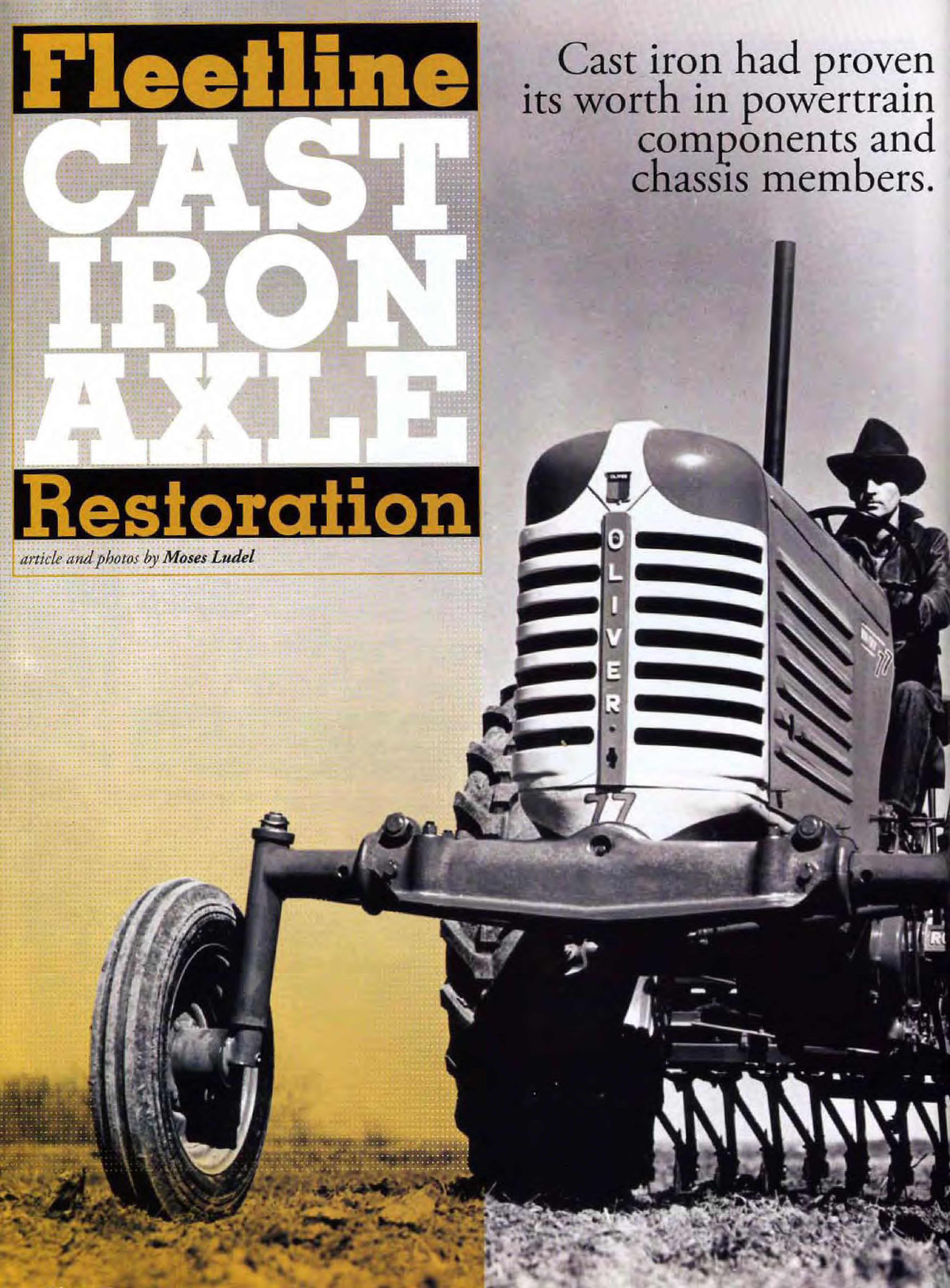


The postwar '77' and '88' models showed great promise, and a popular option was the row crop axle with adjustable track width. The design involved steering knuckle supports that slid into a cast iron center section. Alignment holes in the tubes and a pair of lock pins allow widening or narrowing the wheel track width to serve various crops.

