

HOWARD ROTAVATOR COMPANY LIMITED

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HOWARD
ROTAVATOR.

SERVICE FACTS ABOUT THE

200

BANTAM

300 & 350

400

700

GEM

ENGINES

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"200" SERIES

**HOWARD
ROTAVATOR**

Originally produced in 1954, and named Bullfinch or Demon according to engine size. Subsequently named Howard'200', and fitted with two alternative engines. Finally with one engine only.

SERIAL NUMBER

Stamped in two positions:

1. On brass plate on top of the front shield.
2. Between the two clamps on the rear end of the worm housing.

ENGINES

1. Bullfinch:
Fitted with JAP 2A 98 c.c. engine.
2. Demon:
Fitted with BSA 120 c.c. engine.
3. '200':
Fitted with Villiers Mk. 10/1 98 c.c. engine from Serial Number 18321, and Villiers Mk. 12/1 120 c.c. engine from Serial Number 18404.

The changes are as follows:

Old Part Number	Description	New Part Number	Description
	Bullfinch JAP 2A		Villiers 10/1
	Demon BSA 120 c.c.		Villiers 12/1
14056	Cradle (JAP BSA)	14215	Cradle (10/1 & 12/1)
14150	Base Plate (JAP)	14228	Base Plate (10/1 & 12/1)
14201	Base Plate (BSA)		
14203	Belt Stop (BSA)	14111	Belt Stop (10/1 & 12/1)
14204	Clutch Lever (BSA)	14063	Clutch Lever (10/1 & 12/1)
21238	Throttle Lever (BSA)		Deleted
14152	Engine Pulley (JAP)	14230	Engine Pulley (10/1 & 12/1)
14207	Engine Pulley (BSA)		
14155	Engine Clip (JAP & BSA)	Deleted	
14156	Handlebar Clip 3 off (JAP & BSA)	85-5931	Cable Clip 3 off (10/1 & 12/1)
14212	"V" Belt (BSA)	20707	"V" Belt (10/1 & 12/1)
	Gib Key $\frac{3}{16}$ " square x $1\frac{1}{2}$ " long		Gib Key $\frac{3}{16}$ " square x $1\frac{1}{2}$ " long (10/1 & 12/1)
14178	Grub Screw (JAP)		Grub Screw $\frac{1}{2}$ " BSW x $\frac{1}{2}$ " long, cup-pointed slotted head (10/1 & 12/1)

Conversion of engine to Villiers 12/1; the following additional parts are required to enable the 12/1 engine to be fitted in place of previous engines.

Part Number	Number Off	Description
14228	1	Base Plate W/A
	4	Bolt $\frac{3}{8}$ " UNC x $1\frac{1}{2}$ " long
	4	Philidas Nut $\frac{3}{8}$ " UNC
14215	1	Engine Cradle W/A
14230	1	Engine Pulley
	1	Gib Head Key $\frac{3}{16}$ " square x $1\frac{1}{2}$ " long

Note: The handlebars will require modifying by welding an additional control lug Part Number 14074 to the opposite side of the cross bar. The correct "V" belt to use is Part Number 20707.

Note: The reason that a new engine cradle is required is that the 12/1 engine has the carburettor on the left-hand side of the

engine, and would foul the existing clutch control rod, thus the hinge position is changed from right to left so that the clutch control rod can be operated on the right hand side.

ENGINE SUMP CAPACITY

JAP	$\frac{1}{2}$ pint	·3 litres
BSA	$1\frac{1}{2}$ pints	·7 litres
Villiers 10/1 and 12/1	1 pint	·6 litres

ENGINE PULLEYS

Three different pulleys were used according to engine and were fitted to the relevant crankshafts with a Gib head key as follows:

JAP	Pulley Part Number 14152
BSA	Pulley Part Number 14207
Villiers 10/1 and 12/1	Pulley Part Number 14230

'V' BELTS

Both JAP 2A and Villiers 10/1 and 12/1 use same drive belt Part Number 20707, but the BSA used belt Part Number 14212.

THROTTLE CABLES

Engine	Throttle
BSA 120	86-3145 Cable 21238 Lever Assembly
JAP 2A	21127/1 Cable 21127 Throttle Assembly
Villiers 12/1	C.M. 2450/M Cable 5' outer
12/2	V1376 C/D Lever $\frac{1}{4}$ " bar

Export Dealers Only

The Villiers Engine Co. will no longer supply 'bare pistons' for engines of their manufacture. All orders supplied will now comprise the piston complete, with piston rings, gudgeon pin and circlips. The Part Number to be used for this assembly will be that formerly used for the piston only.

Engine Mk. 10/1	Spec. 759C	Piston Standard	BM 503
		Piston +·015"	DM 659
		Piston +·030"	DM 659
Engine Mk. 12/1	Spec. 760C	Piston Standard	DM 927
		Piston +·015"	DM 1272
		Piston +·030"	DM 1273

FRONT WORMSHAFT ASSEMBLY

The driven pulley is screwed with right-hand thread on to the wormshaft, and the front oilseal and bearing are retained by a circlip. The rear bearing is 'press fitted' into the wormbox housing, the bearing has an integral oilseal. This bearing must be fitted with the seal to the rear of the assembly to ensure adequate lubrication of the bearing, and the prevention of oil leaks.

GEARBOX ASSEMBLY

One speed only, controlled by sideways twisting movement of the control rod from handlebars. This rod actuates spring loaded selector, which in turn locks into an indent in the wheel lock.

WHEEL LOCK

The three pins which form the moving part of the wheel lock are permanently supported within the wormwheel, and by moving them to the right they lock into holes in the wheel axle shaft. Adjustment of the movement of these pins is effected by the introduction or removal of gaskets between the faces of the two halves of the box. The wheel axles are inserted directly into the gearbox axle housing without bushes.

WHEEL SHAFTS

Up to Serial Number 2231001 wheel shaft had tapered splines with mating wheel centres. From this number onwards a parallel spline replaced the tapered spline on the wheel shaft and the mating wheel centres. Up to Serial Number 2231001 the Wheel Shaft Part Number was 14081 and 14984. From Serial Number 2231001 Wheel Shaft short Part Number BGA 20 and the Wheel Shaft long BGA 23 respectively.

WHEELS

The wheel and tyre originally Part Number 14026/38 was used up to Serial Number 2231001, has been replaced with Part Number BGA 86.

DRAIN PLUG

The drain plug is located in the side of the wormbox, and was originally a tapered plug which was changed to a flange type plug because it was found that the tapered version could be screwed right in until it fouled the wormwheel inside.

ROTOR UNIT

The rotor is driven direct from the gearbox by a worm and worm-wheel. There have been changes in the design of the worm. Machines up to 1957 used worm shaft Part Number 14096, worm wheel Part Number 14025 and thrust washer Part Number 14033. The design was changed to an 'hour glass' version, used up to Machine Number 17633, the Part Numbers of this type were, worm shaft Part Number 14222, worm wheel Part Number 14223, and thrust washer Part Number 14224. It is important to note that they can only be fitted in pairs and not separately.

Up to Machine Number 18095 the worm shaft was supported by an LS7 angular contact bearing to take the end thrust. From Serial Number 18095 the angular contact bearing was replaced with a plain bearing, a thrust bearing and a new end cap.

The parts affected are as follows:

Old Part Number	Description	New Part Number
14222A	Worm Shaft	14225
14036	Spacer	14227 Thrust Pad
LS7AC	Bearing	LS7RTH 1018 Torrington Thrust Bearing

From Serial Number 2231001 the worm shaft Part Number 14032 was replaced with rotor worm shaft Part Number BGA 25, and the end cover 14122 was replaced with BGA 32, at the same time the rotor worm shaft spacer was replaced with Part Number BGA 30, and Hoffmann W 58 thrust bearing was used with the new end cover BGA 32.

ROTOR DRIVE SHAFT

Supported by the bores of the gearbox and side plate with no bearings, and located to the worm wheel by two keys, the shaft is sealed from dirt and oil loss by an oilseal and dust cover caps which are clipped on to the outside of the casting.

Up to Serial Number 2231001 the rotor drive shaft had tapered spline, but from this Serial Number was changed to a parallel spline.

ROTOR

The original Bullfinch had two blades per flange whereas the Demon and subsequent '200' models had three blades per flange.

TOOL BAR

From Serial Number 2231001 the Tool Bar frame when fitted must include the support bracket Part Number 14634, this bracket is not required for earlier machines.

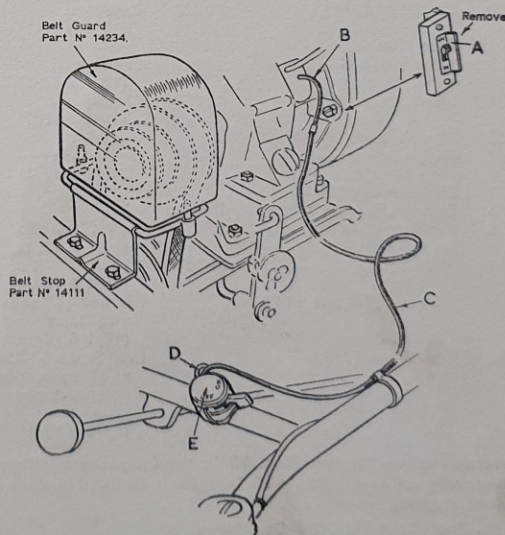
ANCILLARY EQUIPMENT

DRIVING BELTS

Engine	Attachment	Drive Belt
JAP 2A		20707 (24½" inside length) Fenner PA 26)
	Lawn Mower	Fenner A 78
	Cutter Bar	Fenner A 30
	Circular Saw	Fenner A 60
	Flexible Drive Equipment	A 22
	Flexible Drive Equipment	A 23
BSA 120		14212 (25" inside length)
	Lawn Mower	Fenner A 78
	Cutter Bar	Fenner A 30
	Circular Saw	Fenner A 60
	Flexible Drive Equipment	A 22
	Flexible Drive Equipment	A 23
Villiers 12/1-12/2		20707 (24½" inside length) Fenner PA 26)
	Cutter Bar	Fenner A 30
	Circular Saw	Fenner A 60
	Flexible Drive Equipment	A 22
	Flexible Drive Equipment	A 42
	Hedge Trimmer and full Heli-Strand Range	

SAFETY REGULATION KITS

In the United Kingdom special safety regulations for hand controlled machines have been introduced and whereas new machines will have safety features built into them, earlier machines can be so fitted by obtaining and supplying Kit Part Number 67674 which is fitted as follows:



1. Engine Stop Switch

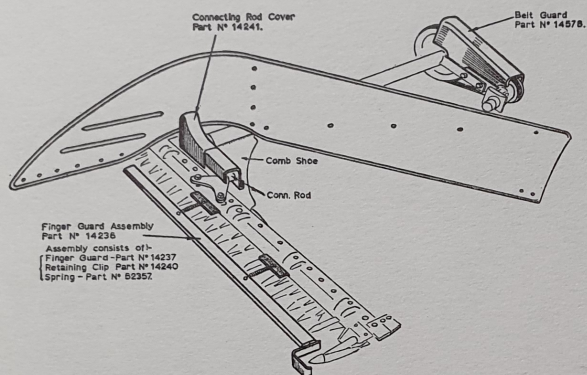
- Remove the existing switch (A) located on engine and expose the magneto connector lead (B).
- Fit engine stop cable (C) and earthing cable (D) to switch (E). The short earthing cable (D) is fitted to the centre terminal on the switch.
- Position the switch in the most accessible position on the handlebars and ensure earthing cable (D) is connected to the clamp screw. Remove sufficient paint from under switch clamp to ensure a good earth contact.

- (d) Connect cable (C) to the magneto connector lead (B).
- (e) Move switch to the 'ON' position, start engine and test that engine cuts out with the switch in the 'OFF' position.

2. Belt Guard

- (a) Remove existing belt stop Part Number 14111 by removing the two $\frac{5}{16}$ " bolts.
- (b) Replace with new belt stop which incorporates two sockets and has the same Part Number 14111.
- (c) Fit belt guard Part Number 14234 by inserting the locating pins into the sockets of the belt stop, with the guard opening towards the engine.

