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Wheel-less vehicles with legs for walking, running, and jumping may be the tanks and jeeps of the future

Now the Army is working on

Tanks That Walk and Jump

By Martin Mann

MAN'S greatest invention is the wheel, but this handy device isn't good enough for the U. S. Army. For the astonishing truth is that an Army design group is working on machines that walk, creep, run, and jump.

These strange vehicles have legs and feet like animals, and they *move* like animals. The first model of a machine that walks is now being tested. Others that borrow ideas from horses and grasshoppers have been designed.

The Army wants legged vehicles because legs are still the fastest way to cross rough country. The humbling fact is that, while airplanes fly faster than birds and ships swim faster than fish, no ground-supported machine yet built can get over broken terrain as fast as a horse, mule, or donkey.

Perfected, such a machine might have revolutionary effects. Sportsmen, geologists, and surveyors might snap it up to get into rugged back country. Farmers might find it easier on their priceless soil than tractors. Miles upon miles of secondary roads, now maintained at great expense, might no longer be needed—

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The horse runs with short, graceful leaps

Masterfully engineered for sustained speed, horse stretches its legs to go fast, folds them

with tax savings that are pleasant to dream about.

Military men say there is an urgent need for vehicles that can carry tank-like loads at animal-like speeds. Battles are rarely fought on roads, and great advantages come to the force that isn't tied to a road network. But tanks and jeeps are surprisingly slow once they get off the road. Even on fair terrain the best they can generally do is 10 m.p.h., and 5 m.p.h. is more common. Some rocky land and steep bluffs can't be managed at all.

Speedy animals. On a flat track, race horses have hit 38.7 m.p.h. over a mile. Speeds around 30 can be sustained on less-perfect surfaces for some distance. A wild ass has been clocked making an average 30 m.p.h. over 16 miles. An elephant that escaped from a circus camp in the mountains was found 10 hours later 130 miles away.

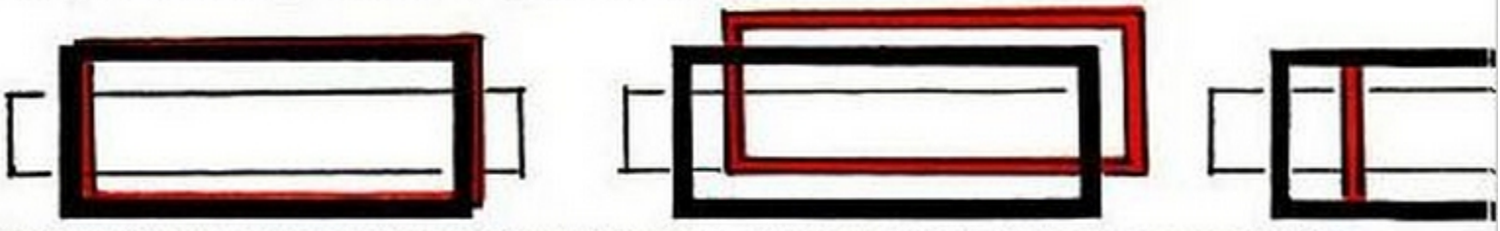
But more important, legs can go where wheels and track-layers can't. Mountain troops all over the world still rely on supply by mules. Kangaroos clear obstacles that would stop a tank.

If nature's designs, perfected over millions of years, are superior, we could be smart to copy them. So the Army hired university researchers to check out legs. There has been no breakthrough yet. But a two-foot-long platform *does* walk, and some of the weirdest mechanical designs ever conceived illustrate official papers.

Building a horse. Prof. R. K. Bernhard of Rutgers took on running and jumping. Both motions involve leaping, but running (as a horse does it) is a rhythmic series of leaps, whereas jumping (as a grasshopper does it) is made up of individual, nonrhythmic leaps. Professor Bernhard designed fantastic contraptions to imitate each animal.

