

REHAB *T e c h*

Monash Rehabilitation Technology Research Unit



**Hydraulic Knee
Controller
Test Rig**

Jevan Devenport



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AIM:

The aim of the project was to design and develop a rig, capable of providing data that would indicate or assess the performance of hydraulic knee controller's.

BACKGROUND:

Monash Rehabilitation Technology Unit suggest that the hydraulic knee units used in above-the-knee prosthetic limbs sometimes exhibit catastrophic failure, and quite often experience performance failure, whereby the unit does not perform to its appropriate standard.

Like many technological units no tool is available to test how deteriorated the unit has become. Instead, it is left up to the so-called "experts" to determine in a purely interpretational manner, whether its performance is satisfactory or not. This can be demonstrated by an automobiles car suspension system. In order to determine the effectiveness of the system, a mechanic will simply push on the car and see if the car continues to oscillate. Depending on the interpretation of the mechanic, repairs may result. However before this occurs, the user must first sense that the car is not performing as it should, otherwise it may never get checked. The same occurs when investigating the performance of hydraulic knee controller's.

Previous work has indicated that the time for the piston on the hydraulic knee unit to return to its equilibrium position from a fully compressed position, varied greatly between new and the old units. This suggested that a simple stop watch could be a method of early detection of catastrophic failures.

METHOD:

It was necessary to do develop several ideas for experimental rigs that would be capable of timing the extension process of the unit.

The following outlines the initial design process.

Design Requirements:

- Make it as portable as possible
- Low cost
- Rigid
- Easy to assemble
- Since the measurement can be performed by the use of a stop watch, it becomes important to stress the fact that the design, maintenance, etc be kept very simple.

TIMING ACTIVATOR:

- **TA1** Activated by mechanical-electrical switch
- **TA2** After release, piston rod of HKU pushes circular conductive arc on to a switching plate creating a closed circuit.

TIMING DE-ACTIVATOR:

- **TD1** Activated by mechanical-electrical switch
- **TD2** As the rod reaches the top it pushes a thin conductive plate, causing it to disconnect the electric circuit driving the timer.

POWER:

RELEASE MECHANISM:

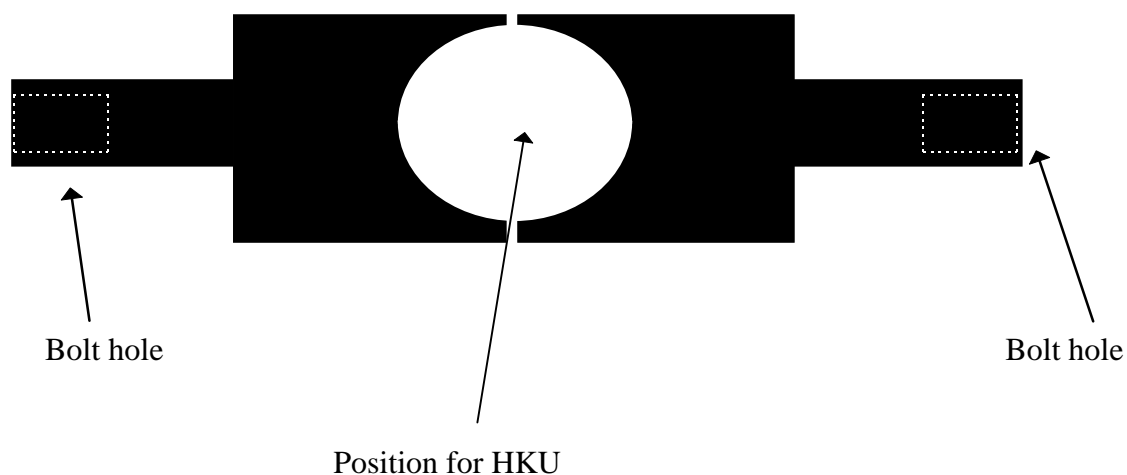
- **PR1** Small electric motor if required (BATTERY OPERATED)

TIMER:

- **PT1** Computer
- **PT2** Battery

CLAMPING DEVICE FOR HKU:

- **C1** Clamping device to be manufactured similar to below diagram.



- **C2** Twist and lock clamping device.

