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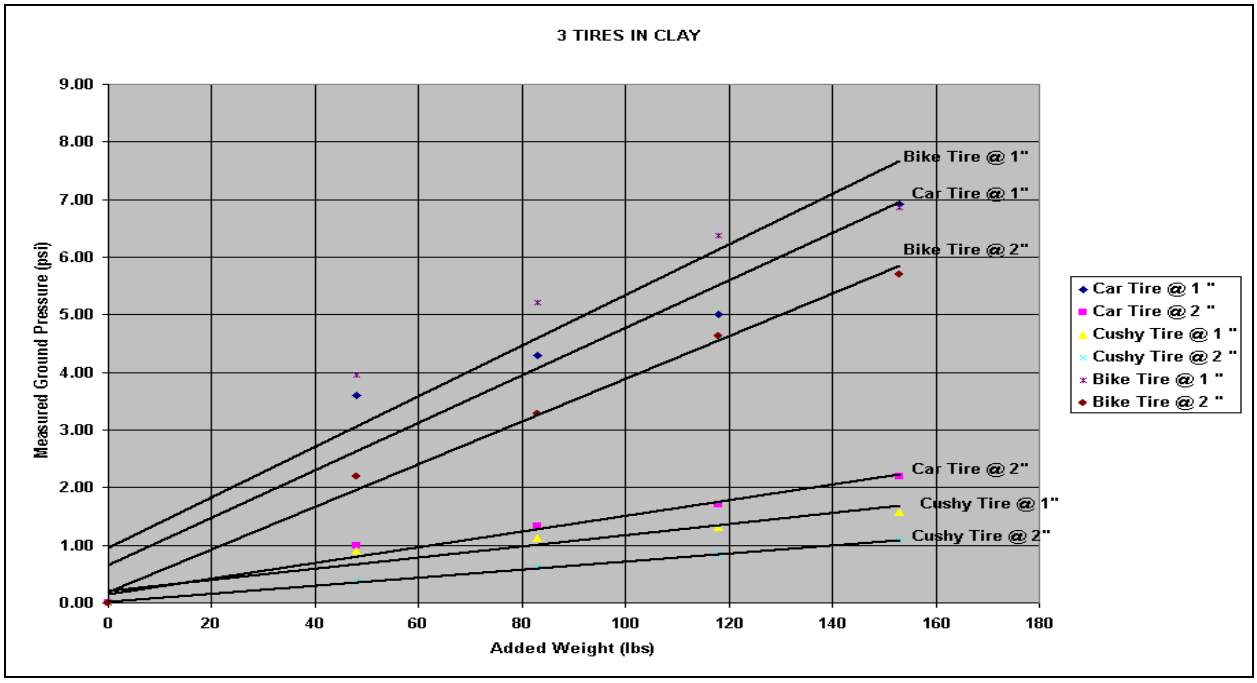

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With the anti-tank mine-like casing it is in, any external effects which the device feels due to the environment are also things which would be felt by a land mine.

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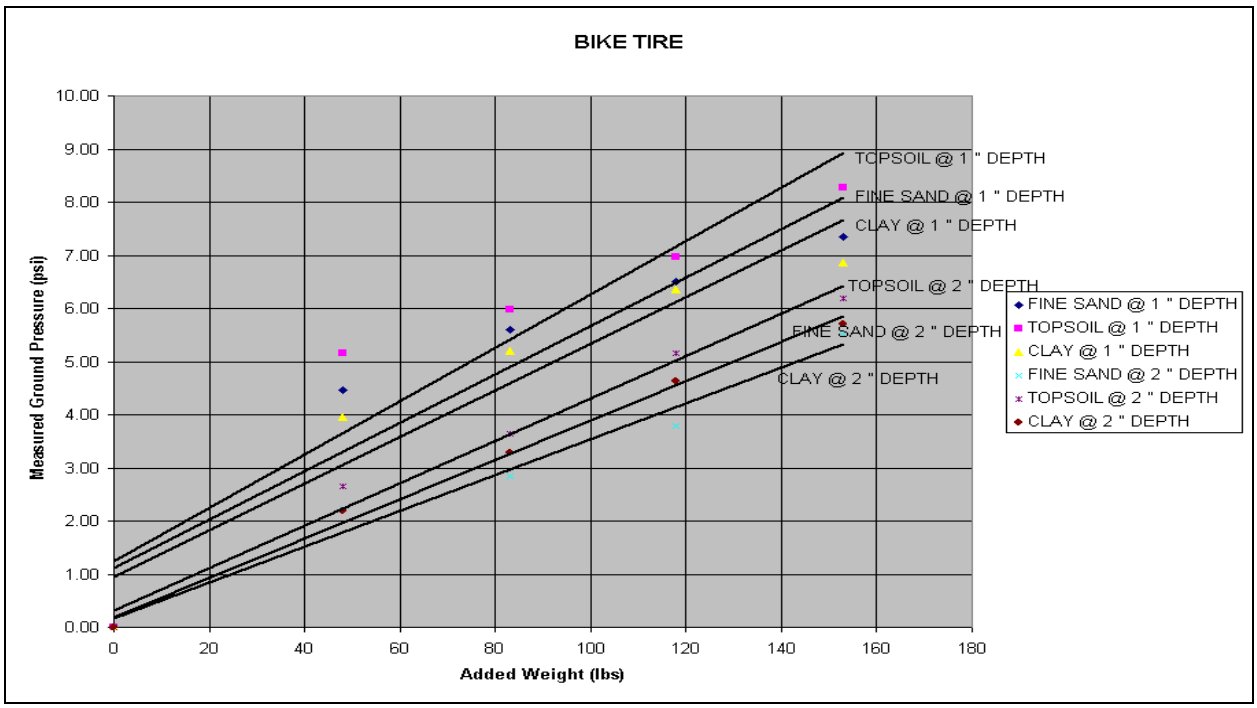

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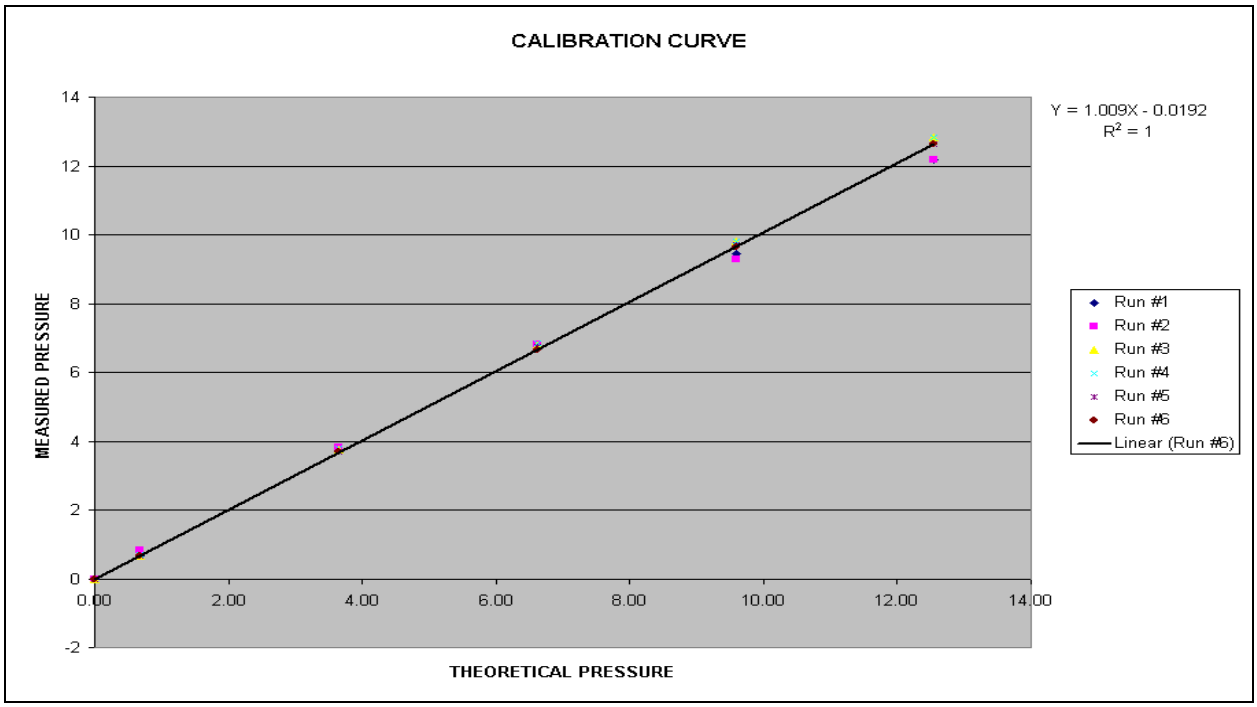

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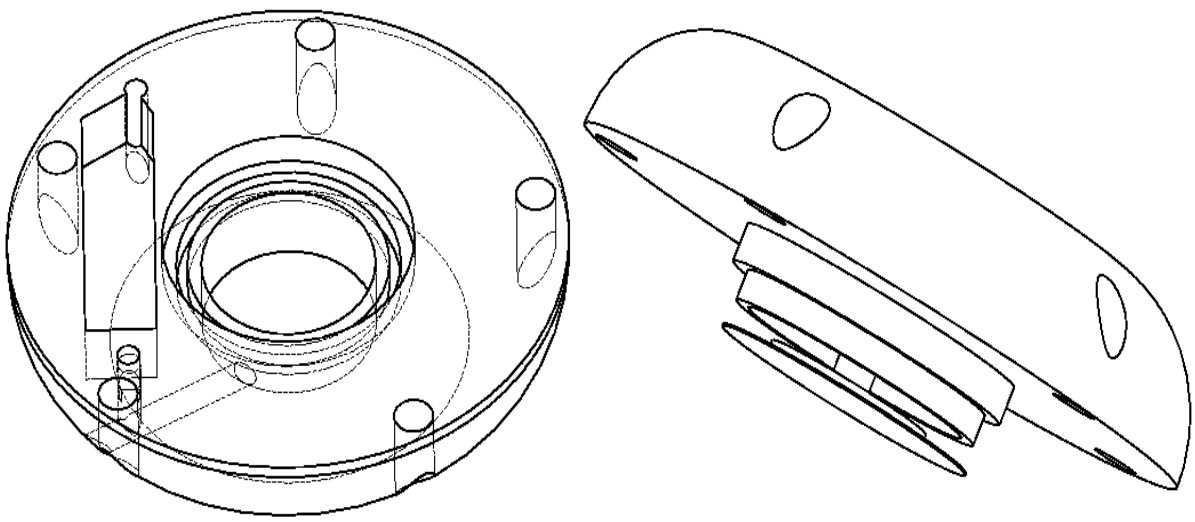

