EDUCATIONAL VERSION FOLLOWS

🏛️ Structural Baseline & Dynamic Core System Summary

The core system architecture centers on a dual-chamber free-piston hydraulic compressor and pump unit. It replaces a traditional crankshaft assembly with direct linear transmission, coupling chemical combustion force directly to high-pressure fluid output.

Immutable Core Engine Parameters (160 page v... pp. 2, 32):

- **Engine Core Weight:** 23.0 lbs encased in a high-strength Duplex 2205 structural steel housing (160 page v... p. 32).
- **Peak Continuous Output:** 500 Watts (0.67 HP) operating at a standard 60 BPM (1.0 Hz) cycle frequency (160 page v... p. 32).
- **Cruising Pulse Rate:** 19.2 BPM idle frequency (one fire cycle every 3.1 seconds) to maintain low acoustic and thermal tracking signatures in wilderness environments (160 page v... pp. 32, 34).
- **PCfire (Combustion Cylinder) Geometry:** 3.5-inch bore diameter with a 2.6-inch total cycle stroke (160 page v... p. 2).
- **PChyd (Hydraulic Pump Cylinder) Geometry:** 2.6-inch bore diameter with a 2.6-inch total stroke (160 page v... p. 2).
- **Solid Driving Transmission Rod:** 0.75-inch solid cylindrical shaft connecting the two high-pressure faces.
- **Inertial Acceleration Matrix:** A compact, high-density 600-gram pure tungsten insert embedded directly behind the steel crown of the `PCfire` piston to bridge the work-energy expansion deficit (160 page v... p. 34).

System Operating Pressures & Direct Fluid Loops (160 page v... pp. 2-3, 34):

- **Hydraulic Accumulator Threshold:** Maintains a locked constant resistance of **20 atmospheres (293.92 PSI)** via an active spring-loaded displacement piston (160 page v... p. 2).
- **Peak Combustion Pressure Target:** Holds a flat **12.0 atm (176.40 PSI)** and **385°F** constant-temperature isobaric push during the controlled fuel injection window (0.00" to 1.20" displacement) before transitioning to an adiabatic coast from 1.20" to 2.60" BDC (160 page v... p. 34).
- **The Closed Anatomy Loop:** High-pressure fluid travels from the accumulator out through the **Aorta** to fuel multi-axis joint cylinders and electrical motor-generators (160 page v... p. 2). Spent, low-pressure fluid aggregates into a common return line—the **Vena Cava**—which passes directly back into the intake check valve of the `PChyd` pump, creating a completely sealed fluid recirculation matrix (160 page v... p. 4).

🦿 Structural Architecture & Bone Cross-Sectional Analysis

The structural skeleton is designed to withstand extreme compressive, torsional, and impact forces encountered during wilderness terrain navigation, far exceeding the limits of traditional lightweight electric bipeds (160 page v... pp. 31, 37).

1. Duplex 2205 Stainless Steel Tibia Geometry

The structural bone matrix utilizes high-strength Duplex 2205 Stainless Steel arranged in a specialized, double-channel H-beam truss configuration.

- **Visual Anchor (Solid Metal Shin Blueprint):** The design incorporates a tight, geometric vertical double-channel beam cross-section that nests internal linear hydraulic cylinders directly along its central axis (160 page v... p. 34).
- **Cross-Sectional Area: 0.9179 square inches** (160 page v... pp. 31, 34).
- **Ultimate Yield Strength:** Because Duplex 2205 features a minimum yield strength of over 65,000 PSI, this sub-1-inch cross-section allows the lower leg structural bones to safely withstand **60,000 pounds (30 tons)** of pure vertical crushing force before experiencing any physical deformation (160 page v... pp. 31-32).
- **Tactical Advantage:** If the 198-lb biped encounters a severe obstacle, slips, or falls from a steep rock terrace, the frame easily absorbs the entire physical shockwave (160 page v... p. 31). The leg utilizes its **3,693 lbs of linear thigh cylinder thrust** to instantaneously launch itself back into a standing posture and continue marching (160 page v... pp. 31-32, 34).
- **Spatial Packaging:** Because the high-strength steel housing is optimized to be incredibly narrow, the lower leg profile remains completely streamlined (160 page v... p. 34). This allows one ankle to swing cleanly past the opposite ankle in a direct, straight-line human-mimicking gait without colliding, eliminating the wide, un-athletic "waddle" found in traditional bulky electric robots (160 page v... p. 34).