PROCESS SELECTION:

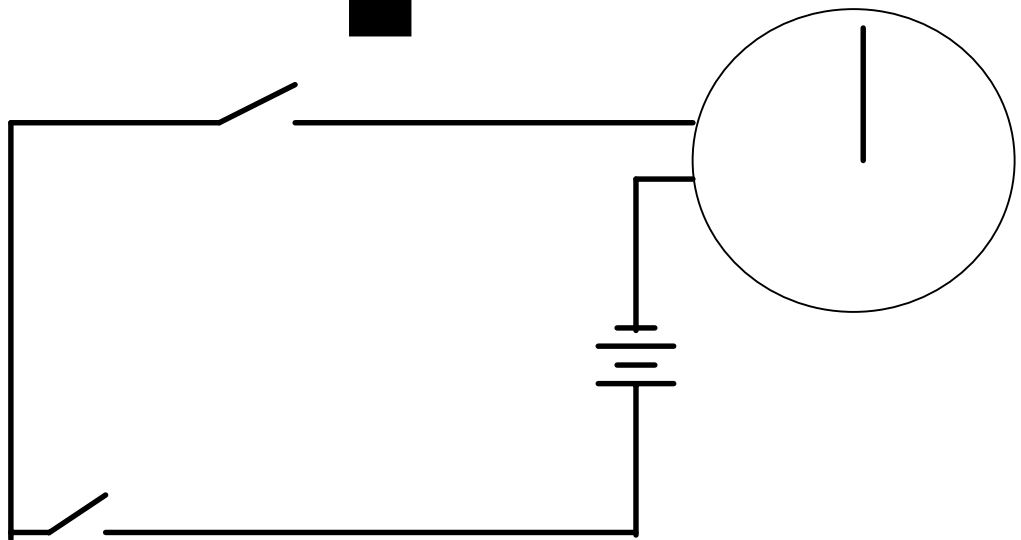
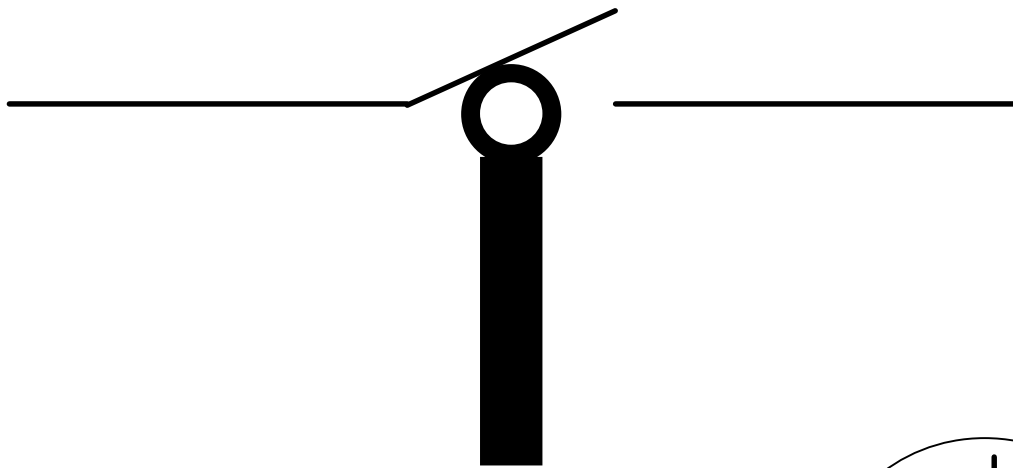
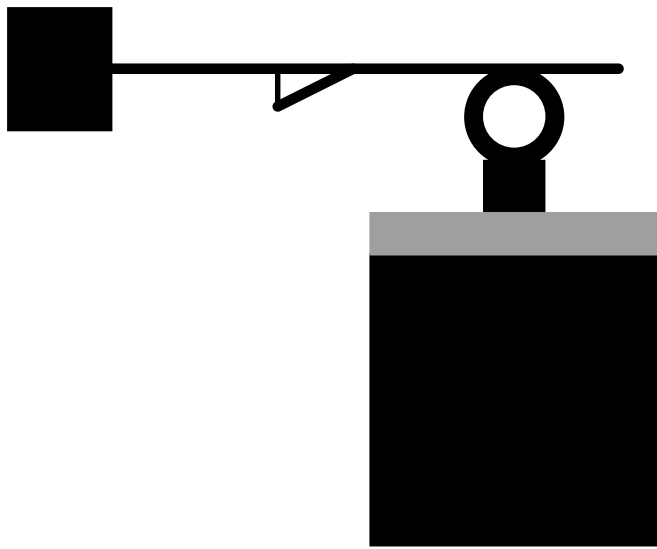
The following table rates the selected processes above on a scale of 1 to 10. The rating considers items such as cost and feasibility of each component.

