Clinton

SERVICE BULLETIN

NO. 81

SEC. VIII, DIV. A
ROTARY MOWERS
Revised October, 1958
Supersedes July, 1957

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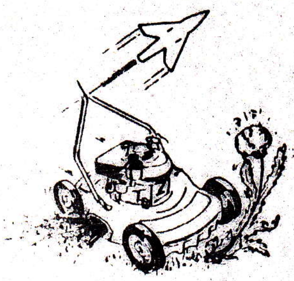
SUBJECT: Maximum Speed of Rotary Mowers

ALWAYS BE SAFE

Most vertical shaft engines have been used on rotary type mowers where the blade is fastened to the crankshaft through various types of adaptors or connectors.

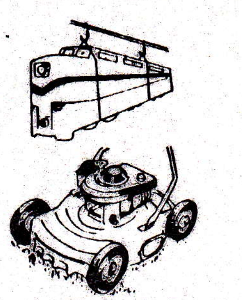
The first thing regarding these engines is the maximum R.P.M. at which they are to be operated. On the Long Life and Gem series this is 3600 R.P.M. while on the Panther it is 3800. When in doubt as to maximum, refer to Sec. II, general specifications for the engine in question. While this is the maximum R.P.M., it is not the normal operating speed which does vary. The engines when shipped from the factory are set at 3400 R.P.M.

ALWAYS BE SAFE



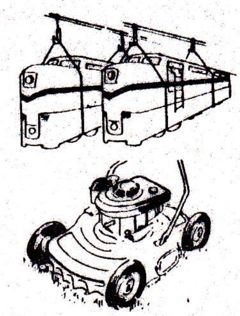
187 M.P.H.

A rotary mower with a 21" blade and with the engine operating at 3000 R.P.M.'s, the tip of the blade is traveling at 187 miles per hour.



27 TONS IMPACT
(One Locomotive)

If blade is stopped within ¼ inch, by hitting some object such as a stake, there is an impact of 27 tons applied to the unit.

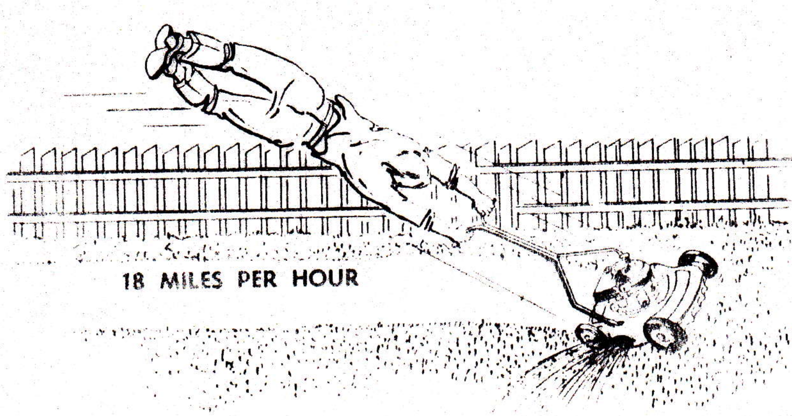


54 TONS IMPACT
(Two Locomotives)

If the unit is operated overspeed at 4200 R.P.M.'s and stopped similarly within ¼" this force is doubled — or approximately 54 tons.

½-INCH CUTTING

If the operator is walking at approximately 3 miles per hour, the blade passes over any given area of grass six times if the 21-inch blade is sharpened three inches and the mower is operating at 3000 R.P.M. In other words, only ½ inch at the tip of the blade is actually doing the cutting.



If this same 21-inch blade traveling at 3000 R.P.M. was to take a continuous full cut with no overlap it would be necessary for the unit to travel 18 miles per hour.

SUBJECT: Maximum Speed of Rotary Mowers

From the preceding it is evident that in very few cases should it be necessary to operate at maximum R.P.M. and **never above** maximum R.P.M. to get satisfactory cutting, as the force created is determined by the speed. Possible damage to the engine, mower deck and blade increases as the engine speed increases.

When any vertical shaft engine on a rotary mower is brought in for service with a complaint of hard starting, excessive vibration, low horsepower and/or extreme variances in speed, the first thing to check is the condition of the blade as to tightness, sharpness and balance. In servicing every rotary mower these items should be checked before the unit is returned to the customer.

A blade which is loose can cause any one of the above conditions and is also dangerous. To check a blade for looseness, first remove the ignition wire from the spark plug then tip the mower with the spark plug in the upward position and while holding the starter pulley in a locked position attempt to turn blade. If blade turns, remove and replace any worn parts of the adaptor unit or if blade is bent, replace. Also, check the hole in the blade for out of roundness. If the hole is enlarged or out of center lengthwise or crosswise it should not be used. Next, re-sharpen and re-balance the blade (Note: Shown in Figure 1 and Figure 2 are two types of blade balancers available).

