

SYRINGE DRIVER  
Type MS26

TECHNICAL SERVICE MANUAL

SM113 Issue 5

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Whilst every attempt has been made to ensure the accuracy of the information contained in this Manual, as a result of continuing development some differences may exist between the product as supplied and the description within. However, please contact us on any points about which you are in doubt.

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## GENERAL INFORMATION

### INTRODUCTION

1. The Syringe Driver - Type MS26 is a portable, battery-operated device, designed for the continuous infusion of small volumes of liquids, from commercially available disposable syringes, over a period of 24 hours. It is also equipped with a 'boost' facility to enable doses to be administered at any time during the infusion.
2. The syringe plunger is operated by a linear actuator, at rates ranging from 1 to 99 mm/24 hours, set by adjustment of two digital rotary switches. Most types of syringe can be fitted to the unit and a millimetre scale is provided to measure the stroke length of the syringe in use, so that a figure for mm/ml may be calculated.
3. Patient controls consist of two rotary SET RATE mm/24 hour switches (screwdriver operated) and the START/BOOST pushbutton. To start the infusion it is only necessary to fit the (primed) syringe and press the pushbutton. When held down, the button tests a safety cut-out circuit, and on release, it starts the drive circuit. Once started, the front panel lamp (LED) flashes approximately once every 25 seconds. When the plunger reaches the end of its travel (syringe empty), the unit switches itself off electronically.

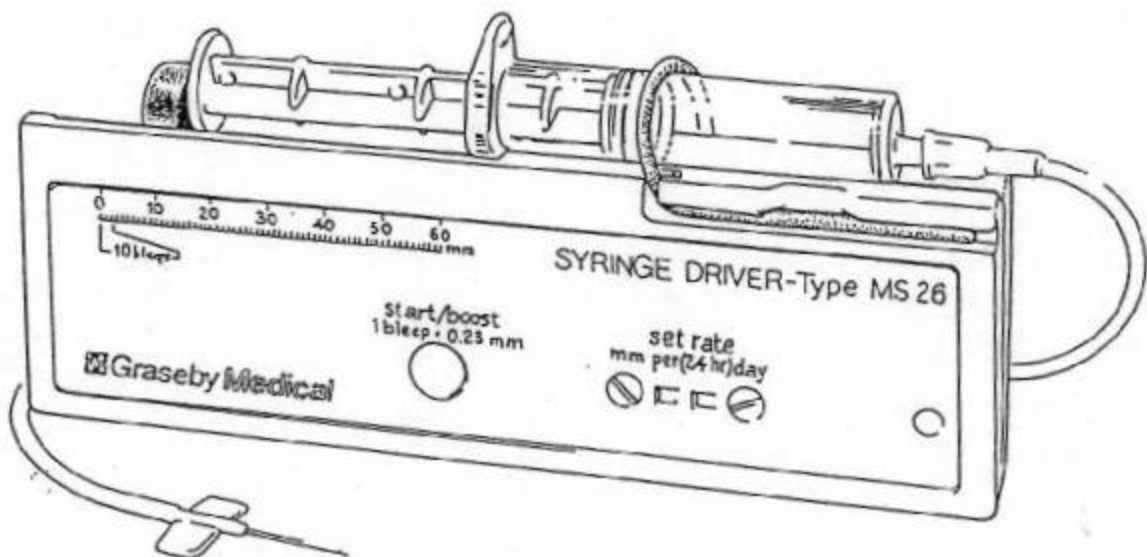


Figure 1 - Syringe Driver - Type MS26

4. The Syringe Driver is designed to activate an audible alarm if it stops for any reason. This means that an alarm is given if the syringe plunger has come to the end of its travel or if the plunger has jammed for some reason. The alarm will also sound and the driver will stop if the START/BOOST button is held down continuously for more than 8 - 10 seconds.
5. Boost doses can be administered at any time during the infusion by pressing the START/BOOST button. While the button is held down the liquid is infused quickly. An audible 'bleep' accompanies each boost increment, which corresponds to 0.23 mm of plunger movement. In the 8 - 10 seconds before the safety circuit operates, somewhere between 4 and 10 boost increments can be delivered. The button can be released and held again to continue the boost dose, if desired

