Harman Motor Works' Pneumatic Tractor Mk1 Operator's Manual

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Contents

1. Purpose of this Manual

This manual has been written to provide an in-depth understanding of the Pneumatic Tractor Mk1 by Harman Motor Works.

This manual is so structured to provide a background on the components of the Tractor and also covers operation and maintenance tasks.

This manual is not intended to provide instruction on modifying the Tractor in any way, shape or form, and those who choose to undertake such modifications do so at their own risk.

2. Notes about this Manual

Symbols are provided throughout this manual which are designed to direct attention to important information. The meaning of each of the symbols is shown below:

 - this symbol denotes that damage or injury may occur if care is not taken. Pay particular attention to the information provided here.

 - this symbol provides noteworthy information.

3. Components of the Tractor

The Tractor's main components can be divided into the following four distinct items which are further detailed in this section:

1. Air system
2. Engine
3. Transmission
4. Brake system

Air System

The air system can be considered as the most critical component of the Tractor. Both the engine and the brakes rely on a supply of air pressure to operate and this supply of air must be of a sufficient pressure; therefore it is in the operator's best interests to ensure that the air system is free of leaks and other irregularalities at all times.

The air system in the tractor comprised of a network of flexible pneumatic pipes and directional air valves which serve to direct and restrict air pressure accordingly.

Source

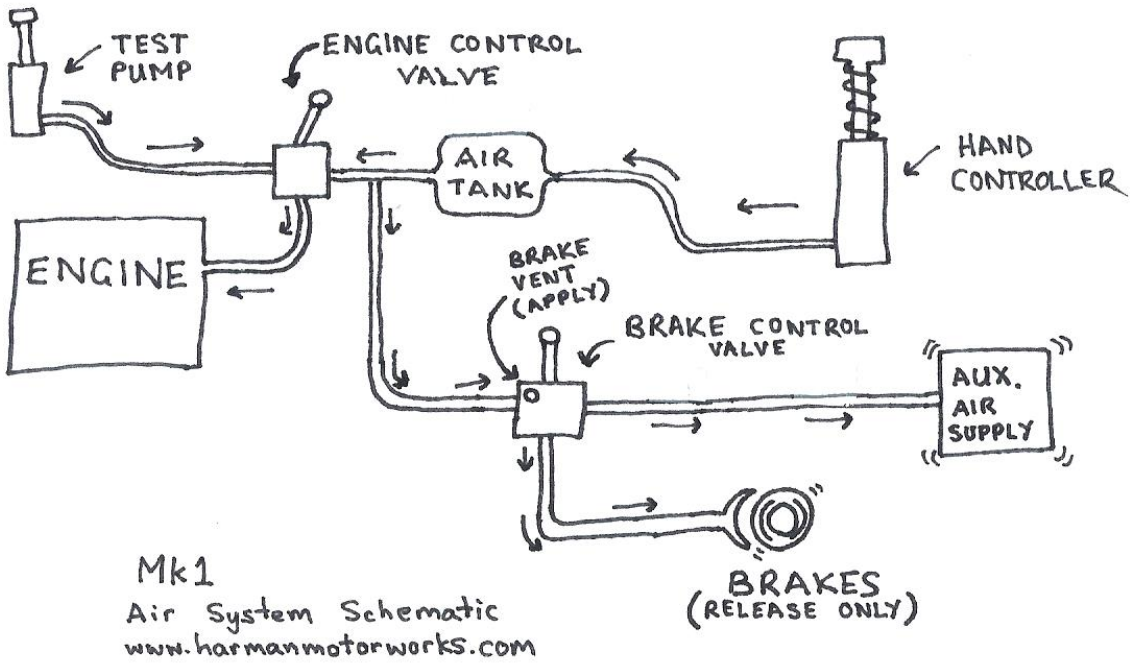
Air pressure is sourced from a hand controller which serves as a pump to furnish a pressurised flow of air to the Tractor. During normal operation of the Tractor, the hand controller should only need to be operated in a regular, deliberate manner and not at an excessive rate.

⚠ It is not recommended to utilise compressed air from mechanical sources (such as air compressors) as the air pressure and flow output from these machines may be unpredictable and can cause damage to the Tractor's air system and its associated components.