Setting the track width begins with unloading weight from the front wheels. The axle tube pins stay in place with cotter or hitch pins. Each side has a U-bolt and nuts that clamp the tube to the cast iron center member. The operator removes the pins, positions the knuckle support tubes in the desired location, reinstalls the pins and secures the U-bolts.

Cast iron had proven its worth in powertrain components and chassis members. Considering the casting's mass, the row crop axle gave every appearance of strength and stamina. In actual service, however, a pattern of fatigue and cracks soon emerged. By mid-1950, the 77 and 88 models abandoned use of the cast iron center section. Oliver upgraded the front axle to a tubular steel member with welded flanges.

Analyzing a Cast Iron Axle Failure

The popularity of postwar 77 and 88 models calls for a closer look at the row crop axle. Most of these row crop castings failed in service, and our project specimen proved no exception. Years ago, the iron center section had been repaired by brazing technique. This created an opportunity to examine a vintage axle repair and the cause.

Rust and scale obscured the repair work. The first step was thorough sandblasting of the casting. Remove the stay bar and bumper cushions. Protect the bronze pivot bushing from abrasive. After blasting, grind and flush away all traces of silica before welding or brazing. The alternative use of steel or carbide abrasive will eliminate risk of silica contamination.

Stripped to a bare casting, the cracks and old brazing repair stood out. Apparently, Oliver had chosen cast iron for its cost vantages. Once cast, there were few extra steps: finishing of knuckle tube bores, drilling holes for U-bolts and lock pins and boring the stay bar mount holes. This required far less labor than welding sleeves and flanges on a tubular axle.

Oliver engineers had strived for strength through sheer mass; the bare casting tips the scale at 150 pounds! Non-ductile iron has nominal "give," and the obvious goal was to make this axle rigid. Gray iron, common and popular at the time, could be readily cast. Postwar America had plenty of foundries, and the row crop axle was not complex. The slag and casting flaws confirm that a large number of these axles came out of the molds.

The Fleetline axle's fatigue points are obvious. U-bolt clamps at the inner end of the knuckle support tubes became the high stress point for axle loads. Wider wheel track settings increase these stress loads. Jarring up and down in service cracked the casting.

Iron in Various Forms

Iron comes in a variety of types, each used for different applications. Some irons, like the nodular types known for their high strength and elasticity, work well for crankshafts or an axle's differential housing. Ductile or nodular iron yields considerably before reaching the breaking point. "60-40-18" ductile iron with magnesium alloy has a minimum tensile strength of 60,000 psi, minimum yield strength of 40,000 psi and 18% elongation per two inches.

By contrast, the gray iron in the Oliver axle has virtually no elongation (1%), low fatigue strength (likely 20,000 psi) and less tensile strength than a typical ductile iron. The strong points of gray iron are its high compressive yield strength, exceptionally low deformation under load and reasonably high shear strength. Gray iron handles uniform heat cycling in components like exhaust manifolds.

Commercial gray iron is also easy to machine. This saves labor time and stretches the lifespan of tools like milling machines, boring bars and drills. Casting can be done at a mass level, making gray iron attractive for production items like the early Fleetline axle. Gray iron makes good engine blocks, where cylinders and block webs must keep their shape under heat and loads. Frozen, expanded water, however, can readily crack a rigid, gray iron engine block.

Cast Iron Repair Choices

Cast iron repairs can be challenging. Gray cast iron is non-ductile and high in carbon. Heat expansion and contraction can wreak havoc with this kind of cast iron. Heating up a confined section of gray cast iron, like a smaller area of an engine block, is often disastrous. Without an avenue for expansion, the heated cast iron thickens or warps. The surrounding, cooler iron remains rigid. As this hot section cools in its distorted shape, the shrinkage pulls surrounding iron inward, cracking the casting. This can also occur when welding or brazing iron.

To overcome this issue, some shops heat an entire casting within a furnace. Welding the damaged area takes place at high temperatures, often within the furnace. This is a multi-step repair and costly. Large, irregularly shaped castings like engine blocks are generally not candidates for furnace welding. A sensible engine block repair would be a cold method like Lock-N-Stitch® (see www.locknstitch.com). This involves drilling and the use of plugs. LNS developed a successful cold repair kit for common 1999-2001 Cummins '53' block casting cracks.