#### DATA

6. Syringe Sizes The unit will accommodate most types and sizes of disposable syringe up to 35ml capacity and with strokes of up to 60mm, although it may not be possible to completely fill some of the larger syringes. The holster supplied will enclose most types of syringe up to 20ml capacity.
7. Battery Type The unit uses an IEC 6LR61 battery (9V, Alkaline, PP3 size), e.g. DURACELL MN1604.
8. Battery Life A fresh battery should deliver the contents of 50 full syringes.
9. Accuracy of Delivery The rate of the actuator is accurate to within plus or minus 5% of the rate set on the rotary switches.
10. Size and Weight The unit, without a syringe fitted, measures 165mm x 53mm x 23mm and weighs 180 gm including the battery.

Complies with BS5724 Part 1 and IEC 601-1.

Type BF



Splashproof



## BATTERY REPLACEMENT

11. The battery should be changed whenever the indicator light fails to flash.

Slide the battery compartment cover towards the rear of the casing and remove the cover. Turn the syringe driver upside down and let the battery fall into the hand. Insert the replacement battery in the battery compartment, observing the correct polarity as shown by the illustration in the battery compartment. The unit is protected against the effects of accidental reversal of the battery. Replace the battery compartment cover, ensuring that it snaps into place when closed.

## CLEANING

12. Clean the unit by wiping with a damp cloth (soapy if necessary). Allow to thoroughly dry before use.

DO NOT IMMERSE UNIT IN LIQUID.

To maintain efficient operation and reduce wear on the actuator assembly, keep the leadscrew clean. This is best done using a small brush with stiff bristles eg. a toothbrush.

$$\frac{\text{min PP}}{\text{min}} = \frac{\text{rotations/min}}{f}$$

$$f = 1.70 \text{ min/rotations}$$
$$f = 1.64 \text{ min/rotations}$$

See Fig 2 for adjustment for R.P. (note nearest 1.64)  
(Distance of Leadscrew drive point of LED (should be 2.20))

## CIRCUIT DESCRIPTION

Refer to Figures 2 and 3

### LOGIC CIRCUIT

13. The Custom Integrated Circuit IC1 contains a very low power oscillator, which operates at a fixed frequency. The output of this master-clock is fed into a divider chain, which includes binary-coded switches S4 and S5, so that rates over a 99:1 range can be selected.
14. IC1 also contains the switching electronics which control the 'Start', 'Motor Drive' and 'Guard' circuits.

### START CIRCUIT

15. The battery return line (0V) is switched by transistor TR3, which is controlled by IC1/11 (pin 11 of IC1). This control is reset by a negative-going pulse at IC1/10. Since IC1/10 is biased low through resistor R2, the negative-going pulse is provided in the transition period during operation or release of the START/BOOST pushbutton (S1). Diode D1 (a low voltage-drop type) protects the circuit components from damage if the battery polarity is reversed.

### MOTOR DRIVE

16. In the operating mode, IC1/21 produces a square-wave pulse train, the frequency of which is determined by the setting of the SET RATE rotary switches S4 and S5. When the output from IC1/21 goes high, transistor TR2 is turned on and TR1 is turned off. With the cam-operated switch (S3) in the position shown in Fig.2, the motor circuit is completed via TR2, and the motor runs until the cam operates the switch S3, (1/6 revolution). Because TR1 is turned off whilst TR2 is conducting, the motor circuit is broken and the motor stops (perhaps after some overrun). When the output from IC1/21 goes low, transistor TR2 is turned off and TR1 is turned on. The motor circuit is now completed via TR1 and the motor runs until the cam-operated switch (S3) returns to its original position (another 1/6 revolution). Because TR2 is turned off whilst IC1/21 remains low, the motor circuit is once again broken until the next high output from IC1/21 restarts the sequence.
17. Since each motor pulse results in 1/6 of a revolution of the leadscrew, the actuator advances the syringe plunger by 1/6 of the thread pitch, that is by 0.117 mm.