Air System Schematic

Fully understanding the operation of the air system will allow the operator to better operate the Tractor and troubleshoot any problems if and when they occur. The air system is complex and whilst little maintenance is required during normal operation, a keen ear and sound understanding of the system will allow the operator to identify problems and rectify them with minimal fuss.

The following schematic provides a visual representation of the air system with their explanations provided under 'Air System Components'.



Air System Components

The names and labels given to components shown in the schematic above are explained further in this section.

Hand Controller

The hand controller provides the chief source of air for the pneumatic system. It consists of the hand controller unit and pneumatic piping which connects to the rear pneumatic fitting of the tractor.

Air Tank

The air tank receives air from the hand controller only and is designed to regulate air pressure within the air system and ensure a smooth delivery of air to the various pneumatic components. Generally, no specific procedures or maintenance of the air tank is required.

Engine Control Valve

The engine control valve primarily controls the routing of air pressure to the engine, however it also serves as a pressure venting/exhaust device as required, as it is also connected to the rest of the Tractor's air system. The engine control valve offers three distinct settings:

- RUN – in this setting, air from the air tank (which is in turn sourced from the hand controller) is allowed to enter the engine's cylinders and, if the pressure is sufficient enough, power the engine. Air can also simulataneously enter the rest of the Tractor's air system (i.e. the parking brake air system and the auxiliary air system), however at a reduced pressure.
- STOP – in this setting, air pressure from both the air tank or the test pump is NOT allowed to enter the engine. Instead, any incoming air from the air tank is routed directly to the rest of the air system of the Tractor (i.e the parking brake air system and the auxiliary air system). This setting is useful for isolating the engine from the rest of the air system (in order to ensure maximum air pressure can enter the parking brake system for initial brake release, for example).
- TEST / E.STOP – in this setting, it is possible to operate the engine using the test pump (the hand controller will not function, as it will vent any air pressure directly out to atmosphere). Note that if you engage this setting during normal Tractor operation (e.g. whilst previously operating in 'RUN'), air in BOTH the air system and the engine is immediately vented to the atmosphere. This allows for an 'emergency stop' feature should you need to stop the engine immediately.

Test Pump

The engine on the Tractor is equipped with a low-capacity *test pump*. The sole purpose of this pump is to supply a volume of low-pressure compressed air run the engine at a very low speed, in order to check that it is running freely and without issue, since, if any problems are encountered, only low pressure air will be in-use and thus engine damage will be avoided.

Brakes

See Parking Brake System

Brake Control Valve

See Parking Brake Control Lever

Engine

The engine is responsible for converting compressed air into mechanical force which can move the Tractor. The engine is first and foremost a very clean machine. No unwanted exhaust fumes or deposits occur, and engine noise is not at all excessive. Further, since no great amount of heat or friction is generated by the engine during normal operation, only minor lubrication is required.

Type

The engine is a two-cylinder, double-acting pneumatic machine of the reciprocating type. The crankshaft of the engine is set at a 45 degree offset, which means that the engine can start itself from a dead stop and requires no external cranking assistance to start. The only requirement for the engine to start providing power is a supply of compressed air. This supply of compressed air is normally supplied via your hand controller.

Principles of Engine Operation

The engine operates because a flow of compressed air is directed to each of the two cylinders in a predetermined sequence. Once compressed air reaches the inside of the cylinder, it is directed to push against a piston, as it has nowhere else to go. Each piston in a cylinder is connected to the engine's crankshaft, which is forced to revolve as the pistons move up and down. Finally, the crankshaft is connected to the Tractor's transmission.

The engine can continue to run as compressed air flow to a given cylinder *alternates* as the piston in that cylinder moves up and down.

As the piston reaches the bottom of a cylinder, compressed air is routed to the bottom of the cylinder to push the piston upwards.

