Mine Resistant Tracks

Tracks that just roll over exploding mines?

Vietnam-era research proved it could be done

by Ralph Zumbro

Tank losses to mines in Vietnam spurred research on mine-resistant tracks. Above, troops repair a track on an M48 that struck a mine near Chu Lai in August, 1967.

The rocket-scarred tank, which with most of its crew, was a veteran of Operation Desert Storm, prowled through a battered, dreary, almost deserted Bosnia town as cautiously as an alley cat. The big landship was never meant for city combat, and she'd already lost a running mate to a new threat. The narrow Balkan streets were alive with fanatic, deadly tank hunting teams. Magnetic limpet mines, satchel charges, and Molotov cocktails were back in the tanker's vocabulary.

Slowly, all sensors at max, turbine whining softly, tracks thudding against the patched cobblestones, the big hull shouldered between two buildings... WHAM! A puff of dirty gray smoke belched from under the right track and the tank jerked to a stop as the driver slammed on the brakes to avoid rolling the track off the return rollers. Almost simultaneously, a sleet storm of machine gun fire raked the turret top.

"Goddamn, it Sarge," the driver yelled over the intercom. "The right track's busted...."

"Keep a lookout... Uh oh, we're boarded," the TC replied. The driver heard a twin thud as the TC and loader slammed their hatches shut and a call went out over the microlink. The driver could see dark shapes climbing the hull, carrying something roughly cylindrical. The TC barked on the radio, "Three-three, this is Four, we're boarded. Scratch my back and see if you can break some grunts outta their Bradleys, over... OMYGAWD, we're DEAD."

The tank, immobile and trapped between two buildings, had been boarded by two enemy soldiers carrying a homemade thirty-pound shaped charge that they clamped to the turret top with magnets. The LMG fire from the second story windows had ceased just long enough for the charge to be placed and the two men to leave. Then it started up again... covering yet another pair who slide from an alley with RPGs.

At that range, they couldn't miss, and two rockets slammed into the projectile trap between the turret bustle and the hull, shattering the traverse ring. In a hidden room, safe down the street, their controller pressed the switch of his radio detonator and three concentrated lances of explosive energy met in the center of the fighting compartment.

The platoon sergeant and his crew never had a chance. The explosion cremated them, setting off the rounds that, in defiance of regulation, the loader had resting against his knee. The blast blew the safety bulkhead from the inside, setting off the ammo supply for the main gun, which took the top off the turret and shattered the second stories of neighboring buildings.

As the tank rocked on its tracks from secondary explosions, the rest of the platoon and a pair of Bradleys arrived...but too late. The company commander would be writing more letters that night, because of an antiquated track design that could have been replaced years ago.

The small wars of history have always bred desperate men. Stories of believers wired with explosives came out of Desert Storm. Somalis had swarmed the Marine tanks in Mogadishu. Japanese had charged Shermans with satchel charges in last-ditch stands on their Pacific islands. This sacrificial behavior in the face of certain death is a warrior's trait with a long history. Men inculcated with a belief in Paradise, or a divine Emperor, will die just as willingly as men who die for freedom and love of country, and one of the favorite weapons of desperate men is the land mine. It is available, cheap, and effective. Mines are also very unselective.

While a fragmenting style antipersonnel mine will kill a rifleman, or a little girl hunting for firewood, a simple blast type antitank mine rarely kills the tank's crew. It is what comes after the tank is immobilized that is lethal. Research confirms this. Mines don't usually kill tankers; they just hold them still for the next stage of the ambuscade.[1] Statistics indicate that, in Vietnam, 70% of the mobility kills of tanks were accomplished by mines.[2]

We are letting our tracks be blown off by little 5-lb. charges that couldn't penetrate anyplace else on the tank. It is high time that we hardened the tracks, too. It can be done.

The purpose of an AT mine is threefold. First, of course, it's to stop the tank force from participating in a battle. The opposing commander is not out for kills, he just doesn't want to be bothered by rude strangers with armor-protected cannons. The second and third purposes are to delay the tank so that it is vulnerable to weapons covering the mine obstacle or hunter teams who can swarm the tank when it is stopped. In European wars, mines have traditionally been placed so as to stop the tank in front of an antitank weapon, whether a German 88 or the latest Russian-made ATGW. Or when stopped, the tank can swarmed by men on foot. Robert Swackhamer, a tank repair officer on Iwo Jima in 1944, told me that the main Japanese use of mines was to stop the tank long enough for infantry with grenades or satchel charges to swarm aboard. In some cases, they stayed there long enough for the charges to go off, even if they had to be tamped by human flesh. Nearby Marines made short work of most of the swarmers.