NOTE: The amount of overrun at each step, though indeterminate, is non-cumulative. (After 60 pulses the cam will have rotated through ten revolutions plus the error of the last step).

18. Transistor TR4 and its associated components form an adjustable current regulator which is pre-set to limit the torque of the motor and therefore the maximum actuator thrust.
19. Because the motor drive pulses are quite infrequent, a light emitting diode (LED) is driven at a fixed frequency by IC1/14. This provides a continuous check on the functioning of the oscillator and the low battery indication (see para.27).

#### GUARD CIRCUITS

20. Primary Guard Circuit Whenever the motor is energised (i.e. whenever M- is held low), this is sensed at IC1/22, and if this condition prevails for more than 8.9 seconds (896 cycles of the master-clock) then the output from IC1/11 causes TR3 to switch off. In normal use, the motor does not need to run for so long, so the guard circuit only operates when the motor is stalled (e.g. when the syringe is empty), if a transistor or the cam-operated switch fails, or when the START/BOOST switch is held depressed.
21. Secondary Guard Circuit The guard system described above would not function in the case of a failure of the main oscillator, and in this unlikely event the 'on' time of the motor is limited by a back-up guard circuit. When the motor is energised, capacitors C2 and C6 acquire a charge via resistor R4 (the charge is quickly dissipated at the end of the motor drive pulse by diode D4). If the motor attempts to run for longer than approximately 10 seconds, then the voltage on the capacitors (i.e. voltage at IC1/9) falls to a critical level, causing the output from IC1/11 to switch off TR3.
22. From the foregoing description it can be seen that the MS26 will fail safe (switch off), regardless of how M-came to be held low for longer than the normal operating pulse duration.

#### SWITCH-OFF ALARM

23. The piezo-transducer (X1) and associated components (TR8, R18, R15, R16) are arranged so that an alarm tone sounds when the bottom end of R16 is held low. This occurs for a few seconds whenever TR3 switches off, owing to TR9 being turned on until C5 is discharged via R17.

## BOOST/TEST CIRCUIT

24. When the START/BOOST switch is pressed and held, TR3 is turned on by operation of switch S1 (see 'Start Circuit') and the motor circuit is completed via switch S2 and the base/emitter of TR7. The motor will now run until it is switched off by the primary guard circuit or the pushbutton is released. When the switch is released the syringe driver reverts to the normal drive mode.

## BOOST INDICATOR

25. When the START/BOOST pushbutton is pressed and held, the alarm circuit is energised via TR6 and TR7. As TR6 is switched on only when its gate is high, the cam switch successively enables and disables the alarm circuit. This produces a 'bleep' with every 120 degrees of cam rotation and this corresponds to 0.23 mm of plunger movement.

## SAFETY FEATURES

26. Part of the circuit (associated with pins 9, 10, 11 and 12) operates, via TR3, to allow the operation of the MS26 only while safe conditions exist. A crucial design feature of IC1 is that this area of circuitry is completely separated within the silicon chip by a diffusion well and has a separate power supply (V'ss).

Protection against overdosing is provided by three basic concepts:

- (1) Breaking of the motor current itself by the cam-operated microswitch.
- (2) The complementary, master-slave action, of transistors TR1 and TR2.
- (3) The 'Guard Circuit', with two methods of activation.

## LOW BATTERY INDICATION

27. The master-clock in IC1 causes pin 14 to be grounded approximately once every 25 seconds. During this pulse, transistor TR5 conducts, thus illuminating the LED, provided the battery voltage is sufficient to cause about 0.6 volts to be developed across resistor R13. When the battery voltage is too low to switch on transistor TR5, the LED will cease to flash.