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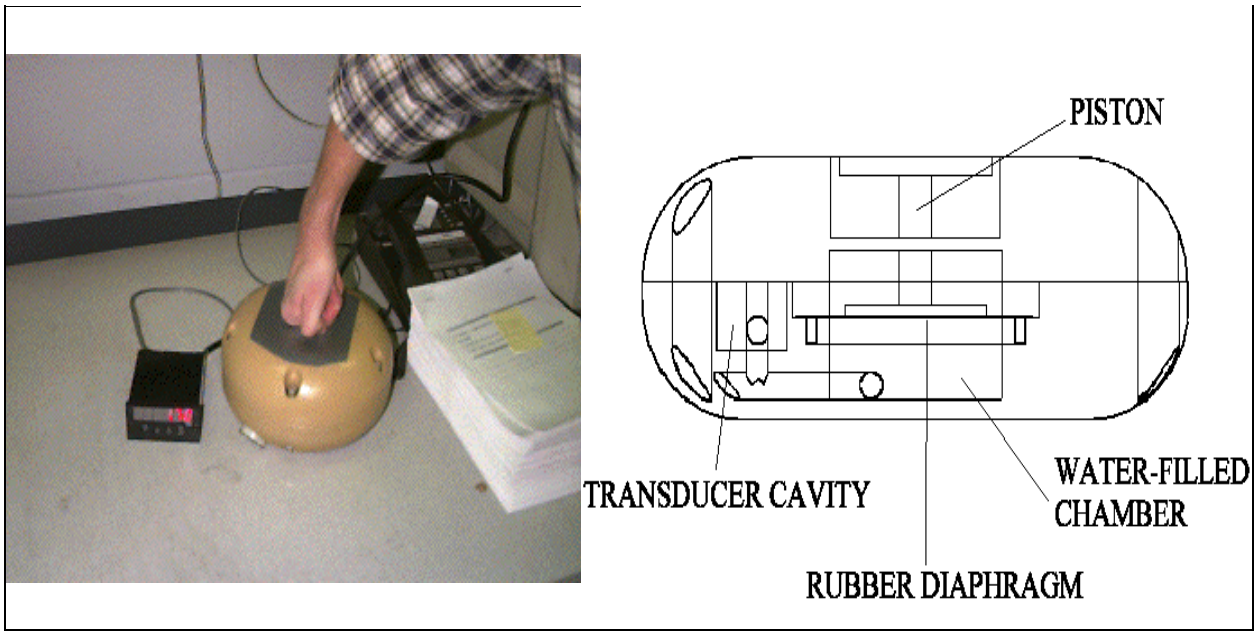

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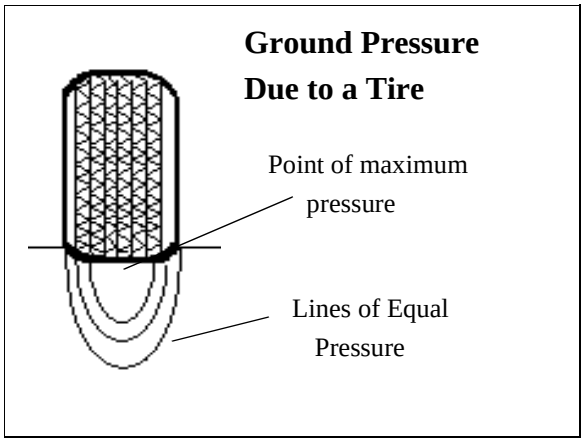
This paper will describe an experimental ground pressure measurement system, which can accurately and reliably measure the ground pressure under vehicular and environmental conditions. This can be used as a valuable tool in the vehicle design process. As changes are made in vehicle design, their effects on ground pressure can be analyzed.

2. Land Mines and Ground Pressure



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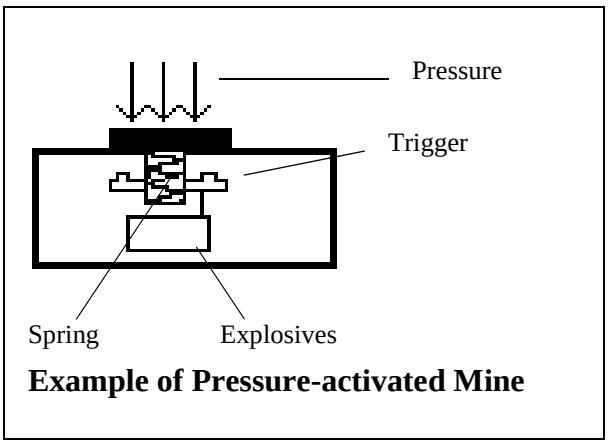

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The ground pressure exerted by a vehicle is an important constraint in demining because it is the direct cause of land mine detonation (see Figure #2). Many land mines are set off by a certain range of ground pressures. Anti-personnel land mines may detonate at a low range, approximately 3-12 psi, while anti-tank mines may detonte in a larger, higher range, approximately 10-80 psi. These pressure ranges can be used as a design constraint. For example, if a demining vehicle needs to safely traverse a minefield laden anti-tank mines, a ground pressure lower than 10 psi must be exerted.

GROUND PRESSURE MEASUREMENT SYSTEM

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ABSTRACT

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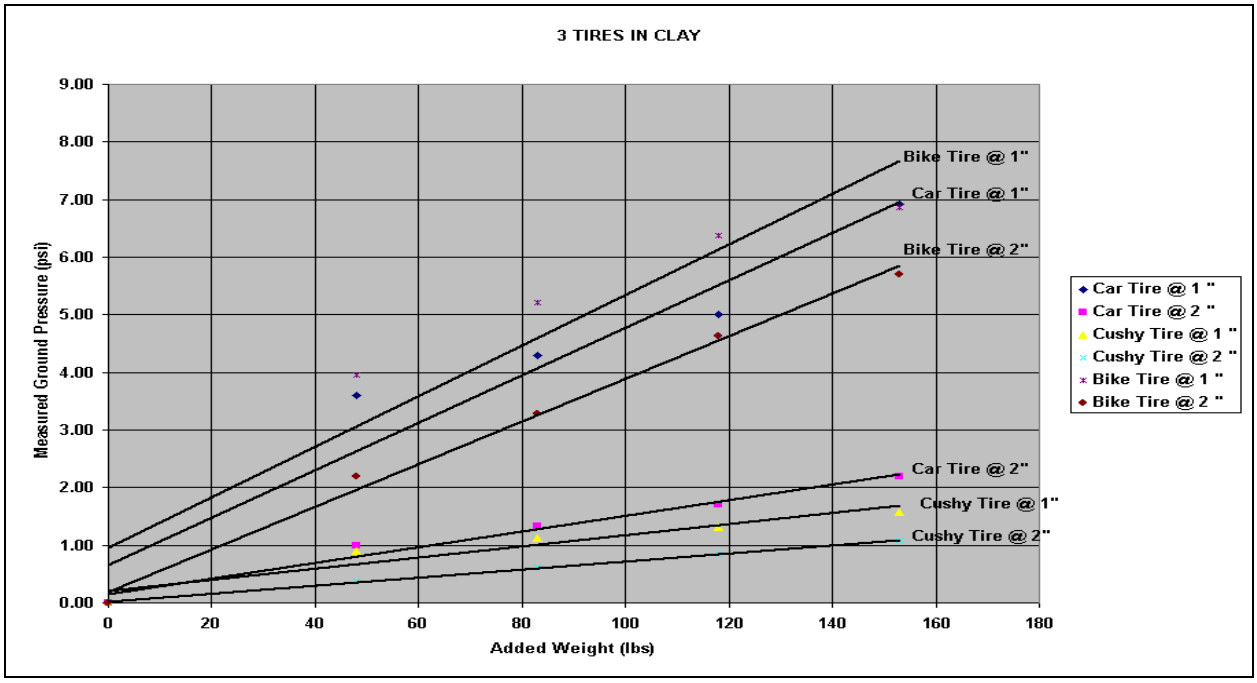

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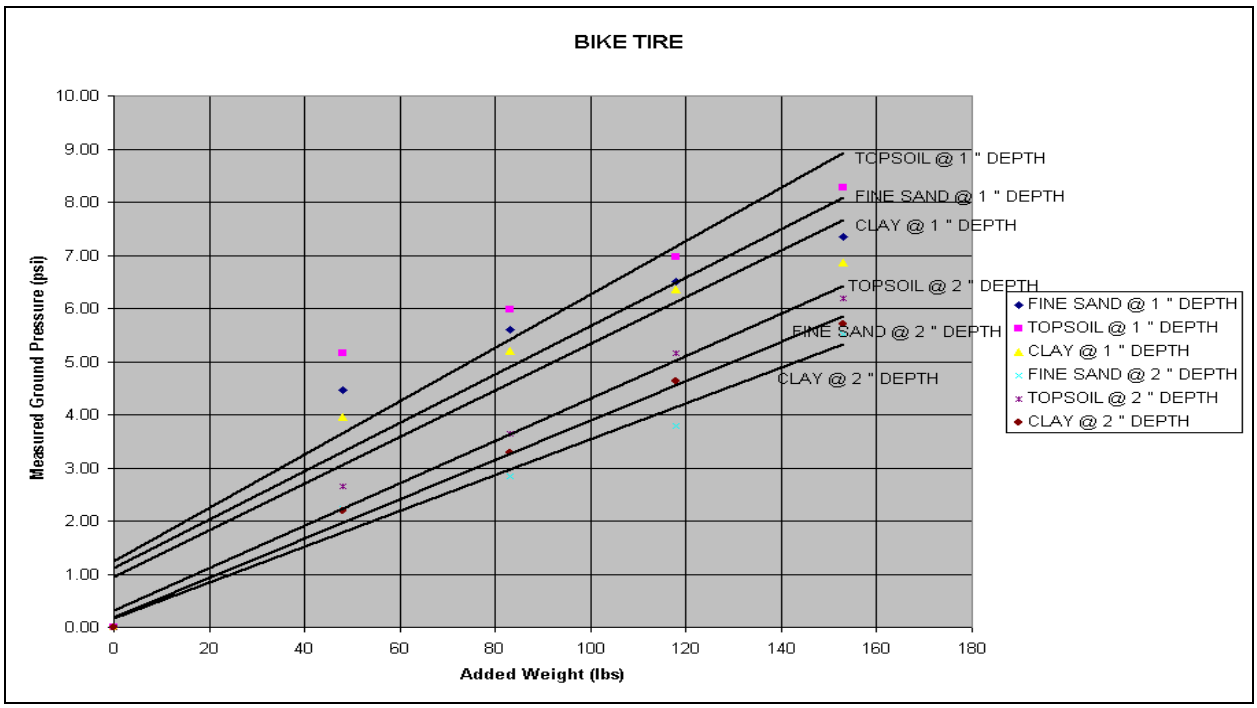