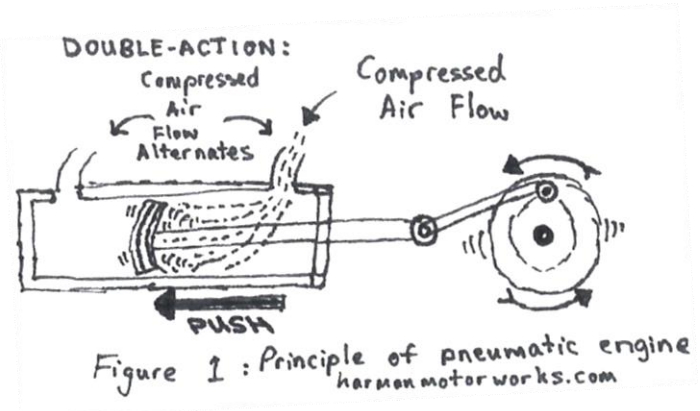


Figure 1 : Principle of pneumatic engine

When the piston reaches the top of the cylinder, the compressed air is routed to the top of the cylinder, pushing the piston down, and the cycle repeats as long as compressed air is supplied.

This is referred to as the 'double-acting' or 'double-action' process.

Figure 1 above shows this basic principle, however note that the piston is depicted as moving sideways (left-to-right) in the above drawing, whereas in the Tractor, the pistons are moving up and down. In either case, the principle of operation is precisely the same.

The result is a continuous rotation of the engine crankshaft, which is directed to the transmission, which then feeds power to the rear wheels.

Characteristics of the Engine

With regard to running characteristics, the pneumatic engine fitted to this Tractor can be likened to a steam engine, and perhaps also to a more distant cousin, the diesel engine; the pneumatic engine will furnish a very impressive amount of torque.

Depending on the pressure of the compressed air supply, overall engine speed is generally not high however and whilst the Tractor may appear to run slowly, the engine is able to supply more than enough torque to overcome most obstacles and will pull a great amount of load provided there is sufficient traction.

From running this Tractor it will be clear that the engine will very sufficiently supply torque to run the Tractor, as well as any other accessories or loads in addition. The pneumatic engine will rarely stall under load, and in fact, will continue to run at the risk of causing over-load to the transmission components.

⚠ Care must be taken when running the Tractor under heavy load, to ensure that excessive torque is not transmitted through the transmission, as the pneumatic engine will continue to run almost relentlessly even in the face of extreme loads and resistance. It is these characteristics of the pneumatic engine that make it so well-suited to its role powering the Tractor.

Timing

Timing refers to the duration and point at which compressed air pressure is directed to the top and bottom of each cylinder, as the engine runs. This routing of compressed air is controlled by two timing valves, one dedicated for each cylinder.

As the crankshaft of the engine rotates, it is keyed to operate each of the timing valves (through a system of connecting rods and timing gears) in a pre-determined, fixed sequence, allowing this action of compressed-air-routing to occur.

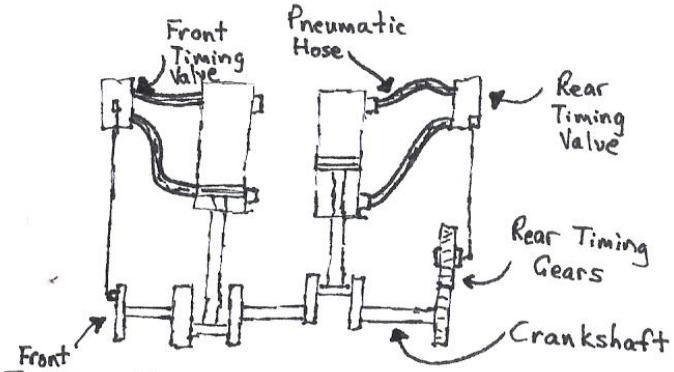


Figure 2: Side-view concept 2-cylinder pneumatic engine

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It must be noted that correct timing is absolutely critical to the operation of the engine, and thus, the timing sequence has been well-designed so that maximum performance and reliability from the engine can be achieved.

Should engine timing ever be adversely affected, the engine may run poorly or may not run at all.

The timing of the engine is fixed and is not intended to be adjustable; furthermore the engine is designed to rotate in one direction only.

It is strongly recommended that no attempt be made to deliberately adjust the engine timing as no noticeable gain in performance will be achieved without first considering and applying other modifications which are well beyond the scope and intent of this manual.