VARIABLE	RATING
RH1	2
RH2	3
RH3	7
RH4	5
RH5	6
RA1	6
RA2	6
T1	4
T2	8
T3	7
T4	3
TA1	9
TA2	6
TD1	9
PR1	5
PT1	3
PT2	9
C1	5
C2	7

BEST PROCESS:

1. RH5 - T2 - TA1 - TD1 - PT2 - C2

THIS DESCRIBES THE PROCESS IN WHICH THE RELEASE MECHANISM IS CONTROLLED BY A PUSH BUTTON MECHANICAL - ELECTRICAL SWITCH. AS THE BUTTON IS PUSHED, A PLATE WILL MOVE ALLOWING THE HKU TO RECOIL. AT THE SAME TIME THIS HAPPENS THE ELECTRIC CIRCUIT BECOMES CLOSED ALLOWING A CURRENT TO FLOW TO THE CLOCK, THUS STARTING IT. THIS CLOCK WILL BE POWERED BY AN APPROPRIATE BATTERY. WHEN THE HKU REACHES ITS MAXIMUM POINT IT RAISES AN ELECTRICAL SWITCH, CAUSING THE CIRCUIT TO BECOME CLOSED, THUS STOPPING THE CLOCK, ALLOWING THE TIME TO BE READ DIRECTLY FROM IT.



After evaluating the feasibility of each of the above components, the final design was achieved. This entailed selecting a twist-and-hold clamping device. The reason this was chosen is due to the reason that any device clamping the main outer casing would greatly affect the performance, and could in fact breach warranty conditions. For this reason also, it was decided not to use any bolts to hold the unit in place.

The release mechanism uses a steel lever connected to a spring. The lever is released by a pin, allowing the spring to raise the lever, thus allowing the hydraulic knee controller to begin the extension process.

The timing is measured using a hand-held digital stop watch, having a resolution of 1/100 second.

The timer is controlled by three long-leaf microswitches. The first and second microswitch's are activated by the release lever beginning motion. The third microswitch is activated when the unit reaches its full extension. The first switch begins the timer, the second switch prepares the third switch to be able to stop the timer.

INCORPORATION OF AN OBJECTIVE TEST:

It was decided to incorporate a test that would allow the user to establish their own feeling for the units performance. The primary purpose of the test was to have an objective test similar to tests currently undertaken. The benefit of such a test would be to provide a standardised, thus more accurate test.

Current testing is performed with the hydraulic knee unit still within the prosthesis. The tester flexes and extends the hydraulic knee, taking note to the resistance of the unit.