Another item which can cause excessive vibration and improper operation of the unit is loose or missing mounting bolts. This can cause breakage of engine bases, mower decks and loss of engine parts.

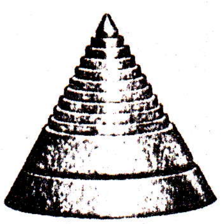


FIG. 1

Order From:
SMITH IMPLEMENT CO.
CARTHAGE, ILL.

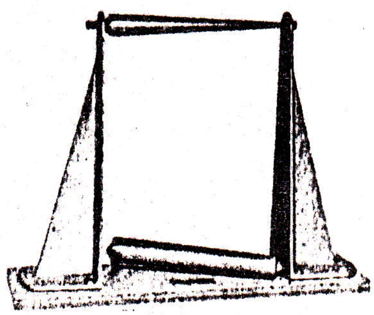


FIG. 2

Order From:
HAGEDORN MFG. CO.
ERLANGER, KENTUCKY

BLADE, ADAPTER AND SPEED DATA

By conducting exhaustive controlled tests in the laboratory, actual field usage, and in independent research organizations, on all series of air-cooled engines of both CLINTON-manufacture and competition, on all types of applications, we have accumulated a vast amount of data. We wish to pass this information on for your guidance.

The greatest number of applications of air-cooled, single cylinder gasoline engines are on equipment used in the care of lawns and gardens.

A problem prevalent in our field of manufacture is failure due to vibration. Tests have proven that vibration of certain frequencies and amplitudes center in gas tanks and other external engine components, causing fatigue failures beyond the capabilities of design and manufacturing costs. The same is true in the components of the lawn and garden equipment causing deck and bracket fatigue failure, excessive shaft and bearing wear, and excessive wheel and tire wear.

Some of the greatest contributions to excessive vibration of the rotary lawnmower are: Out-of-balance blades and blade adapters, blade mounting holes not centered, adapters not centered to blade, adapting holes poorly fit during customer use. More emphasis should be placed on the user maintaining properly sharpened and balanced cutting blades, for in doing so the customer will receive more satisfaction from the equipment, and a more trouble-free use of his equipment.

There are many engine and equipment difficulties that are due to improper couplings of the source of power to the equipment. This is predominant in the rotary lawn mower field due to blade coupling design and clutches. There is a wide variance of opinion among the manufacturers as to the most successful method of connecting the blade to the crankshaft, however, our testing records have produced facts and eliminated some theories. The clutch coupling must have a design strong enough to continually withstand the entire force of the explosion pressure without slippage during operation. We do not say that the design of all clutch couplings are inadequate, however, our tests prove that many are inadequate and are ineffective, and in many cases do cause troubles to the lawn mower manufacturer, and user, and engine manufacturer. We, therefore, have come to the conclusion that a rigid mounting of the blade to the crankshaft is the most desirable, trouble-free application for rotary mowers.

When a revolving blade strikes a solid object, the stresses set up are dependent upon the masses of the equipment, the speed of the engine and rotating system, the forward motion of the equipment, the "give" of the struck object, etc. The force necessary to stop the revolving crankshaft goes up as the square of the speed. Therefore, the force to stop a blade can be as high as several tons.

THE FORCE GENERATED IN SUDDEN STOPPAGE OF LAWNMOWER BLADES

1. FORCES:

A typical lawnmower has a moment of inertia as follows:

21 x 2¼ inch blade	85.6 lbs. in.^{2} (mass 2.3 lbs.)
Flywheel — VS-100	18.
Crankshaft — VS-100	1.4
SYSTEM TOTAL:	105.0 lbs. in.^{2} or .73 lbs. ft.^{2}

The kinetic energy of such a system varies with the square of the RPM and is given by:

$$K.E. = .70 \times 10^{6} \times I\,n^2$$

Where: I = Moment of Inertia

n = The RPM

At 3,000 RPM the K.E. = 1,120 ft. lbs.

At 4,000 RPM the K.E. = 1,990 ft. lbs.

If a lawnmower blade strikes a pipe and stops in ¼" of travel, this energy is dissipated in this distance and from the definition of: Work = Force x Distance, the average force may be calculated.

$$\text{At 3,000 RPM } F = \frac{1{,}120 \times 12}{.25} = 54{,}000 \text{ lbs., or 27 tons.}$$

2. BLADE VELOCITY

The tip velocity of a 21-inch blade at 3,000 RPM is 275 ft./sec., or in more common terms, 187.5 miles per hour.