American military forces are now entering on a period of small wars, like it or not, and we are going to have to solve the problem of the track-breaking mine. Fortunately, the task is already half-accomplished.

Antitank mines have an attractive economy: as early as WWII it was calculated that a very small investment in mines could kill a very expensive tank, and with tanks becoming ever more costly, the balance is getting worse.[3] It is now possible for a 5-lb. scatterable mine to break the track of any battle tank. This battlefield equation is unacceptable, but by picking up the threads of some research begun in the early 1970s (and abandoned nine years later), something might be done about it. In 1973, an Army-sponsored program was launched at Martin-Marietta's Orlando, Florida facility to develop a mine-resistant suspension system. Right at the start of the program, the engineering team built what they called the baseline track, using three basic and revolutionary design principles.

First, to end your suspense, they made it work. The baseline track would roll over a 5-lb. charge and keep on moving to the end of its run. That same track would also take a 25-lb. AT mine and retain at least enough tractive integrity to allow the driver to back out of the minefield and get behind some kind of defilade. That is historical fact and the research reports are available from Defense Technical Information Center (DTIC). Their document numbers are listed at the end of this article.

The men who designed this miracle track, however, were not experienced tankers and were after only one thing, track survival after mine explosions. The track they created would resist mines, but not high endurance, cross-country abuse. They had not been told that we also use the tracks to break things like stone walls. Also, due to financial problems, they were not able to complete the series of tests. Their designs and principles, though, are still valid, and we can pick up where they left off in 1982 when their funding died out.

The design team started with one basic assumption, that of jujitsu. Don't stand flat in the face of a punch; let it slide by you. Reasoning that the solid structure of the conventional tread soaks up all of the explosive force, with no give at all, until its breaking point is reached, they developed their three principles, creating two sacrificial track components — and one unbreakable one.

First, instead of a solid cast track link body, they would create a frangible pad which, rather than soaking up the blow, would sacrifice most of its mass going up and away. This required the use of some quite sophisticated plastics, and in their day, the plastics industry was nowhere nearly as advanced as it is today. The science of engineered materials also, was in its infancy, nor had advanced ceramics been fully developed.

Second, they engineered a fiberglass roadwheel which had circular epoxy-resin rings between the hub and the rim. The purpose of those rings was to flex and absorb some of the punishing blast which normally deforms or destroys a steel roadwheel. That worked from square one. Not one of those wheels ever completely failed an explosive test. The problem that they had was one of overheating on endurance runs and flexion tests. Also, it was then known that blast is trapped between conventional twinned roadwheels (this writer has seen one pair go ¼ mile from point of detonation). That fact is what caused them to use the single roadwheel.

Third, and most important, they created an almost unbreakable chain of tractive effort which, protected by the sacrificial track pads, would hold together through the explosion and allow the tank to either proceed with its mission or at least to back out of there to effect repairs. As Figure 1 shows, the design was, to say the least, unconventional.

You will note that the four strong steel links are the only steel parts of this experimental tread. They were designed as male-female links and could easily have been manufactured in a division ordnance shop. One of the most important concepts of this design is that they completely eliminated the full-width pin, replacing it with four large bolts. The reason for this is that, if the pin is broken, the whole track is broken. If the pin is bent, that joint won't hinge, and it breaks anyway. In effect, with four separate chains, the tank can still move. The sacrificial parts were the composition rubber tread and the composite body. There was a fiberglass reinforcement over the shoe, which was a silica filled epoxy, with an epoxy-resin grouser. Obviously, this design wouldn't take too much convoy duty. This, however, was the baseline. The next illustration is that of the fiberglass roadwheel (See Fig. 2).