Transmission

The transmission is connected directly to the engine's crankshaft and is responsible for directing the power generated from the engine to the rear wheels. It is also responsible for providing torque multiplication of the engine as required (when pulling heavy loads or driving on uneven terrain), and reversing the output of the engine so that the Tractor can run in reverse. Torque requirements for the Tractor will vary greatly and these are dependant on several factors including trailer load, terrain and grade.

Type

The transmission is of a two-speed, constant gear mesh type. Two forward gear ratios are provided: *Direct* and *Low*. In addition, a single *Reverse* gear ratio is provided. A *Neutral* range also exists which allows the engine to run without driving the Tractor and also allows for the Tractor to be moved freely without the use of the engine*.

There is no clutch incorporated into the transmission, and thus the input portion of the transmission always revolves whenever the engine's crankshaft is in motion. The gear levers of the transmission control the connection of the input and output portions of the transmission as well as the output ratios.

* Note that the Tractor is also fitted with an automatic parking brake which must be released if the Tractor is to be moved without running the pneumatic engine.

Components

The following components of the transmission control and effect its operation:

Gear Levers

The Tractor features several gear levers which link to linkages which control the *dog clutches* in the transmission to select gears as appropriate.

Never engage more than one gear lever at any one time during Tractor operation, as severe transmission damage may result.

Gears and Dog Clutches

The transmission contains an arrangement of gearwheels which effectively transmit power flow according to the the position of the dog clutches. The dog clutches can be controlled through the operation of the aforementioned gear levers.

Reversing Triple-Gears

These special gears are mounted at the rear-most section of the Tractor, behind the differential, and serve to reverse the direction of power flow to the Tractor's rear wheels. These gears are only used when reverse gear is selected.

Transmission Modes

The following transmission modes are available for selection:

- **DIRECT :** this ratio is one which is most-commonly utilised when driving the Tractor and is generally sufficient enough to power the Tractor in most situations, providing a good balance between speed and torque. As the name implies, the pneumatic engine makes one complete revolution for each revolution of the output of the gearbox, meaning that the only gear reduction supplied is that from the rear differential and final drive components.

☞ Use DIRECT ratio as far as possible and only switch to LOW if the pneumatic engine should stall whilst moving a heavy load or travelling over uneven terrain.

- **LOW:** this ratio is to be used only when torque multiplication is required from the gearbox. For example, when towing or pushing/pulling heavy loads, or traversing difficult terrain. Whilst driving in LOW, the pneumatic engine makes three (3) complete revolutions for every revolution of the output of the gearbox, of which is then *further* multiplied by the rear differential and final drive components. Note that tremendous amounts of torque will be generated within the transmission when operating in LOW, therefore always aim to travel over the smoothest terrain possible.

- **REVERSE:** this ratio reverses the output of the engine using the triple-gears, effectively making the Tractor move backwards. The gear ratio is equal to LOW, however, power from the engine is routed to the wheels in a slightly different way, utilising a seperate gear train at the rear of the Tractor. The gear train used for reverse can be considered as the most sturdiest on the Tractor, and therefore may be able to safely handle greater torque than any of the forward ratios. This setting

is also most-recommended to brake the Tractor when parking or otherwise leaving it unattended for extended periods of time.

- **NEUTRAL:** selecting this setting in the transmission means that the pneumatic engine is disconnected from the output of the transmission. This is useful when you wish to run the pneumatic engine without moving the Tractor. This is also useful for allowing the Tractor to be towed or otherwise moved using an external power source. **CAUTION: never leave the Tractor unattended in NEUTRAL, as there is a danger of the Tractor rolling or moving by the force of gravity.**

Transmission Levers

The transmission is controlled via three levers, located either side of the driver's seat.

The transmission levers have colour-coded knobs so that you can easily distinguish their purpose just by observing them. The following colour codes apply:

- GREY knob lever: DIRECT gear (normal forward operation)
- YELLOW knob lever: LOW gear (low speed, high-torque operation)
- RED knob lever: REVERSE/BRAKE (reverse motion/recommended parking setting)

☞ Think of the colours in terms of severity; 'grey' is the lightest severity and provides normal operation; 'yellow' is slightly more severe and provides low gear operation; 'red' is the most severe and moves he Tractor in reverse or applies the transmission brake.