3. '200' Cutter Bar—Safety Regulation Kit Part Number 67678



- (a) Remove the existing belt guard Part Number 14565 and replace with the new guard Part Number 14578.
- (b) Align the new connecting rod cover Part Number 14241 to ensure free oscillation of the connecting rod. Mark off, drill and tap two $\frac{1}{4}$ " UNC holes in comb shoe using the cover as template.
- (c) The finger guard assembly Part Number 14326 must be in place as shown in drawing when ever the cutter bar is not operating, standing or travelling.

LUBRICATION

Engine	Lubrication Point	Capacity		Grade of Oil
		Pints	Litres	
Villiers Mk. 12/1	Worm Drive Gearbox (front)	$\frac{1}{2}$	·3	140
	Worm Drive Gearbox (rear)	$\frac{1}{3}$	·2	140
	Oiling Points			140
	Sump	1	·6	90°F. + 40 16°F. to 90°F. 30 0°F. to -16°F. 20
	Air Filter			As Engine

BANTAM

HOWARD
ROTAVATOR

Medium size Rotavator with rotor width of 10" to 14" cut.
The Rotavator has two forward speeds but it has no reverse.
Manufacture started in 1950 and ended in 1961.

SERIAL NUMBER

The Serial Number is located in two positions:

1. On the left-hand handlebar support bracket.
2. On the brass plate on the side of the engine.

The first Serial Number was 2391 and the last 53123.

ENGINES

The first machines were fitted with the Villiers 25C engine, which was later replaced by the Howard AC engine, which gave way to the BSA 120 c.c. engine, and finally the machine was manufactured with the Villiers Mk. 15 147 c.c. engine.

At present there is a Kohler engine conversion kit Part Number 20516, which will suit the Bantam up to Serial Number 39718, which includes the AC engine and the Villiers Mk. 15 versions. For machines after Serial Number 39719 and on American assembled machines having Briggs & Stratton or Clinton engines fitted, conversion kit Part Number 20155 is required.

The earlier Villiers 25C and Howard AC engines were hinge mounted transversely, with belt drive, also transversely to the gearbox drive shaft. The later BSA and Villiers engines were mounted on an engine platform which was pivoted on the right-hand side of the machine, and moved as near vertical as would be possible to tighten or slacken the belt.

The pivot bolt of this engine mounting platform was increased in diameter from $\frac{5}{16}$ " to $\frac{7}{16}$ ", Part Number 21249, up to $\frac{7}{16}$ " diameter, Part Number 21157. This took effect from Serial Number 50653.

Separate mounting plate for use with the engine cradle was manufactured as follows:

Part Number 35245 for the BSA engine.

Part Number 36106 for the Briggs & Stratton engine.

Part Number 39719 for the Villiers 15 HS engine.

The engine cradles to suit the above engines are, up to Machine Number 40915 Part Number 20480, from Machine Number 40916 to 50652 Part Number 21457 and from Machine Number 50653 to the end of the Series Part Number 21153.

Early model engines were fitted with aluminium pulleys, which were changed to cast iron, due to the tendency for the aluminium pulley to wear rapidly due to the action of the 'V' belt which is used as a clutch. Note that different pulleys are required for each type of engine, and that all 'V' belts are of different lengths. These belts are as follows:

Engine Pulleys and Vee Belts

	Pulley	Belt
Villiers 25C 2-stroke	20472	20707
BSA	21289	A 23
Briggs & Stratton	20280	20198
Kohler & Clinton	21224	20198
Villiers 15 and 15 HS	20200	20196 (up to Serial Number 39718 then 20198)
AC	20099	20198

The adjuster for the drive belt on the more modern engines is found beneath the platform and belt tension is increased by turning the adjusting screw inwards, after first loosening the lock nut. The brake lock should be adjusted on the setscrews so that it

presses into the 'V' of the wormshaft pulley just sufficiently to prevent the machine moving forward when the clutch is in the disengaged position.

WORM SHAFT ASSEMBLY

The front wormshaft assembly driven from the 'V' belt consists of a pulley screwed onto the wormshaft with a right-hand thread. This shaft is located in the housing with a bearing provided at each end. The meshing wormwheel is connected to the gearbox drive shaft with setscrews, which are wire locked. The drive shaft is supported on a bronze bush in the worm housing. When replacing this bush the oil hole must be drilled after the bush has been fitted into the housing. Front wormshaft and wormwheel have Part Numbers 20444 and 20453 respectively.

GEARBOX

The drive shaft, which protrudes through the worm housing, is threaded at the end and two gears are screwed on to this shaft with a left-hand thread, the larger gear of the pair first.

Sliding gear cluster supported on shaft in the gearbox permanently engaged with the bullwheel is arranged to slide and engage with the gears on the drive shaft. This bullwheel forms part of the drive shaft assembly to the road wheel. Care should be taken when fitting this drive shaft through the oilseal in the gear casing to avoid tearing the seal. The clamp nut on the right-hand side of the wheel assembly has a left-hand thread and must be kept tight at all times. Loose nut will allow the wheel assembly to float sideways with eventual loss of drive. The rear end of the wormbox a sliding dog is provided from the worm shaft. Care must be taken in adjusting this sliding dog to ensure that the operating control does not maintain a pressure between the selector face and the sliding dog. The selector must be centralised.

ROTOR UNIT

The rotor unit consists of worm drive reduction within a housing, driving directly on to a rotor fitted with blades. The wormbox assembly consists of a housing supporting a wormshaft and wormwheel. The wormshaft drive dog is screwed onto the front end with a right-hand thread. This shaft is supported at the front by a bronze bush, and at the rear with an angular contact bearing, this bearing is fitted to take the rearward thrust of the shaft. The wormwheel driven from this shaft is secured to the transverse drive shaft by four setscrews. This shaft revolves in bronze bushes in the housing, and the oil way for this bush must be drilled after fitting the bush to the casting.

Two types of rotor worm housings have been used, a small version with the Villiers 25C engine up to Serial Number 10809, and from then on a larger version. Up to Serial Number 10809 worm shaft and worm Part Numbers 20449 and 20453 have been used, from Serial Number 10810 Part Numbers 20882/3 were used and replaced by 21020/1 from Serial Number 49421. Part Numbers 20882/3 are now obsolete and 21020/1 should be fitted, in this particular case they must be fitted as a pair, but on machines after 49421 they may be supplied separately. Where earlier versions up to Serial Number 10809 require to be changed the heavier later type housing and worm wheel and shaft should be used, the items required are as follows:

Part Number	Description
20881	Gearbox
20884	Gearbox Cover
20895	Gearbox Cover Gasket
20885 10"	Drive Shaft Housing
20905 14"	Drive Shaft Housing
21020	Worm Wheel
21021	Worm Shaft

The left-hand side of the rotor is splined and located onto the rotor drive shaft within the wormbox, and oil is prevented from escaping by an oilseal at the end of the rotor. Two widths of rotor have been provided, 10" and 14", and a draw bolt is arranged to pass through the right-hand side frame, down the centre of the rotor tube and threaded into the rotor drive shaft, this is left-hand thread, the bolt must be kept tight.

"300" & "350"

**HOWARD
ROTAVATOR.**

Medium sized Rotavator with 16" rotor width as standard.
Commenced production in 1962 at Serial Number 236/1.

CODE NUMBER

Four systems of numbering have been used for this machine. When production commenced in 1962 the first numbering sequence was 236/1 up to and including machine Serial Number 236/24. The second system commenced at machine Serial Number 300/25 and went up to and including machine Serial Number 300/775. The third method was introduced at machine Serial Number 2511001; this system continued to machine Serial Number 2321065.

The present system commenced at machine Serial Number 3121001.

SERIAL NUMBER LOCATION

On brass plate on clutch operating arm or handle bar main spar, or left-hand engine bearer.

ENGINE

The first '300' Rotavators were fitted with the Briggs & Stratton 4-stroke 4.3 h.p. engine Model 141200.

From Serial Number 3132828 the engine was changed to a Kohler model Number K 91. From machine Serial Number 3133201 an alternative Kohler engine was introduced Model K 141.

The Kohler K 91 4-stroke, 3.1 h.p. Governed speed 3,600 r.p.m.

The Kohler K 141, 4-stroke, 5.3 h.p. Governed speed 3,600 r.p.m.

It is possible to convert the early Briggs & Stratton engine machines to the Kohler engine version, and conversion sets have been prepared, and the relevant parts are listed as follows:

Part	Part Number Briggs & Stratton	Part Number Kohler K 91	Part Number Kohler K 141
Drive Key	66927	68312	66927
Clutch Drive			
Shaft	66924	68311	66924
Back Plate	66436	68313	68313
Setscrew	$\frac{5}{16}$ " x $2\frac{1}{2}$ " long (2 off)	—	—
Socket Head c/s Screw	—	$\frac{5}{16}$ " UNF x $\frac{5}{8}$ " long (4 off)	—
Setscrew	—	—	$\frac{3}{8}$ " UNC x $\frac{3}{4}$ " long (4 off)
Spacer	66439	—	G 316 (4 off)
Power and Frame Unit			
Muffler Elbow	—	68317	—
Bolt	—	$\frac{1}{2}$ " UNC x $1\frac{1}{2}$ " long (2 off)	—
Spring Washer	—	$\frac{1}{2}$ " dia. (2 off)	—
Belt Guard	64479	68318	68318
Engine Mounting Plate	64461	68306	68306
Bolt	$\frac{5}{16}$ " UNC x $1\frac{7}{8}$ " long (4 off)	$\frac{5}{16}$ " UNC x $1\frac{1}{8}$ " long (4 off)	—
Bolt	—	—	$\frac{3}{8}$ " UNC x $1\frac{1}{4}$ " long (2 off)
Bolt	—	—	$\frac{3}{8}$ " UNC x $1\frac{1}{8}$ " long c/s head (2 off)
Flat Washer	$\frac{5}{16}$ " (4 off)	$\frac{5}{16}$ " (4 off)	—
Spring Washer	$\frac{5}{16}$ " dia. (4 off)	$\frac{5}{16}$ " dia. (4 off)	—

Shakeproof Washer	—	—	$\frac{3}{8}$ " dia. (4 off)
Nut	$\frac{5}{16}$ " UNC (4 off)	$\frac{5}{16}$ " UNC (4 off)	$\frac{3}{8}$ " UNC (4 off)
Switch Stop	—	Miller D2	Miller D2
Cable and Terminal	—	67782	67782
Cable Clip	—	85-5931 John Bull Size 'S'	85-5931 John Bull Size 'S'

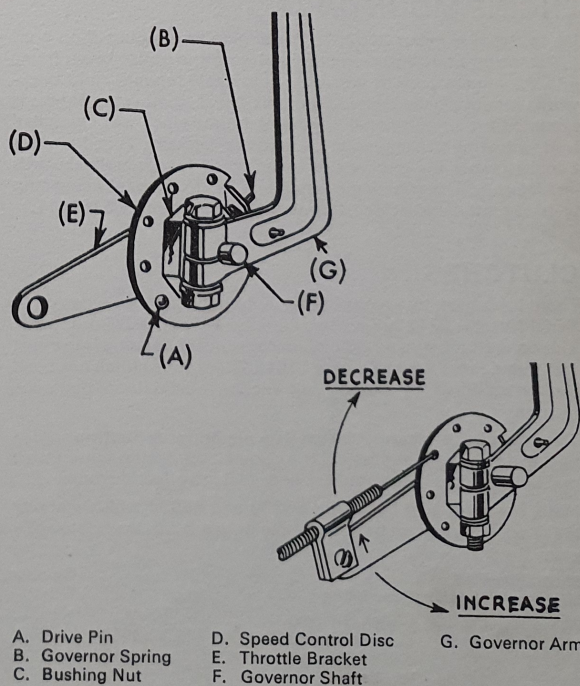
KOHLER ENGINE THROTTLE CONTROL CABLE

The throttle cable, Part Number 27001220, WC 223 57 $\frac{1}{2}$ " x 54 $\frac{1}{2}$ " is necessary in both cases, and is fitted as follows with reference to the Owner's Manual, page 7.

Remove the drive pin (A) loosen the bushing in position, re-tighten the nuts. Cut off approximately $\frac{1}{4}$ " of the inner cable wire, and set the end parallel to the main cable by $\frac{1}{2}$ " beginning $\frac{1}{2}$ " from the end.

Insert this bend through the speed control disc (D) into the first hole above the hole from which the pin was taken. The cable clamp is bolted to the bottom end of the throttle bracket (E) with a $\frac{3}{16}$ " x $\frac{1}{2}$ " bolt. Adjust the cable by sliding the outer cable through the clamp. It may be necessary on some models of the K 141 to crank the throttle bracket.