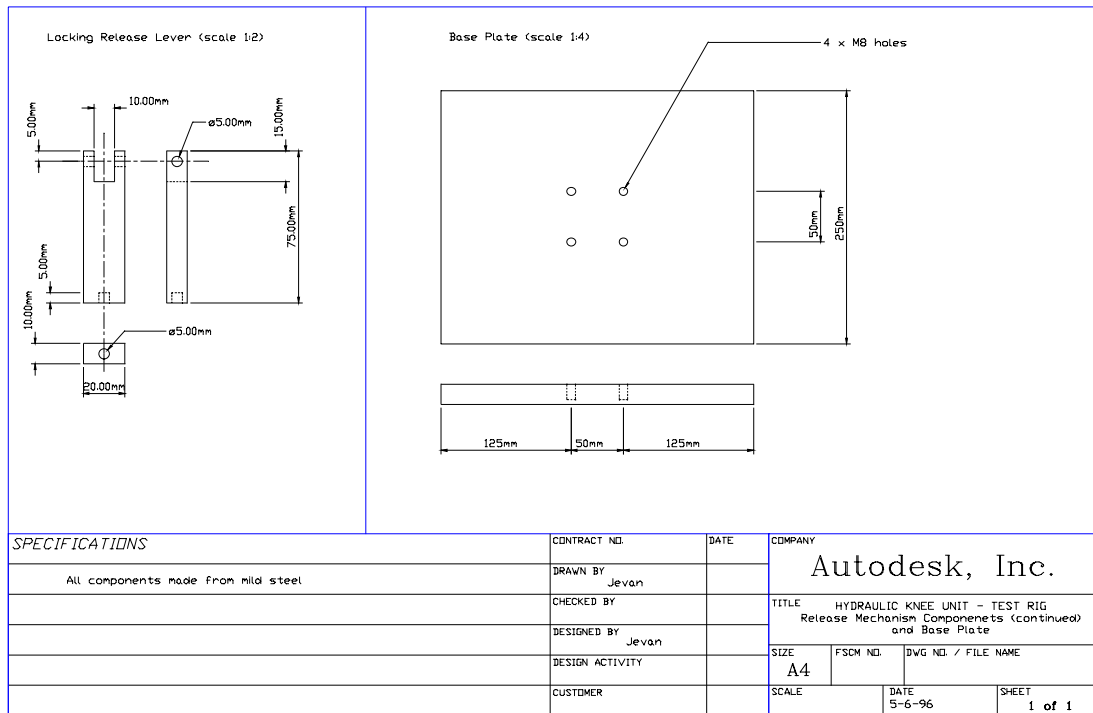
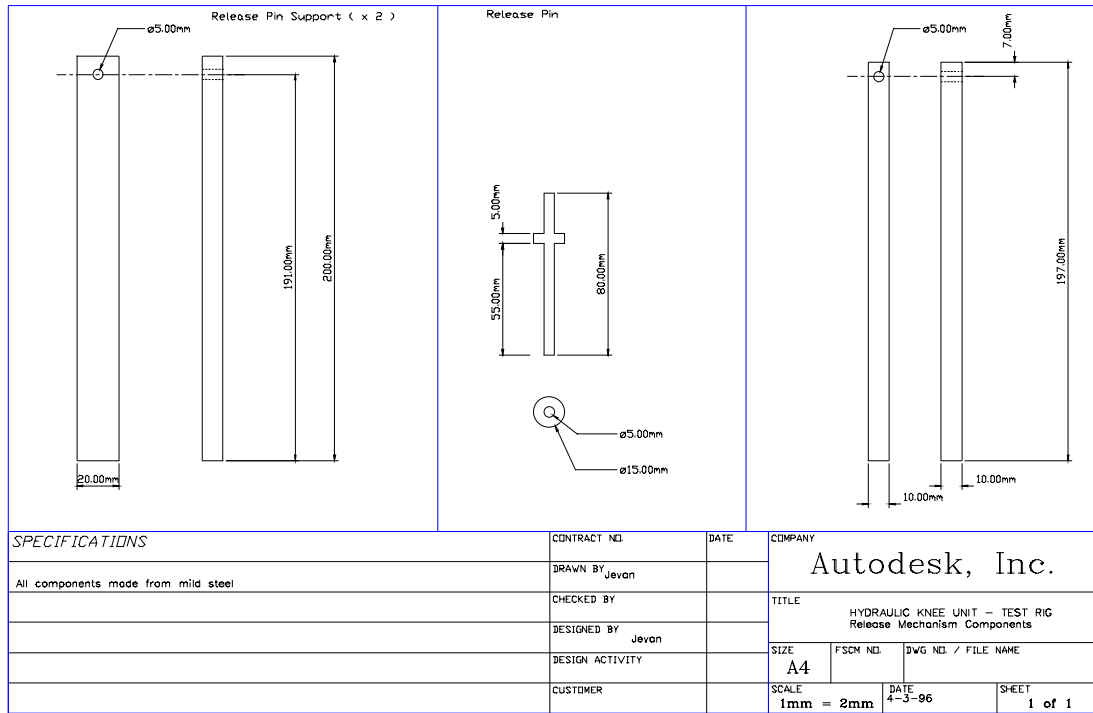
The objective test allows the tester to gain a feeling for the resistiveness of the hydraulic knee units at various settings by compressing and extending the units using a lever.