⚠ Each transmission lever can move independently of the others to engage the transmission, therefore it is imperative that you do not use more than one lever to engage the transmission at any one time.

Please study the following information carefully as severe transmission stress or damage may result if you attempt to operate the engine with the transmission levers set incorrectly.

Transmission Lever Movement

The following provides further detail on the proper movement and use of the transmission levers to avoid damage:

- Levers which control **forward motion** (grey and yellow knobs) have a range of movement ranging from completely vertical, to completely forward, tilted at an approximate 45 degree angle

- The lever which controls **reverse motion** (red knob) has a *sliding* range of movement from fully forward to fully rearward (reverse) – the lever itself remains vertical throughout its movement range.

When moving the **forward** transmission levers (grey or yellow knob) forward, make sure they are moved to the full-forward position (approximately 45 degrees) and cannot move any further. You will generally hear and feel two 'notches' or 'clicks' as you move the forward transmission levers to engage or disengage drive; 'click-click': this is an indication of positive engagement or disengagement.

Note: never attempt to move any **forward** transmission levers (grey and yellow knobs) fully aft (backward) and past the vertical position, as transmission lever linkage disconnection or damage may result.

When moving the **reverse** transmission lever (red knob) either backwards or forwards, make sure it is moved until it hits the stop at either end of its range, otherwise positive gear selection will not be achieved. There is no audible 'clicking' as the reverse lever is moved, therefore positive engagement can only be verified by observing the physical position of the lever itself.

Selecting Gears

DIRECT

To select DIRECT drive, move the transmission lever on the left hand side of the driver's seat (grey knob) fully forward. CHECK to ensure the right-hand-side transmission lever is fully vertical (neutral) and the reverse lever (red knob) is fully forward (neutral).

LOW

To select LOW, move the transmission lever on the right hand side of the driver's seat (yellow knob) fully forward. CHECK to ensure the left-hand-side transmission lever (grey knob) is fully vertical (neutral) and the reverse lever (red knob) is fully forward (neutral).

NEUTRAL

To select NEUTRAL, move BOTH forward transmission levers (grey and yellow knob) to the fully vertical position (neutral) and the reverse lever (red knob) fully forward (neutral).

REVERSE

To select reverse, slide the reverse lever (red knob) fully backwards against the stop. This engages the reverse gear ratio in the transmission. CHECK to ensure the left-hand-side *and* right-hand-side forward transmission levers are fully vertical (neutral).

Acceptable: if additional holding power is recommended on a steep grade, engage ONE of the forward or reverse levers (grey, yellow or red knobs) and ensure that both of the

remaining levers are in neutral. This will securely lock the transmission using the gears. It will also ensure that no damage can occur to the transmission should the engine be run.

NOT RECOMMENDED: it is possible to ***IMMOVABLY LOCK*** the transmission by engaging more than one transmission lever at once. Because this setting will effectively engage more than one gear ratio at any one time, making it impossible to turn the transmission, this setting **should be avoided** as severe transmission stress and damage may result if the engine is run.

> ⚠ As aforementioned, each transmission speed and direction is controlled by a seperate lever, therefore it is possible to engage more than one gear at a time, effectively LOCKING the transmission. NEVER operate the pneumatic engine with both the DIRECT and LOW transmission levers fully forward at one time, or with the REVERSE lever in the rearward position with either or both of the forward transmission levers foreward, or with ALL transmission levers engaged at one time. **Severe transmission stress, binding and damage may result.**

Parking Brake System

The Tractor is fitted with a unique parking brake system which automatically applies whenever air pressure in the brake system drops below a certain point. This parking brake system is only intended to function to secure the Tractor against movement when stopped.