While the graphite in gray iron takes a distinct, flaky form, ductile iron forms spheroidal (ball-shaped) graphite. Nodular or ductile iron is frequently welded or brazed. Damaged crankshaft journals, nodular housings and other applications respond well to welding. Ductile irons expand and contract more like mild and alloy steels. You will find welded and brazed nodular iron in automotive, machine tool and agricultural equipment.

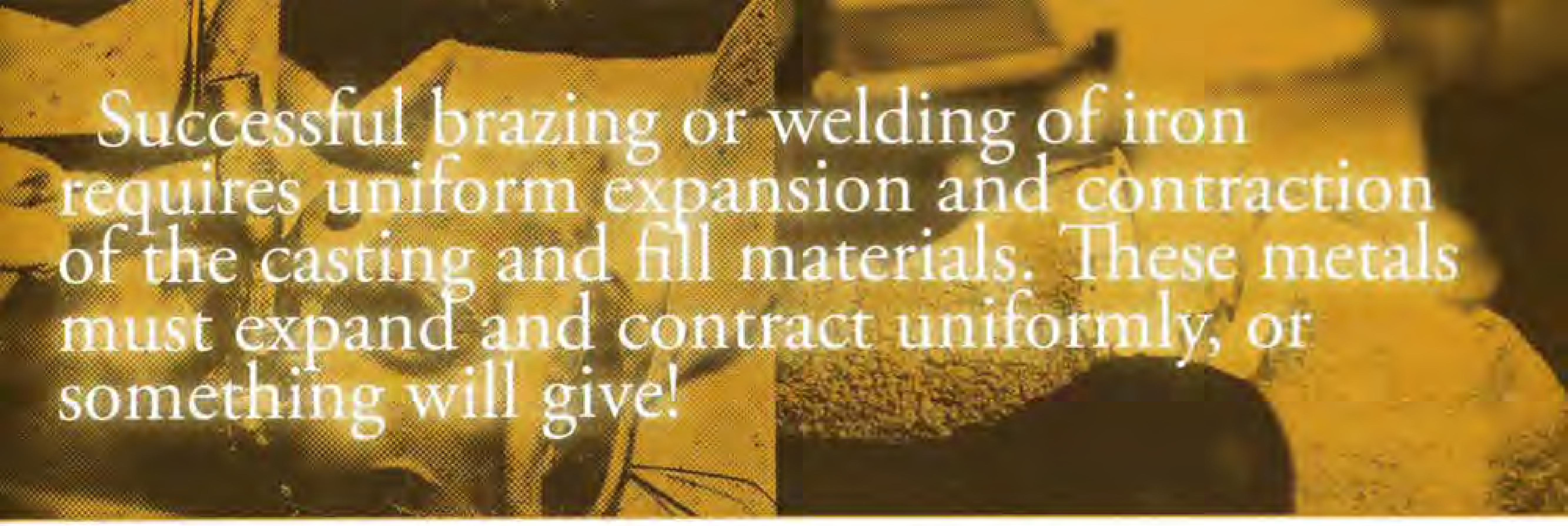
Successful brazing or welding of iron requires uniform expansion and contraction of the casting and fill materials. These metals must expand and contract uniformly, or something *will* give! The cooling rate is a factor as well. Iron must cool slowly, in a controlled, uniform way. Most of us know that an overheated engine, filled too quickly with cold water, is a classic cylinder block or head buster. The cause is rapid cooling—and shrinkage—in one area of the casting. The rest of the block is still ultra hot in an expansion state. By contrast, that same gray iron block can tolerate a half-century or more of *uniform* heat-up and cooling cycles.

A time-honored method for repairing cast iron is brazing. Brazing rods melt at much lower temperatures than fusion welding. This is useful for cast iron repairs, *since the number one risk when heating and cooling cast iron is cracking.*

Items like exhaust manifolds are not candidates for brass repairs. When a manifold reaches 500-degrees F, brass loses enough strength to become unstable. Although expensive, silver brazing rod can produce ductile, high tensile, heat resistant results. With careful cleaning and prepping of the casting, bronze and high-tensile silver brazing rod produces quality iron repairs.

Modern low-fuming bronze is also available in higher tensile strengths. These ductile brazing materials will "give," where gray cast iron cannot. A popular rod like Radnor® low-fuming bronze, found at most farm equipment supplies and Airgas outlets, has 50,000-psi tensile strength—stronger than the gray cast iron found in the Oliver axle casting.