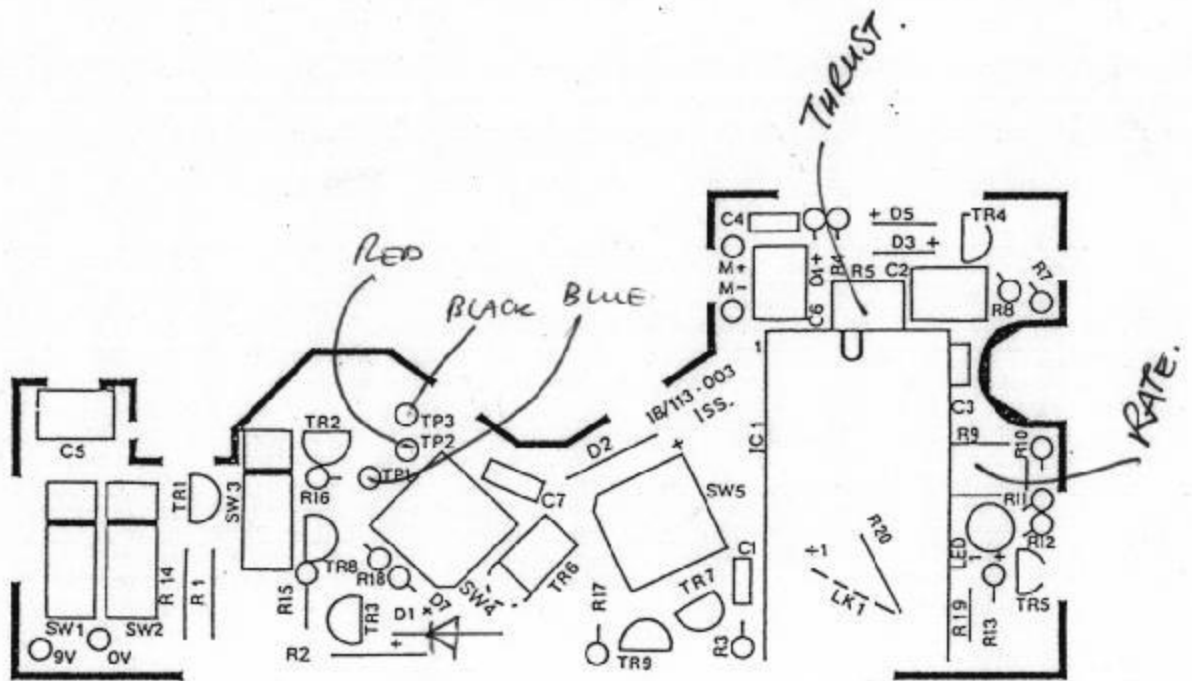


Figure 3 - P.C.B. Layout

## OVERHAUL AND REPAIR

### GENERAL

Item numbers quoted refer to Figure 6.

28. This section details the dismantling and subsequent assembly operations necessary for the replacement of spares items, except where obvious. On completing any repair work and before considering the unit as fit for use it must be taken through the TESTING sequence step by step (see paras.39 - 44).

It is strongly recommended that if a fault is located on the P.C.B., the entire board be replaced by an exchange board. The use of alternative components as replacements may affect the correct functioning of the equipment.

CAUTION: The moving parts of the drive do not require any lubrication during their lifetime. Any worn or stiff parts should be replaced.

CAUTION: With the case dismantled take great care to avoid contamination of the exposed switches (eg by the entry of solder particles).

### DISMANTLING PROCEDURES

#### 29. Case Assembly

1. Lay the unit face downwards.
2. Slide off the battery cover (item 21) and remove the battery.
3. Remove the three screws securing the two halves of the case assembly. Lift off the rear half (item 10), the case may have been sealed and will need to be opened by gently prising the two halves apart. Any sealant left adhering should be cleaned off at this stage.

#### 30. Leadscrew and Bearing Assembly

1. Dismantle the case assembly as in para.29.
2. Loosen the motor clamp (item 6) sufficiently to allow the motor and gearbox assembly (item 5) to be tilted.
3. Grasp the leadscrew (item 1) between the thumb and forefinger, and draw it gently away from the motor and gearbox assembly until it is disengaged.

