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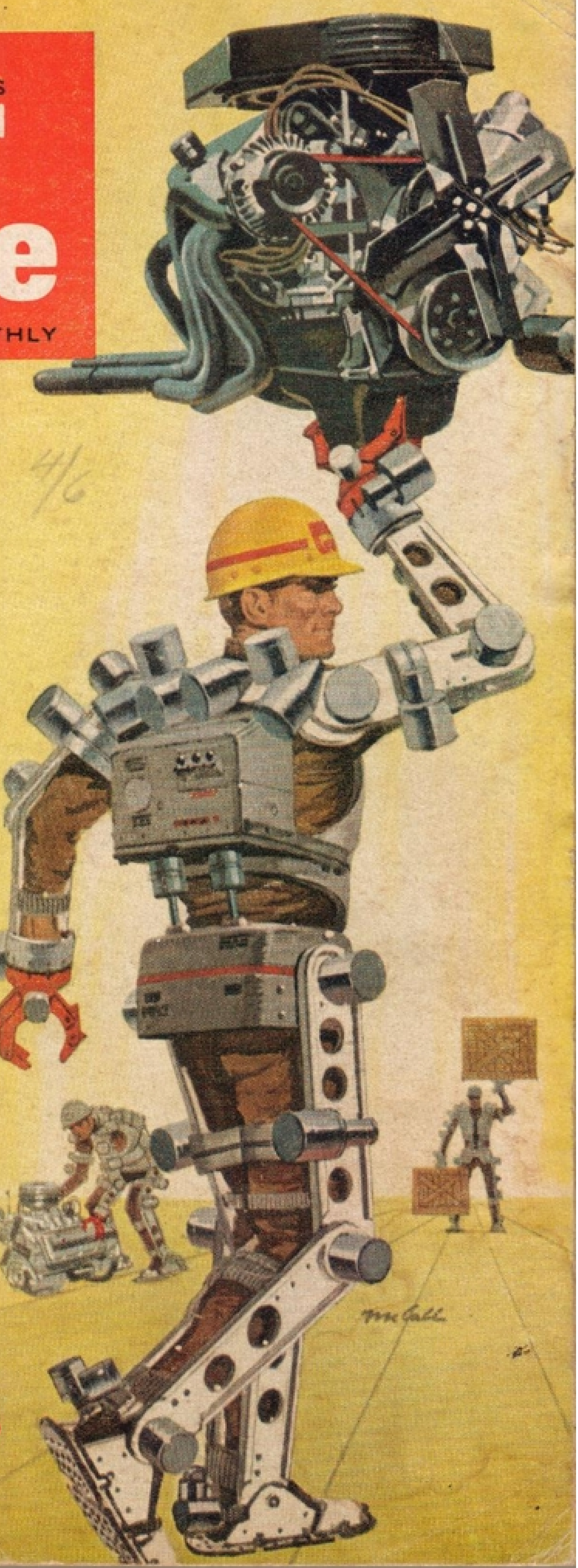

Why Can't We Make Cars Safer?
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Now It's Man Amplifiers: MACHINES THAT LET YOU CARRY A TON

MAN AMPLIFIERS:

Superman suit is modeled by the author at Cornell Aeronautical Lab, Buffalo, N.Y. Joints will be powered to multiply the wearer's strength as structure follows his movements.

Machines That Let You Carry a Ton

Strap on the "exoskeleton" and your strength is multiplied many times over—you'll be able to handle a ton with all the flexibility of human muscle power

By WALLACE CLOUD/*PS Science Editor*

When they strapped me into the superman suit, I felt like Frankenstein's monster getting up off the operating table.

I clonked around the room like a gorilla, with this 35-pound jointed "exoskeleton" hanging onto me.

"Why are you bent over like that?" said Neil Mizen, the project engineer at Cornell Aeronautical Laboratory.

I straightened up and discovered that I could move freely, even though the exoskeleton didn't have quite as many joints as I did. It wasn't up to some of the intricacies of the frug, but it followed me pretty closely.

The next step will be to put hydraulic motors at all the joints, and then it really will be a superman suit. Wearing it, any normal person will be able to heft 1,000 pounds—with each hand. You'll be able to carry a ton like a sack of groceries.

You'll have an 80-pound power pack on your back—a 20-horsepower gasoline engine plus fuel tank. But you won't be carrying it. The powered exoskeleton will be,

