NASA TECHNOLOGY BENEFITS ORTHOTICS

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Engineers at NASA's Marshall Space Flight Center (MSFC) in Huntsville, Alabama have designed a knee brace to aid in the rehabilitation of medical patients. The device, called the Selectively Lockable Knee Brace, was designed for knee injury and stroke patients but may potentially serve in many more patient applications. Individuals with sports related injuries, spinal cord injuries and birth defects - such as spina bifida - may also benefit from the device. The Selectively Lockable Knee Brace is designed to provide secure support to the patient when weight is applied to the leg; however, when the leg is not supporting weight, the device allows free motion of the knee joint. Braces currently on the market lock the knee in a rigid, straight or bent position, or by manually pulling a pin, allow continuous free joint motion.

The Selectively Lockable Knee Brace effort began when orthotic laboratories approached the MSFC Technology Transfer Office with a need for an improved method of supporting a knee joint of a recovering patient in such a way that the joint would "lock up" only when weight was applied. The Technology Transfer Office contacted various organization at the Center, and worked to match up available NASA technologies that might apply to this need. A mechanisms design team in the MSFC Propulsion Laboratory was one of the areas contacted.

During discussion between the MSFC mechanisms design team and the orthotists, the requirements for such a device were developed. These requirements included the following:

1. Should prevent the knee from collapsing when weight is applied
2. Should allow free motion of the knee when weight is not applied
3. Desirable to allow the knee to be straightened when weight is applied
4. Should not require manual activation for locking or unlocking.
5. Should be compact and light weight
6. Desirable to have the capability to be worn under clothing

Existing knee braces require manually pulling a pin to unlock them. This is not practical while walking so the patient is forced to walk in a straight leg condition. This type of brace must be worn over clothing so there will be access to the release pin. A brace with the capability to straighten when weight is applied allows a patient, who has gained sufficient strength in their leg, to climb stairs.

"We design turbomachinery, combustion devices, and control mechanisms for space applications. The knee brace design project drew from our experience in all of these areas from a material selection standpoint but mainly our experience in control mechanism design", said Mr. Neill Myers, MSFC Propulsion Laboratory engineer, and

co-inventor of the Selectively Lockable Knee Brace. "We are routinely called when the Technology Transfer Office has been contacted with a mechanical design issue. In the past we have worked on a wide variety of interesting design problems, from requested help in analyzing a transmission, to a large company that wanted to improve the seals in their line of hydraulic cylinders, to a small company that needed help with the design of a vacuum bagging machine which was intended to cut grass on sports fields and along highways while simultaneously picking up any foreign objects and separating them from the grass clippings. Through the request and cooperative venture with the company, we were able to improve the efficiency of this device such that it became a commercially viable product"

With the knee brace requirements established, various concepts were developed. Of great value was the engineers' past design experience with a variety of space mechanisms. One such project was the design of a zero- gravity clamping fixture capable of single-handed operation, to be used by Space Shuttle astronauts to transfer new batteries to the Hubble Space Telescope during a servicing mission. A relevant past project was the design of a space vehicle rendezvous docking mechanism. When two spacecraft have been maneuvered into close proximity, a docking mechanism is needed to securely join the two vehicles together. This particular mechanism worked to capture a mating bar on the other vehicle, pull it in and lock it down, firmly securing the vehicles together. Other propulsion-related projects that provided background expertise for the engineering team were the designs of actuators for rocket engine Thrust Vector Control systems, which gimbal, or pivot a rocket engine to provide steering capability for the rocket booster or spacecraft.

"One of the concepts we considered was based on existing artificial limbs designed for amputees", said Myers, "which accomplished locking of the joint by utilizing the forces transmitted through the joint. These forces were generated by the individual's weight being applied to the prostheses. This concept was not carried forward because in the case of rehabilitation, it is unclear which portion of the individual's weight is to be carried by the brace and which portion by their own leg. It is likely, therefore, that there would be insufficient force transmitted by the brace to achieve positive locking."

"We felt we needed a reliable and consistent means of generating the locking force. So we developed a heel strike mechanism to actuate locking of the knee brace. The heel strike consists of a small plate located beneath the rear of the heel which is depressed by the patient's weight whenever his heel is in contact with the ground. A 1/16 inch diameter cable runs up each side of the lower leg brace and transmits the force to the locking mechanism at the knee."