When fitting the K 141 engine make sure that it sits squarely on the platform. It may be necessary to file the welding of the belt tension bolt stop.



WIDTH OF CUT

16" Standard, extendible to 23".

DEPTH OF CUT

Depth of cut 8".

CONTROLS

The controls of the '300' are grouped at the handlebar as follows: Engine throttle control by lever from the handlebar. Clutch control by grip hand lever on left-hand handlebar. Gear change lever, incorporating spring safety reverse, operated from the handlebar. Rotor depth control is by hand lever locating into a series of holes in the depth control quadrant situated above the rotor.

Rotor Control

On early machines the rotor selector lever was mounted on the transmission housing, but later models have a modified version which is spring loaded and operated remotely from the rotor depth control quadrant. Refer to page 8, paragraph 'Rotor drive selector gear'.

WHEELS

400 x 8 Ground Grip.

Tyre pressure should be 20 p.s.i.

OIL CAPACITIES

Briggs & Stratton	2½ pints SAE 30
Kohler K 91	1½ pints SAE 30
Kohler K 141	2 pints SAE 30
Gearbox and transmission	1½ pints, was SAE 30 is now SAE 90

The transmission oil level must be checked when the machine is tipped forward onto the engine bearers. The oil level screw is on the right-hand side of the transmission casing back plate. Oil should just seep over the threads when the plug is removed.

ENGINE MOUNTINGS

Up to Serial Number 3162610 the engine was mounted on 4 off $\frac{5}{16}$ " setscrews through elongated holes on the transmission frame into the engine base. It was thus adjustable forwards and backwards for drive belt tension. From this Serial Number the engine is mounted on an additional engine platform which has elongated holes allowing the engine to be adjusted laterally. Thus from this Serial Number the engine can be adjusted forwards, backwards and laterally. The engine mounting arm has had a reinforcing strip welded on the underside beginning at Serial Number 3162611.

CLUTCHES

There have been two types of clutch, two friction disc types up to Serial Number 2312808 when a cone type clutch was introduced. This cone clutch was an aluminium cone inner operating into a cast iron outer. From Serial Number 3161267 the cone clutch has been further modified by introducing friction material on the cone facings.

This type of clutch cannot be used on the Briggs & Stratton engine because this engine relies on the cone clutch facing inner thrust pad between the clutch and the back plate to effect the braking.

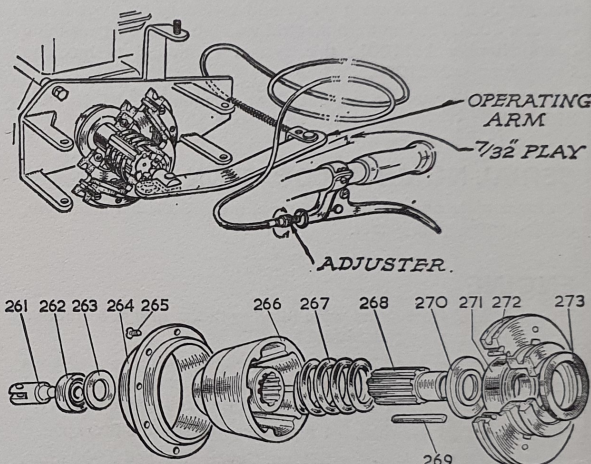
Note, however, that the cones 68930 and 68908 which embody the lined material, can be used on the Briggs & Stratton clutch as a pair.

Illustration Number	Part Number	Description	Number Off
261	66926	Clutch Release	1
262		Ballrace Fischer DN 2062 $\frac{5}{8}$ " i.d. x 1 $\frac{7}{16}$ " o.d. x $\frac{7}{16}$ " double sealed	1
263	14509	Washer	1

Illustration Number	Part Number	Description	Quantity
264	66921	Clutch Cone—outer	1
265		c/s Setscrew No. 10 UNC $\frac{1}{2}$ " long	8
266	66922	Clutch Cone—inner	1
267	66923	Spring	1
268	66924	Clutch Drive Shaft	1
269	66927	Key	1
270	66925	Spring Pad	1
271		Ballrace LS 12 RSV 3 1 $\frac{1}{4}$ " i.d. x 2 $\frac{3}{4}$ " o.d. x $\frac{1}{8}$ " W double sealed	1
272	66920	Engine Pulley	1
273	67021	Thrust Pad	1

Cone Clutch Adjustment

To maintain the correct setting as the clutch wears, keep $\frac{1}{8}$ " of free movement on the operating arm, measured at the thrust bearing and socket position of $\frac{3}{32}$ " at the arm end (see diagram). Adjustment is obtained by means of the knurled screw on the control lever.



CONE CLUTCHES BRIGGS & STRATTON ENGINES AND METAL TO METAL CLUTCHES

When all the adjustment has been taken up on the operating cable due to wear on the clutch cone, an oversize clutch cone outer, Part Number 67783, can be fitted in place of Part Number 66921, Illustration Number 264. This makes a satisfactory repair without the necessity of changing both inner and outer cones. The condition of the cone parts after a little wear will appear to be scuffed or present a rough appearance, this is normal and requires no repair, and where a slight squeaking emanates from the clutch, a drop of oil on the thrust pad between the clutch and the back plate will soon rectify this. This pad is assembled originally with a coating of graphite grease. We recommend Loctite grade 'A' for retaining these screws.

VEE BELT DRIVE

The adjustment of the belt is that it should deflect $\frac{1}{4}$ " at the centre of the span, under a load or weight of 6 lbs. Adjustment is effected by moving the engine appropriately by the adjuster on the mounting frame.

BREATHER TRANSMISSION HOUSING

Originally located on the back plate, was redesigned and moved to be incorporated in the filler plug on the gearbox.

GEARBOX

Driven by the large alloy 'V' pulley by splined drive shaft protruding through the chaincase and sealed by conventional oilseals. Gearbox embodies drive shaft, reverse shaft and intermediate shaft assemblies. The gearbox incorporates two forward speeds and one reverse, controlled by suitable gear selectors and rods from the control column. The reverse gear is spring loaded as a safety precaution and has to be held into gear to operate.

CHAINCASE ASSEMBLY

The complete unit is in two sections, bolted together, and consists of a chain case and back plate, which is sealed with thick gasket and a number of nuts and bolts.

Tow axle housings are rivetted or 'huck' bolted to the transmission assembly. The road wheel axle passing through the transmission assembly is driven by a large bullwheel direct from the gearbox within the transmission housing, and is lubricated from the general oil. Oilseals are provided within the housings to prevent oil leakage from the axle.

ROTOR CHAIN DRIVE ADJUSTER

From Serial Number 2321063 a chain adjuster was embodied in the machine. A regular check of tension is desirable and as there is no opening in the chaincase through which to view the chain or touch it, the adjustment must be effected from outside. Use the chain adjuster as follows: Unlock the adjusting screw locknut and with a screwdriver screw in the adjuster until resistance is felt as the chain tightens. Unscrew the adjuster one complete turn from this point and lock the locknut. Note that the chaincase weld assembly Part Number 66593 now embodies a boss for the chain adjuster, and will be used on all machines from Serial Number 2321063.

TRANSMISSION ASSEMBLY

Various changes in the transmission commencing at Machine Number 3121001:

64317	Thrust Washer	was 3 off now 1 off
67257	Thrust Washer	2 off added
64354	Rotor Idler Gear Assembly	replaced by 67248
64356	Spacer	replaced by 67256
64357	Rotor Drive Sprocket Assembly	replaced by 67251
64332	Drive Sprocket Spindle	replaced by 67255
64333	Idler Pinion Shaft	replaced by 67250
67275	Chain Tensioner	1 off added
67280	Adjuster Screw	1 off added
67281	Sleeve	1 off added
$\frac{3}{16}$ " UNF x $1\frac{3}{8}$ " bolt hexagon head		1 off added
$\frac{3}{16}$ " Philad Nut GUF/L		1 off added
$\frac{3}{16}$ " Locknut		1 off added
64309	Final Drive Pinion	replaced by 67260
64311	Gear Spacer	replaced by 67262
64312	Cluster Gear Assembly	replaced by 67258
64345	Thrust Washer	replaced by 67264
64314	Intermediate Shaft	replaced by 67263
66272	Shim .015"	replaced by 67495
66273	Shim .010"	replaced by 67494

The original lubricant used in the transmission assembly had a viscosity of SAE 30. This must be changed to SAE 90 on all machines. Machines from Serial Number 3121001 were supplied with SAE 90 lubricant in the transmission assembly.

ROTOR DRIVE SELECTOR GEAR

There have been three types, and from Serial Number 3151596 a new selector control has been incorporated, remotely operated from a position at the rear of the depth control quadrant. This control can be fitted to all earlier '300' and '350' machines.

From Machine Number 3151596 alterations have been made to the rotor selector assembly, affecting the following parts:

New Part	Old Part
Selector Control Assembly 68792	Selector Control Assembly 64380
comprising:	
Rotor Selector Arm 68793	Rotor Selector Weld Assembly 66170
Selector Rod 68795	Rotor Selector 64390
Selector Gate 68798	Gasket 65499
Control Rod 68801	
Trunnion 68910	
Spring 68909	
Trunnion Block 20545	
Bracket 68831	
Rotor Selector 64390	
Gasket 64599	

CHAIN DRIVE

The $\frac{5}{8}$ " pitch chain transfers the drive from the idler gear shaft to rotor drive shaft.

ROTOR DRIVE SHAFT

Early models incorporate a shaft having tensile strength of 40 tons, this has now been improved to shafts of 65 tons strength. Needle bearings support the shaft on either side of drive sprocket, and the inner sleeve of these races cannot be removed from the shaft at all, it is necessary to break the race away from the shaft when fitting new bearings. Oil seals on either side of the bearing housings are double lipped and it is important to have one lip facing outwards and one lip facing inwards.

To replace the oilseals (Illustration Number 163) in the rotor drive shaft housings the following method can be used in order to cut the dismantling time.

1. Remove the shield (225) and the draw bolt (211) which locates the rotor halves to the drive shaft (168) remove rotor halves.
2. Remove the two oilseals (163) from both drive shaft housings by levering with narrow wedge shaped rod.
3. Replace new oilseals, ensuring the inner seal is facing lip inward, and the outer seal with the lip outward.
4. Reassemble machine ensuring the rotor halves are fitted correctly (as Fig. A in Instruction Book) and that draw bolt is inserted from the RIGHT-HAND side of machine looking from the rear.

An improved oilseal is available for machines prior to Serial Number 3151727 under Part Number INA5D 30 x 37 x 4 mm., this seal has twin lips and can be used in place of the existing seal. From Serial Number 3151728 alterations have been made to the rotor drive bearing housing affecting the oilseal Part Number for the new bearing housing is 68714, and the oilseal is Part Number 175 118 18, these parts can be fitted to machines prior to Serial Number 3151728 providing both oilseals and housings are used.

ROTORS

Rotors with splined centre tube are fitted to the splined ends of the rotor drive shaft, and are clamped together by a draw bolt through the centre. This bolt MUST be fitted with the nut at the left-hand side otherwise it may become loose and allow the rotor to damage the splined drive shaft, or the rotor may come completely off the shaft. From machine Serial Number 3151422 a longer draw bolt has been used, Part Number 64427, this allows two $\frac{5}{8}$ " UNC lock-nuts to be used to retain the two rotor halves in place of the original $\frac{5}{8}$ " UNC nut.

When the two rotor tubes Part Number 64420 are replaced on the splines of the rotor drive shaft, ensure that the blades are fitted with the leading edge of the blade forward. Viewed from the right-hand side of the machine, the rotor turns clockwise. It is also important

that the correct spline on the rotor drive shaft is selected to give equal spacing of the blades. The rotor scroll pattern must be maintained to ensure that only ONE blade enters the ground at a time.

ROTOR SHIELD

From Serial Number 3123912 the kit for the 23" shield conversion now contains a long securing pin Part Number 64439. This pin is provided to replace the very short securing pin Part Number 67284 fitted to the front of the standard 16" shield.

WEED CUTTERS

Weed cutters should be fitted so that inner or centre blades of the left-hand rotor are 30° forward of the right-hand centre blade; this will give a blade entry pattern of 1, 3, 2, 4 on a standard 16" rotor.