The parking brake system of the Tractor comprises two distinct components:

1. Mechanical components – which physically brake the tractor to secure against movement
2. Pneumatic components – which control the application and release of the mechanical components of the parking brake system; the pneumatic components utilise the Air System of the Tractor (see Air System)

Mechanical Components

The mechanical components of the brake system consist primarily of powerful springs which act on an arrangement of levers and linkages and finally brake shoes which press upon brake drums located inside each rear wheel of the Tractor. They will apply this force at all times whenever the brake air system has little or no air pressure (such as when the Tractor is parked for long periods).

The parking brake supplies sufficient braking force to hold the Tractor stationary, however if the Tractor is connected to a heavy trailer load, or is situated on steep terrain, it is recommended that the transmission is also engaged to increase the braking force of the Tractor.

⚠ It is important to note that the parking brake system applies braking force to the rear wheels of the Tractor only.

The following mechanical components of the brake system are used to effect braking action on the Tractor.

Parking Brake Release Pedal ('REL2')

This pedal is connected mechanically to the brake system and serves to assist in releasing the parking brakes ONLY once sufficient air pressure has first been trapped in the parking brake system. To operate, the pedal must be fully depressed after fully charging the parking brake system with air pressure.

Depressing this pedal without first having sufficient air pressure in the parking brake system WILL NOT effect a proper parking brake release.

Parking Brake Application Springs

The most important mechanical component of the parking brake system are the application springs. These three powerful springs mounted under the Tractor serve to constantly apply evenly-distributed force to the mechanical linkages of the parking brake system and thus apply the parking brake shoes against the brake drums. Only a sufficient supply of air pressure can work against the force of these springs in order to release the parking brakes.

Parking Brake Linkages and Shoes

The parking brake linkages allow the force from the application springs to be applied to the parking brake shoes, which in turn press against the parking brake drums on the rear wheels and prevent the rear wheels from moving.

Pneumatic Components

The parking brake system is so designed so that an absence of sufficient air pressure within the parking brake system will immediately apply the brakes. Therefore, in order to release the parking brakes and move the Tractor, the brake system is reliant on a high pressure supply of air which is first fed to the brake system and then immediately trapped within the brake system for as long as required to drive the Tractor.

In most cases, this initial charge and retention of pressurised air in the brake system will be sufficient to keep the brakes released for several hours, however, should the brakes begin to apply during Tractor operation, stop the Tractor, re-apply the parking brakes, then re-release the parking brakes. If the parking brakes begin to apply again after short periods of time, this indicates potential trouble in the pneumatic air system piping or valves (e.g. air leakage) and this should be investigated.

The following pneumatic components of the brake system are used to effect braking action on the Tractor.

Parking Brake Control Lever

This lever is the primary means of controlling the air pressure flowing into, and out of the parking brake system. This lever allows you to charge the parking parking brake air system, release the parking brakes, and apply the parking brakes.

The parking parking brake control lever has three distinct positions:

1. **REL** (release) – this position connects the parking brake air system to the rest of the Tractor's air system. If there is sufficient air pressure built up in the Tractor's air system (using the 'charge' position of the lever beforehand), it will rush into the parking brake air system and allow the brakes to release
2. **CHG** (charge) – this position isolates the parking brake pipe system from the rest of the Tractor's air system and allows for a high head of air pressure to build (i.e. 'charging the brakes') when initially attempting to release the brakes; this setting is best used with the engine control valve placed in the 'STOP' position. This position is also used when operating the Tractor once the parking brakes have been released.
3. **APP** (apply) – this position vents any air pressure to atmosphere and effectively applies the parking brakes using the spring force from the application springs; it also vents any air pressure from the Tractor's air system effectively stopping the engine.

It is important to reiterate that no air pressure is required to actually apply the brakes and the 'apply' setting of the parking brake control lever simply vents air pressure to the atmosphere to allow the brakes to apply with the force of the application springs. Therefore, regardless of the position of this lever, it is possible for the parking brake system to become applied if the parking brake air system loses sufficient air pressure (due to eventual leakage or fault).

This lever is also very important, as it receives its air pressure supply directly from the engine's air supply source, and thus can also be used to exhaust the Tractor's air system to atmosphere and effectively stop the engine in an emergency. This can be achieved by placing the lever in the apply-brake position (fully aft).