"The upper and lower sections of the brace are joined at the knee via needle bearings. These bearings permit free rotation of the joint while supporting the loads carried by the brace. Locking of the joint is accomplished with a unique clutch design. We developed this clutch for the knee brace and refer to it as a Releasable Conical Roller Clutch. The locking function is initiated by the heel strike. When the heel strike is depressed it pulls

downward on the cables which in turn pull the actuation rods in the knee joint. Each actuation rod, via a cam mechanism, engages a clutch on each side of the knee joint. The clutches consists of a conical surface which, when activated, comes in contact with a set of rollers. The rollers reside in tapered pockets in the mating housing. The tapered pockets cause the rollers to pinch when rotation is attempted in the direction of the taper. This locks the knee joint preventing rotation and providing support. Rotation in the opposite direction is still possible because the rollers tend to move away from the taper. Thus, if weight is applied while the foot is raised, as in climbing stairs, the joint will lock in one direction providing support but can be straightened allowing the patient to move up to the next step. When pressure is removed from the heel strike a return spring forces the actuation rod to retract. This rotates the cam back to its original position thus disengaging the cone from the rollers allowing the joint to again rotate freely."

The Releasable Conical Roller Clutch provides very positive locking with very little wear. It is a compact design which will free-wheel in both directions then, when engaged, will limit rotation to just one direction. This unique design makes it possible for the Selectively Lockable Knee Brace to meet all the requirements imposed at the outset of the project.

The development of this innovative knee brace was motivated in part by the utility of the Technology Transfer Program at MSFC, which is moving scientific discoveries and newly developed technologies from NASA's laboratories and facilities to the non-Government industrial community. MSFC has in place an outreach program aimed at partnering with American business, industry, and academia, with a goal of enhancing America's competitiveness in the world marketplace, and ensuring that the technological breakthroughs in NASA laboratories benefit taxpayers and the many industries making up America's industrial base. The "bottom line" is that Federal Government developed technology and expertise is being made available for public re-use through these partnerships and exchanges.