DEPTH CONTROL SKID

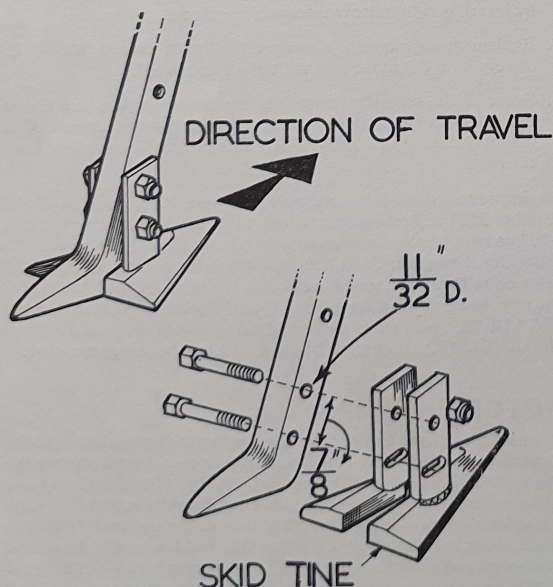
Depth control skid is fitted immediately behind the chaincase. The skid is raised to increase depth and in very hard ground the point of the skid may be reversed to point forward to be used as a sprag. This increases penetration and prevents forward overthrust of the machine.

DEPTH CONTROL SKID AND TINE SKID

Part Numbers 64446 and 68488 respectively

An additional hole $\frac{1}{2}$ " diameter has been drilled $\frac{7}{8}$ " above the bottom hole in the lower part of the depth control skid Part Number 64446. This allows fitment of a new skid tine, Part Number 68488 designed to assist full ground coverage when the machine is used for shallow cultivation. When fitting to the depth control skid, ensure that the skid tine is allowed to pivot on the retaining bolts. Tighten the Philidas nuts so that the bolt does not drop out, but is not so tight as to pinch the tine to the skid. The sketch shows the new skid tine in position on the depth control skid.

The tine skid is an optional extra.



PLOUGH HITCH BRACKET 65517

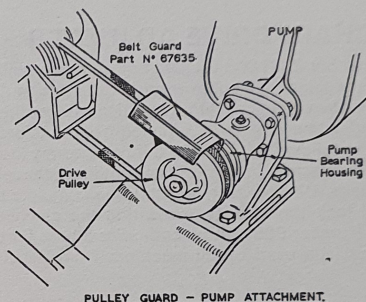
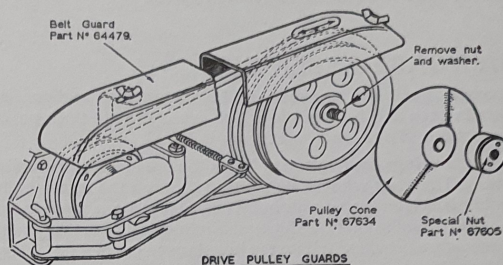
There is a change in the design of this bracket to enable it to be fitted to all machines including those with modified shields. The

alteration involves the removal of a portion of the flat section and the use of five of the six holes in the original design.

SAFETY KITS

Part Number 67675 Drive Pulley Guard

Fitting instructions:



- Remove the existing belt guard Part Number 64479.
- Remove the belt pulley retaining nut and washer and fit new nut Part Number 67605. Where the belt pulley incorporates six holes it is necessary to fit the pulley cone Part Number 67634. Solid wheels do not require the cone.
- Fit new 'U'-shaped belt guard. This has the same Part Number as the earlier version 65579.

Part Number 67738 Pump Pulley Guard

Slacken two of the four retaining nuts holding the pump bearing housing and fit the belt guard Part Number 67635 at the 'run on' position of the belt.

IMPORTANT

Machines up to Serial Number 3121741 have belt pulleys with six holes and will require the full kit. From this number the pulley is solid and the sheet metal cone Part Number 67634 is not required. The special nut 67605 has been omitted and must be fitted to comply with the regulations. The nut is standard from Serial Number 3122252. Machines up to Serial Number 3122110 will require the special 'U' guard Part Number 64479 to the belt drive.

Machines from Serial Number 3122124 to 3123013 have been fitted with Part Number 66076 rotor selector and belt guard bracket fitted with $\frac{5}{16}$ " UNF bolt welded on. This means that the rear bolt to secure the belt guard on these machines will be UNF threaded, whereas those before these Serial Numbers and after have all been UNC threaded. These machines having the Serial Numbers shown will have the front wing nut of UNF thread and the rear wing nut of UNC thread.

TOOL BAR REAR MOUNTING BRACKET

The 1964 version of this machine requires a new type mounting bracket, Part Number 67589. This version supersedes the earlier type but may be used on all machines including the earlier models.

"400"

HOWARD
ROTAVATOR®

SERIAL NUMBER

The Serial Number, which can be found stamped on to the right-hand handlebar at the lower end, or on the gearbox on the top of the rotor mounting flange, began at Serial Number 2411001 in 1967, the prefix '24' indicates the '400' Series machine.

ENGINE

Up to Serial Number 400/962 the Clinton $3\frac{1}{2}$ h.p. was fitted, and from this Serial Number either a JAP 4/3 $3\frac{1}{2}$ h.p. engine or a Hirth 2-stroke diesel engine type D 24 were fitted.

From Serial Number 1593 the fuel tank on the JAP engine was moved to improve the fuel flow. This involved providing new fuel tank bracket Part Number 60984. From Serial Number 1868 this tank bracket was further altered to embody a brace Part Number 62952 and a bracket for the air cleaner Part Number 61748. The modified tank bracket was given Part Number 62950. From Serial Number 2113 the JAP engine was fitted with the new AC Delco air cleaner, which has a replaceable paper filter element Part Number LB20A.

From Serial Number 2441046 the Kohler 161 engine, 6.9 h.p. at 3,400 r.p.m. was fitted, and is in use to the present day.

ENGINE CONVERSION KIT

To enable the Kohler engine to be fitted to machines of early manufacture Kit Part Number 68721 has been provided, which consists of the following components:

Description	JAP 4/3 Part Number	Kohler K 161 T Part Number
Clutch Adaptor	60497	68421
Setscrew		$\frac{1}{16}$ " UNF x $\frac{1}{2}$ " long
Spacer		68434
Engine Adaptor	62681	68420
Setscrew		$\frac{3}{8}$ " UNC x 1" long (4 off)
Spring Washer		$\frac{3}{8}$ " dia. (4 off)
Setscrew		$\frac{7}{16}$ " UNF x $1\frac{1}{2}$ " long (4 off)
Spring Washer		$\frac{7}{16}$ " dia. (4 off)
Switch Stop		Miller D2
Cable and Terminal		67782
Cable Clip		85-5931 John Bull Size 'S'

CONTROLS

1. Gear change lever, on right-hand side of head stock swivel.
2. Rotor engagement lever, located on the left-hand side of head stock.

Note: From Serial Number 400/638 the notches on the right-hand side of the gear lever quadrant were removed and this involved the following part changes:

Old Part Number	Description	New Part Number
62149	Headstock Swivel W/A	62307
62123	Lever W/A	62306
62247	Brass Plate	62309
62263	Clamp Nut	$\frac{3}{8}$ " UNF

3. Clutch control by hand grip lever and cable on left-hand handlebar.

4. Throttle control by Bowden cable on right-hand handlebar.

Throttle Cable Assemblies:

Clinton SK 599 Throttle Assembly

JAP 4/3 3209/10 Cable

21815 Lever

Hirth 62423 Cable

Doherty 1" Lever, right-hand

FLYWHEEL AND CLUTCH

The flywheel rivet assembly Part Number 62226 fitted to the early Clinton machines was changed with the introduction of the JAP 4/3 engine to Part Number 62425.

The clutch is a double plate type made up of two friction material discs between three steel clutch plates. The front plate is threaded with bolts screwed in, which are locked and tab washered.

This clutch is very positive in its action and will produce a 'clonking' noise in the gearbox during initial operation. This noise is not detrimental in anyway since it is produced by the take up of the various back lashes in the gear assemblies.

To facilitate easy removal of the clutch pressure plate, Part Number 62068, a further three holes have been added drilled and tapped $\frac{3}{8}$ " equispaced on a 2" pitch circle diameter. These holes make it possible for the clutch plate to be removed with a simple plate type extractor.

CLUTCH ADJUSTMENT

Maintain $\frac{1}{4}$ " free movement on the hand lever. When replacing, the clutch thrust bearing should be lubricated with a Lithium grease on assembly, it's subsequent lubrication is maintained from the gearbox.

CLUTCH SHAFT

This shaft is supported from the rear of the gearbox and is located by a circlip behind the bearing at the rear of the shaft. The front of the shaft is supported by the pilot bearing in the flywheel.

GEARBOX

Two forward speeds and one reverse. Driven by a heavy duty worm and wormwheel from the clutch shaft by a series of spur gears to the wheel axle.

Up to Serial Number 126 the gearbox cover plate Part Number 60997 was fitted, if necessary this may be replaced by cover plate Part Number 67044 together with axle spacer Part Number 62085, and bush Part Number 62052, all of which were used from Serial Number 127.

From Serial Number 162 the gearbox Part Number 60998 and axle housing Part Number 60999 were changed to Part Numbers 62043 and 62051 respectively.

WORM AND WORM SHAFT

The worm wheel is located on the drive shaft with six setscrews which are wire locked.

REVERSE GEAR

Supported on two bronze bushes on a transverse shaft at the top of the gearbox.

WHEEL AXLE

The wheel axle is supported on bronze bushes in the axle housings, which are bolted to the gearbox. The axle housings are suitably sealed with oilseals. The axle is bolted to the bullwheel within the gearbox and the bolts should be secured and locked with tab washers.

WHEEL HUBS

The wheel hubs have tapered splines to suit the tapered splines on the wheel axle. The hubs are secured to the axle by Philidas self-locking nuts.

WHEELS

Five-hole fixing wheels are fitted with 400 x 12 ground trip tyres, and the tyre pressure is 14 lb p.s.i.

BEVEL GEARBOX ASSEMBLY

Within the bevel gearbox the driven dog is secured on to the pinion shaft with a right-hand thread. This shaft is located within the ball bearing in the front end, and a bronze bush at the rear. The bearing in the original models was an angular contact type which has later been changed to a ball bearing. They were Part Numbers LS8ACD and LS8 respectively.

CROWN WHEEL AND JACKSHAFT

The crown wheel is splined on the jackshaft and secured with a circlip. This shaft is supported by ball races at each end, the crown wheel back lash is .008" to .010" and the adjustment is effected by inserting or removing gaskets between the jackshaft housing and the bevelbox shaft.

SPROCKET AND CHAIN

Originally $\frac{3}{4}$ " pitch chain was found satisfactory, with the increased h.p. engine and 9T sprocket the heavy duty chain was fitted from Serial Number 2173, this required a thicker gasket between the chaincase cover and back plate.

From machine Serial Number 2333 the 8T sprocket Part Number 62171 was changed to a 9T sprocket Part Number G 460.

Chain Assembly:

Old Part	New Part
16783 Chain Assembly	60968 Heavy Duty Assembly
52630 Gasket	61791 Gasket
$\frac{1}{4}$ " UNF x $\frac{1}{4}$ " Bolt (4 off)	$\frac{1}{4}$ " UNF x $\frac{7}{8}$ " Bolt (4 off)
$\frac{1}{4}$ " UNF x $\frac{5}{8}$ " Bolt (9 off)	$\frac{1}{4}$ " UNF x $\frac{3}{4}$ " Bolt (9 off)
$\frac{1}{4}$ " UNF x $\frac{7}{8}$ " Bolt (1 off)	$\frac{7}{8}$ " UNF x $\frac{7}{8}$ " Bolt (1 off)
$\frac{1}{4}$ " UNC x $\frac{7}{8}$ " Bolt (3 off)	$\frac{1}{4}$ " UNC x $\frac{7}{8}$ " Bolt (3 off)
51544 Adjuster Screw	62631 Adjuster Screw
51985 Back Plate	62630 Back Plate

CHAIN ADJUSTMENT

Checked through the filler plug hole, the maximum movement $\frac{3}{8}$ ".

LUBRICATION

Engine	Lubrication Point	Capacity Pints	Litres	Grade of Oil SAE
	Oiling Points			90
	Main Gearbox	2 $\frac{1}{2}$	1.5	90
	Bevel Gearbox	$\frac{3}{4}$.4	90
	Chaincase	$\frac{1}{2}$.3	90
JAP 4/3	Sump	2	1.2	40 32°F. + 30 0°F. —
Hirth D 24	Air Filter Sump	1 $\frac{1}{2}$.75	Paper Element Type 20/20W H.D.
	Air Filter			As Engine

Stub axle bearings, shield hinge and control rod joints should be lubricated by oil can with SAE 90.