Given the strength, ductility and 1,350-1,600-degree F wetting and melting points for flux-coated bronze, brazing seems fast and practical. (Silver alloy brazing rod provides more strength with even lower melting temperatures.) Brazing is ideal for bonding lapped,



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thinly spaced metals. Fluxing and capillary action create great strength in close-fit parts like tubing joints. Fillet brazing can join metal plates at angles.

For joining plate metals end-to-end (butt), brazing is not advisable. Brazing is no stronger than its tensile and bond with the metal faces. Chamfers and "V" grooves increase these contact surfaces. Another issue with brazing is whether the color matches the base metal. In the weather, bronze or brass will tarnish, as evident with the project axle. Chemical exposure can corrode bronze. This is not as important with the painted Oliver axle casting.

Brazing is never stronger than the mating zone with the base metal. The process occurs below the melting point of iron or steel base metals, so fusion does not take place. When the base metal is hot enough, molten non-ferrous brass or bronze "wets" the base metal, much like soldering. Liquefied flux and molten filler rod diffuse across the heated base metal surface. Acting as a cleansing agent and shield against oxide formation, flux does not mix with the metals. The braze filler and base metal form alloys and bond metallurgically at this stage.

The lower temperatures of brazing help prevent brittleness in the heated zone. Typical bronze rod contains copper, zinc, silver, manganese, silicon, tin, iron and aluminum. Such a ductile mix will not shrink excessively as it cools. This reduces the risk of cracking in the heat-affected zone (HAZ). Filler material for cast iron fusion welding must also minimize shrinkage and cracking risks as the metal cools.

In recent years, powder or spray welding has gained popularity and needs mention. Since the powders are made up of ferrous materials like iron and nickel, the process has a unique outcome. Like brazing, the iron casting does not reach melting temperature. Although this is not fusion welding, the spray weld powders are similar to the base metal. The metallurgical bond is more like a weld than with non-ferrous brazing.

Powder spray welding uses a special oxygen-acetylene torch with a trigger operated powder hopper. The technique involves careful cleaning, flux in the powder and "wetting" of the base metal for proper bonding. At the right point, the operator drops powder into the torch stream. The powder melts and flows in thin layers onto the repair area. Correct timing and flow reduce risk of porosity and assure strength. High tensile powder alloys are available, and this technique has a following in the cylinder head restoration field.

CRACKING: The Scourge of Cast Iron Welding

The biggest concern with gray cast iron repairs is cracking. Without uniform expansion and contraction of the casting and filler material, cracks can develop. Furnace welding helps eliminate thermal shock when repairing iron. The entire casting heats to 1000-1500 degrees F. Once heat distributes uniformly and de-stresses the piece, welding can take place. After welding, the entire piece cools slowly within the furnace, typically at a controlled rate of 100-200 degrees F per hour.

A gray iron engine block with cooling jackets and irregular thicknesses would have difficulty expanding uniformly and thoroughly. For that reason, furnace welding is not as popular for blocks as iron cylinder heads.

Many cast repairs benefit from stress relieving. Here, the casting and weld have survived the weld process without cracks. An additional, controlled cycle of heating and slow cooling can stabilize the molecular structure within the casting and weld. Cooling rate is

critically important with cast iron. Rapid cooling can turn non-ductile iron into carbide-tough, highly brittle material. Especially when machining follows, localized hardening should be avoided on iron casting repairs.

The Cast Iron Axle Repair

Cast iron repairs can be challenging. If a casting is rare and part of a valuable restoration—like a Fleetline 77 or 88 model's row crop axle—scarcity of replacement pieces plays a decisive role. It would be difficult to find another axle casting without similar cracks. Restoration becomes a viable choice.

The project axle had two original cracks. Deep "V" grooves had been ground into the thick casting, yet crack remnants were still visible. The brazed area spanned a critical stress point in the casting. If the Oliver were a trailer queen or museum piece, grinding down and shaping the unsightly overlay of brass might provide a cosmetic fix. However, the patched casting would be even weaker and prone to breaking. Given the location of the cracks and previous repair, fusion welding would be the repair of choice.

Hours of furnace welding would be very costly. MIG (wire feed) welding with short stringer beads might work, although the heat affected zone (HAZ) and cracking risk would be greater than with TIG welding. Stick electrode welding provides self-cleaning flux and shielding but also requires chipping and grinding of slag. This would be a daunting approach, much like pipeline welding.