At 3,000 RPM = 50 revolutions per second with a blade having a cutter at each end, the cutting strokes are 100 per second. This means that if there was to be no overlap in the cutting edge of successive blades (assuming a 3-inch blade) the lawnmower would move forward at:

$$\frac{100 \times 3}{12} = 25 \text{ ft./sec., or 17 miles per hour.}$$

In reality, the upper limit of speed for walking and pushing is probably about 3 miles per hour, or 4.4 ft./sec. Therefore, the blade is striking fresh grass at:

$$\frac{4.4 \times 12}{100} = .53 \text{ inches (Per. Stroke)}$$

An element of ground is covered about 5.7 times in mowing. These figures are presented as a matter of interest in determining the optimum speed.

The question arises as to how, when the slip clutch is removed, a better installation would result. This is answered from facts of many tests, rather than theory.

When a rotary mower cutting bar strikes an object, there is, of course, a reacting force that must be absorbed. Where a "Give" or built-in slippage is present, a repeated shock must be absorbed. A creeping occurs, a loosening of blade or adapter will occur, and the climbing of the cutting bar over the object will result. Where a solid adapter is used, the reacting forces are absorbed primarily by the mower deck and the struck object, rather than by the cutting bar and crankshaft. We have reviewed all possible blade-to-crankshaft adapters and made a thorough study, and we respectfully submit suggested designs to assist you (see page 6).

Our recommendations are:

1. The elimination of slip disc clutches.
2. Where at all possible, use a "channel" keyway with a "sunk" key, rather than a Woodruff key, as a greater holding surface is obtained. An interference fit of the key to the keyway is desirable to avoid a "rocking" condition that will set up severe vibrations in the equipment and heavy wear in the keyway of both the crankshaft and adapter.
3. A positive locking of the blade to the adapter.
4. A close control of blade weights. Maintain an adequately durable blade, yet light so as to increase the natural frequency of the vibrating elements.
5. Maintain a close control over the balancing of blades and adapters; a balance to 250 mil. gram and a blade tip flutter not to exceed 1/64" is recommended.

The engine speed as shown would be the range where the best foot pounds of torque would be secured. It can be noted that with the cutting bar tip speed, as shown on the preceding chart, and the average forward travel of 3 MPH, the grass is covered many times by the cutting tip. The more speed, the more unnecessary rotations of the blade.

We have found in our many thousands of hours of controlled testing, as well as from the results returned from the field by actual owner users, that speed in excess of the normal governor speed setting of 3,400 RPM, + or — 100, results in undue engine and moving equipment difficulties and, naturally, in customer dissatisfaction, even though it is known that the owner, user, in many instances tampers with the speed controls. Governor springs are shortened, rubber bands are used to replace springs, governors are tied open with wire, etc. In cases, governor springs have been snagged by brush and shrubs, and the user, not being acquainted with the engine, has not made the necessary correction, and serious damage resulted.

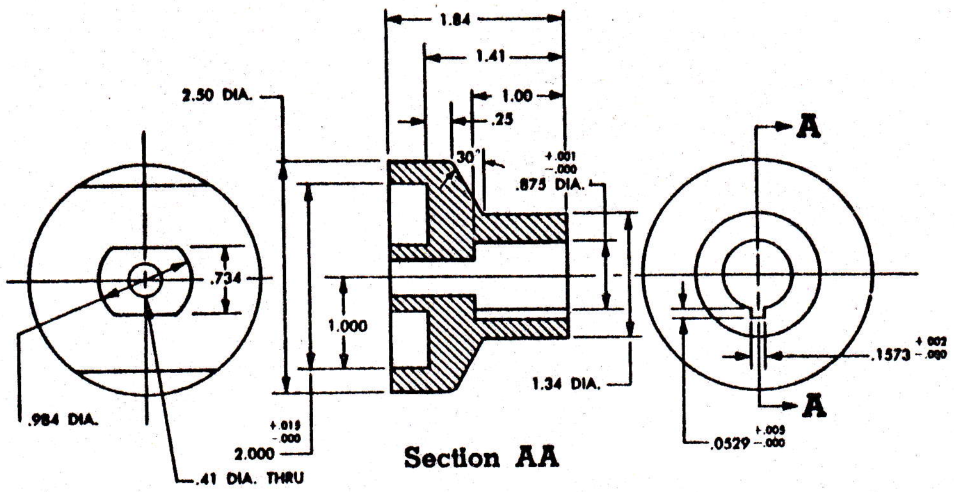
We now have available on all vertical shaft engines for rotary lawnmower applications, a unique protection against brush damage and tampering with the governor and accidental snagging of the governor spring, as well as a simplified speed control that is used for fixed speed, hand control, and remote control. This same throttle control is available with a "touch and go" start, run and stop by a remote control for the convenience of the user. Please view the sketches on page six, and you will recognize the advantages of this type control.