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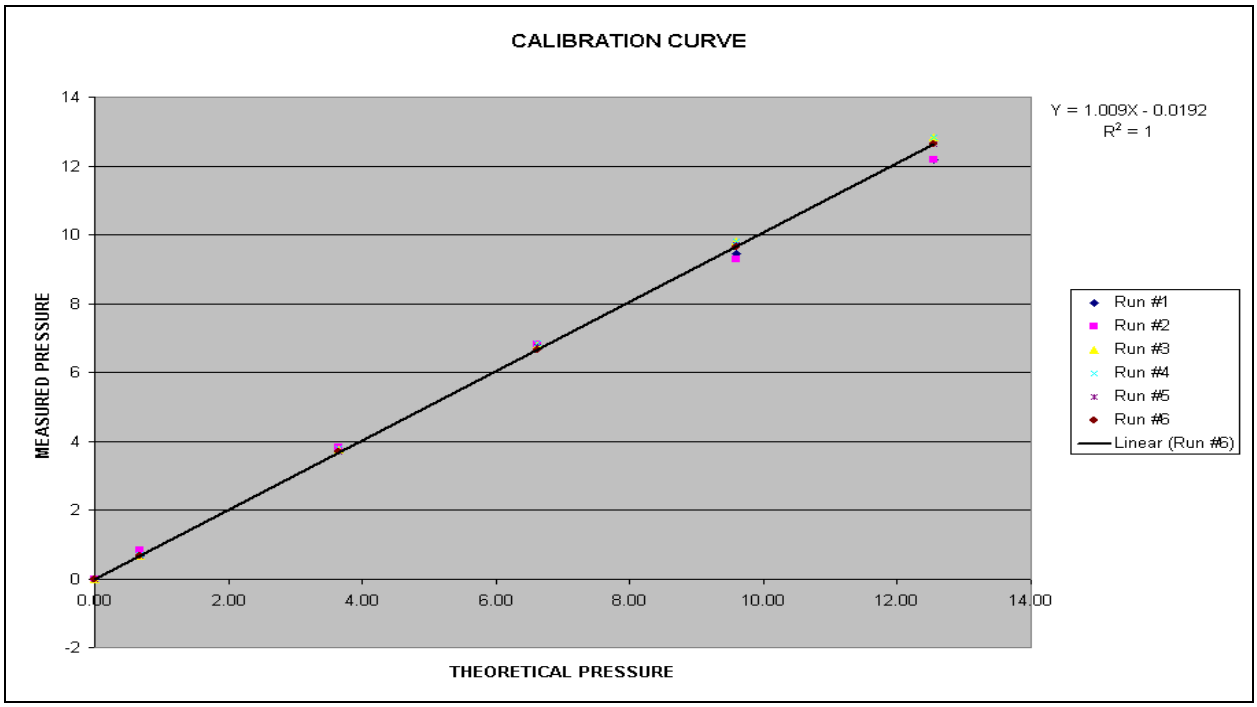

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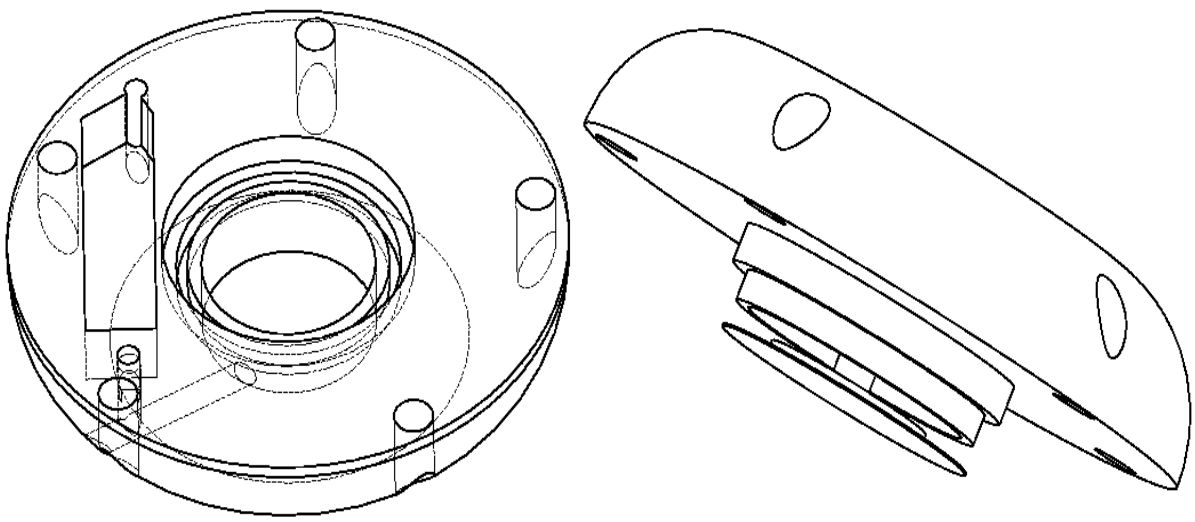

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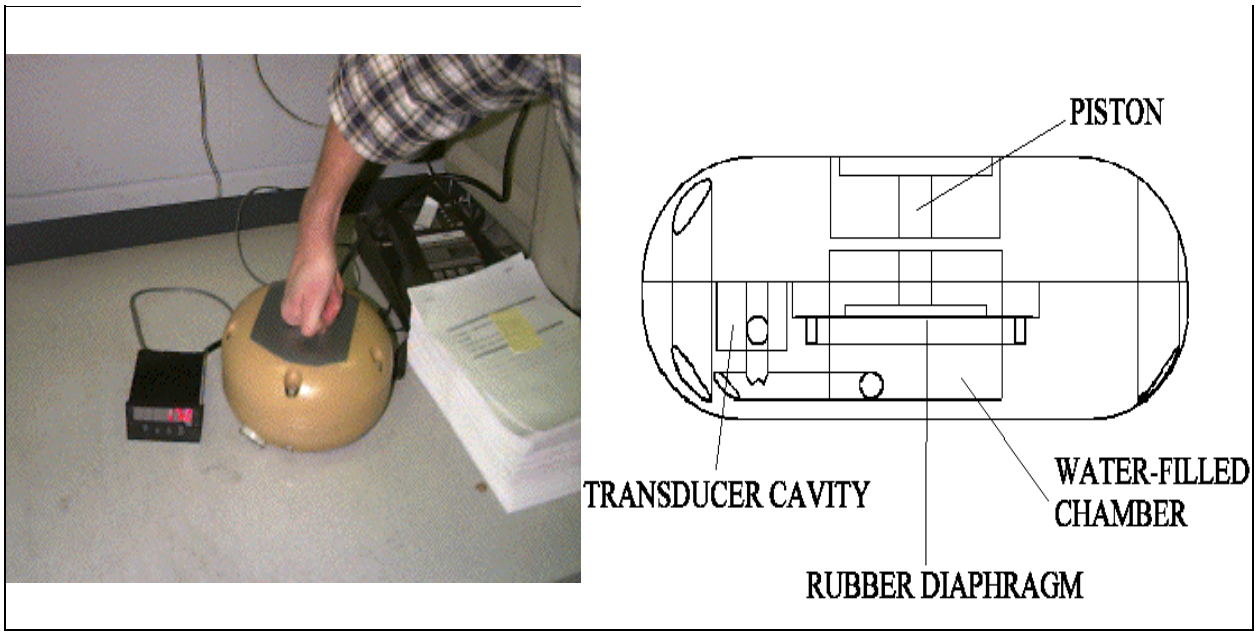

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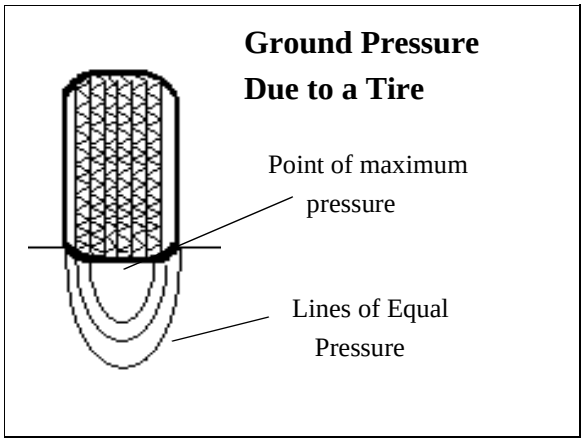

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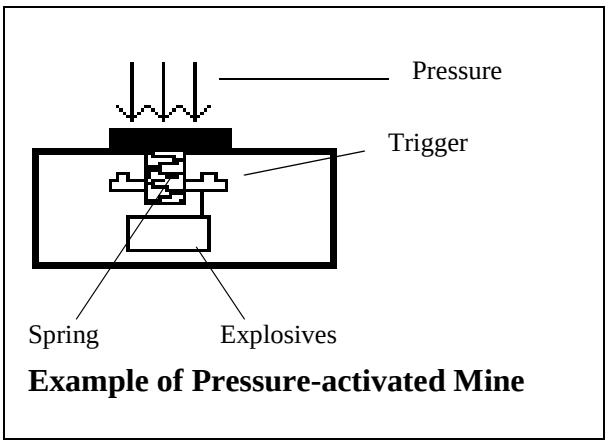