2. The Polyether Ether Ketone (PEEK) Materials Variant

For ultra-lightweight deployments requiring extreme structural efficiency, the platform architecture scales down to a specialized composite frame variant:

- **Total Standing Platform Height:** 6.0 feet tall
- **Total Master Platform Weight: 28.0 lbs**
- **Structural Load Capability:** Despite weighing under 30 lbs, the PEEK variant can comfortably support a static localized load of **200 lbs applied directly onto its knee joint**. It achieves a structural load-to-weight ratio that traditional electromagnetic rotary gearboxes cannot match without experiencing thermal breakdown or structural shell failure.

🥾 Articulated Tripod Footprint & Follower Link Decoupling

The lower leg connects to a fully articulated terrain adaptation matrix designed to stabilize a 198-lb combat load on unimproved, crumbling mountain steps without relying on power-hungry software stabilization loops (160 page v... pp. 31, 34, 37).

- **The 3-Toe Dynamic Tripod Layout:** The base contact plate features a segmented tripod consisting of a wide medial big toe, a lateral little toe, and an identical heavy matching heel block (160 page v... p. 34). Each independent digit houses a dual-cylinder connection: one cylinder serves as an inline, fluid-bypass passive shock absorber to soak up high-impact alpine terrain shocks, while its partner acts as a CPU-driven active positioning actuator to claw into loose stone or deliver propulsion force (160 page v... p. 34).
- **The Mechanical Follower Link:** To resolve the geometric conflict between bending a foot up and down (plantar/dorsi flexion) and tilting it side-to-side (inversion/eversion), a custom physical follower arm linkage isolates the kinematics (160 page v... p. 34).
- **Kinematic Decoupling Logic:** The follower arm dynamically shifts the mounting anchor point of the twin gold-capped ankle leveling cylinders along a perfect matching arc during a stride (160 page v... p. 34). As the foot pushes off its toes, this mechanical linkage handles the vector calculation physically, ensuring that up-and-down movement cannot cross-talk or alter the side-to-side inversion setting (160 page v... p. 34). The fluid remains perfectly trapped inside the tilting cylinders for **zero electrical processing overhead** and zero accidental shifting (160 page v... p. 34).

⚙️ Auxiliary Power Distribution & Sentry Mode Metrics

Energy conversion is governed by a split-tier auxiliary power architecture that mimics a biological metabolism, alternating between extreme energy-density sleep states and full-power mechanical operation (160 page v... p. 34).

The Passive Valve Clamping Loop (The WOW Metric):

To achieve an efficient **147 Mechanical Watts** cruising consumption rate at a steady 2.0 MPH, the robot utilizes **Passive Hydraulic Valve Clamping** (160 page v... pp. 32, 34). The moment a limb finishes a step and establishes a firm surface stance, the high-pressure fluid valves seal shut, locking the cylinders into rigid steel pillars (160 page v... p. 34). The platform supports its full vertical mass against gravity using **zero continuous electrical current**, only drawing accumulator pressure during active 38-inch strides or 3-inch vertical step lifts (160 page v... pp. 32, 34).

Dual-Tier Power Generation Loops:

1. **The Standby Sentry Loop (Hibernation Metabolism):** When standing motionless on watch, all large-displacement muscle cylinders are isolated and locked. The main 500W engine stays cold and dark (160 page v... p. 34). A miniature, low-volume fluid line feeds a **baby hydraulic motor** that spins a **baby generator**, trickling a trace 10 to 15-watt current into a **baby battery buffer** to keep low-

frequency VLF radio ears and local sensor cameras active (160 page v... p. 34). This tier consumes a microscopic **27.0 grams of diesel fuel every 72 hours**, requiring the free-piston core to wake up and execute just one single, isolated heartbeat stroke every ~1.8 hours (160 page v... p. 34).

2. **The Active Combat Loop (Full Engagement Metabolism):** The instant a local sensor trips, the CPU brings the **large-displacement hydraulic motor/generator setup** online (160 page v... p. 34). The main free-piston engine instantly scales from zero up to its 19.2 BPM cruising loop or its 90 BPM sprint frequency, flooding the aorta with high-pressure fluid to engage natural, high-velocity kinematics (160 page v... pp. 32, 34).