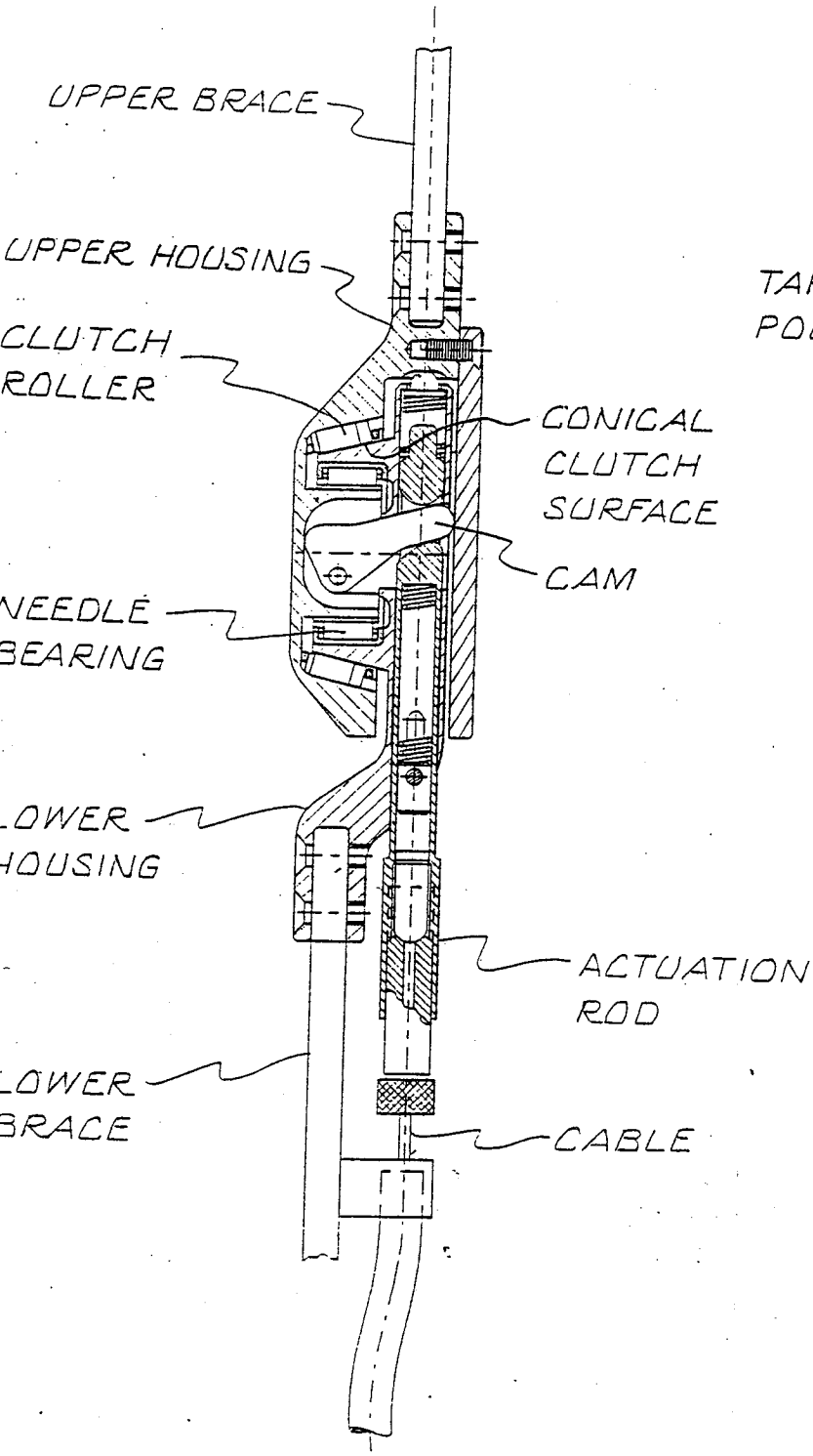
While the Selectively Lockable Knee Brace was in development and early prototyping, The MSFC Technology Transfer Office began to seek out possible avenues for commercialization of this innovation in American industry. Horton's Orthotic Laboratory, in Little Rock, Arkansas, expressed interest in the device, and provided follow-on design requirements and prototype-level patient testing for the MSFC designers. With completion of the prototype development, the invention was patented by NASA at the Marshall Space Flight Center, and was advertised to American industry in a period of open solicitation. Horton's responded to the solicitation, and was granted an exclusive license by NASA to manufacture the brace. The brace is presently undergoing clinical trials at Horton's to prove its effectiveness and reliability. At the same time, it is being evaluated to determine if it can be economically mass produced. If the knee brace demonstrates the capability to benefit patients and is commercially viable, then the technology transfer process has once again worked as intended to benefit U.S. industry and the general public through the commercialization of NASA technological expertise.

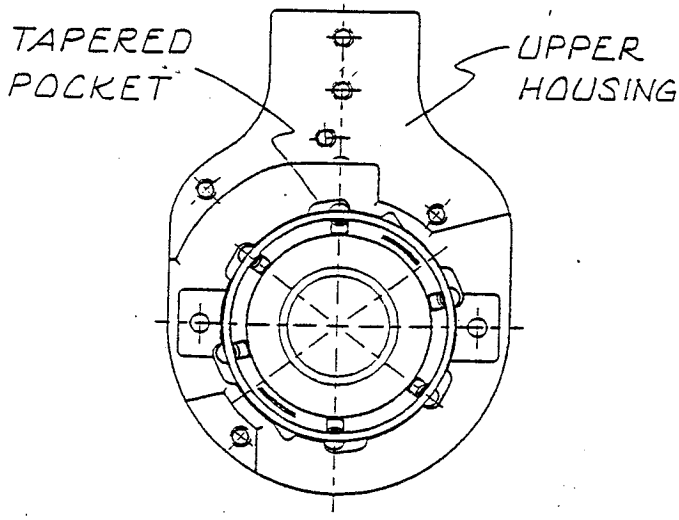
The primary purpose of the MSFC Technology Transfer Office is to plan and coordinate the Center's initiatives in pursuing strategic alliances and technology transfer partnerships with industry, academia, other Government agencies, and state and local governments which serve both NASA and its partners. "The exposure to American industry of the Selectively Lockable Knee Brace is an excellent example of the technology transfer process. This project really drives home our theme that 'The technologies that we need to reach the stars are the engines to drive America's future'", said Ms. Sally Little, Director of the MSFC Technology Transfer Office. "The MSFC Technology Transfer Program recognizes the tremendous value of the expertise and knowledge that have accrued as a result of the United States' technical ventures into space missions. This research over the past several decades is a strategic asset in maintaining this country's technological competitiveness in a global marketplace."