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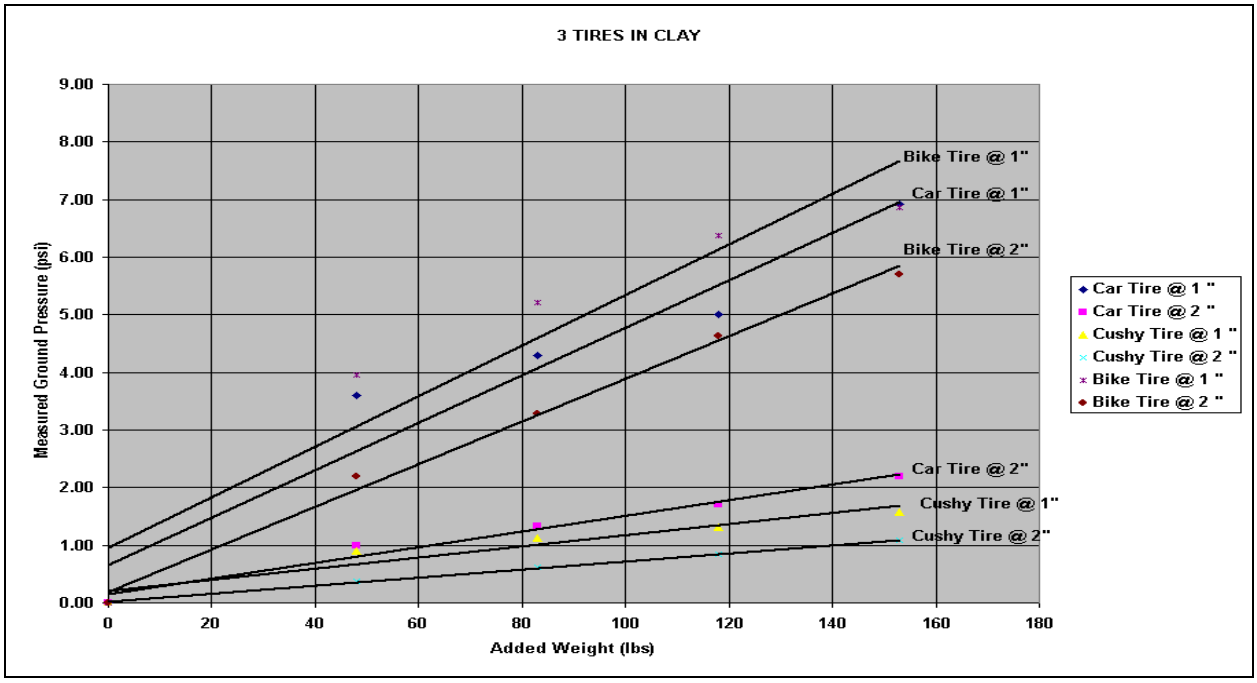

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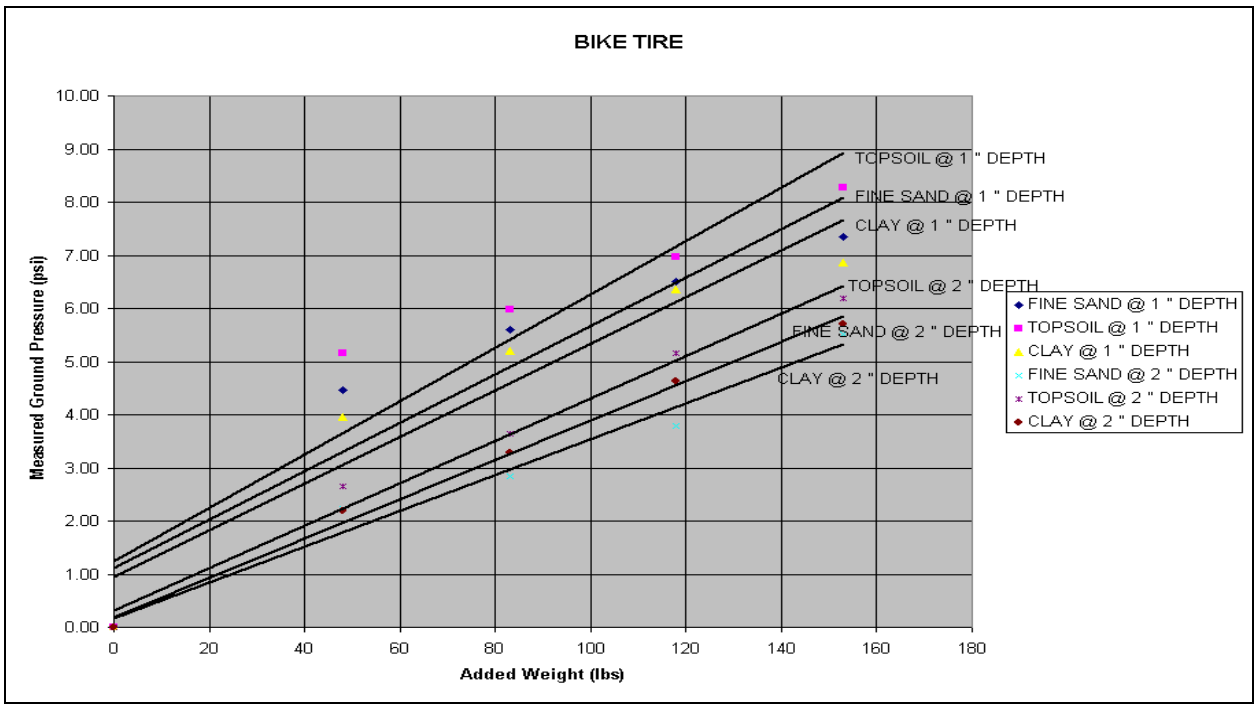

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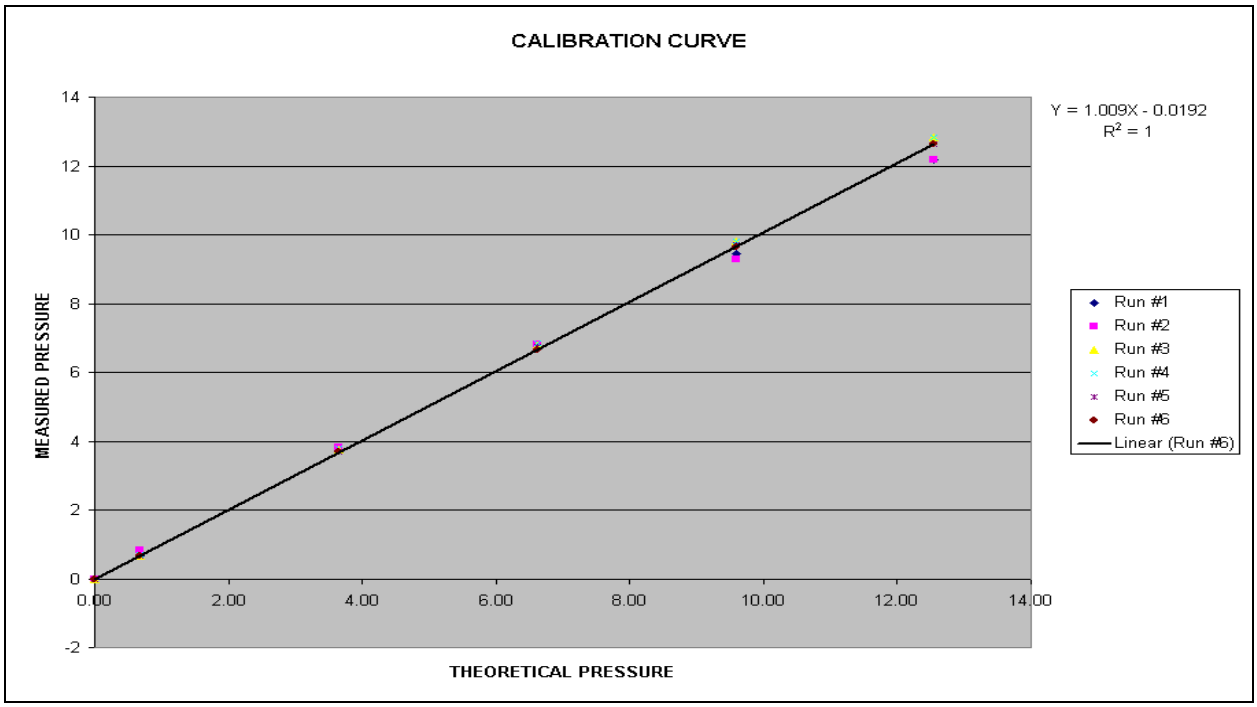

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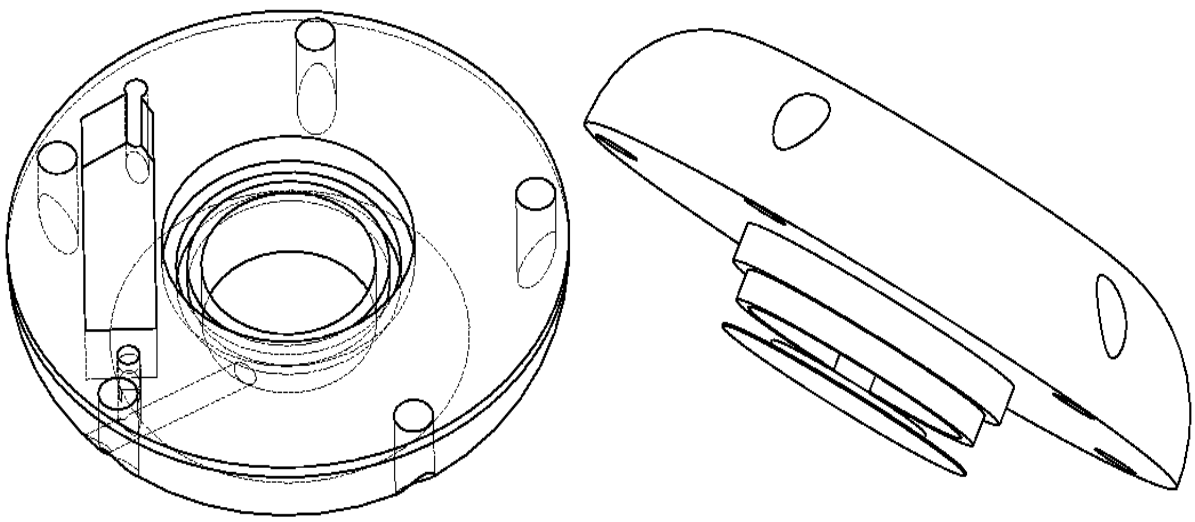

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These components easily fulfill the requirements set upon it. In order to be a useful tool, the device must be able to aid in the design of large as well as small vehicles. This means being able to measure a large pressure as well as a