The mechanical horse could be jounced along by a motor swinging eccentric weights. This would make the vehicle bounce rhythmically along the ground.

Army's walking machine plods along



Clumsy gait of model walker is indicated in these diagrams, which follow movement of two

Jumping machine was to hop like a grasshopper

Levers modeled after animal legs could jump vehicle across the ground. But shocks of

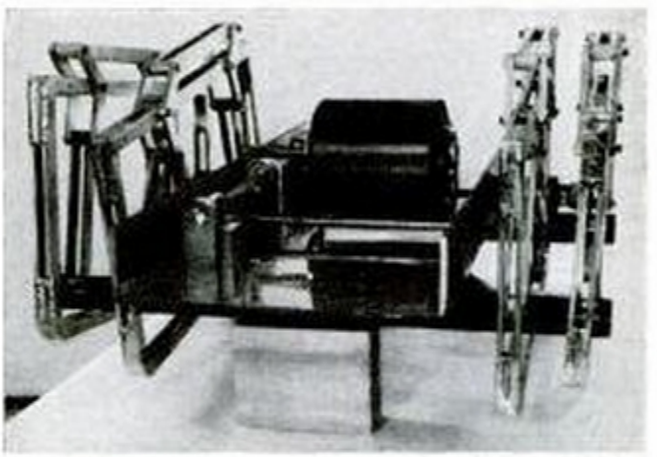
short to lessen inertial force. Photos are from Muybridge's famous series, shot in 1870s.

Power unit and crew would ride a softly sprung platform. Unfortunately, the horse machine couldn't hurdle large obstacles. And it couldn't run very fast.

The grasshopper machine. Professor Bernhard's proposal for a man-carrying grasshopper was stranger yet. It was to leap by means of a power-operated pogo stick. This would be an adaptation of a commercial machine called a rammer, used to compact soil in construction work. It has a one-cylinder engine with a tamper fastened to the piston rod.

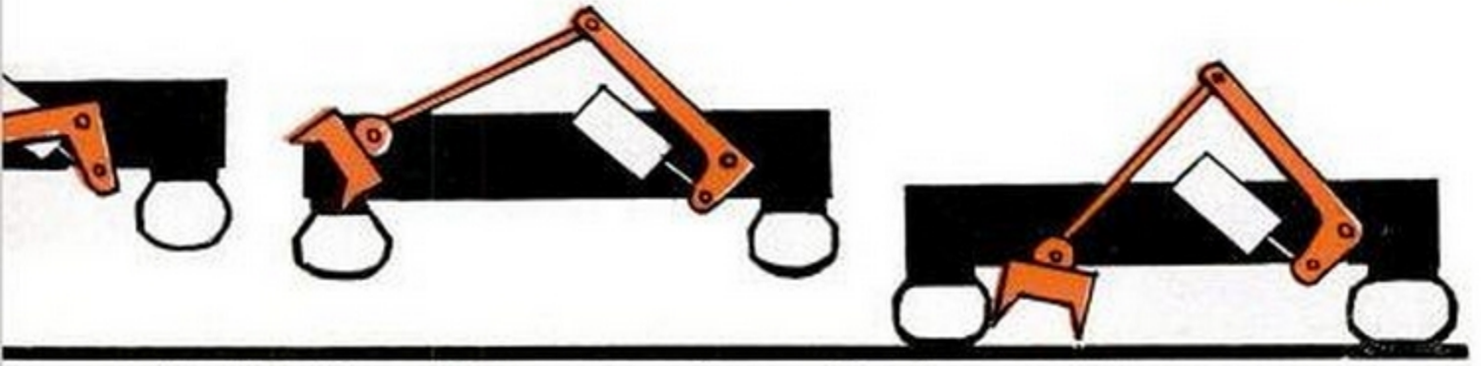
Professor Bernhard planned to equip a frame with rammers set at an angle, their piston rods linked through levers (equivalent to thigh and leg bones) to pronged "feet." When the rammers fired, the levers would extend to propel the machine up and forward, exactly like a grasshopper. The machine would land on big air bags to cushion the shock.