DEPTH OF CUT

Maximum 9".

Obtained by more than one pass. Controlled by depth control skid adjusting in $\frac{3}{4}$ " stages.

ROTOR DRIVE SHAFT

The design of this shaft is different from other machines of Howard manufacture in that it is fitted through the back plate from the rotor side. No rotor clutch is fitted.

ROTOR

Standard two-bladed with two right-hand blades on the left-hand end flange, the right-hand flange carries two left-hand and two right-hand blades.

WIDTH OF CUT

Standard 16".

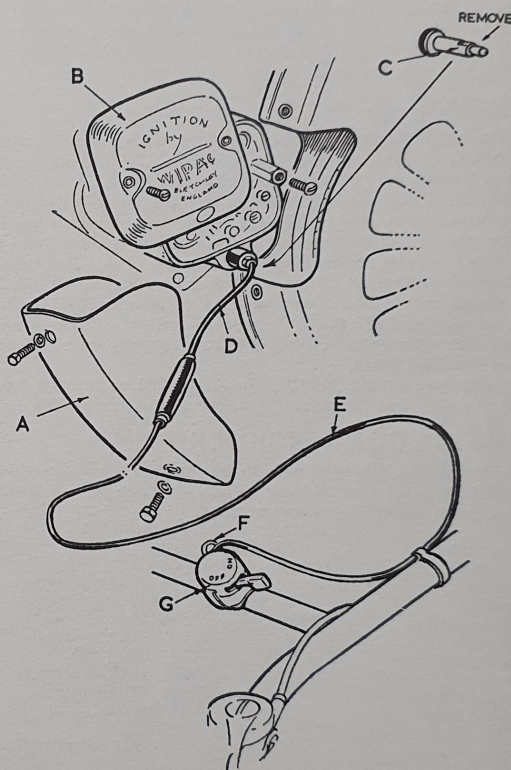
STUB AXLE ASSEMBLY

Consists of a stub shaft, bearing, oilseal, an oilseal spacing sleeve, a felt and a left-hand thread bearing cap. This stub axle assembly is retained to the right-hand side plate with nut and tab washer. To prevent lubricant travelling along the rotor tube an end cap is fitted in the stub axle end of the rotor. A round head screw located on the inner side of the right-hand flange is screwed into the rotor tube.

The stub axle is lubricated through the hole in which the round head screw is fitted. Use SAE 90 oil every 25 hours by inserting with an oil can.

SAFETY KIT

Kit Part Number 67676



Fitting instructions:

- Remove the small section of engine cowling (A) by removing the two retaining screws.
- Remove the magneto end cover (B).
- Unscrew the magneto stop button (C) complete with the insulator which is no longer required.
- Screw the new connector lead (D) into the magneto in place of the stop button.
- Refit the magneto cover and the section of engine cowling.
- Fit engine stop cable (E) and earthing cable (F) to the switch (G) and short earthing cable (F) should be fitted to the centre terminal of the switch.
- Position the switch in the most accessible position on the handlebars, remove sufficient paint from under the switch clamp to make a good earth contact, and ensure the earthing cable (F) is connected to the clamp screw.
- Connect engine cable stop (E) from switch to magneto connecting lead (D) using rubber connector.
- Move switch to the 'ON' position start the engine and ensure that the engine stops when the switch is moved to the 'OFF' position.

"700"

HOWARD ROTAVATOR

The Howard '700' Rotavator is one of the most versatile Rotavators produced, and was designed with a view to producing a machine which was capable of other operations than rotavating, and was thus developed as a power unit with various attachments.

SERIAL NUMBER

The machine Serial Number began at 1001 in 1958 and finished in 1961 at machine Number 3419.

The Serial Number may be found on the main control column, and the number of the Rotavator unit is stamped on the top face of the bevel box.

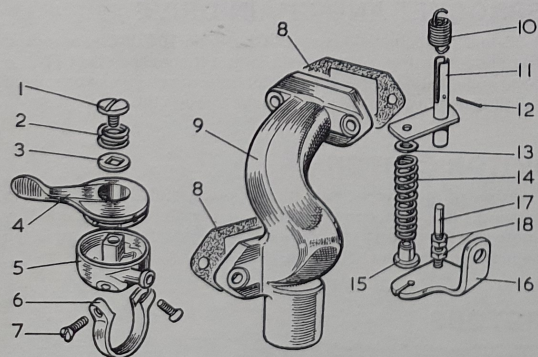
Machine Numbers:	1958	1001
	1959	1300
	1960	2631
	1961	3419

ENGINES

Machine was introduced with either the Villiers 28B $3\frac{1}{2}$ h.p. 2-stroke at 2,800 r.p.m., or Hirth diesel D 24 2-stroke $6\frac{1}{2}$ h.p. at 2,200 r.p.m.

Various modifications to the Villiers 28B engine were introduced from time to time from machine Serial Number 2245. These affected the control lever, the inlet manifold, the governor control mechanism. The following list shows the new parts:

Illustration Number	Part Number	Description	Quantity
1	V 1368E	Screw	1
2	V 1572E	Spring	1
3	V 1371E	Locating Washer	1
4	V 1483C	Control Lever	1
5	V 1538E	Control Body	1
6	V 1529E	Clip	1
7	V 1525E	Clip Screws	2
8	E 8237	Joint Washer, Inlet Pipe (unchanged)	2
9	C 10715	Inlet Pipe	1
10	EM 2232	Governor Spring	1
11	EM 2555	Fixture Bracket Assembly	1
12	V 301E	Split Pin	1
13	26639	Washer	1
14	V 1299E	Return Spring	1
15	26790	Return Spring Guide Bush	1
	EM 2552	Cable End Bracket Assembly comprising:	1
16	EM 2549	Bracket	1
17	EM 2551	Guide Pin	1
18	V 105X2E	Nuts	2



In addition the carburettor throttle stop screw locknut (Illustration Number 33 on page 16 of Villiers 28B Handbook VE 538) has been replaced by V 136 x 6E Spring 1 off.

These modifications were introduced to improve the engine speed pickup from the tick over speed, and to give the operator control of the engine revs. through the full range of the governor operation.

THROTTLE CABLES

Throttle cables to suit the engines are as follows:

Villiers 28B 769B	V 234B/L.F. 7' 8" cable
Villiers 28B 055D	1376C/J lever
Hirth	54697 cable
	Doherty 100 (1") lever, right-hand

FLYWHEEL ADAPTOR

The flywheel adaptor fitted to the Hirth engine was originally secured by six setscrews; due to the tendency of the adaptor to become loose a modification was introduced by fitting four 6 mm. x 1" long dowels.

From Serial Number 2838 the fuel tank assembly for both Villiers and Hirth were changed to improve the ventilation of the engine.

The Part Numbers are as follows:

51841	Fuel Tank (Villiers)
51856	Fuel Tank (Hirth)
51848	Rubber Strip
51852	Support Plate
51847	Strap
51849	Tank Bracket

CLUTCH

A conventional vehicle type clutch was fitted with a single dry plate $6\frac{1}{2}$ " diameter, embodying a splined centre hub. The shorter section of the splined hub should face forwards to the engine when fitting the clutch plate. With the high power and performance of the Hirth diesel engine a spring-loaded splined hub was fitted in place of the standard splined hub. This was introduced to prevent excessive wear and chattering on the splines of the hub and clutch shaft.

CLUTCH CARBON THRUST PAD

On assembly ensure a clearance between carbon face and clutch centre and that the centre is running parallel to the thrust pad.

CLUTCH SHAFT

Originally manufactured from mild steel but case hardened later at both ends to reduce the wear on the splines from the clutch plate and gearbox coupling sleeve.

CLUTCH CABLE

To improve operation all Howard 700 machines from Serial Number 700/3369 have the clutch cable Part Number 53851 fitted with a

grease nipple and adjuster. Either SAE 90 gear oil in a grease gun, or Lithium base grease should be used for lubrication of the clutch cable. Care should be taken when greasing the cable not to apply too much pressure or the outer casing can split.

GEARBOX DRIVE SHAFT

The splines on early versions tended to wear rapidly within the connecting sleeve area; the material was changed to a tougher type EN 24 to overcome this problem.

REVERSE SHAFT

Early versions of the reverse shaft Part Number 51529 embodied a spacer Part Number 51521 to position the bearings at either end of the shaft. The heat generated in the gearbox caused this spacer to expand and pre-load the shaft support bearings. From Serial Number 1857 the spacer was deleted, and the shaft redesigned to incorporate two circlips to position the bearings.

LAYSHAFT GEARS

These gears run at high speeds; care should be taken when changing gear to allow engine speed to drop to avoid teeth chipping.

PICK-OFF GEARS

The only difficulty with these gears has been the tightness of the internal splines; stoning of the spline is sufficient to ease the problem.

HI LO GEARBOX

Used in place of the pick-off gears to provide a further range of speeds without the necessity to change the pick-off gears. Early versions of the gearbox were too shallow and prevented the selector gear from fully engaging. The correct depth may be determined by measuring the bottom of the recess in the box to the box face. This should be $\frac{7}{8}$ ".

WORM SHAFT

The worm shaft is supported with tapered roller bearings front and rear, and care must be taken to ensure free movement of the shaft without end play. A shimming condition is provided at the front end of the shaft to enable the correct adjustment to be obtained.

WORM WHEEL AND DIFFERENTIAL ASSEMBLY

The differential is built into the worm wheel with the differential spindles extending beyond the face of the housing, and secured by nuts and bolts, and from Serial Number 2275 these were locked with locking wires.

DIFFERENTIAL AXLE

From Serial Number 2007 the left-hand half shaft and the outer stub axle were modified to improve axle location:

New Part Number	Description	Old Part Number
51577	Split Collar (4)	—
51578	Thrust Washer (2)	—
52567	Half Shaft, left-hand	53345
52566	Outer Stub Axle	53344

Hub thrust washer 52540 and circlips $1\frac{1}{2}$ " diameter external were deleted.

WHEEL HUBS

The large oilseal in this hub must be fitted with the open side towards the wheel studs, and the facings of the gearbox side cover on which the oilseal revolves must be polished with very fine emery cloth.

DIFFERENTIAL CONTROL

The differential lock quadrant requires to be correctly positioned on assembly, and this should be timed to engage with the selector quadrant. The correct position is that the first tooth of the differential lock quadrant should engage between the second and third teeth of the selector quadrant.

GEAR SELECTION

Early machines were fitted with pawl and notch quadrant which had a tendency to stick. This was caused by the edge of the pawl cutting into the quadrant and preventing gears from moving. From Serial Number 2897 the pawl and quadrant were changed to a sliding bar and sliding selector as follows:

New Part Number	Description	Old Part Number
52259	Quadrant W/A (selector)	51989
52255	Slide Bar (selector)	52691
52572	Pedestal W/A	52008
124/5931	Spring	New part added
52257	Shim	New part added

The pawl and spring 52619 and 20570 were deleted.

HANDLEBAR SWIVEL HEAD FIXING

From Machine Number 2109 a modified pedestal W/A Part Number 52008 and modified index plate Part Number 52007 were fitted in lieu of pedestal W/A Part Number 52647 index plate Part Number 51632 and special nut Part Number 52627. These parts are not interchangeable with the old and the modification was introduced to improve the locking of the index plate. This was effected by bolting the plate to the pedestal W/A using $\frac{5}{16}$ " UNF x $1\frac{1}{2}$ " long bolts instead of securing it by a nut and 4 Mills pins.

ROTOR UNIT

Two types of rotavating units are provided, one to suit the Villiers 28B engine and one to suit the Hirth diesel engine, this is due to the different engine speeds which are 2,800 r.p.m. and 2,200 r.p.m. The low engine revs. of the diesel model necessitates a higher rotor speed. This alteration involves a change from the standard by fitting a different crown wheel and pinion Part Numbers 52288 and 52289 respectively. This rotor unit may be identified by the letters 'HS' stamped on the top face of the bevel box. The correct adjustment of the crown wheel and pinion is .008" to .010" back lash.