This design, which would fit the roadwheel hub of an M-60 tank, was originally a single wheel with a V-shaped rim to fit the groove in the experimental track. Throughout their experiments, the developers kept to the single roadwheel concept, thus putting way too much pressure and heat on their load-bearing surfaces. The circular rings, which flexed just enough to absorb blast, were wound by hand, out of fiberglass tape on a rotating mandrel, and finished on a lathe. Again, nothing that couldn't be done in a division level shop. The rim also was hand wound and then the seven rings and the rim were epoxy bonded to the aluminum hub. Next, they sheathed the assembly in Uralite 3121S plastic, thus ensuring that any heat generated by the flexion would be trapped. If you are an experienced track mechanic, you are already getting nervous, but bear with us. This system was almost mine-PROOF and it deserves to be revived.

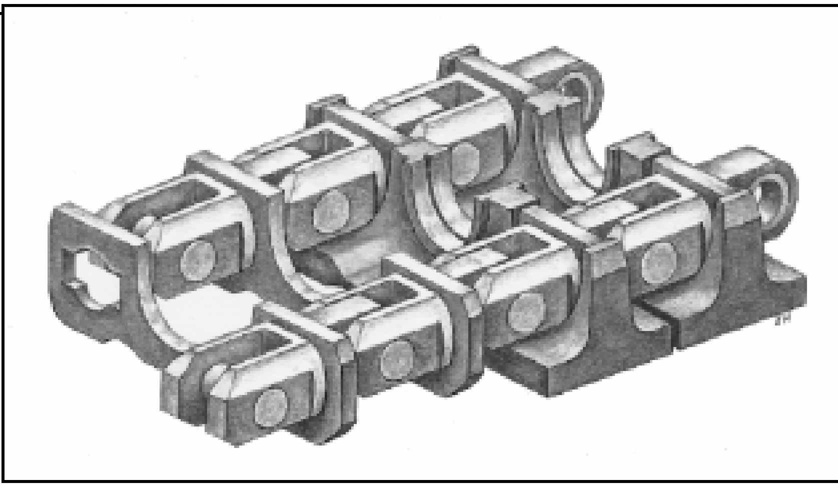

Fig. 1. Open-form track limited mine damage by allowing blast force to pass through the track sections. Even if the track pads were sacrificed, the track remained intact and usable.

You'll note that in Fig. 3, the ends of the male and female links are shown, and they were fastened by standard class 8 1.25" x 6" hexhead bolts. The drive sprocket was replaced by one designed to drive the track on the bolts, as this design totally eliminated end-connectors. They went through several versions of this, finally coming up with a system that might eliminate the dreaded end-connector halt in the middle of a battle. Figure 3 also shows the final cross-section of the roadwheel/track combination with which they went into mobility/blast testing. Notice that they've switched to a semi-circular wheel rim and a matching grooved slot in the track block which was supposed to allow rocking to give cross-country flexion. The two surfaces supporting the tank are now plastic to plastic, in contact. That's just 12 contact areas about the size of a human hand, to take 105,000 lbs. of weight. And that is just standing still. No wonder they had some friction problems.

One thing that should be brought out here is that for much of the testing, they had to manufacture only enough tread sections and roadwheels to test, as they hooked them up first to cement weights, and then, through adaptors, to existing tread on live tanks.

This procedure saved time and money. Lest there be some worry that this design might not be adaptable to the Abrams, rest assured. It was also fitted to the old 125,000 lb. M-103 heavy tank.

Once the research team had a final test configuration designed, they made up a mold for experimental track block materials and started casting. This mold, which could be tooled up by most plastics suppliers, was smooth-surfaced and water-cooled and could take a variety of plastics. Initially, the team started off with glass-filled polycarbonate and experimented through several mixes including Kevlar®-filled epoxy. Eventually, they settled on the glass-polycarbonate mixture and began their tests. As would be expected, there were problems.

The main stumbling point was, and still seems to be, the track block composition. At the end of the test series, four years later, the crew was still fighting the road wear problem. The excessive pad breakout during explosions had been solved by changing from the polycarbonate to a polyester plastic filled with ½" to ¾" glass fibers. A word is due here about polyester resins.

Polyesters are the familiar boat and auto building plastics which, when reinforced with any of dozens of available fibers from glass through Kevlar® to carbon, form many of the products we use in everyday life. If you have ever used Bondo to repair your auto, you have used a polyester filled with industrial talc. The principle is that the plastics take on some of the characteristics of the filler material. The resin can be bought from industrial suppliers in 55-gallon drums and the molds for experimental track blocks can be handmade from polished wooden or metal plugs. This writer has worked for years in the boating industry, and the technology is simple and available.