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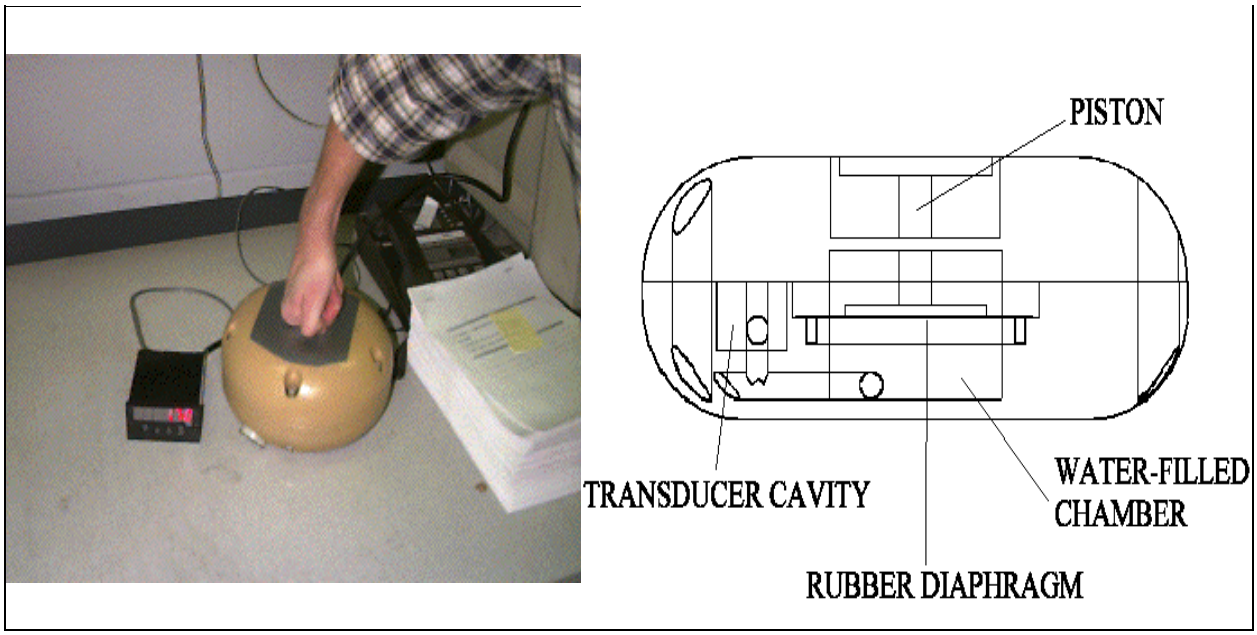

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The important piece of data to be output is the pressure felt at the plate on the top of the device. To measure this

thing to avoid, ground pressure should be minimized. In order to minimize the ground pressure, we must know what variables affect it and to what extent. These variables include vehicle parameters, soil characteristics, and task-related variables such as mobility, speed, etc. To determine the effects each variable has, there must be some way to measure ground pressure as a function of all these variables. But due to the wide range of variables entering this equation, a theoretical calculation of a vehicle's ground pressure is very difficult to make reliably. Since a theoretical calculation of ground pressure is difficult to make, another method is needed.

This paper will describe an experimental ground pressure measurement system, which can accurately and reliably measure the ground pressure under vehicular and environmental conditions. This can be used as a valuable tool in the vehicle design process. As changes are made in vehicle design, their effects on ground pressure can be analyzed.

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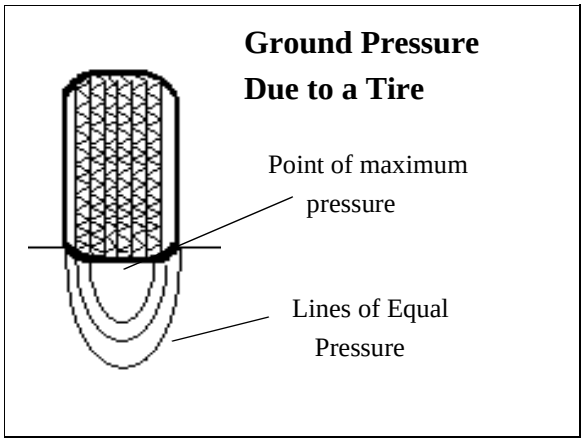

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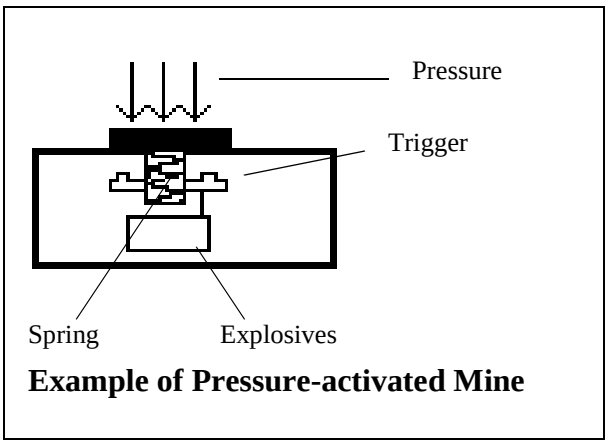

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The ground pressure exerted by a vehicle is an important constraint in demining because it is the direct cause of land mine detonation (see Figure #2). Many land mines are set off by a certain range of ground pressures. Anti-personnel land mines may detonate at a low range, approximately 3-12 psi, while anti-tank mines may detonte in a larger, higher range, approximately 10-80 psi. These pressure ranges can be used as a design constraint. For example, if a demining vehicle needs to safely traverse a minefield laden anti-tank mines, a ground pressure lower than 10 psi must be exerted.

GROUND PRESSURE MEASUREMENT SYSTEM

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ABSTRACT

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Currently vehicle designs concentrate on properly integrating sensors onto a vehicle, paying less attention to whether the vehicles are appropriate concerning safety.

This paper/presentation will describe a ground pressure measurement device which measures ground pressure as experienced by a land mine. Inside a rugged case similar an anti-tank mine, the device accurately measures pressures exerted by a vehicle which could detonate a mine. The device, with a wide pressure range and its sealed case, can be used under a wide variety of conditions. The tests performed to validate the device will be described, and a theoretical analysis of the results using terramechanics will be given. Finally, possible usage of this device will be given, including its applicability in the vehicle design process as well as possible usage as a training device.

Keywords: land mines, ground, pressure, measurement, dummy, surrogate, anti-tank, anti-personnel

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For demining vehicles, a main task is simply traversing a minefield successfully and maintaining the safety of the payload. A constraint unique to this task is the pressure which the vehicle exerts on the ground. If a vehicle exerts too much pressure on the minefield, the land mines will explode and damage or destroy the vehicle. As this is some-

for ground pressure is set, and the vehicle parameters such as size weight, and tires are constrained. In this way, the measurement device can be used to aid us in finding the optimal set of vehicle parameters for a certain situation.

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Not only is this ground pressure measurement device valuable in the process of designing a vehicle for demining, it could also be used to test whether existing vehicles are siutable for the task. Many new detection technologies are simply outfitted onto an readily available platform such as an ATV or a small backhoe. The ground pressure of these vehicles would be tested, and as customizations are made, the ground pressure will be modified as well.

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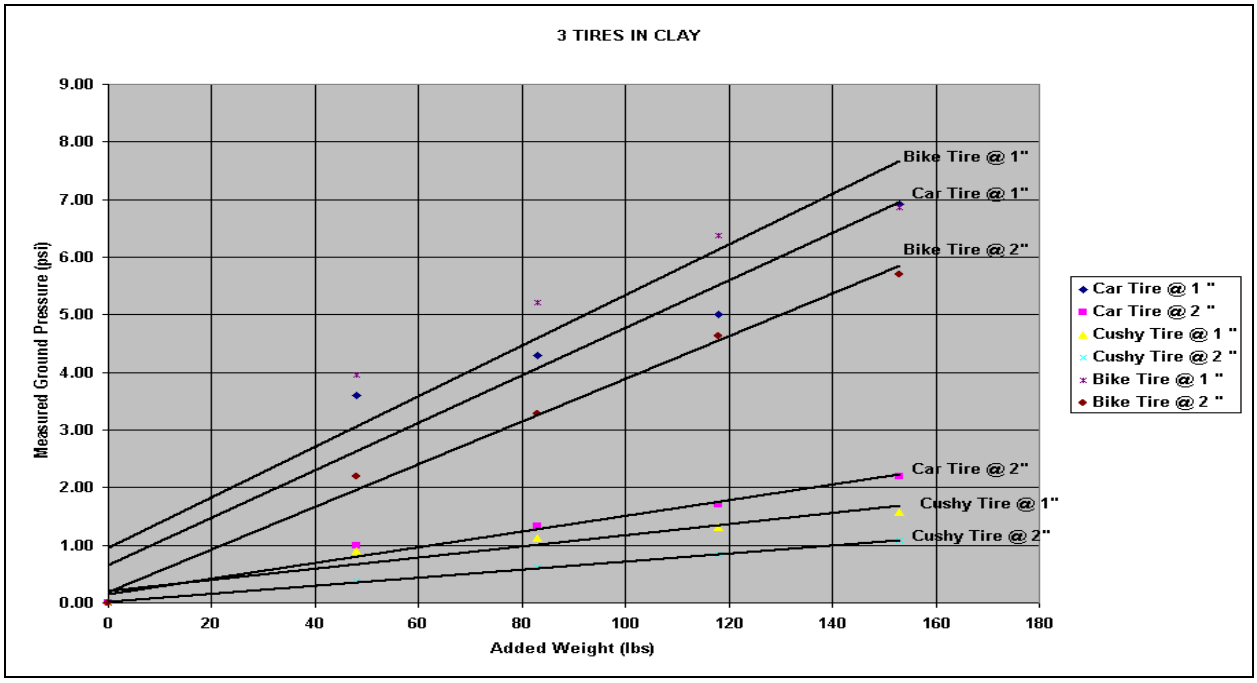