Parking Brake Release

In order to release the parking brakes and operate the Tractor, a high volume of high pressure supply of compressed air must first be fed to the parking brake air system and then immediately held in the system for the duration of the Tractor's operation. This retention of air pressure is necessary to constantly overcome the powerful spring pressure from the parking brake application springs.

Follow the procedure below to release the brakes:

1. Set the engine lever to 'STOP'
2. Place the parking brake control lever to the 'CHG' position (fully vertical)
3. Pump the hand controller until short 'whisps' of air can be heard escaping from the hand controller during each stroke (this indicates that a full head of air pressure has been reached in the air system)
4. Move the parking brake control lever fully forward in one quick movement to 'REL' – this will force a large amount of high pressure air into the brake system to release the brakes
5. Depress the parking brake release pedal ('REL2') fully and then release – this assists in ensuring the brakes are fully released
6. Return the brake control lever back to the neutral position (fully vertical) – this traps required high pressure air in the parking brake system to keep the brakes released
7. Exhaust any remaining air pressure from the rest of the air system by moving the engine control lever to 'TEST / E. STOP'.

☞ The brake control lever must be in the 'CHG' position in step 2 above, otherwise only partial release of the parking brake may result

☞ When depressing the brake release pedal ('REL2'), ensure it is depressed until it stops. This aids in fully releasing the brake shoes from the brake drums

☞ Always return the parking brake control lever to the 'CHG' position for as long as you wish the parking brake to remain released. This stores high pressure air within the parking brake air system and allows the parking brake to remain released while the Tractor is in operation. This high pressure air will eventually leak out, allowing the parking brake to re-apply itself, however this condition takes several hours to take effect, and it is not expected to cause issues unless extended Tractor operation period is anticipated.

Parking Brake Application – Manual

To apply the parking brake manually, pull backwards on the parking brake lever; this will completely exhaust all pressurised air in the system, allowing the powerful parking brake springs under the Tractor to apply pressure against the brake shoes and drums and securely apply the parking brake. This action will also allow vent any air pressure flowing to the engine, effectively stopping it.

☞ For maximum safety, leave the brake lever in the fully backward position whenever the Tractor is parked. This vents the Tractor's pneumatic circuit and leaves it open to the atmosphere to ensure full application of the parking brake, and also ensures that no air can be allowed to pressurise and operate the engine accidentally.

Parking Brake Application – Automatic

The parking brake system is so designed to automatically apply the parking brake once pressurised air has expelled from the parking brake system through eventual leakage. However, this process normally takes at least 60 minutes to occur. No other action is required on the part of the driver; the Tractor is secured against unwanted movement.

⚠ For safety, always ensure you manually apply the parking brake when you have finished operating the Tractor. DO NOT rely on the automatic feature to eventually apply the parking brake.

Pneumatic Pipes and T-fittings

The pneumatic pipes and t-fittings are a critical component of the parking brake system. This network of pipes and fittings route air pressure from the front of the Tractor, through, various valves and allow the brakes to release and apply effectively according to the operator's setting.

4. Tractor Operating Checklist and Procedure

The following is detailed information on running the Tractor. Please follow the directions below in the order that they appear.

Prior to Starting

Before starting the Tractor, perform a general check to ensure there are no obstacles nearby, and that there are no obstructions in or around the engine or running components which may cause binding and subsequent damage.

Test Pump Operation Procedure

This procedure is intended to be carried-out BEFORE operating the Tractor using the hand controller. The following directions will guide you in operating the test pump:

1. Move the main engine control lever fully downward to 'TEST / E. STOP'; in this position, the engine can only receive a compressed air supply from the test pump
2. Ensure the parking brake control lever is positioned directly vertical
3. Extend the test pump handle outward from the engine frame, and begin slowly but deliberately pumping it up and down in complete strokes
4. Carefully watch the engine crankshaft for movement to begin. The engine will rotate very slowly but consistently. It should take approximately 30-50 complete pump strokes to rotate the engine one complete revolution.

   ⚠ If the engine fails to rotate one complete revolution or fails to rotate at all, this indicates potential trouble within the engine. Check pneumatic pipes and

fittings for security and ensure that the transmission is in neutral range, and no obstructions to the engine or drivetrain exist.