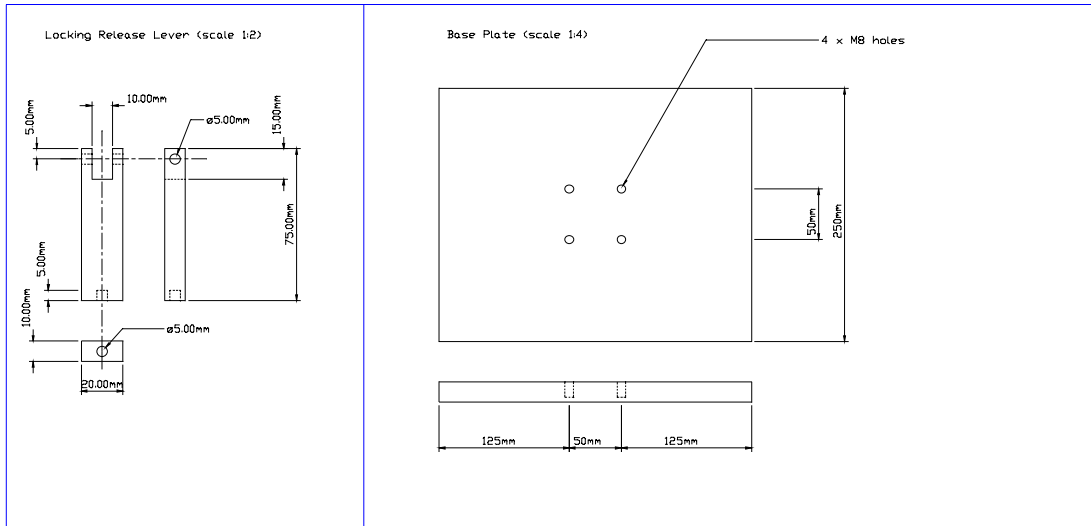
Firstly the tester is required to connect the lever to the hydraulic unit using a pin. The tester then can lower and raise the lever, creating a feeling for the resistance of the unit.

The objective tests around at the moment have many major problems. Current testing does not allow for differences in the height of the leg socket. since we are trying to measure the resistance of the unit by applying a moment arm to it we must have the same moment arm length each time we objectively test the resistance. If this does not occur, then the longer the socket becomes, the less resistance will *appear* to occur. However, a long leg socket appearing to have low resistance may have exactly the same resistance as a short leg socket appearing to have high resistance.

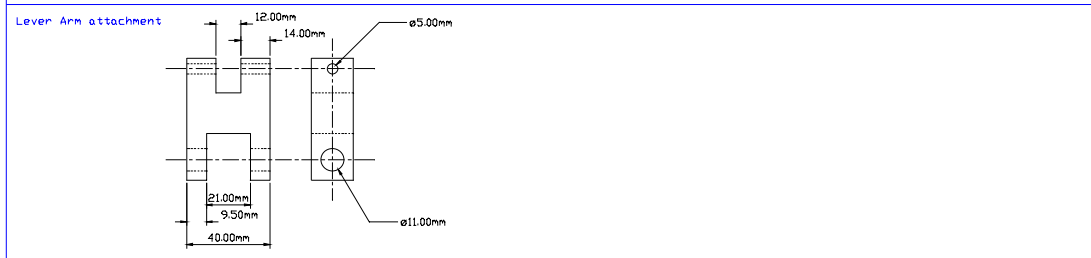
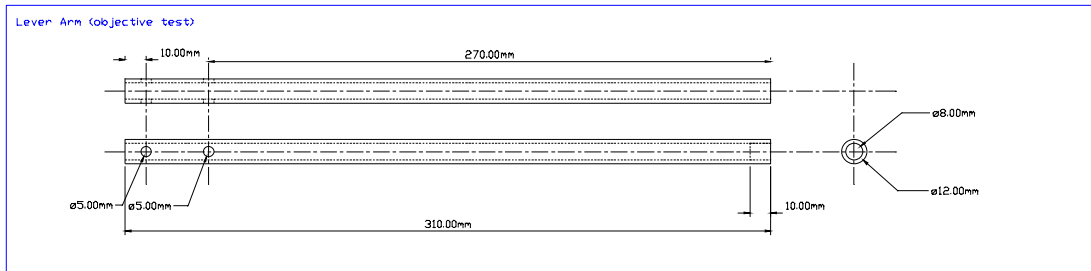
This can be overcome by making the arm a standard constant length, allowing the tester to build up a more accurate objective feeling.