SPEED

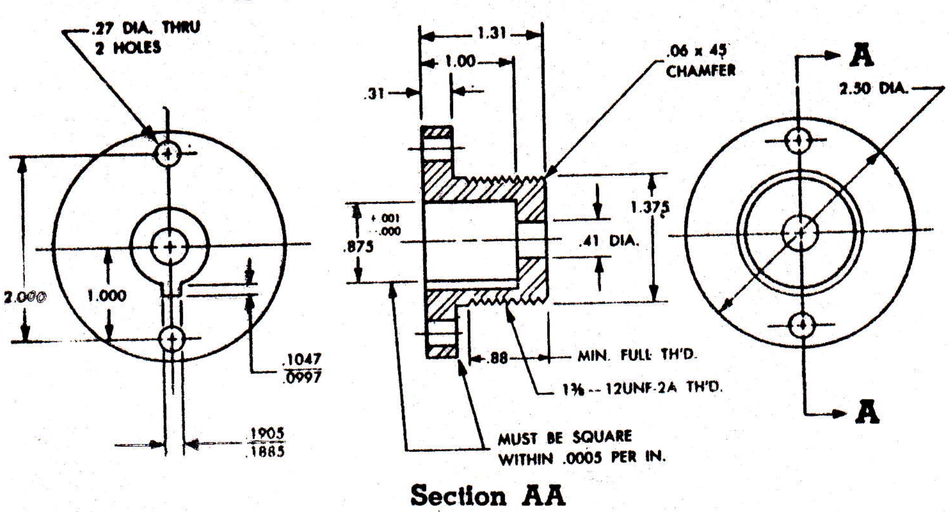
The following table will give you some data we feel will be of assistance to you in determining the required speed for your cutting bar, and will show that it is not necessary for the blade to be traveling at its maximum to give an adequate cutting of the lawn. It will guide you to lower cutter bar tips speeds, more evenly cut lawns, and longer life of the source of power.

ENGINE RPM	BAR TRAVEL RPM. FT.	BLADE LENGTH INCHES	BLADE TIP TRAVEL FT./SEC. (.436 x Blade 100 x RPM)	BLADE TIP TRAVEL MI./HR. (.298 x Blade 100 x RPM)	BLADE TIP PASSES OVER AREA (.190 x RPM x 4 100) / 3
2600	4.1888	16	182	118	6.5
2800	4.1888	16	196	128	7.0
3000	4.1888	16	209	137	7.6
3200	4.1888	16	221	146	8.1
3400	4.1888	16	237	155	8.6
3600	4.1888	16	251	164	9.1
2600	4.7124	18	204	139	6.5
2800	4.7124	18	220	150	7.0
3000	4.7124	18	236	161	7.6
3200	4.7124	18	251	172	8.1
3400	4.7124	18	267	182	8.6
3600	4.7124	18	283	193	9.1
2600	5.2193	20	227	155	6.5
2800	5.2193	20	244	167	7.0
3000	5.2193	20	261	178	7.6
3200	5.2193	20	279	191	8.1
3400	5.2193	20	296	203	8.6
3600	5.2193	20	314	215	9.1
2600	5.4978	21	238	163	6.5
2800	5.4978	21	256	175	7.0
3000	5.4978	21	275	188	7.6
3200	5.4978	21	293	200	8.1
3400	5.4978	21	311	213	8.6
3600	5.4978	21	330	225	9.1
2600	5.7596	22	249	170	6.5
2800	5.7596	22	269	183	7.0
3000	5.7596	22	288	196	7.6
3200	5.7596	22	307	210	8.1
3400	5.7596	22	326	223	8.6
3600	5.7596	22	345	236	9.1
2600	6.2832	24	252	186	6.6
2800	6.2832	24	294	200	7.0
3000	6.2832	24	315	215	7.6
3200	6.2832	24	336	229	8.1
3400	6.2832	24	357	243	8.6
3600	6.2832	24	378	257	9.1
2600	6.8068	26	294	201	6.5
2800	6.8068	26	316	217	7.0
3000	6.8068	26	339	232	7.6
3200	6.8068	26	362	248	8.1
3400	6.8068	26	384	263	8.6
3600	6.8068	26	407	279	9.1

ALLOY ADAPTOR



STEEL ADAPTOR



CAST IRON ADAPTOR