While commercialization of MSFC technological innovations, inventions, and facilities is a primary focus of the Technology Transfer Program at MSFC, the Office also promotes technology transfer awareness through exhibits and publications to the general public. The Program works with the National Technology Transfer Center and its Regional Technology Transfer Centers across the country, and is allied with the Southeast Technology Transfer Center in central Florida. The Program is an active technology service provider to the state-level manufacturing extension programs for enhanced economic development in the Southeast United States.

An active part of the Office's work deals with NASA Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) activities, and other dual-use technology development partnerships with industry, academia, and Government. Numerous reports of new technological innovations and inventions are provided for publication in the NASA Tech Briefs magazine and other scientific and industrial publications. The success of the MSFC technology transfer program for the American taxpayer is measured in terms of the number of technology commercializations, industry/academic partnerships, and published success stories of technology transfer activities.

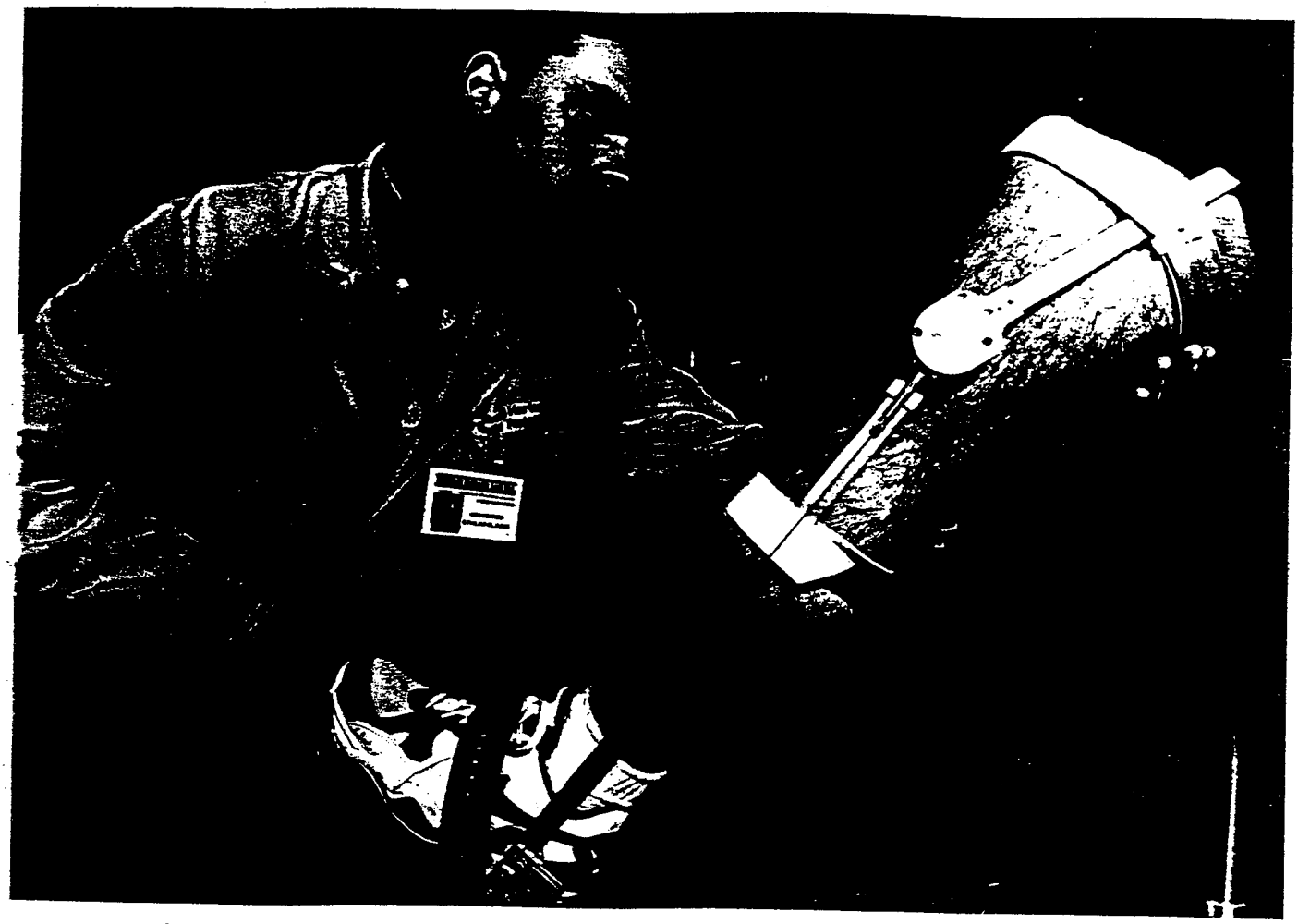
"Designing the Selectively Lockable Knee Brace was an extremely rewarding experience for our design team", said Myers,. "We were able to develop a successful design that has the potential to improve the condition of many peoples lives. We look forward to future opportunities to work with the Technology Transfer Office so that NASA can make a difference, not just in space, but here on earth as well."