SPROCKET AND CHAIN DRIVE

A 52-link $\frac{3}{4}$ " pitch chain is supplied using a 10T driving sprocket. The correct tension of the chain is that it should deflect $\frac{3}{8}$ " at a point immediately below the oil filler hole, the chain can be moved by lifting it with a hooked piece of wire through this hole.

ROTOR CLUTCH

Consists of drive plate, two friction discs, and drive disc and a wearing plate. The correct setting of the clutch is obtained by tightening the nuts on top of the coil springs until the spring is coil bound then releasing half a turn.

ROTORS

15", 20" and 24" widths.

ROTOR FOOT CONTROL

The engagement of the rotor drive dog is effected by a foot control and from Serial Number 15/711/709 this was fitted with different overcentre assembly as follows:

New Part No.	Description	Old Part Number
53754	Selector Arm Weld Assembly	52643
53753	Selector Arm	52505
53752	Selector Guide	52640
52448	Control Rod W/A	53357
52480	Trunnion	51978
10392	Tension Spring	53914
52486	Foot Lever W/A	53812
52487	Foot Lever	53911
52388	Crank	Additional Part
52489	Pin Lg.	53901
52481	Pin	Additional Part
52484	Selector Arm W/A	Additional Part
52485	Selector Arm	Additional Part
52482	Lug W/A	53913
52483	Lug	53358
10669	Washer	Additional Part

Parts Deleted

51652	Spring
52699	Plunger
52642	Spring Holder

POWER TAKE OFF UNIT

All Howard Clifford P.T.O. assemblies from Serial Number 714/142 are fitted with improved selector gear and lever as follows:

New Part Number	Description	Old Part Number
55507	Selector Gear	54588
55501	Selector Lever	54854

CUTTER BAR

Part Numbers 61826 and 61632 actuating arm weld assembly have been strengthened by the addition of side panels to the frame. When fitting this strengthened arm ensure that there is clearance at the point of contact between the arm and the pivot bracket Part Number 61640 at the end of the 'stroke' of the arm. This should be relieved by fitting Part Number 61640 at this point, giving $\frac{1}{16}$ " clearance.

Howard Clifford cutter bars from Serial Number 720/221 have been fitted with the following:

New Part Number	Description	Old Part Number
61826	Actuating Arm	61632
61828	Driving Block	61639
61659	Trunnion Block	61613

and a new cutting head with a heavier back bar.

Torrington bearing B 66 (2 off) and B 812 (1 off) have been added to the assembly. Cutter bars from Serial Number 721/194 have been fitted with Part Number 55507 selector gear in place of the old Part Number 54588 and Part Number 55501 selector lever in place of old Part Number 54584 selector lever.

GEM

HOWARD ROTAVATOR.

This machine, which has been manufactured since 1942, began at Serial Number 101. In 1963 the Serial Number was changed to a seven figured number and prefixed '25', this prefix is the Code Number on this machine.

SERIAL NUMBER

The Serial Number is stamped in two places:

1. On the brass plate on the rotor shield.
2. On the horizontal main spar of the main frame.

ENGINES

Over the years there have been five series of this machine as follows:

Series I

Machines from 101 to 4,800 fitted with BJ engine.

Series II

This began at Machine Number 4801, and was fitted with the original BJ engine or an alternative JAP 600 c.c. Mk. 3 engine. This series finished at Serial Number 14784.

Series III

This machine commenced at Serial Number 14785 and finished at Serial Number 18932, and was fitted with either a JAP 600 c.c. Mk. 4 engine or Mk. 5 engine, or the original BJ engine.

Series IV

Machines produced in this series began at Serial Number 18933 and finished at Serial Number 47066. This series was fitted with either the Howard 810 c.c. engine or the Sachs 500 diesel. Early model Howard engines were fitted with 180° crankshafts. This was later modified to a 360° version crankshaft.

Series V

An improved twin cylinder 810 c.c. engine developing 12 b.h.p. at 2,000 r.p.m. was fitted from Machine Serial Number 47067 and is recognised by a suffix '2' after the engine Serial Number.

From Serial Number 2541825 a Kohler 301 engine was used. The Kohler Conversion Kit Part Number 68634 enables the Kohler engine to be fitted to machines before Serial Number 2541824.

The Kohler Conversion Kit Part Number 68634:

Part Number	Description	Quantity
B 300/090	Kohler 301T Engine	1
68636	Induction Elbow	1
68635	Bell Housing	1
59702	Clutch Extension W/A	1
59756	Spacer	1
BJ 8007	Special Washer	1
68641	Bumper Weight Assembly	1
67782	Cable and Terminal Assembly	1
68610	Engine Label	1
68708	Throttle Control Lever W/A	1
68711	Throttle Control Connector	1
68712	Throttle Pivot Link	1
S 1407100	Setscrew $\frac{7}{16}$ " UNC x $1\frac{1}{4}$ " long	4
S 8071240	Spring Washer $\frac{7}{16}$ " dia.	4
S 1404080	Setscrew $\frac{1}{2}$ " UNC x 1" long	8
S 8040840	Spring Washer $\frac{3}{8}$ " dia.	8
56405040	Socket Head Cap Screw $\frac{7}{16}$ " x $\frac{1}{2}$ " long	1
B 2034095	Elbow 90° galvanised	1
B 2041190	Backnut 1" BSP	1
B 50513041	Ball Journal BRL 1/2	1
B 80008350	Steel Key	1
B 30301190	Drain Plug	1
S 3902040	Setscrew 2 BA x $\frac{1}{2}$ " long	2
S 8030730	Shakeproof Washer	3
B 7005090	Stop Switch	1
S 2902220	Bolt 2 BA x $2\frac{1}{2}$ " long	1
S 1403060	Setscrew No. 10 UNC x $\frac{3}{8}$ " long	1
S 3902030	Setscrew 2 BA x $\frac{3}{8}$ " long	1
S 7902010	Nut 2 BA	1
S 8030730	Shakeproof Washer	1
S 3902080	Setscrew 2 BA x 1" long	2

The engines fitted to the Series IV and V fall within two categories, the twin cylinder 180° model, the Howard twin cylinder 360° model and the Sachs diesel 500. The major point of alteration during the manufacturing period of these engines is as follows:

TWIN ENGINE 180° MODEL CAMSHAFT

Up to engine Serial Number 39497 camshaft Part Number 25190 was fitted, from engine Serial Number 30408 camshaft Part Number 26510 was fitted.

MAGNETO

Up to engine Serial Number 31456 magneto Part Number 25199 was fitted, from engine Serial Number 31457 a new magneto with an automatic advance and retard Part Number 26536 was fitted, and embodying pinion Part Number 25199. A modified timing case Part Number 25691 was necessary, recessed to accommodate the new magneto pinion, has been used since engine Number 30850. This is suitable for either the later or earlier type magneto. However, if the later type magneto is fitted to an engine prior to Serial Number 30850, a modified timing case will be required.

Up to engine Serial Number 32510/2 carburettor fitted was Amal type 225/22.

Up to engine Serial Number 2611166 the Amal type 348/10 carburettor was used.

Following this number the Amal type 397/1 carburettor was introduced. This latter carburettor can replace earlier versions by fitting new fuel pipes Part Number 27047 instead of the earlier fuel pipe Part Number 26895.

From engine Serial Number 32527 the copper fuel pipes were replaced by 'Superflex' tubing, and the air filter by an AC pattern filter supported directly on the carburettor. From Serial Number 46021 a new type air cleaner was fitted comprising CBA 15/5766 Burgess air cleaner, hose pipe Part Number 52561, and 2 off Number 2 jubilee clips. The strap for holding the cleaner to the 27027 bracket is a Burgess part with Reference Number BR 228/229/180.

180° MODEL

From Serial Number 46463 the air cleaner hose was lengthened to give Part Number 27026.

OIL SUMP

The oil sump Part Number 25127 used on this engine is narrower and follows the shape of the crankcase and contains 2 pints (1.2 litres) of oil. Do not confuse this sump with the 360° sump which is wider.

TWIN 810 c.c. 360° MODEL

By comparison with the earlier models fitted on the Series IV machines this engine when fitted to the Series V Rotavator is recognised by the suffix '2' following the Serial Number on the engine. The engine has a modified governor control, modified manifold, both inlet and exhaust, and longer clutch pins to the flywheel.

From Serial Number 35900/2 the 810 c.c. 360° engine is fitted with a new governor control as follows:

Illustration Number	Part Number	Description	Quantity
1	27071	Cranked Spindle	1
2	25587	Mills Pin $\frac{3}{16}$ " dia. x $\frac{1}{8}$ " long GP 3	1
3	27069	Sleeve	1
5	27073	Arm	1
6	27070	Bush	1
7	27075	Spring	1
8		Bolt $\frac{1}{4}$ " BSF x $1\frac{7}{8}$ " long	2
9		Washer $\frac{1}{4}$ " dia.	4
10		Nut $\frac{1}{4}$ " BSF	2
11	27074	Governor Lever	1
12	27060	Throttle Cable Spring	1
13	27059	Cable Assembly	1
14	27076	Cable Bracket	1
15	27072	Trunnion	1
16		Split Pin $\frac{1}{16}$ " dia. x $\frac{3}{8}$ " long	1
17	27063	Rod	1
18		Split Pin $\frac{1}{8}$ " dia. x $\frac{1}{4}$ " long	1

OIL SUMP

The 360° engine has a wide sump Part Number 25905 and contains 3 pints (1.75 litres) of oil. Do not confuse with the 180° model which has a narrower sump and fits flush to the crankcase dimensions. It is important to check the filler mark on both sides of the dipstick, and avoid over filling the sump, which has two compartments, the oil levels of which compensate one another during the operation of the engine but not when standing.

INLET MANIFOLD

From engine Serial Number 35738/2 the inlet manifold has been replaced with an improved design. This gives better performance, increased power and a saving in specific fuel consumption. The exhaust manifold has been improved to correspond with the redesigned inlet manifold.

Old Part Number	New Part Number
26591 Petrol Manifold	26918 Inlet Manifold
26592 T.V.O. Manifold	26919 Exhaust Manifold
	25910 Bridge Piece
26073 Manifold Stud	26921 Manifold Stud

CAMSHAFT

The camshaft for the 360° type engine is Part Number 26176.

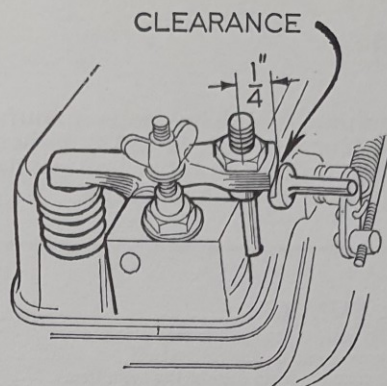
HEATER PLATE

A heater plate Part Number 67561 was introduced for the exhaust manifold of the twin cylinder engine to conduct some of the manifold heat to the carburettor inlet pipe. This prevents icing up at this point, freezing of the butterfly and bad running. Adjustment of the main jets to improve the performance is no longer necessary and excessive fuel consumption may well be cured by the introduction of the plate and readjustment of the jet. The plate is not generally required at temperatures over 55°F.

CYLINDER HEAD

From engine Part Number 261481 the cylinder head Part Number 25825 has been increased in thickness by .065". This raises the rocker shaft assembly and thus increases the range of tappet adjustment.

When a new cylinder head is fitted to an existing engine the clearance between rocker Part Number 26086 and decompression cam Part Number 25966 must be checked to ensure that the distance between the centre of the threaded hole to the end of the rocker is $\frac{1}{4}$ ". If not grind the end of the rocker as shown in the diagram.



ENGINE BREATHER

The engine breather assembly Part Number BJ 8014 was moved from the cylinder head cover to the front of the timing gears case.

MAGNETO

Engines from Serial Number 34809/2 have been fitted with a modified Wico magneto end cover Part Number S 0535.

PISTONS

From Serial Number 33570/2 4-ring pistons were fitted, Part Number 26904, comprising:

- One chrome compression ring.
- One plain compression ring.
- Two slotted oil control rings $\frac{1}{16}$ " wide.

From Serial Number 34673/2 these pistons were further modified to include 5 off $\frac{3}{16}$ " holes drilled through the wall of the piston under the top oil control ring.