The problem with the track pads though, was excessive wear. They had effectively solved the breakout problem, reducing the damage to three pads for a 5-lb. scatterable mine and five to seven with a 25-lb. AT mine, leaving the drive chain intact. The balance between the ability to sacrifice to blast and still take extreme road wear was never quite solved, but much better plastics and ceramics are available today. It is perhaps time to resurrect the experiments. As the nightly news shows, the men who build the mines are not exactly sitting on their hands.

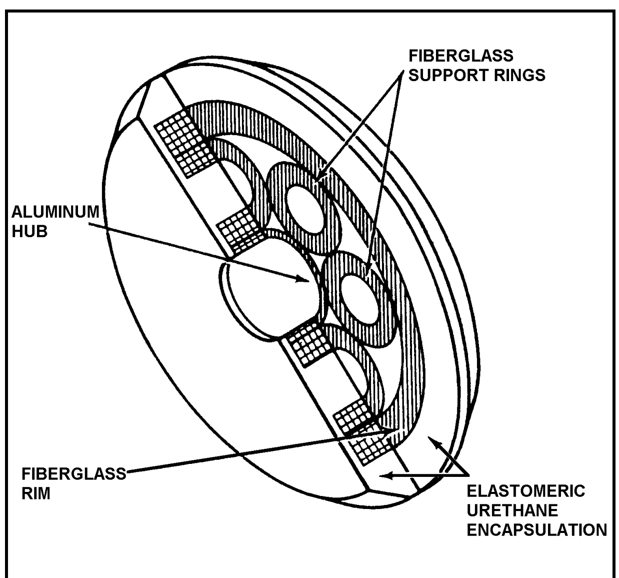

Fig 2. Composite, ring-supported roadwheel configuration.

The roadwheels never seemed to be destroyed, nor did the steel links, even when they went to a two-link instead of a four-link configuration. The chain was almost never disrupted in the static tests, which used only one roadwheel and eight track links. The main damage to the roadwheel seemed to be tearing of the plastic encapsulant. The single roadwheel also effectively vented the explosive force, instead of trapping it like our present configuration.

The only problem which showed up with the links was that, after several tests with the same links, the threads began to shear on the cross-bolts. Thread depth on those standard bolts was only .070" and thread depth and stress weakness starting at the thread groove would prove to be a problem until designed out.

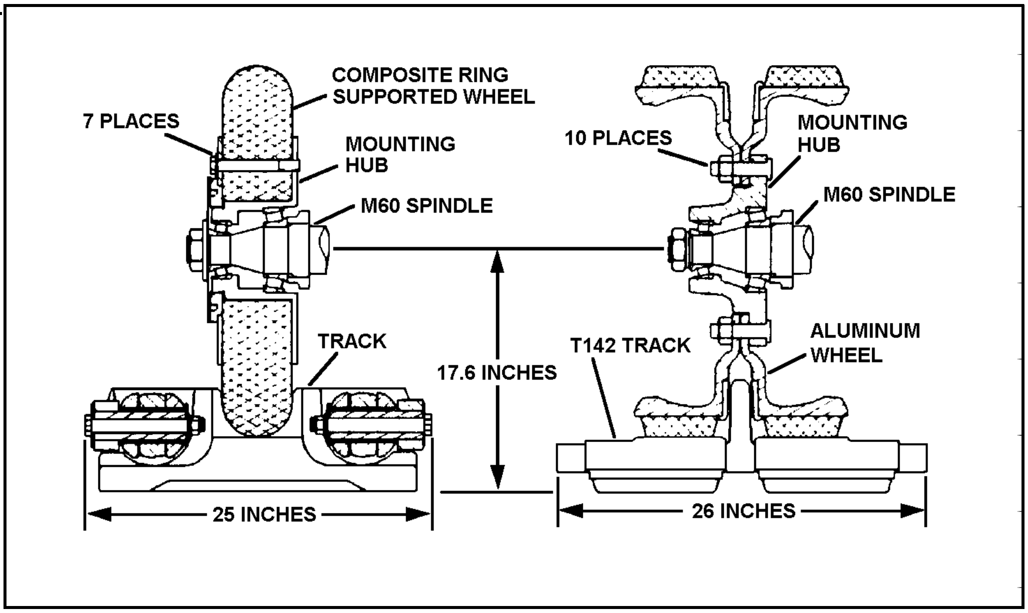

Fig. 3. Blast-resistant track, left, and M60 track are seen in cross-section for comparison.