Stick welding drives a lot of heat into the casting. The process involves preheating the casting, reheating the weld area between passes and making multiple rows of beads. Chipping and grinding out slag between passes takes considerable time. In both stick and MIG welding, weld gaps, inclusions, porosity and contamination become an issue. For stick electrode welding (SMAW), remove all slag and burnt carbon to prevent inclusions. Cracking on cool down is an ongoing concern with any cast iron repair. Wrap the entire piece in a heat shield blanket to slow cooling.

An alternative approach is the use of select fill materials from the tool-and-die industry. Weld Mold Company (www.weldmold.com) offers niche filler materials designed for the field repair of cast iron and alloy steel. These filler rods, electrodes and wires require nothing more than local heating of the casting between weld passes. Depending upon the type of iron and weld involved, some welds are possible without any preheat.

Products like high strength Weld Mold 750 have a high carbon content that forms graphite in the weld. This reduces shrinkage stress and minimizes risk of cracks in the heat-affected zone (HAZ). Rapid peening of each newly laid bead is a crucial part of the cast welding process. This spreads the graphite. Skip welds with stringer beads help heat dissipate evenly into the casting.

The two products selected for this project were Weld Mold 700 (pure nickel) and Weld Mold 750, available in stick electrode, wire and filler rod forms. Weld Mold 700 has a tensile strength approaching 50,000 psi, well in excess of the gray iron Fleetline axle. The 750 rod, designed to join castings, fill holes and build up damaged areas in larger castings, housings, gear cases and sprockets, reaches 75,000 psi tensile as welded.

While most agriculture repairs involve stick electrode welding or wire-feed MIG, tungsten inert gas welding (TIG or GTAW) process has distinct advantages. TIG welding done with the right voltage settings can thoroughly penetrate the base metal or previous weld passes while minimizing the heat-affected zone. TIG also has the distinct advantage of not undercutting at the bead edges. This leaves passes uniform and easy to weld over.

A narrower heat affected zone means less heat pours into the casting. An iron casting of this size dissipates heat readily, and the weld area cools faster. Careful heat input and moderate bead lengths minimize risk of thermal shock and embrittlement.

Use an oxy-acetylene rosebud torch to heat the immediate area. Check surface temperature before starting the first weld and between each weld pass. With multiple rows of beads, controlled heat input and peening will help prevent cracking.

TIG technique takes time and consumes material. Proper restoration and upgrading of a rare, failure prone casting can justify the cost.

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STEP -by- STEP instructions

Follow these illustrated steps, and consider the TIG process for your cast iron restoration projects.

Postwar Fleetline '77' and '88' row crop models featured a cast iron axle. Large numbers of these castings failed in service. Two cracks, repaired years ago with bronze brazing, remained in the casting. This rare axle housing justifies a TIG welding repair. Labor-intensive TIG process provides a quality, lasting fix.

Massive casting is gray iron. Gray iron has high compression strength but low yield strength, nominal ductility and limited tensile strength. Oliver engineers relied upon mass to achieve strength. An option on row crop models with adjustable track width, gray iron housings could not withstand the stresses of hard work in the field.

By mid-1950, a tubular axle replaced the iron castings on '77' and '88' row tractors. Streamlined and lighter, the tube replaced a 150-pound cast iron piece. Pins, U-bolts and adjustable track knuckle tubes carry forth from the iron axle. Weld-on brackets and flanges added production labor to this tubular axle.

A period repair for the iron casting was bronze brazing. Wide weaves lap across deep V-grooves. Cast iron cracks should be ground to the root. On this old repair, the groove cuts were filled with bronze. Brazing takes place at much lower temperatures than fusion welding. The base metal (casting) does not melt in the process.

This is the caliber of the original casting. Gray iron is a commercial grade iron that typically has 1.7-4.5% carbon content, high for metals. Casting slag and blemishes like this one indicate mass production. These castings fit '77' models to mid-1950 serial #332450 and '88' models through #128657. An epidemic of fatigue cracks doomed the iron axle.

First cut with the disc grinder reveals the depth and width of the original repair. The brazing job had no inclusions, pores or voids in the layers of braze. If not properly cooled, the heat required to flow this much bronze could stress and harden iron. The remaining crack, visible at the base of the "V," would continue to spread.