This later modification effected considerable improvement in oil consumption, and prevented oiling up of the plugs. 4-ring pistons not drilled with these holes can be modified by turning a slight recess $\frac{3}{16}$ " wide below the top oil control ring, reducing the diameter by .030", and drilling 5 off $\frac{3}{16}$ " holes on the thrust face, equidistant apart and positioned so that the outer holes do not break into the gudgeon pin bosses. This has the effect of reducing oil consumption by anything up to 50%. Drawing of this modification can be supplied on request.

THROTTLE CABLE ASSEMBLY

From Serial Number 47280 when fitted with twin engines, will be fitted with the new throttle cable assembly as follows:

Old Type	New Type
26694 Cable Assembly	27059 Cable Assembly
26896 Spring	27060 Spring
27041 Support Plate	27076 Cable Bracket
	Doherty 100 ($1\frac{1}{16}$ " R.H. Lever

SACHS 500 LUBRICATION PUMP

As the lubricating pump for the Sachs diesel 500W engine is similar in external appearance to that of other models, colour markings have been introduced to avoid confusion. The pump for the 500W should bear no colour marking at all.

CONSTANT LOSS OIL SYSTEMS

Seizures of the big end bearing in the connecting rod have been traced to a lack of lubrication, because the user has failed to maintain the oil level. The user must be made aware that this is a 2-stroke diesel, and has constant loss oiling system, and that the oil is used up daily, and not recirculated.

In the event that the oil is allowed to run out remember that the oil lines will require bleeding to ensure that the pump is working correctly.

INJECTOR

The Bosch KBA 38S 1/13 nozzle holder and nozzle DN 12 SD 1" are used on this engine. As the nozzle holder is supplied complete with the induction nozzle, only an expert can tell which type of nozzle is fitted into the nozzle holder, therefore, colour markings have been introduced to differentiate the type of nozzle holders. The type used on the 500W bears no colour.

The throttle control bracket Part Number 26576 used up to machine Serial Number 2521471 has now been superseded by Part Number 27217, and was used on diesel engine machines up to Serial Number 2541847. From Serial Number 2541947 machines will be fitted with the more positive throttle control stop 272790, this new type of stop may be fitted to earlier machines in place of the existing stop Part Number 27092.

CLUTCH PLATE

All Series Gem machines up to Series V used a single plate clutch. Series I, II, III and IV the clutch plates were secured by three bolts, towards the end of the Series IV production a 4-bolt type was introduced. The Series V clutch uses the 4-bolt system but has two friction material discs instead of one. The clutch plate was changed to Part Number 62918 with spacer bush G 481 and two friction discs G 220. Be sure that the correct spring length is used when replacing clutch springs. The operation of the twin plate clutch produces a clonking noise within the gearbox. This is caused by the twin plates taking the drive up very rapidly, and is in no way detrimental to the machine provided the correct grade of lubricant is used.

CLUTCH PINS

The old flywheel pins Part Number 26755 were replaced with longer versions Part Number 62832 with the introduction of the twin plate clutch on the Series V machine.

CLUTCH BOLTS

The clutch bolt Part Number G 250 was replaced with improved bolt Part Number 62920.

CLUTCH ADJUSTMENT

Clutch adjustment is checked on the clutch arm on the outside of the gearbox, and is measured as $\frac{1}{4}$ " free movement at the end of the clutch arm.

CLUTCH PLATE CENTRE

Originally the clutch plate centre had a tapered hole to fit to the tapered shaft. With the introduction of the splined clutch shaft the clutch centre was splined to suit. The centre is longer for the double plate version than for the single plate.

THRUST BEARING

You should note that when assembling the clutch thrust bearing, this must be filled with grease before assembly. From machine Number 47067 the clutch operating mechanism was altered to accommodate the operation of the twin plate clutch. Sleeve Part Number G 288 was replaced with a sleeve Part Number 62919, Part Number 62922 clutch cleave, Part Number 62913 bush, Part Number 62963 sleeve.

REMOVING CLUTCH SHAFT

It is not necessary to dismantle the gearbox to remove either the clutch shaft or the driving pinion. The following method should be used.

Remove the engine completely and remove the clutch assembly from the front of the clutch shaft to expose the clutch shaft, Part Number 62921. Remove the front oilseal Part Number 25069. Remove the inspection plate Part Number 16908 on the top of the gearbox, and with a pair of right angle circlip pliers remove the 2" internal circlip from the pinion bearing housing. The ears of the circlip will be found on the top of the shaft, if not, turn the circlip to the top for easy access. The circlip cannot drop inside the gearbox, and will remain suspended on the shaft.

Slide a suitable length of $2\frac{1}{2}$ " steel stub over the front of the clutch shaft until it locates against the inside bell housing casting. The threaded end of the shaft should be exposed outside the tube, and by means of a washer over the end of the tube and the clutch securing nut draw the shaft through the tube by screwing the nut on to the shaft. This should be done in stages until the pinion bearing releases from its housing. Withdraw shaft complete with the bearing, circlip and pinion through the forward oilseal aperture. In those cases where the shaft is broken in such a way as to render the thread unuseable the shaft may be withdrawn in a similar manner to the tube method above as follows:

Weld a long stud on to the front of the shaft, and with a flat bar with a hole in it, over the bell housing, use a nut on the thread of the stud to draw the stud and shaft through the hole in the bar. It is important when replacing the inspection cover 26908 on the top of the gearbox that the trough should face towards the pinion.

From Serial Number 47067 clutch shaft Part Number 62921 replaces old shaft Part Number 25009.

GEARBOX

Provides three forward and one reverse speeds from plate gears of large diameter, suitably mounted on transverse shafts. With the exception of the clutch shaft, all shafts are mounted transversely. The clutch shaft pinion drives the crownwheel on the jackshaft assembly which provides the drive for the plate gears and differential assembly. The jackshaft assembly, which projects through the nearside of the box, provides the drive for the rotor chain drive.

CROWNWHEEL AND PINION

The backlash on the crownwheel and pinion is .010". Shims are provided on the left-hand side of the jackshaft.

GEAR SELECTION AND SELECTOR INTERLOCK MECHANISM

Gear clusters within the gearbox slide on the main jackshaft and engage with the appropriate gears, and are controlled by bronze gear selectors. From machine Number 2531516 an interlock mechanism was introduced to prevent the possibility of engaging two gears at once. The mechanism is fitted on the gear selector arms on the outside of the box.

The mechanism may be fitted to all earlier machines as follows:

Slacken the clamp bolts on the selector arms Part Number 25332 (1st and 2nd) and Part Number 25331 (3rd and reverse) lift them away from the projecting posts. Refit the new arms Part Number 26110 (1st and 2nd) Part Number 26112. These must be so positioned on the posts after the keys before inserting, that the interlocking plates are on the same plane. Finally fit the tie bar Part Number 26107. This tie rod has been introduced between the rear support bracket Part Number 25136 and the triangular part of the main frame. This stay prevents movement of the gate Part Number 25173 and thus difficulty of the gear selection due to the elasticity of the material in the frame. This bracket may be fitted to earlier machines by drilling a $\frac{3}{32}$ " hole in the support bracket $\frac{1}{2}$ " above the existing hole holding the control tube, a further $\frac{3}{32}$ " hole will be necessary $\frac{1}{4}$ " above the control tube in the main frame end.

REVERSE IDLER PLATE GEAR

Carries the reverse idler gear and must be bolted very tightly to the gearbox side plate. With the introduction of the Series III machine the width of the plate gears was increased from $\frac{3}{8}$ " to $\frac{1}{2}$ ". From machine Number 48301 shim Part Number G 554 has been introduced between the plate gears to enable greater accuracy to be maintained in the manufacture of the gears, and to help to correct the neutral position. If the gears are on the top limit of their dimensions in width no shim may be necessary.

DIFFERENTIAL

The bull gear and differential assembly was rivetted to earlier models of the Gem with $\frac{1}{4}$ " soft iron rivets, which were changed later to steel rivets of $\frac{5}{16}$ " diameter. A differential lock operating on the left-hand wheel axle slides along the shaft end, engages three pins into the fixed hub gear, this is so arranged that it is automatically engaged when the rotor is operated.

All Gems from Serial Number 47067 are fitted with new clutch and gearbox parts as follows:

Old Part Series IV	New Part Series V
25027 Reverse Idler Gear	62915 Reverse Idler Gear
25013 Small Plate Gear	62916 Small Plate Gear
25006 Pinion	62914 Pinion
25074 Selector W/A	62910 Selector W/A
25048 Gearbox	62907 Gearbox
25049 Gearbox Side Plate	62908 Gearbox Side Plate

SPEEDS

The machine has a top speed of 2.8 m.p.h. (4.5 k.p.h.) and a reverse speed of 1.7 m.p.h. (2.7 k.p.h.) and a twin plate driving clutch. With the introduction of the Kohler engine, speeds in excess of these are available.

GEARBOX CASTING SERIES V

There is a considerable difference between the Gem V gearbox and side plate and the comparable Gem IV. The bore for the reverse gear idler is placed nearer the front of the box in the Gem V than the Gem IV, it may be recognised by the measurement between the second and third top side plate fixing bolt, which should be at 2" centres on the Gem V, and 2 1/2" centres on the Gem IV. The side plate is, of course, made in similar manner, but a further distinguishing feature is that the distance between the starting dog housing and the boss for the reverse gear spindle is nil on the Series IV, but on the Series V it is almost 3/4". The bosses and plates are not interchangeable.

WHEEL HUBS

The right-hand side wheel hub can foul the gearbox side plate before it tightens on the axle. This may be overcome by removing and machining the inner face of the hub until it clears the side plate. The splines of the shaft are tapered and similar splines on the hub are tapered and must be kept securely tight with the hub nut.

WHEELS

Wheels are attached to the hub discs by clamping them between the plates using the four springs and nuts. The correct setting is that the springs should be tightened until coil bound and then released half a turn. From Serial Number 37690 the size of the right-hand hub was increased to 3/4" BSF. From Serial Number 37690 the wheel casting was altered to enable cap valves to be fitted. This modification consists of increasing the hole size from 1 1/2" to 1 3/4".

Tyre size: 20 x 4. Recommended tyre pressure 20 lbs. p.s.i.

ROTOR DRIVE

It is driven from the jackshaft in the gearbox, the drive is transferred to the rotor by a sprocket and chain. The chain used on all Gems made in heavy duty 54-link 3/4" pitch Renold chain, and is driven by a 9-tooth sprocket, on the jackshaft. Chain tension is checked by using a piece of hooked wire through the filler hole. The tension should be such that a movement of 1/4" to 1/2" movement is obtained. Sets of securing bolts for the chaincase including nuts and washers are available under the Part Number 19001.

CHAINCASE SHOE

There is a protective shoe under the chaincase; it is provided to take the initial wear and should be replaced when worn.

ROTOR DRIVE SHAFT

Provided to drive the rotor from the chain drive, passing through the back plate with suitable oil and dirt seals.

ROTOR CLUTCH

Consisting of a drive plate, two steel discs and two friction material linings and wearing plate, which also acts as a dust cover. Studs fixed to the drive plate lock into holes in the rotor flange, which are secured with coil springs and nuts. The correct adjustment is to tighten the nuts until the springs are coil bound and then release half a turn.

ROTOR

Three lengths of rotor are available to order 20", 24" and 30". Special blade bolts are provided at the end flange with counter-sunk heads.

STUB AXLE

This must be lubricated every 25 hours with SAE 90 oil, by removing the oil filler screw which is screwed into the right-hand end flange close to the rotor tube.

SAFETY KITS

1. Engine Control (Part Number 67677)

- Remove nut (A) which is located beneath the magneto stop strip (B).
- Remove the washer (C) insulator (D) and the stop strip.
- Replace the insulator (D).
- Fit the new connector lead (E) and secure with the washer (C) and nut (A).
- Fit the stop cable (F) to switch (H) and the earthing cable (G) ensuring that it is connected to the switch centre terminal.
- Position the switch in the most accessible position on the handlebars ensuring that the earthing cable is connected to the clamp screw and that the paint has been removed from under the switch clamp to make a good earth contact.
- Connect the engine stop cable (F) to the magneto connector lead (E) using the rubber connector.
- Move the switch to the 'ON' position, start the engine and ensure that the engine stops when the switch is moved to the 'OFF' position.

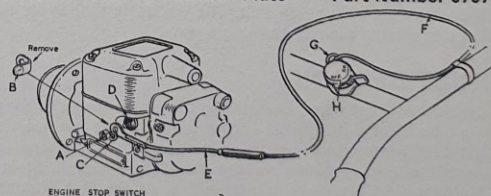
2. Power Take Off Pulley Guard (Part Number 67737)

Fit the 'U' clamp around the power take off housing positioning the guard centrally over the pulley and tighten the securing nuts of the 'U' bolt clamp.