So, now they had a tread design that would absorb a scatterable mine and keep on tracking, and at least stay together after a 25-lb. charge long enough to clear the area. When the team went to roadability tests though, they failed, partly due to material weakness and partly due to what this writer considers a basic design flaw. There is no way that a single roadwheel will take the weight of a main battle tank and transmit it to a track block with either full mobility or material durability. Even before actual road testing, static flexive tests showed that the wheel encapsulant, Uralite 3121S, would melt right where a tanker would expect: where the radius of the rounded wheel tried to flex in its single groove in that massive track block. A neutral steer on a hillside can put most of the weight of a tank on just the three center roadwheels, and the plastic couldn't take it.

It's probably better to keep our dual wheel, centerguide system, which has proven mobility and reliability, and adapt the Martin-Marietta system to existing equipment. Mr. Rene Gonzalez, of TACOM, recommends a frangible outer wheel and here, perhaps, is a use for those much-maligned aluminum roadwheels that wouldn't stand up to a mine anyway... Simply mount them as the outer roadwheel, paired with a steel wheel, and we've GOT a sacrificial roadwheel.

The other critical concept, that of the sacrificial track pad, was still giving trouble at the end of Test Series One, with from seven to eleven pads breaking out at the detonation of a 5-lb. charge of C4. The breakout mechanism, it was deduced, was differential motion between sets of links, and in the second series of tests, the team set out to cure that problem by installing a bracing yoke across the length of the track pad, to control the motions of the links under blast impetus (Fig. 5).

After several variations in yoke and connecting link design, the yoke shown in Fig. 5 was cast in the plastic track block. Note that it has a one-inch cross section and spans the full width of the block. The two slots in its ends are designed to take the massive track links which, by then, had been completely redesigned as shown in Fig. 6.

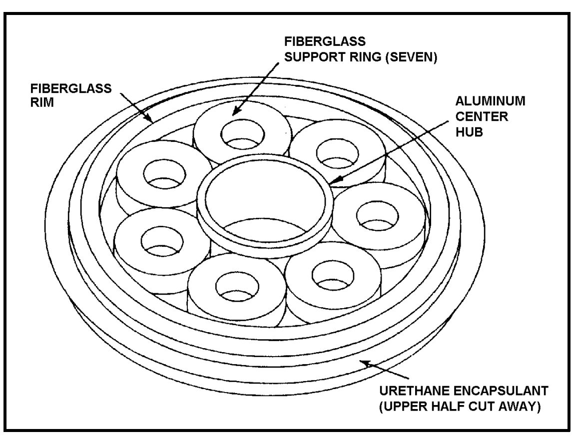

Fig. 4. Starting Point Roadwheel Configuration.

The link had by then reached what the team considered its final form. The separate male/female links had been replaced by a machined link with a female fork like a giant clevis on one end, and a matching male blade on the other. They were manufactured with a groove between the two so that the blade could be inserted into that keyed hole in the yoke and locked in place by rotating it 90 degrees. Then the whole assembly was inserted in the mold and the polyester casting resin injected around it.

You'll note that there is a lot of distance between the end of the male blade and the recess of the female clevis. This was done so that a sprocket could be designed which drove the tread through those holes, exactly as the M113 track is driven. When the tread was to be driven on an M-60, end connector adaptors were fabricated so that the track could be tested in comparison with the standard T-142 track.

The final component, the link pin, went through several versions, from the 1.25" standard bolt to the 1.5" pin shown with the track link. Held in place by the small locking bolt shown, and cushioned with a steel and rubber bushing, that design completely eliminates the end connector.

That heavy track, whose links are 4.75" across the horns, has just taken a full 25-lb. blast, and in the past, has survived an M21 AT mine under number one roadwheel. The assembly is mounted on an M-103 heavy tank, which, after the explosion, was then started up and DRIVEN back to the motor pool under its own power. That, gentlemen, is a contribution to mobility.