Ductile bronze helps prevent shrinkage cracking in the heat-affected zone (HAZ) of the casting. There were a few pounds of brass in these grooves. Before attempting a weld repair, you must grind out all traces of bronze. Grind the surface slightly to remove iron saturated with carbon from the brazing heat.

Grind a V- or U-groove in line with the cracks. A die grinder with round-nosed burr tool works fast in cast iron. Drill a hole at the end of the crack *(top)* to stop the crack from spreading. The original crack forked. The two drilled holes mark the ends. Begin welding at the holes to contain that stress point and prevent the crack from spreading.

Grind through the root or, preferably, leave just enough original metal to bridge the gap. You will burn through that thin metal with the first weld passes. A faint remnant of the original crack is visible in the root. Steel plate will bolster the backside of the casting and bridge the gap to ease the first weld passes.

The V-groove is deep, round at the bottom. With TIG welding, the shield gas must engulf the weld. A "gas lens" extends the 1/16" tungsten electrode from the nozzle tip. The lens and narrow nozzle help channel gas into a dense column. This works well here. First pass will burn through the original casting and eliminate any remnant of the crack.

Rosebud torch heats the weld area to 500-degrees F before each pass, lowering risk of thermal shock and shrinkage cracking. After each pass, hammer peen the weld with firm, rapid blows. An infrared gun spot checks surface temperatures of the casting and weld area. TIG penetrates with a minimized heat-affected zone (HAZ).

Initial passes weld the mild steel backer strip to the root of the "V." Controlled TIG heat in each stringer bead penetrates the casting or previous weld pass. Multiple passes build material from the V-root to just above the original casting height. Weld content, penetration and overlapping passes create more strength than the original casting material.

Peening is an important part of the process. As the weld pass ends, pick up the hammer and begin rapping rapidly on the hot weld. Steady, moderate blows along the weld line help graphite form uniformly throughout the weld. High carbon content of Weld Mold 750 filler rod promotes graphite formation to prevent shrinkage stress and HAZ cracking.

Note gradual buildup of beads, one row at a time. TIG provides outstanding fusion without undercutting at the bead edges. Fusion at the casting edges is complete and strong. Weld Mold 750 is 75,000-psi tensile as welded. This dilutes with the gray iron, making the fusion zone much stronger than the original casting material.

Curving beads overlap and penetrate the previous passes. The goal is to create a solid, metallurgically sound weld mass. Finished welds create a new section in the casting. Welding fully restores the casting, creating higher strength at fusion zones and reinforcing an otherwise weak area of the axle.

For added strength, beads build above the original casting. This restoration upgrades a weak design. 3/32" non-thoriated (tri-mix) electrodes and 1/16" diameter Weld Mold 750 rod fill the large void. Carefully placed skip welds dissipate heat evenly. Areas with concentrated carbon benefit from Weld Mold 700 (pure nickel) rod.

TIG welding leaves no undercut at the bead edges. Overlapping beads and excellent penetration of previous passes make TIG a sure method for creating new sections of metal. Gas shielding is crucial for clean, uncontaminated welds on high-carbon iron. Each bead must be properly formed and protected from oxidation.

Although cast iron repairs always require care, TIG does the best job of all welding processes. Note how welds fuse with the casting. There is no undercut or burn back of the original iron. The foremost benefit of welding over brazing is complete fusion of metal along the margins with the base metal.

Iron dissipates heat in all directions. Slow cooling helps the piece stabilize. Wrapped in a non-asbestos welding blanket, this casting takes 9-10 hours to cool down completely. Welding took place over three days, with cooling after each welding session. This produced a crack-free, strong axle.

The original axle design lacks support where the knuckle tube fits into the housing. A solution is this steel strap, shaped to the contour of the axle's housing bore. Weld Mold 750 rod easily joins the steel strap to the iron casting. Carbon in the rod and metals leaves a trace around the weld. Clean carbon away with a stainless wire brush.

The gap between the strap and bore step fills with weld. Strap doubles as a backer for the root pass on the opposite side. U-bolts create a stress zone on these axles. Without additional support like the strap, the inner end of the knuckle tube can rock upward and flex the rigid iron casting. Cracks develop near the U-bolt.