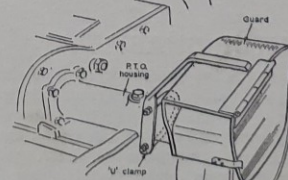
3. Indicator Plate (Part Number 26105)

- Remove the existing direction plate Part Number 25226. This is secured by two drive in rivet screws must be loosened and twisted to remove. Alternatively, chop off the rivet head with a chisel and remove the plate.
- Mark off the existing holes where possible and drill the new indicator plate to suit. Alternatively, drill two new holes away from the existing holes. Fit the 26105 indicator plate and secure with the two drive in rivet screws provided.

Part Number 26105 Indicator Plate Engine Control Part Number 67677



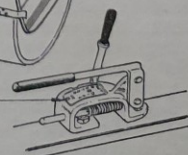
ENGINE STOP SWITCH



Part Number 67737

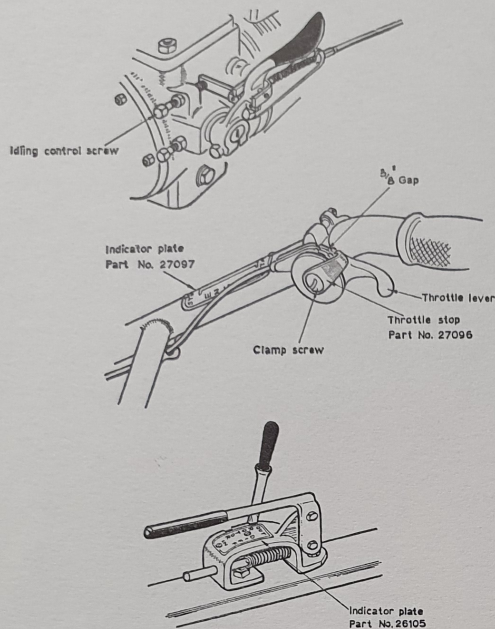
PULLEY GUARD - PTO ATTACHMENT

Remove indicator plate Part No 25226
Replace with Part No 26105



Gem V Diesel 500-600

Safety Regulation Kit Part Number 67739



Fitting Instructions:

- (a) Remove throttle control clamp screw and fit Part Number 27096 throttle stop. This stop must be fitted to ensure the lever is held open by approximately $\frac{5}{8}$ ".

- (b) Start the engine and close the control lever completely, the lever 'over riding' the throttle stop.
- (c) Adjust idling control screw so that the engine stops, lock the screw in this position.
- (d) Move the control lever to the control stop position, start the engine and check that the engine is 'slow running' correctly. Check also that by pushing the lever past the 'stop' the engine cuts out.
- (e) Remove the rotor indicator plate and fit with Part Number 26105 indicator plate (see full instructions under kit for petrol version).

Gem V—Sachs Diesel Version

The throttle control bracket Part Number 26576, used up to machine Number 2521471 has now been superseded, from that Serial Number by Part Number 25215 throttle control bracket.

BLADES

The G 900 and G 900/1 with the $\frac{3}{8}$ " diameter hole used up to machine Number 4870, these have been replaced by blade Part Number 9923 and 9924, which are universal type blades. The rotor flanges will need to be redrilled to $\frac{23}{32}$ " holes. From Serial Number 2541180 will be fitted with blades Part Number 9923/4.

BLADE BOLTS

The type of thread used on the G 919 end flange blade bolt has been changed from BSF to UNC although the Part Number remains the same. The intermediate flange blade bolt, Part Number G 918, has been discontinued for the same reason and is replaced by blade bolt Part Number 61095. Because of the alteration of thread, the BSF nut Part Number 2640 has also been discontinued, a UNC nut Part Number 61188 taking its place.

SCHEDULE OF OVERHAUL DIMENSIONS

810 c.c. TWIN CYLINDER PETROL AND T.V.O. ENGINE

Piston Clearance in cylinder bore .006".

Piston Ring Gap in cylinder bore .006".

Oversize Pistons +.020" and +.040".

Valve Timing. Inlet opens 10° after T.D.C. and closes 42° after B.D.C. Exhaust opens 48° before B.D.C. and closes 8° after T.D.C.

Ignition Timing. Petrol—points just breaking 35° before T.D.C. T.V.O.—points just breaking 30° before T.D.C.

Tappet Clearance. Exhaust and Inlet .006" when cold.

Reground Crankshaft Sizes. —.010", —.020", —.030".

Sump Oil Troughs. One hole in each, drilled $\frac{5}{16}$ ".

Spark Plug Gap. .025" KLG F 50 14 m.m.

Magneto Point Gap. .018".

Connecting Rod. Big end bolt torque—45 ft./lbs. maximum.

Governed Speed. No load—2,250 revolutions.

Never fill the sump above high level on the dipstick.

T.V.O. Model—Adjust the carburettor when the engine is hot and running on T.V.O.

A.C. ENGINE

Piston Clearance in cylinder bore .004" to .005".

Piston Ring Gap in cylinder bore .004" to .006".

Oversize Pistons. +.020", +.040", +.060".

Valve Timing. Inlet and exhaust valves equal (rocking) with the piston at T.D.C.

Ignition Timing. Magneto points just breaking when the piston is $\frac{1}{2}$ " before T.D.C.

Tappet Clearance. Exhaust .006", inlet .004" when cold.

Oiling. Fill the sump to level mark on the dipstick.

Reground Crankshaft Sizes. —.010", —.020", —.030".

Spark Plug Gap. .020" Champion L 10 14 m.m.

Magneto Point Gap. .020".

Carburettor. Initial setting main jet, screw right in and two and a half turns back.

Governor Control Lever is clamped to governor crank horizontal with the block in its lowest position.

Governed Speed. No load 2,250 r.p.m.

Connecting Rod. Big end bolt torque $7\frac{1}{2}$ ft./lbs. maximum.

B.J. ENGINE

Piston Clearance in cylinder bore .007" to .008".

Piston Ring Gap in cylinder bore .007" to .008".

Oversize Pistons. +.010", +.020", +.040".

Valve Timing. Inlet and exhaust equal (rocking) with the piston at T.D.C.

Ignition Timing. Magneto points just breaking with the piston $\frac{3}{8}$ " before T.D.C.

Tappet Clearance. Exhaust .010", inlet .008" when cold.

Oiling. Dry sump, the oil being returned via the filter to the tank. Change the oil after every 24 hours work.

Carburettor. Adjust the main jet to give the maximum revs at full throttle when engine is hot.

Spark Plug Gap. .025" Champion 7 or 8 COM L 18 m.m.

Magneto Point Gap. .020".

If the oil does not return to the tank, check all pipe and pump connections for air leaks, also wear on the oil pump right-hand side.

SACH ENGINE

Oversize Pistons. 80.5 mm. and 81.0 mm. diameter.

Big End Shell for reground crankshaft 0.25 mm. and 0.5 mm. smaller diameter.

Lubrication. Forced feed. Bosch pump.

Fuel Injection. 1,764 lb p.s.i., must not be below 1,470 lb p.s.i., injection commences 25° before T.D.C. Never allow the engine to run short of fuel or oil.

Oil Shortage will cause serious damage in a short space of time.

Fuel Shortage will make it necessary to bleed the entire fuel system.

Starting Fuses. Always insert the starting fuses in the holder, never light or drop them in the cylinder. A Number 4 wood screw is useful for extracting burnt fuses from the holder. Oil should always be visible in the sight glass of the front compartment of the engine. Always use the starting knob (right-hand side from the front of the engine) pulling the knob retards the injection and prevents kick-back.

The Oiling is the total loss system and a certain amount of oil is blown from the exhaust, increasing with light work. If showers of sparks are blown from the exhaust the silencer needs cleaning and should be burnt out with a blowlamp.

Air Filter. This is most important and must be kept clean at all times.

Fan Belt. This can be adjusted by taking off the three nuts on the front of the pulley and rotating the front half.

Connecting Rod. Bolt torque 8 ft./lb

HIRTH DIESEL ENGINE

Oversize Pistons. 3.051" and 3.071" diameter.

Crankshaft Assemblies. Supplied complete.

Injection Pressure. 2,000 lb p.s.i., must not be below 1,750 lb p.s.i. If showers of sparks are blown from the exhaust the silencer needs cleaning, the end plate can be taken off to do this.

The Belt can be adjusted by shims between the pulley flanges.

The Oiling is the total loss system and a certain amount is blown from the exhaust, increasing with light work. Check the oil level in

the governor housing, level plug is in the cover plate below the starting knob and the filler plug is on top of the housing. Oil should always be visible in the sight glass at the side of the engine. Never allow the engine to run short of fuel or oil.

Oil Shortage will cause serious damage in a short space of time. **Fuel Shortage** will mean bleeding the entire fuel system.

Starting Fuses. These should always be inserted in the holder, never light or drop in the cylinder. A Number 4 wood screw is useful for extracting burnt fuses from the holder. Always pull the starting knob (left-hand side from front of engine) when starting, this retards the injection and prevents kick-back.

JAP 4/3 ENGINE

Piston Clearance in cylinder bore .006".

Piston Ring Gap in cylinder bore .006".

Oversize Pistons. +.020" and +.040".

Undersize Con Rod Bearings. 1.1150" and 1.1050".

Tappet Clearance. Exhaust .010", inlet .008".

Valve Timing. Exhaust opens 48° before B.D.C. and closes 9° after T.D.C. Inlet opens 17° before T.D.C. and closes 52° after B.D.C.

Carburettor. Main jet Number 77.

Ignition Timing. Points just breaking 25° before T.D.C.

Spark Plug Gap. .025" Lodge CN 14 m.m.

Magneto Point Gap. .015".

Governed Speed. No load 2,400 r.p.m.

Keep oil level up to high mark on the dipstick, check daily. Open the release tap which is fitted to the inlet pipe when starting a hot engine.

BRIGGS & STRATTON 14 ENGINE

Oversize Pistons. +.010", +.020", +.030".

Piston Ring Gap in cylinder bore .007" to .017".

The exhaust valve seat can be replaced.

Tappet Clearance. Inlet .007" to .009", exhaust .014" to .016".

Magneto Point Gap. .020".

Spark Plug Gap. .025".

Governed Speed. No load 2,900 r.p.m.

Connecting Rod. Bolt torque 175 ins./lbs.

VILLIERS 10/1 ENGINE

Tappet Clearance. Exhaust and inlet .006" to .010".

Magneto Point Gap. .012" to .015".

Oversize Pistons. +.015" and +.030".

Spark Plug Gap. .025" Lodge BN.

Connecting Rod. Big end undersize liner —.020".

Valves. Oversize stems, exhaust and inlet +.005".

Oil level should be checked every day, the sump must be level when checking.

Piston Ring Gap. .008" to .013".

Ignition Timing. Points just breaking $\frac{3}{8}$ " before T.D.C.

VILLIERS Mk. 15 ENGINE

Piston Clearance in cylinder bore .004" to .005".

Piston Ring Gap in cylinder bore :

Angle cut .007" to .011".

Square cut .011" to .015".

Oversize Pistons. +.015" and +.030".

Magneto Point Gap. .012" to .015".

Spark Plug Gap. .018" to .015" Lodge C 14.

Taper Needle. Setting Number 2 notch.

Rockers. Clearance cold—inlet .003", exhaust .006".

Ignition Timing. Points just breaking $\frac{1}{8}$ " before T.D.C.

Check oil level every day, the sump must be level when checking.

VILLIERS 28B ENGINE

Oversize Pistons. +.015" and +.030".

Piston Ring Gap in cylinder bore .008" to .030".

Ignition Timing. Points just breaking with piston $\frac{3}{8}$ " before T.D.C.

Magneto Point Gap. .012" to .015".

Spark Plug Gap. .018" to .022" HH 14. Plug should be cleaned and the points reset after every 100 hours running.

Petrol/Oil Mixture. $\frac{1}{2}$ pint of oil to 1 gallon of petrol.

Governed Speed. 2,250 r.p.m.

Carburettor must not be flooded to start when the engine is hot.

Crankshaft Assembly. Supplied complete.

A light smear of grease on the magneto cam will prevent wear on the rocker arm pad.



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to Her Majesty the Queen
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