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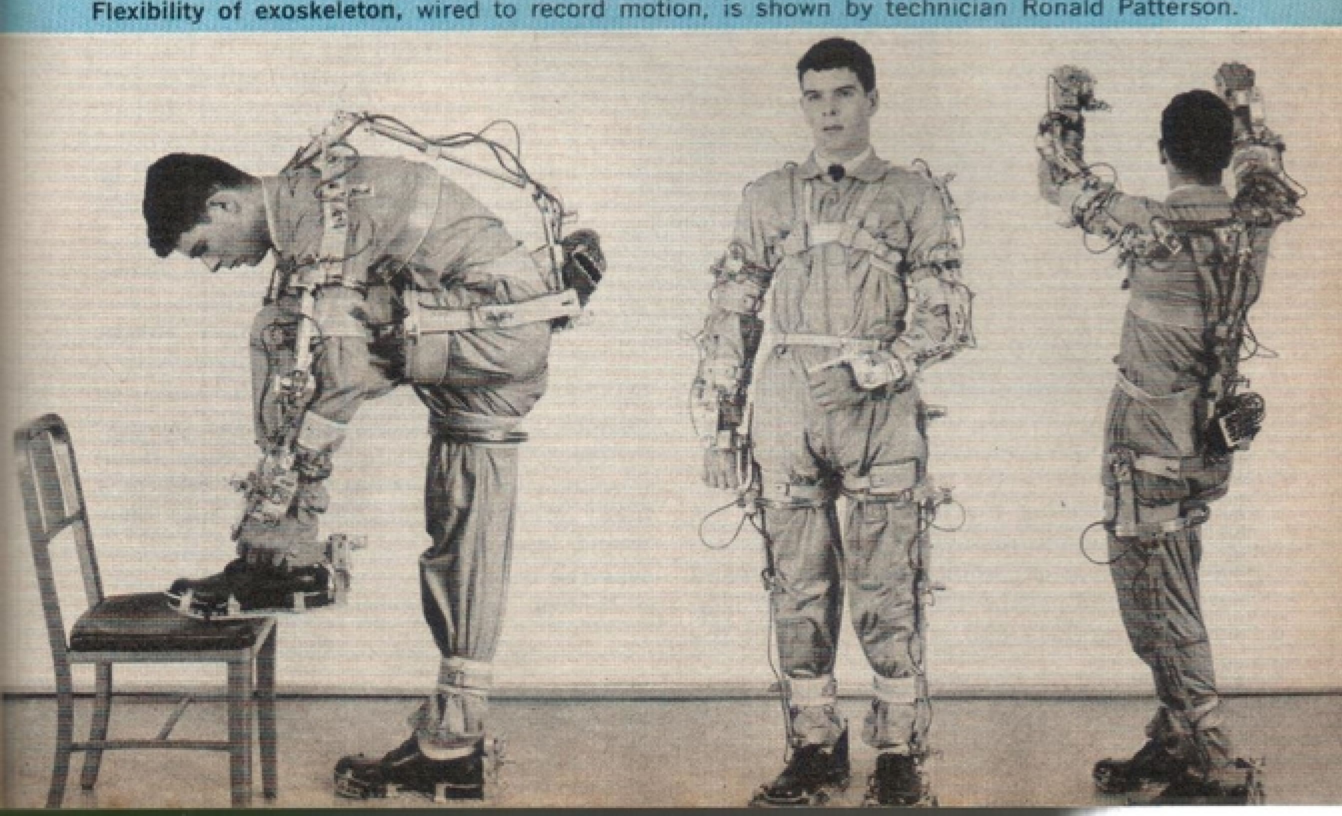
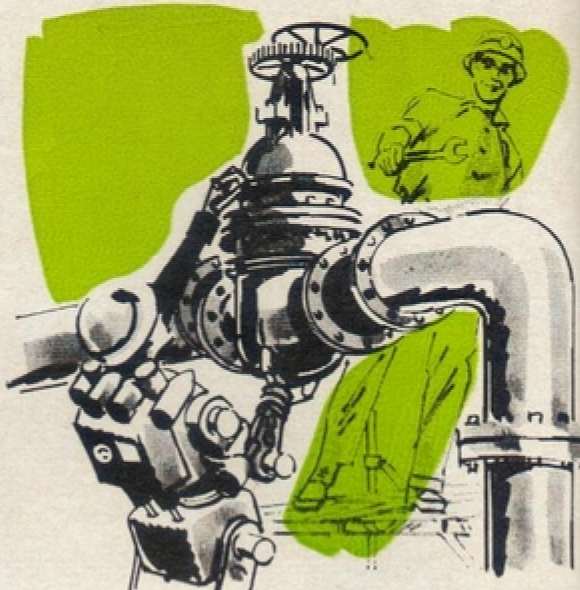
Flexibility of exoskeleton, wired to record motion, is shown by technician Ronald Patterson.



Tricky problems remain to be solved, but the uses of man amplifiers—

First uses of the exoskeleton are expected to be military. Here, a GI in a superman suit unloads munitions at a jungle helicopter landing field.



Superman-suited construction worker positions a heavy valve on site of a chemical plant—one of many civilian uses foreseen.

and it will also be supporting its own weight of about 400 pounds.

What a nutty idea, I thought when I first heard of it. But it turns out this is no joke. It's being developed for the Office of Naval Research.

The Navy wants the superman suit to help sailors manhandle torpedoes, bombs, and machinery in the cramped quarters aboard ship and in submarines. The exoskeleton could take the place of any number of hoists, overhead cranes, and other special-purpose weight-lifting equipment.

The Air Force and the Army are also interested. Exoskeletons would be useful for unloading and handling cargo and weapons in rugged terrain such as the jungles and rice paddies of Vietnam, and for construction work where a lot of specialized machinery is not available.