CONCLUSIONS AND RECOMMENDATIONS: The Martin Marietta design team did a superlative job in negating the effect of mine blast. That track, as is, could be used as a mine field prover, or could be used to remove all the AP mines from a given area, but only for about a hundred miles at low speed, before the plastics used begin to melt or crack. When those tests were conducted, however, CAD-CAM had not been thought of, nor were the computers that we now all use available. There have also been some giant leaps in plastics, manufactured materials, and high strength ceramics, which would have to be plugged into the calculations.

It should be possible for someone with the full data available from the two reports — which contain full manufacturing info, including sources — to create a program which could simulate reality well enough to give us a test design which could be fabricated in ordnance shops. Then, instead of calling industry in, let's change the procedure a bit, and build an Army-designed pilot model.

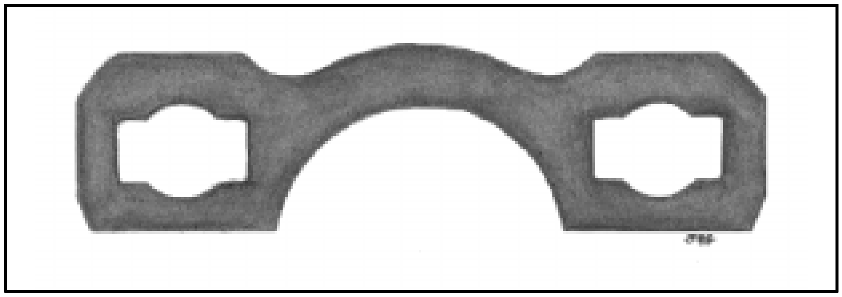

Fig. 5. Bracing Yoke formed from 1-in. steel plate.

First off, we ought to stick with the dual roadwheel and the centerguide. We are more than familiar with that configuration and know its capabilities. If the aluminum roadwheel doesn't protect the steel wheel, the design team can always switch to a fiberglass model. If that track yoke were fabricated flat instead of grooved, a centerguide segment could be welded to it. Better yet, a third chain could be added to the block, for the purpose of supporting the centerguides. This design change would allow a tread to be fabricated which would be compatible with existing suspension and drives.

Then, when the computer work is done, Ordnance could set up a soldier-operated, short-term assembly line and run off enough blocks to test a design concept. When they get to the point where a compatible design can resist a scatterable mine, it would be time enough to call industry in, but we really ought to do the preliminary work ourselves. History has shown that only tankers know what the iron is really going to do for a living.

Document I.D. numbers: "Hardening of Armored Vehicle Suspension System Components:"

Phase I USAMERADCOM 70-77-C-0060

Phase II USAMERADCOM 70-78-C-0015

(DTIC #ADB 069-394)

Notes

[1]Johns Hopkins University Operations Research Office, OEO-T-117, 31 Mar 51, Survey of Allied Tank Casualties in WWII.

[2]Southeast Asia Battle Damage Report. Surviac Tech Report #TR90-004, 7 Feb 94.

[3]Survey of Allied Tank Casualties in WWII.

Consultants

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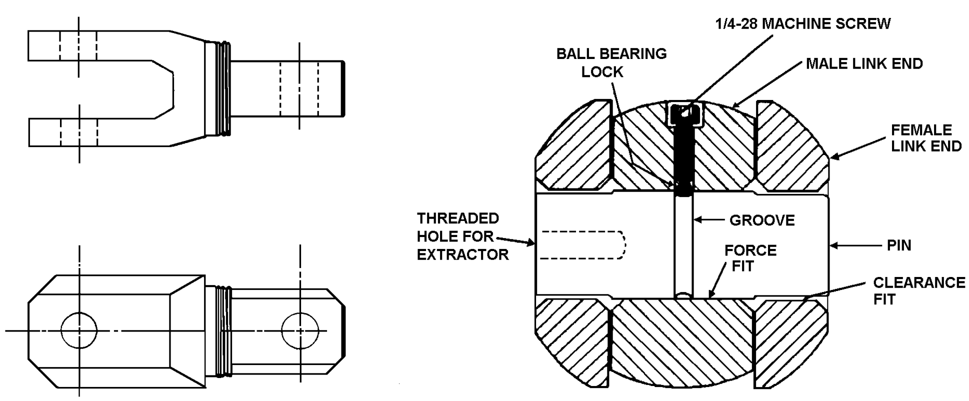

Fig. 6. Side, top, and end views of the final track link design.

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