The grasshopper machine could go fast (maybe 30 m.p.h.) and jump obstacles. But it couldn't back up easily and might spill if it landed on a rock. More important, the shocks of takeoff and landing threatened to pulverize a crew, and maybe the machine as well. Impact absorption is a major problem; on certain kinds of rough going, a jeep can take



THIS CONTRAPTION WALKS: Complicated linkages move the four legs (open metal rectangles) of working model of Army's walking machine. Motor cranks levers through egg-shaped gears.

legs on one side of the body. Action is inefficient, but might achieve 20-m.p.h. speed.



takeoff and landing would be too great for a machine large enough to carry men, weapons.

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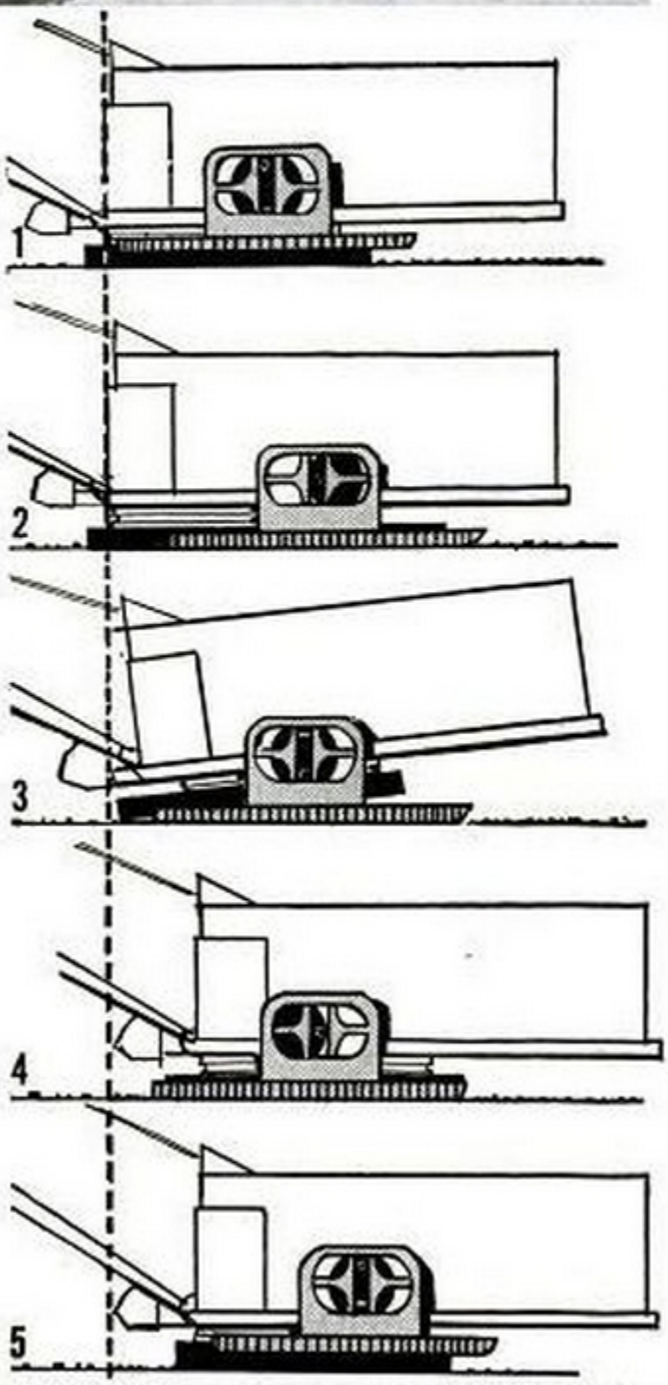
These leg-propelled machines are already in use



WALKING DRAGLINE, Bucyrus-Erie's huge excavating machine, hitches itself across ground on long feet. It goes backwards only (see sketches). At work (1), feet are off ground, dragline resting on central baseplate. Rotating cam moves feet to right and down (2), tilts body (3), slides body to right and down (4), lifts feet again (5). The monster's top speed: ⅛ m.p.h.