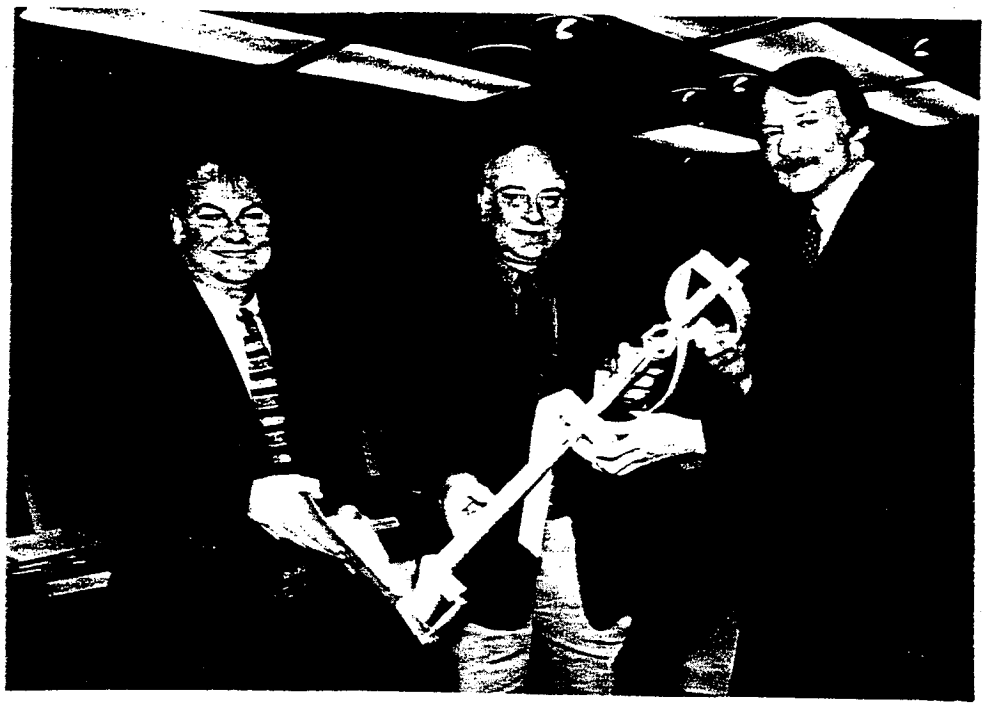


CUTAWAY VIEW
UPPER HOUSING

KNEE JOINT MECHANISM INCORPERATES THE RELEASABLE CONICAL ROLLER CLUTCH



HORTON'S ORTHOTIC LAB TECHNICIAN CHECKS A PATIENT WHO HAS BEEN FITTED WITH THE SELECTIVELY LOCKABLE KNEE BRACE



MARSHALL SPACE FLIGHT CENTER ENGINEERS NEILL MYERS (RIGHT) AND MICHAEL SHADOAN (LEFT) PRESENT THE SELECTIVELY LOCK-ABLE KNEE BRACE PROTOTYPE TO GARY HORTON (CENTER), PRESIDENT OF HORTON'S ORTHOTIC LAB.