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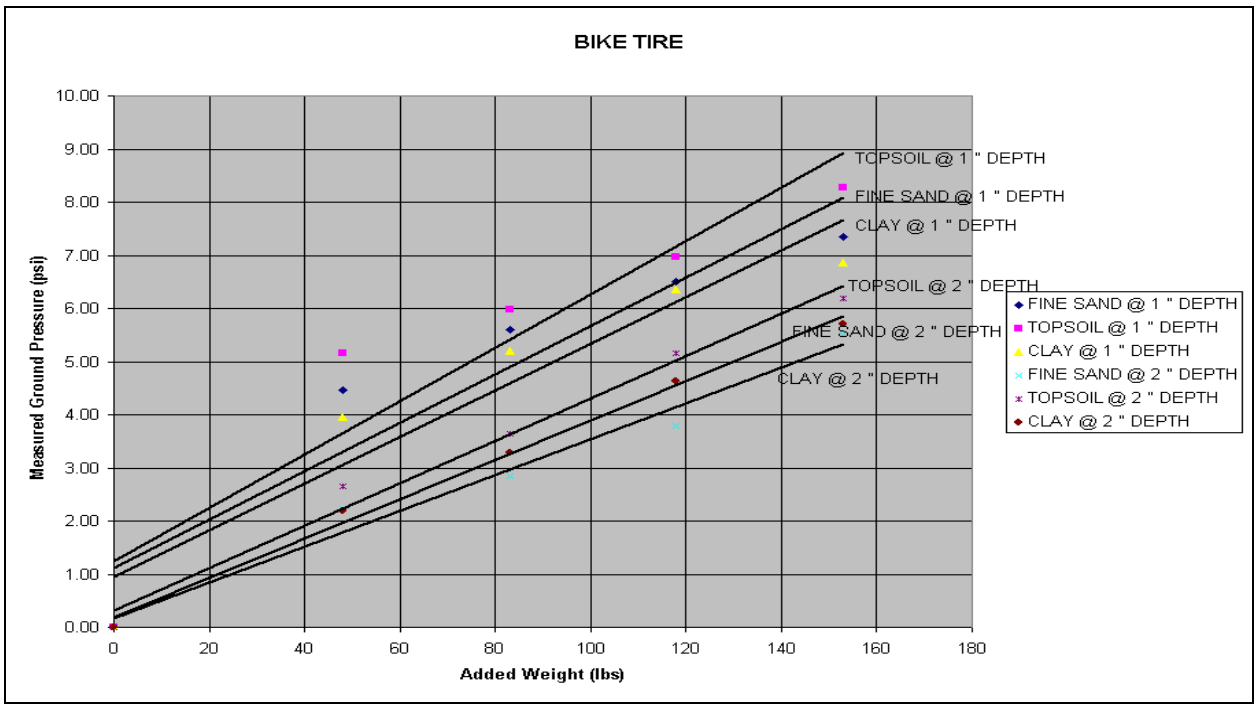

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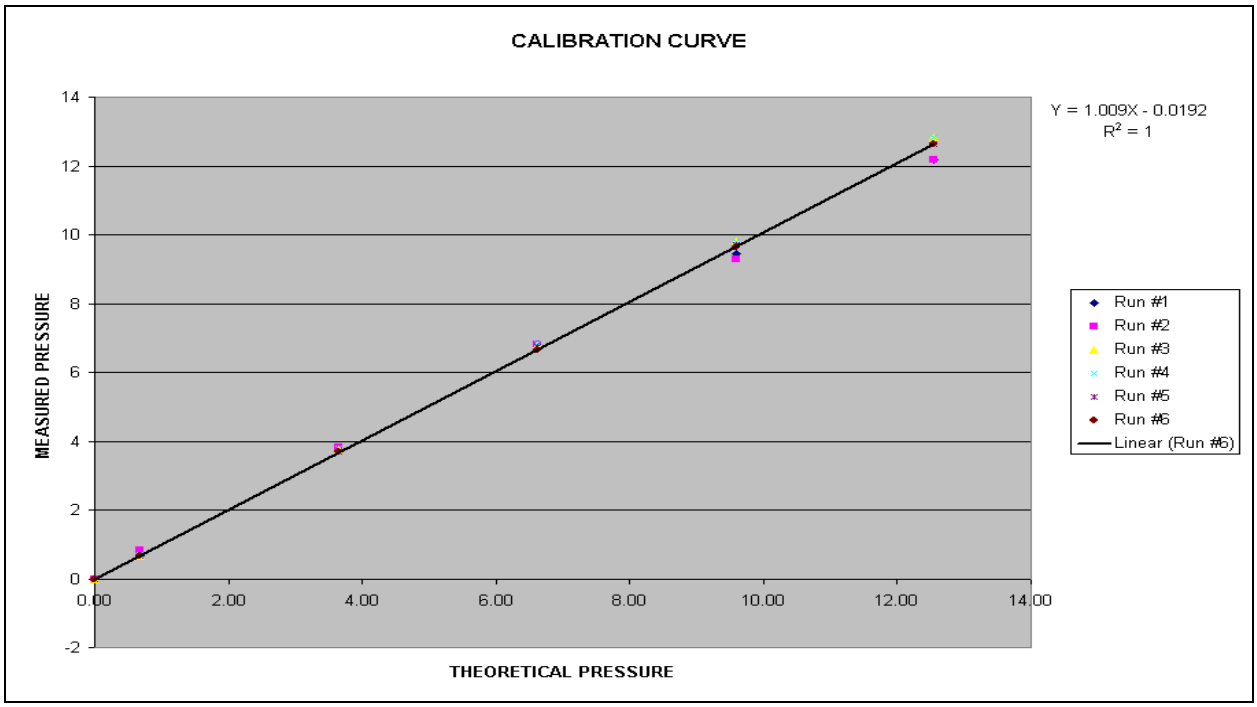

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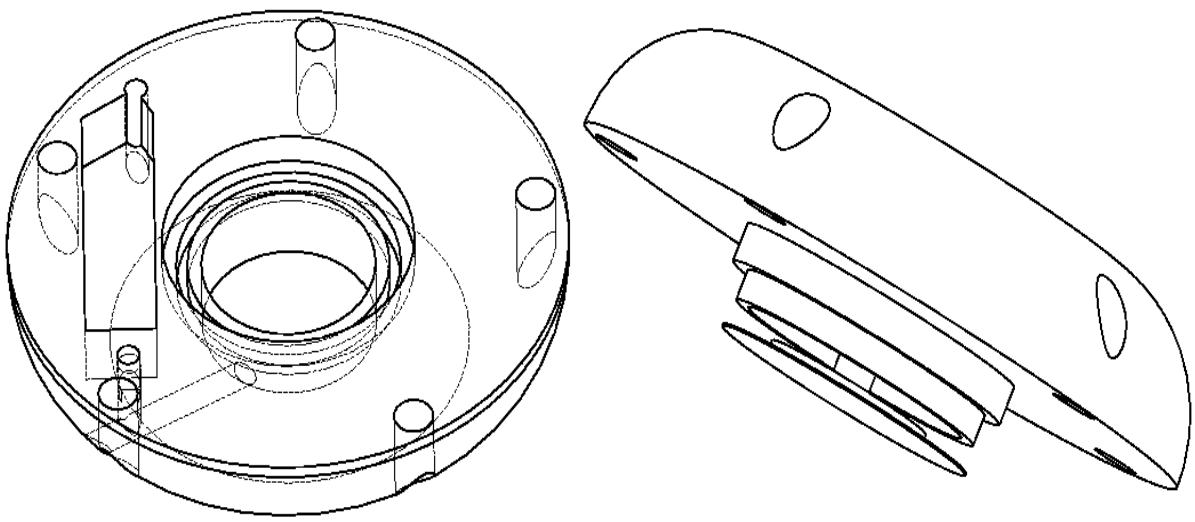

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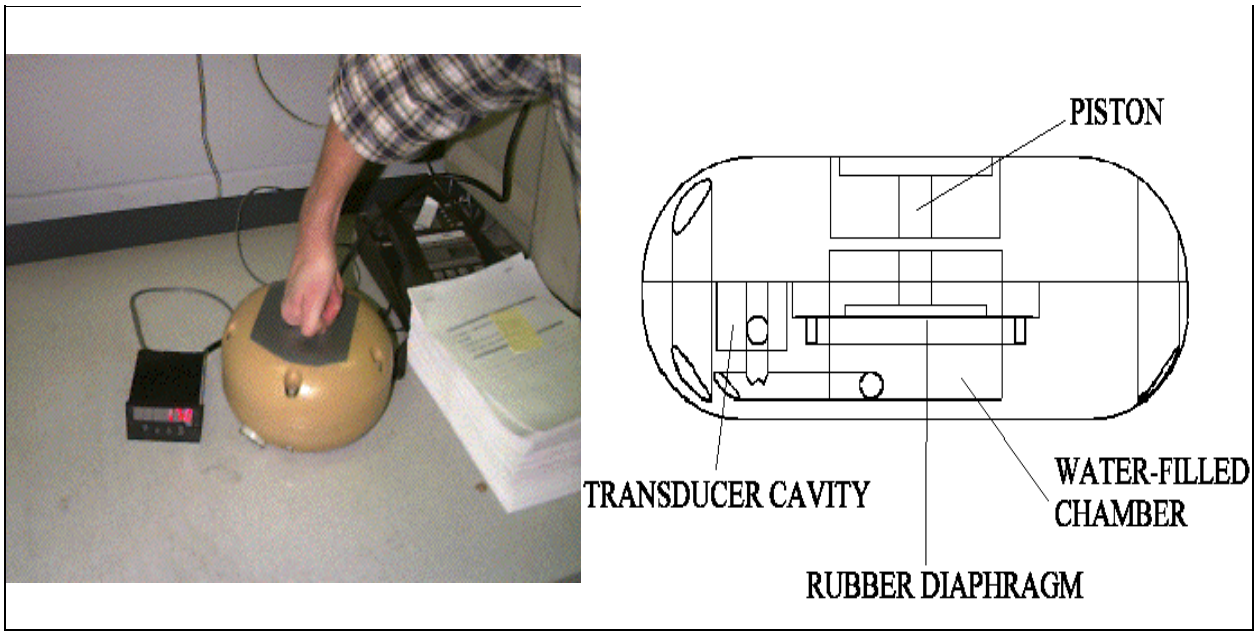

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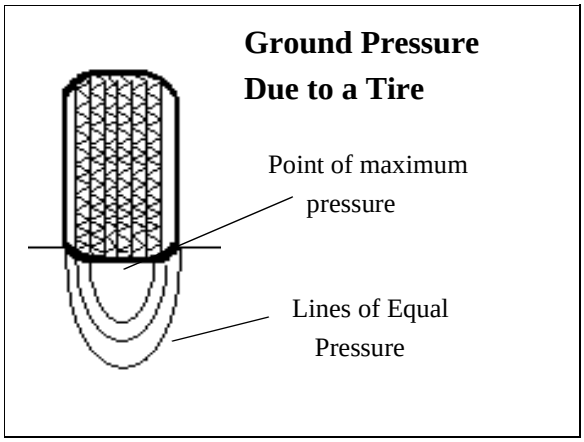

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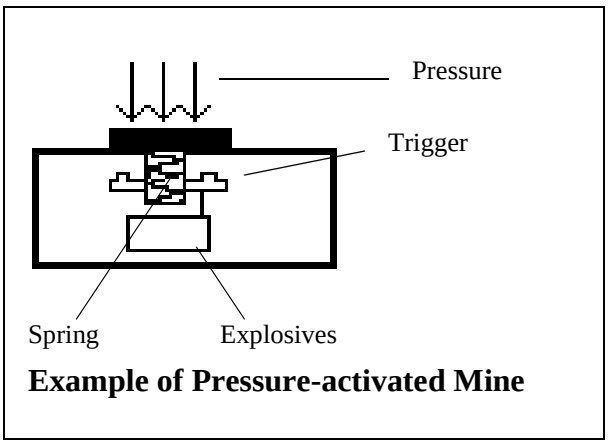