RAMMER, Barco's hopping dirt-tamper, has wide foot fixed to piston rod of a one-lung engine. It jumps 14 inches, 60 times per minute. When tilted, it hops along like a pogo stick.

bumps that human passengers cannot.

A 20-m.p.h. walk. After Professor Bernhard filed his report (no models were built), the Army pulled in its reins and decided to try walking before running and jumping. This assignment went to the University of Michigan's Prof. Joseph E. Shigley. He hit upon a contraption that looked as if it might walk: a shuttle linkage used for conveyors. He turned this gizmo upside down and drove it through egg-shaped gears cunningly calculated to eliminate sudden accelera-

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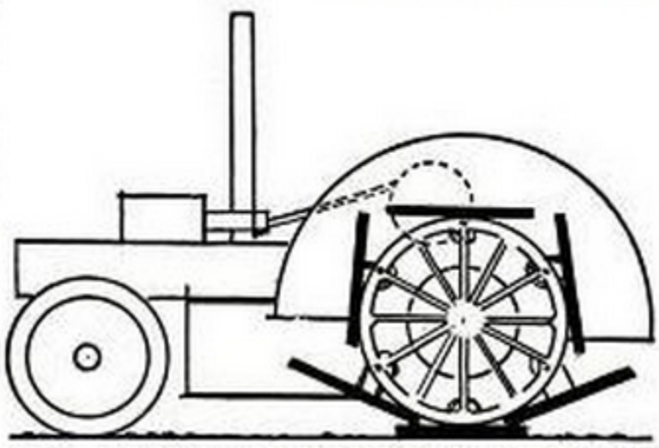

FEET—hinged to wheels, not to legs—propelled this steam tractor invented by Boydell. It was an excellent cross-country vehicle, widely used until the caterpillar tractor replaced it.

[Continued from page 54]

tions. The gears will prevent teeth-rattling jolts to the crew, he hopes.

The newly built model has four feet that look like square wheels. They overlap each other almost completely, two on each side of the body. They are moved up, forward, and down by a nightmare of levers requiring nine pivot points for each foot. The action is ungainly and inefficient: Two feet move together while the other two support the vehicle, but all four rest on the ground 40 percent of the time.

The object, however, is not grace but speed. And Professor Shigly is shooting for at least 20 m.p.h. Even half that would elicit hurrahs from the Army.

Research from the ground up. Vehicles with legs are only one small part in the research program of the Army's Land Locomotion Research Laboratory at the Detroit Arsenal. The Laboratory's civilian director is stocky, white-thatched M. G. Bekker, author of The Book about ground vehicles *(Theory of Land Locomotion)*. In it, he maintains that ships and airplanes evolved from a careful study of the machines in their elements—that is, in towing tanks and wind tunnels. To build good off-road vehicles, *their* element—the ground—must be studied. The big modern laboratory outside Detroit houses two huge "soil bins"—10-by-150-foot steel tanks full of dirt—in which wheel and track units can be tested. This fundamental work has already paid off in improved tank treads and an odd-ball wheel with a flexing tire.

The attempt to imitate animals is, Bekker concedes, a long shot. He points out that Nature is way ahead of man at engineering. Simply copying the motions she has devised won't be enough.

Even the stupidest animals have brains that delicately control muscle action and automatically compensate for missteps.

Muscles are better than any engine. They produce more power, weight for weight, and can adjust their output over wide ranges.

Bones, too, represent an ideal combination of weight, strength, and resilience.

A mechanical animal needs the same masterful combination of structure, power, and coordination. That's not easy. But the Army can't afford to miss a bet.