Once the engine has rotated at least once, fully retract the test pump handle, and let the test pump withdraw itself back into the engine frame.

Parking Brake Release Procedure

1. Set the engine lever to 'STOP'
2. Place the parking brake control lever to the neutral position (fully vertical)
3. Pump the hand controller until short 'whisps' of air can be heard escaping from the hand controller during each stroke (this indicates that a full head of air pressure has collected in the air system)
4. Move the parking brake control lever fully forward in one quick movement – this will force a large amount of high pressure air into the brake system to release the brakes
5. Depress the parking brake release pedal ('REL2') fully and then release – this assists in ensuring the brakes are fully released
6. Return the brake control lever back to the neutral position (fully vertical) – this traps required high pressure air in the parking brake system to keep the brakes released
7. Before running the engine, exhaust any remaining air pressure from the rest of the air system by moving the engine control lever to 'TEST / E. STOP'. Then return the engine control lever to its prior position.

Engine Running Procedure

Once you are satisfied that the Tractor is ready to run, and you have performed a test run of the engine using the test pump and released the brakes as mentioned in the section above, follow the procedure below to prepare the Tractor for operation:

1. Move the main engine control lever fully UPWARD to 'RUN' (remember: 'up, up and away!'); in this position, the engine can ONLY receive a compressed air supply from the main air supply fitting at the rear of the Tractor (this is normally connected to your hand controller)
2. Select an appropriate gear ratio in the transmission
3. Operate the hand controller pump and observe as the Tractor begins to move. The Tractor may be steered using the steering wheel mounted between the transmission gear levers.

Tips and Hints for Efficient Operation

- Whilst the Tractor has very high ground clearance and a robust construction, always operate the Tractor over the smoothest terrain possible to avoid problems

- If it is necessary to operate the Tractor over rough, soft or uneven terrain, engage LOW gear immediately the first signs of engine labouring occur; do note however that there is an increased chance of bogging over soft terrain whilst operating in LOW gear

- Should the Tractor become bogged on soft terrain, consider engaging reverse gear and attempt to choose another path. Should this not be possible, it may be possible to place objects such as sticks or other pieces of wood, etc under the rear wheels to increase traction.

- **In an emergency situation, to stop the rotation of the engine as quickly as possible,** swiftly move the main engine control lever fully DOWNWARD and cease operation of the hand controller; this will vent MOST of the compressed air currently within the engine's cylinders directly to atmosphere (with an audible sound) and effectively bring the engine to a stop as quickly as possible. Note: whilst most of the compressed air will be vented to atmosphere, a small amount will remain within the cylinders, however the engine should generally stop rotating.

5. Post-Operation

Following operation of the Tractor, perform the following procedure to ready it for storage:

1. Apply the parking by moving the parking brake control lever fully BACKWARD
2. Move the main engine control lever fully DOWNWARD to 'TEST/Emerg. Stop' to fully exhaust any remaining compressed air within the engine (you may hear the exhaust of the compressed air)
3. Move the main engine control lever to the CENTRE 'STOP' position; in this position, the engine cannot receive a supply of compressed air from ANY source whatsoever
4. Select a gear ratio in the transmission by moving a transmission lever fully forward

It is recommended to drape a suitably-sized clean cloth over the Tractor whilst it is in storage, in order to protect it from dust.

6. Maintenance

Little periodic maintenance of the Tractor is required, however the following items may be attended to as required.

It is important to note that in the case of any lubrication requirements, less is definitely more, and only silicone-based oil should be used.

- ☞ Wipe down the Tractor and its components to ensure dust and dirt do not excessively collect.
- ☞ Check the alignment of all gears and shafts within the drivetrain.
- ☞ Check the pneumatic pipe-work and fittings for any leakage or obvious looseness. Correct as needed.
- ☞ Lubricate (very lightly!) the connecting rods of the engine. DO NOT OVER-LUBRICATE – A LIGHT SMEAR IS SUFFICIENT
- ☞ Lubricate (very lightly!) the gears in the gear train only if heavy loads are regularly towed by the Tractor. DO NOT OVER-LUBRICATE – A LIGHT SMEAR IS SUFFICIENT