### 31. Actuator and Back Bearing

1. Dismantle the case assembly as in para. 29 and remove the leadscrew and bearing assembly as in para. 30.
2. Remove the back bearing (item 8) from the end of the leadscrew.
3. Depress the plunger on the actuator (item 2) and slide the actuator off the leadscrew at the back bearing end.

### 32. P.C.B. Assembly

1. Dismantle the case assembly as in para. 29.
2. Remove the five screws and fibre washers securing the P.C.B. assembly (item 15) to the case (item 9). The three wires for the piezo-transducer assembly (item 19) may be held down by an adhesive pad on the motor clamp (item 6) and they should be carefully lifted away from the pad. Pull the battery connector springs out of their locating slots and lift off the P.C.B. assembly complete with the microswitches. The START/BOOST pushbutton, seal and switchplate (items 16, 17 and 18) may remain in the case.
3. To release the piezo-transducer assembly, unplug IC1 from its socket, exposing the fixing clip. Remove the piece of rubber from the clip. Do not pull on the metal disk, but push the clip through, whilst gently holding the transducer assembly. When re-assembling, check that the three locating pegs on its base have gone into the holes in the P.C.B.  
[Wiring guide: BLUE-TP1, RED-TP2, BLACK-TP3]
4. To remove the P.C.B. assembly completely, remove the motor and gearbox assembly (item 5) from the case as described in para.33.

### 33. Motor and Gearbox Assembly

1. Dismantle the case assembly as in para. 29 and the leadscrew and bearing assembly as in para.30.
2. Remove the P.C.B. assembly as in para.32.
3. Remove one screw, one washer and the motor clamp (item 6).
4. Remove the motor and gearbox assembly (item 5).
5. If the motor is being discarded, pull off the cam assembly (item 4) for subsequent re-assembly to the replacement motor and gearbox, and unsolder the motor leads from the P.C.B.

## ASSEMBLY PROCEDURES

### 34. Motor and Gearbox Assembly

1. Connect and solder the motor leads to the P.C.B. Red to M+ and Black to M-.
2. If a replacement motor is being fitted, line up the pin in the cam assembly with the slot in the gearbox shaft and press the cam assembly firmly onto the shaft.
3. Replace the P.C.B. assembly; along with the motor and gearbox, and the leadscrew assembly, as described in paras. 35,36 and 37.

### 35. P.C.B. Assembly

1. Replace the two dials (items 11 and 12), on the rate switches SW4 and SW5 (items 14). A rubber seal (item 22) must be fitted firmly into the groove, in each of the dials.
  - A) Place the two dials face-upwards on the bench, side by side, so that the numbers on each dial, on the adjacent sides, are the correct way up (if upside down, change the dials left to right).
  - B) Keeping the dials in the same relative position insert the left-hand dial in SW4 and the right-hand dial in SW5, ensuring that the dial position and switch position correspond (see Fig.4).