SPECIFICATIONS:





SPECIFICATIONS All components made from mild steel	CONTRACT NO.	DATE	COMPANY		
	DRAWN BY	Jevan	Autodesk, Inc.		
	CHECKED BY		TITLE		
	DESIGNED BY	Jevan	HYDRAULIC KNEE UNIT - TEST RIG Release Mechanism Components (continued) and Base Plate		
	DESIGN ACTIVITY		SIZE	FSCM NO.	DWG NO. / FILE NAME
CUSTOMER		SCALE	DATE	SHEET	
			5-6-96	1 of 1	



SPECIFICATIONS All components made from mild steel	CONTRACT NO.	DATE	COMPANY		
	DRAWN BY	Jevan	Autodesk, Inc.		
	CHECKED BY		TITLE		
	DESIGNED BY	Jevan	HYDRAULIC KNEE UNIT - TEST RIG LEVER ARM COMPONENTS		
	DESIGN ACTIVITY		SIZE	FSCM NO.	DWG NO. / FILE NAME
CUSTOMER		SCALE	DATE	SHEET	
		1mm = 2mm	5-6-96	1 of 1	

PROBLEMS TO BE OVERCOME:

The weight and size of the rig could be reduced, by making minor modifications to the design. One method would be to use a material such as aluminium instead of mild steel.

Longleaf microswitches are rather flexible, after a period of time they might lose there shape resulting in different times being recorded.

**HYDRAULIC KNEE CONTROLLER
PERFORMANCE PROTOCOL**

Remove unit from prosthethesis and replace or check nyliners and/or bearing surfaces.

Time Elapse Displacement Test

MINIMUM FLEXION

SETTINGS	TIME		
Minimum Extension			
Medium Extension			
Maximum Extension			

MEDIUM FLEXION

SETTINGS	TIME		
Minimum Extension			
Medium Extension			
Maximum Extension			

MAXIMUM FLEXION

SETTINGS	TIME		
Minimum Extension			
Medium Extension			
Maximum Extension			

- Take note during testing, whether or not the unit returns to its maximum extension. This is done by noting whether the unit can be raised manually any higher than where it naturally stops. The height the piston rod can be further extended is an indication of the amount of oil lost from the unit.

Rate the oil loss on a scale of 1 to 10. Where 1 corresponds to 1 mm of lost expansion and 10 corresponds to 10 mm of lost expansion.

- With the unit still in the rig attach the lever mechanism. Pull lever down, compressing the unit, then push lever up, extending the unit for various settings, making sure to note any abnormalities.

Rate the overall performance using the lever on a scale of 1 to 10. Where 1 indicates high performance.

- Place your thumb on the piston rod. With your other hand jiggle the lever up and down. If the piston rod has any play in it, it will be felt by your thumb. This is an indication that the hydraulic unit has a problem. If this is not the case and play is still felt, then the problem is probably occurring from the bushes or the lever mechanism.

Rate the play in the hydraulic knee unit from 1 to 10 (10 represents high play)

Rate the play in the bushes.

- Hold the unit, rotating the piston rod. Take note whether the rotating motion is smooth or rough. If the motion feels rough, it is an indication that the seals on the piston are worn.

Please rate the roughness on a scale of 1 to 10 (10 indicates very rough motion)

- If the unit makes a squishing noise during motion, it may indicate that air has entered the system. To overcome this effect, compress the unit, raise the mode lever (entering into flexion lock), extend the unit, and then lower the mode lever to allow flexion. This process is repeated several times until the air is eliminated.

Rate the squishing noise (scale 1-10) before the above process (1 implies no noise)

Rate the Squishing noise (scale 1-10) after the above process

USER DETAILS

AGE: _____
WEIGHT: _____
SEX: _____

- **Rate the user's general activity level (scale 1-10)**

1 is the equivalent of a extremely non-active user.

- **Rate the type of activity being performed (scale 1-10)**

1 is the equivalent of sitting down

10 is the equivalent of high impact activity (ie jumping)



Please note any unusual walking or motion styles that could effect the performance of the knee unit in any way.

For example - stiff walking style, limping, etc

- **Rate this walking style from 1 to 10, where 10 indicates extremely poor walking style and 1 indicates ideal walking cycle.**