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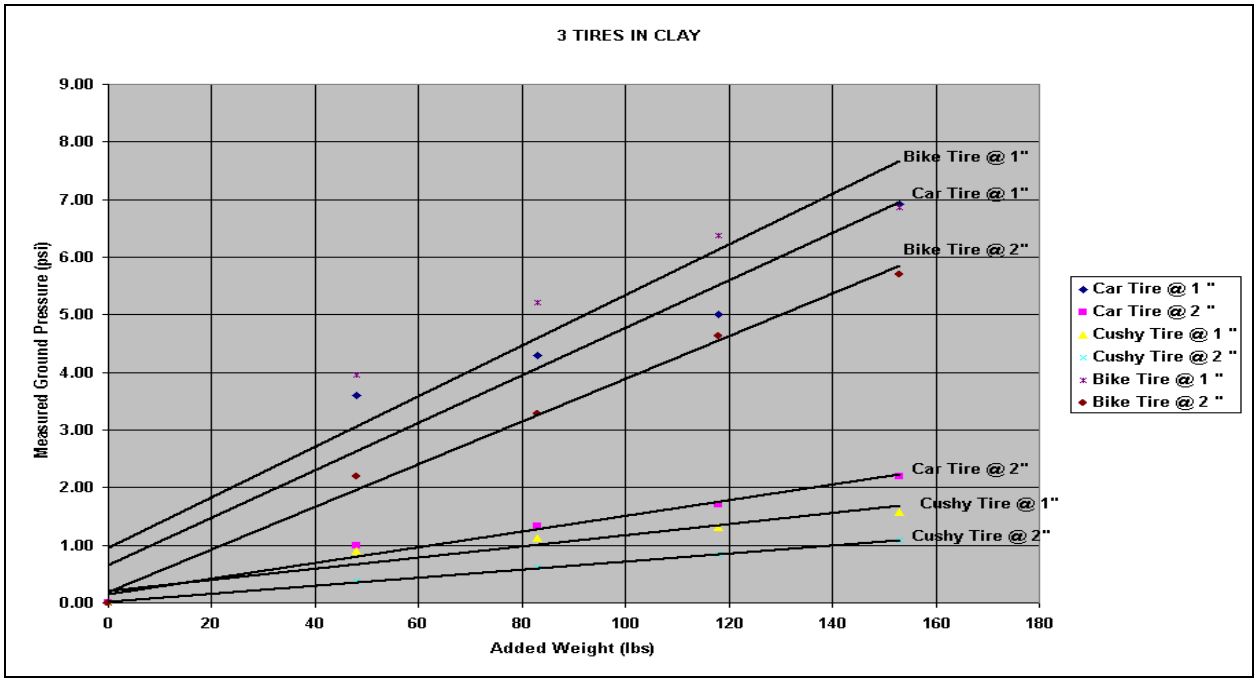

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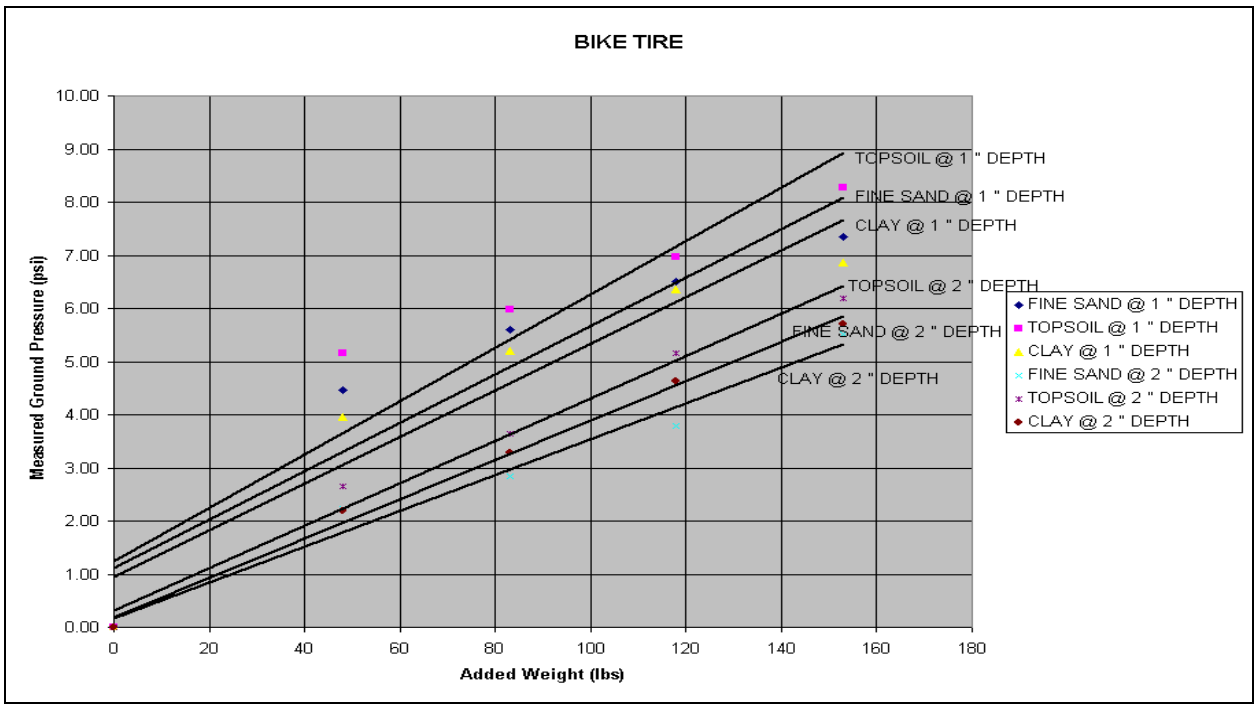

Figure #6: Analysis Example

In this example we see the case of a motor bike tire, laden with varying amounts of weight. Notice how the pressure increases consistently as the weight increases. In this analysis, the three different soils and the three different

small pressure. This also takes into account the wide range of detonation pressures on land mines. The approximate range of most anti-personnel mines is 3-12 psi, and the range for anti-tank mines is around 10-80 psi. This low value means that the device must measure very low values, the high values allows for a maximum measurement needed. The low value also sets a requirement on the accuracy needed on the device. Generally a fraction of the lowest value is used as the accuracy needed, in this case the accuracy is 0.10 psi.

4. Calibration

Before experimentation, a calibration curve (Figure #5) of the device's performance was generated. This was one by loading the device with various loads in no soil. This allowed an easy calculation of the actual pressure (Weight / plate Area) to be made. In comparing the actual pressures to the measured pressures, we see that the device works remarkably well.

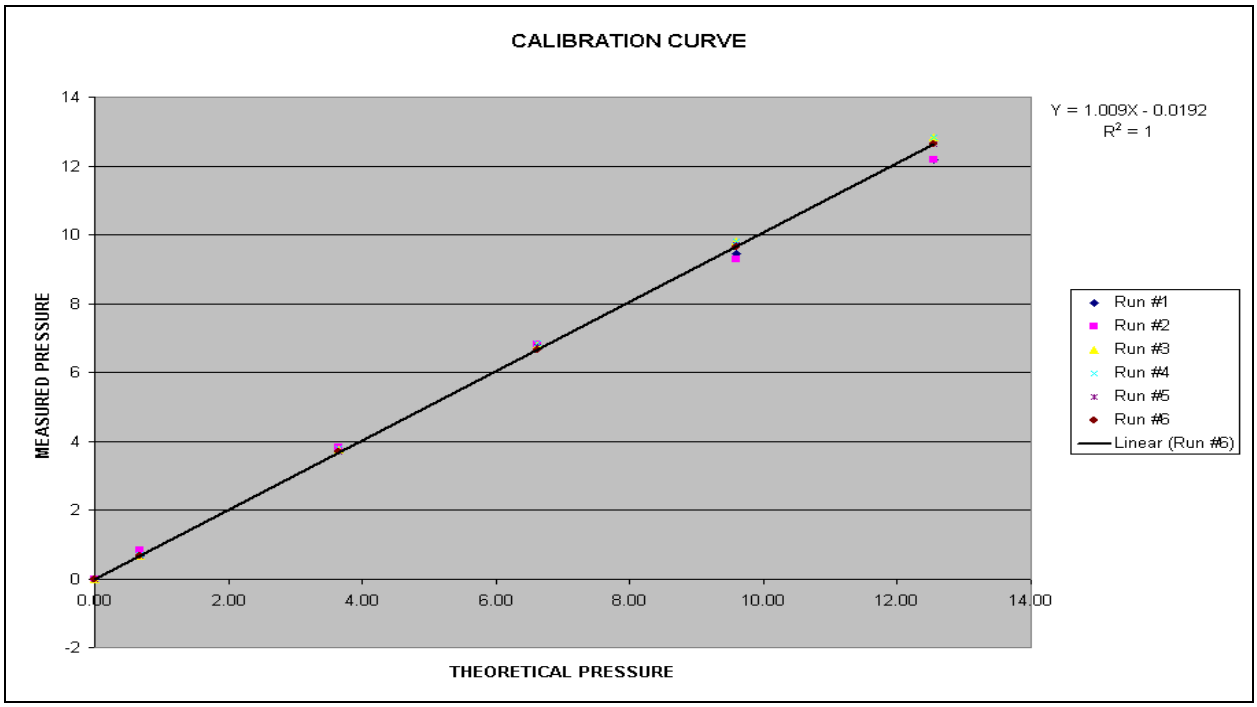

Figure #5: Calibration Curve

The calibration curve show a function of Y = 1.009X. This slope so close to 1 shows that the output of the device can be relied on. This device does not require different calibration depending on the environment the device is in.

pressure, the piston transfers the pressure down to the water-filled chamber in the center. Through the water, the pressure is transferred to a pressure transducer, which is fit in a cut-out chamber inside the casing. Connecting the water-filled chamber and the transducer are two drilled channels. This allows the pressure to be equally transferred from the top plate to the water and to the transducer.

The device was assembled from two halves, which fit snugly together, and sealed with 6 bolts around the perimeter of the casing. In the center of the casing, at the slot and ridge which forms the chamber, a thin diaphragm of 1/32“ thick rubber was used to seal a compartment. This sealed the water-filled chamber, preventing leaks and keeping measurements consistent. The transducer fit into a threading made in the plastic, creating a seal at that point. Asmall plug was put on the outside of the device where one of the holes was drilled through.