Tungsten inert gas (TIG) welding does not require flux. Filler rods, electrodes, the casting and weld passes must be thoroughly clean for TIG to work. Use a lint-free rag and denatured alcohol or acetone to wipe away oil, grease, carbon and other surface contaminants. Sand blasting silica must be completely removed before welding.

Peen after each weld pass. Brush away carbon with a stainless steel brush to prevent inclusions and other contaminants in the welds. Shielding gas is crucial for smooth, non-porous welds. Pure argon with a flow setting of 15-18 cubic feet per hour consumed 230 cu. ft. of gas during the repair—the rosebud torch used up oxygen and acetylene.

Beads continue to build. In addition to repairing cracks, the project compensates for the earlier brazing job. The U-bolt seat must be built up with welding beads to restore height and strength. Clean away casting and weld carbon with a stainless wire brush. Over three pounds of specialty welding rod went into this repair.

At the reinforcement strap, a simple cut-off wheel levels the weld material and dresses the strap. A feeler gauge and straight edge help align the strap with the original knuckle tube bore in the casting. This upgrade adds thickness to the casting section and additional support for the inner end of the knuckle tube.

Welding is now complete. Disc grinding begins. The weld buildup provides extra strength. This upgrade enhances the stamina of the axle. Removing too much material would create the same weaknesses as the original design. Contours must blend the new weld section with the original casting.

Like time under the welding hood, grinding and finishing take awhile. Measure the U-bolt nut seats and match them side-to-side. The repaired U-bolt hole will be sized and reamed to match the other holes. This effort is worthwhile on a rare axle casting. Restoring vintage tractors often requires this level of attention.

Texturing can be achieved with a simple drum sander and drill motor. When the original casting is course and full of pores, a fresh repair section stands out. Creative contouring knocks down that polished look and blends the new section and old casting. Despite the many bead layers, the repaired section has no voids, carbon inclusions or porosity.

Disc grinding, sanding discs and abrasive pads on a 3M arbor help shape the repair area. This in-depth restoration used more materials than the braze repair. The result is a stronger, improved axle casting. Since there are no "NOS" axles around, and a used Fleetline axle is likely to have cracks, the effort is worthwhile.

This is the foot of the repair. High tensile Weld Mold filler material is indistinguishable from the surrounding casting. There are no signs of stress in the iron. The hidden steel backer strip provides support. Curves and ledges match the original axle casting. The goal is a stronger section that resembles the shapes of the original casting.

At 75,000-psi tensile strength, the new weld section increases the axle's stamina. Blends and contours mask the additional weld material and achieve the right "look." Abrasive finishing enhances the axle. The increased thickness around the U-bolt hole reinforces a weak area in the original casting.

PPG's Omni epoxy primer and catalyst work well on freshly prepped bare metals. MP172 is a black primer that has high durability and sets up hard with MP175 catalyst. Reducer or acetone can be added, up to 10% by volume. These materials require a fresh air mask system or respirator for VOCs. A color coat of acrylic enamel can follow.

Heavy coats of epoxy primer enable wet block sanding of the repair area. Epoxy fills and seals. Wearing a respirator, you can filter and mix paint and catalyst at 2:1 ratio. Add 10% compatible reducer if the ambient temperature is high or you like a wetter paint flow. Allow drying (18-24 hours) before sanding between coats.

Graco's Finex HVLP spray gun is gravity feed, providing easy paint application without excessive overspray. A smaller compressor works fine with high volume, low-pressure (HVLP) guns. Paint flows nicely, with controlled volume. Better adhesion and the ability to create a durable seal make commercial primer and spray equipment valuable.

The epoxy primer helps smooth contours. Blended surfaces look "original," the goal with restoration work. Actually, this repair has increased the thickness of the casting and reinforced vulnerable areas. Considering the time and labor for this kind of restoration and upgrade work, the tractor must have value.

Hidden from view are the steel back plates. The U-bolt hole at the weld section has been reamed to match the opposite side. U-bolts must fit readily through the holes and secure the knuckle support tube against the casting and reinforcement plate. The plate relieves stress in the U-bolt area.

The axle can now be painted and returned to service or show. Before painting, the primer should be scuffed very lightly with 500-grit wet sandpaper. Once painted and installed, this axle casting will appear stock and provide reliable performance. Vintage Oliver '77' and '88' row model tractors can benefit from these upgrades.