Multiplying muscle power. Cornell's exoskeleton is one of several "man-amplifier" projects underway in the U.S. Although there are differences, the basic idea is to put a man inside a machine that will duplicate his movements, but with greatly amplified strength and endurance.

One of these is the well-known "pedipulator," or walking machine, which GE has been developing for several years. This 18-foot-tall monster would walk on jointed legs, duplicating the movements of a man standing inside a cab at the "hips" of the machine. GE is working on the legs now, planning to add powerful arms.

A number of laboratories are doing research on controlling such machinery with "myoelectric" signals—electric currents generated by the muscles. The signals can be detected by means of electrodes taped to the skin. This research is aimed largely at developing better artificial limbs for amputees, but myoelectric signals could provide fast, sensitive control of man amplifiers.

When production models of man amplifiers are available, it's unlikely that they will be limited to military use. In factories and construction work, man amplifiers, perhaps costing only a few thousand dollars, will be able to do more things than present materials-handling equipment. They will be able to operate without special installation or site preparation, and will also make it possible to move and manipulate heavy objects with delicacy and precision.

Some tricky problems remain to be solved. At Cornell, project engineer Mizen explained, the approach was to build an unpowered exoskeleton that would cling to a man, to see what kind of strength-increasing structure could be built, and how many joints it would need and how they would have to move. The one I tried on was the result.

It was built to the measurements of

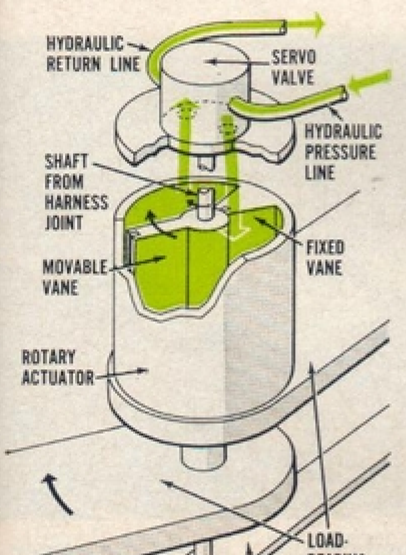
[*Continued on page 204*]

military and civilian—are limited only by your imagination

Exoskeleton can be made bigger or smaller than the man in the control harness. Here, a giant version replaces a derailed ore car at a mining site.

A miniature version, exposed to radioactivity, works to free jammed control rod of a nuclear reactor as operator watches on a TV monitor.

Next phase of development: applying power to the joints



Acid test of Cornell's exoskeleton design is whether power applied to the joints can be controlled precisely by the wearer. Mock-up shows sizes and locations of the hydraulic motors or actuators that will power the exoskeleton's arms and shoulders. This load-bearing structure will be linked to a harness like the unpowered exoskeleton shown on preceding pages. How each harness joint controls the corresponding joint of the structure is depicted in the diagram, an exploded view of the hydraulic actuator and servo valve attached to the joint. Movement of the harness joint is transmitted by its shaft to the servo valve atop the actuator. The valve regulates the pressure of hydraulic fluid on each side of the movable vane in the actuator. Movement of the vane is conveyed by its shaft to the structural member, positioning the structure joint so it corresponds to the position of the harness joint. Some pressure is fed back through the valve, so the wearer knows the position of the structure.

Machines That Let You Carry a Ton

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Ronald Patterson, a Cornell lab technician, but is adjustable enough to fit anyone of near-average build. Patterson has done a lot of walking, running, climbing, and lifting in this harness, with the joints wired to measure the range of movement and speed at each point. Now Cornell proposes to build a powered version of the arms and shoulders; later a completely powered superman suit can be put together.

The powered version will consist of two layers, Mizen said. The inner layer will be a harness like the present exoskeleton, strapped to the man. The harness will be linked to an identically jointed outer load-bearing structure, but not rigidly. At each joint a servo valve will register the angular movement of the harness joint. This will control the flow of fluid into a rotary hydraulic actuator that applies torque to the same joint of the outer structure to line it up with the harness joint. The servo valve will feed back a small amount of force to the harness, so the man is aware of the position of the outer structure.

Feeling his weight. The man will feel only a small fraction of the weight he is carrying. He has to feel enough weight to get a sense of balance when he moves the load—a few pounds at most. When he holds it steady, the sensation of weight will diminish.

Only experiment will show how easily a man can learn to use the powered exoskeleton. When he moves any part of his body, there will be a time lag before the structure moves; and when the load shifts, there will be a delay before he can respond. He will have to learn how to avoid staggering out of control. Also, there's no way to reduce the unbalancing forces caused by swinging or turning a heavy weight—there's always a danger that momentum will topple the man in the superman suit.

Falling under the weight of the exoskeleton and its power pack (about 500 pounds altogether) could be serious. Mizen thinks there will have to be some sort of panic button so the operator can instantly lock all the joints to prevent injury if he feels himself falling.

The Cornell engineers feel that these problems can be solved, that an exoskeleton that lets a man handle a ton—for a start—will be developed successfully. After that, the number of things it can be used for are limited only by your imagination. ■■