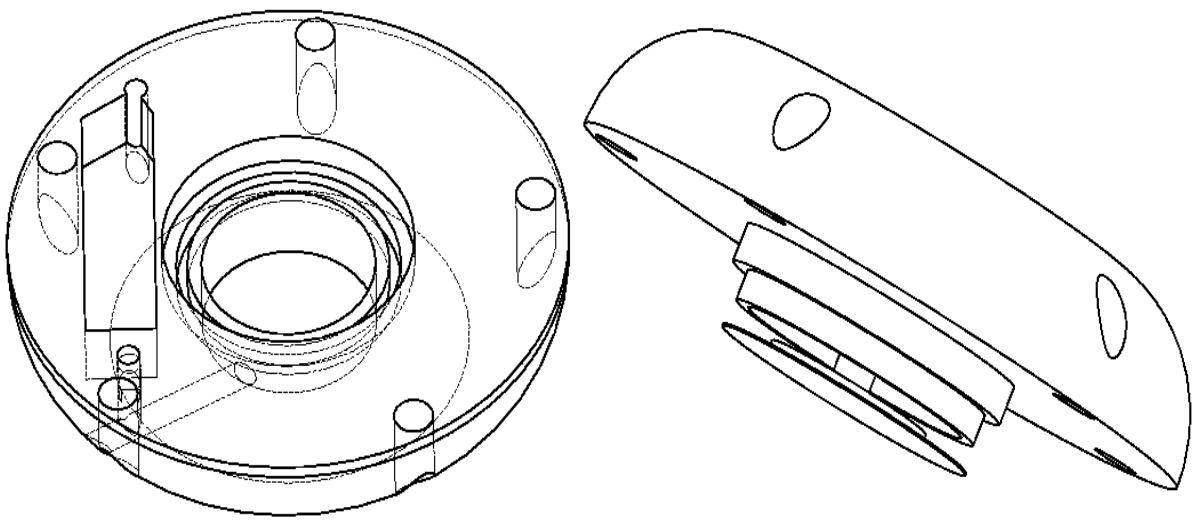

Figure #4: Device before assembly

The plastic casing was obtained from Mil Corporation. The pressure transducer used in this prototype was a Series 30 from pressure systems. It is cylindrical with about a one inch diameter and five inch length. Its range is 0-100 psig, with a static accuracy of 0.10 psi. This range and resolution fits in well with this application, as the range covers low pressures with a small enough accuracy, and also convers the very high range for very heavy vehicles.

These components easily fulfill the requirements set upon it. In order to be a useful tool, the device must be able to aid in the design of large as well as small vehicles. This means being able to measure a large pressure as well as a

As land mines are buried beneath a layer of soil, the pressure they feel also depends on the depth at which they are buried. Pressure from a load source on the surface creates arcs of equal pressure beneath the ground (see Figure #1). These arcs can show how although a vehicle may not perfectly drive over a mine, it may still set one off. This also shows that a simple calculation of weight over tire area cannot be done in the case of buried mines.

The ground pressure which a vehicle exerts in a certain environment depends on the vehicle's size, weight distribution, and tire properties. This allows for many customizations to be made in order to fit the vehicle within the ground pressure constraint. Using this measurement device, we can determine which customizations affect the ground pressure most significantly.

3. Measurement Device Description

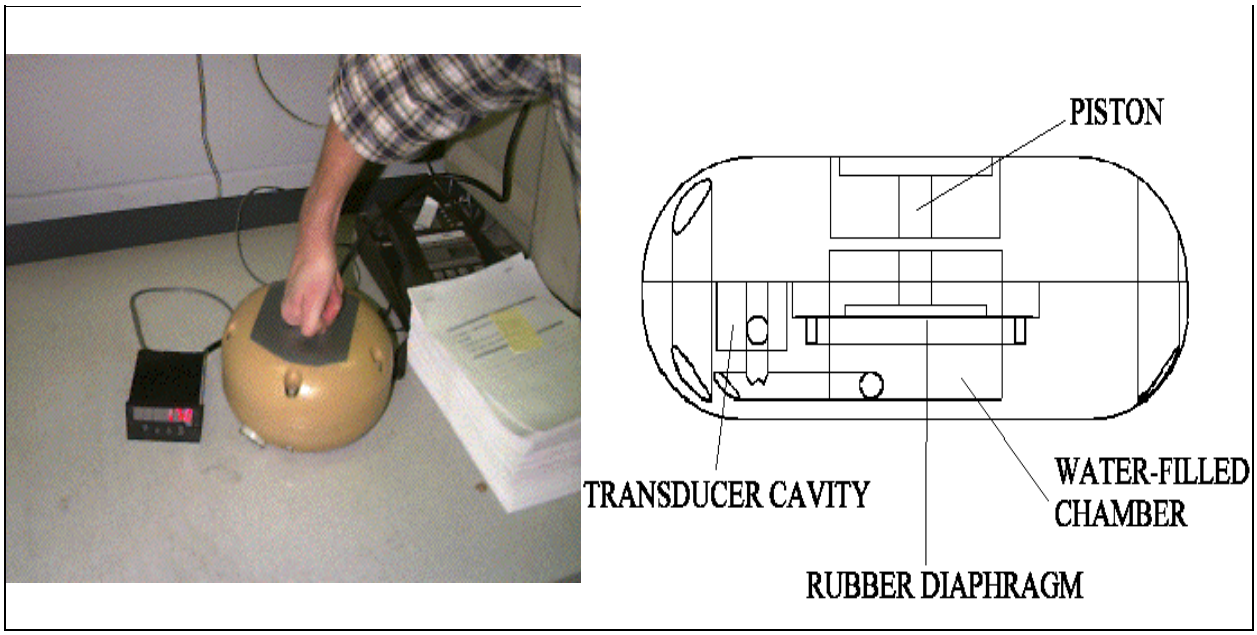

Figure #3: Ground Pressure Measurement Device

The concept of the measurement device is based on a simple water-based piston mechanism. It contains a small piston, a water-filled cylindrical chamber, and a pressure transducer. All of these items are built into a plastic case similar an anti-tank mine. Outside of the casing is a small power supply/ readout device, connected to the transducer. The transducer wiring comes out through a hole in the casing which is dug from the transducer area.

The important piece of data to be output is the pressure felt at the plate on the top of the device. To measure this

thing to avoid, ground pressure should be minimized. In order to minimize the ground pressure, we must know what variables affect it and to what extent. These variables include vehicle parameters, soil characteristics, and task-related variables such as mobility, speed, etc. To determine the effects each variable has, there must be some way to measure ground pressure as a function of all these variables. But due to the wide range of variables entering this equation, a theoretical calculation of a vehicle's ground pressure is very difficult to make reliably. Since a theoretical calculation of ground pressure is difficult to make, another method is needed.

This paper will describe an experimental ground pressure measurement system, which can accurately and reliably measure the ground pressure under vehicular and environmental conditions. This can be used as a valuable tool in the vehicle design process. As changes are made in vehicle design, their effects on ground pressure can be analyzed.

2. Land Mines and Ground Pressure

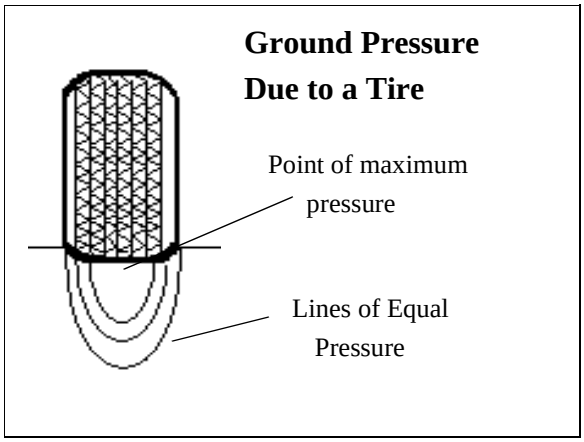

Figure #1

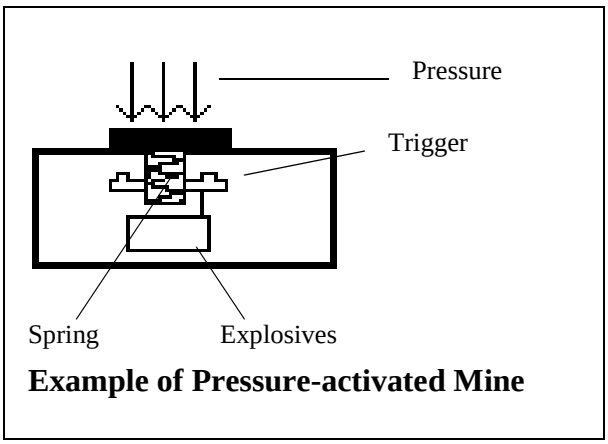

Figure #2

The ground pressure exerted by a vehicle is an important constraint in demining because it is the direct cause of land mine detonation (see Figure #2). Many land mines are set off by a certain range of ground pressures. Anti-personnel land mines may detonate at a low range, approximately 3-12 psi, while anti-tank mines may detonte in a larger, higher range, approximately 10-80 psi. These pressure ranges can be used as a design constraint. For example, if a demining vehicle needs to safely traverse a minefield laden anti-tank mines, a ground pressure lower than 10 psi must be exerted.

GROUND PRESSURE MEASUREMENT SYSTEM

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ABSTRACT

An important constraint upon the design of unmanned demining vehicles is the pressure they exert on the ground. To provide for the safety of the expensive equipment carried, vehicles designed to detect land mines must disturb the ground in a mine field as little as possible.

Currently vehicle designs concentrate on properly integrating sensors onto a vehicle, paying less attention to whether the vehicles are appropriate concerning safety.

This paper/presentation will describe a ground pressure measurement device which measures ground pressure as experienced by a land mine. Inside a rugged case similar an anti-tank mine, the device accurately measures pressures exerted by a vehicle which could detonate a mine. The device, with a wide pressure range and its sealed case, can be used under a wide variety of conditions. The tests performed to validate the device will be described, and a theoretical analysis of the results using terramechanics will be given. Finally, possible usage of this device will be given, including its applicability in the vehicle design process as well as possible usage as a training device.

Keywords: land mines, ground, pressure, measurement, dummy, surrogate, anti-tank, anti-personnel

1. Introduction

For demining vehicles, a main task is simply traversing a minefield successfully and maintaining the safety of the payload. A constraint unique to this task is the pressure which the vehicle exerts on the ground. If a vehicle exerts too much pressure on the minefield, the land mines will explode and damage or destroy the vehicle. As this is some-