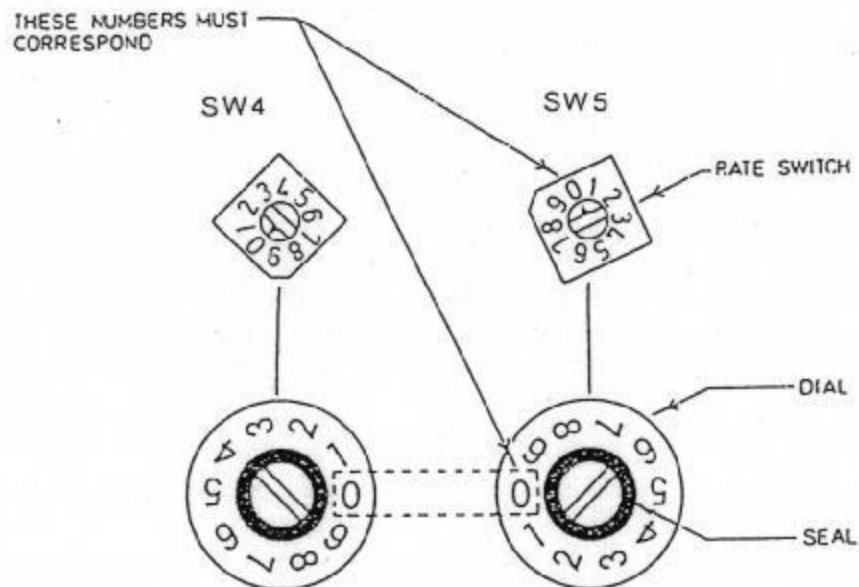


Figure 4 - Configuration of Dials and Rate Switches

2. Assemble the START/BOOST pushbutton, seal and switch plate (items 16, 17 and 18) and place them in position over microswitches SW1 and SW2. Make sure the cam lever (item 3) is on SW3 and that it pivots freely.
3. Place the front case half (item 9) over the P.C.B. and hold it in position with the thumb and fingers. Turn the P.C.B. and case over so that the P.C.B. is uppermost. Check that the leads for the motor and battery connector springs are not trapped, and secure the P.C.B. in position with five screws and fibre washers.
4. Check for correct operation of the START/BOOST pushbutton and that clockwise rotation of both rate switches causes the dials to indicate increasing numbers.
5. Push the battery connector springs into their slots (Red to + and Black to -, using the illustration in the battery compartment as a guide).
6. Place the motor and gearbox in position (see Fig.5). If the motor had a packing sheet underneath, refit this. Replace the motor clamp (item 6) and the securing screw and washer, but do not tighten the screw.

NOTE: The motor case has two pegs on the front face; take care to align the motor so that these do not foul the locating pillar in the case assembly.

7. Assemble the actuator and back bearing as in para.36, and the leadscrew and bearing as in para 37.

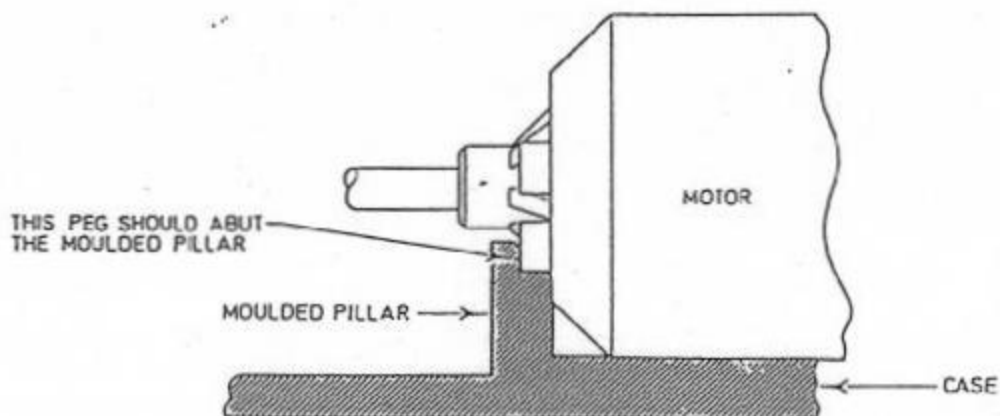


Figure 5 - Correct Orientation of Motor

36. Actuator and Back Bearing

1. Depress the plunger and slide the actuator onto the leadscrew from the back bearing end. Fig.6 shows the correct way the actuator (item 2) should face.
2. Fit the back bearing to the end of the leadscrew.
3. Assemble the leadscrew and bearing assembly as in para.37.

37. Leadscrew and Bearing Assembly

1. Align the pin on the leadscrew and bearing assembly with the slot in the cam assembly and press the leadscrew into position.
2. Ensure that both the front and back bearings are in position in their respective recesses in the case assembly.
3. Check the motor is still correctly positioned (see Fig. 5) and secure the motor clamp by tightening the screw. If present, re-use the adhesive pad on the clamp to hold down the wires for the piezo-transducer assembly (item 19).
4. Assemble the case as described in para. 38.

38. Case Assembly

1. Assemble the two halves of the case and secure with three screws. Re-sealing the case is optional, instructions are given in Appendix 1.
2. Replace the battery in the battery compartment, observing the correct polarity as shown by the illustration in the battery compartment.
3. Replace the battery compartment cover.

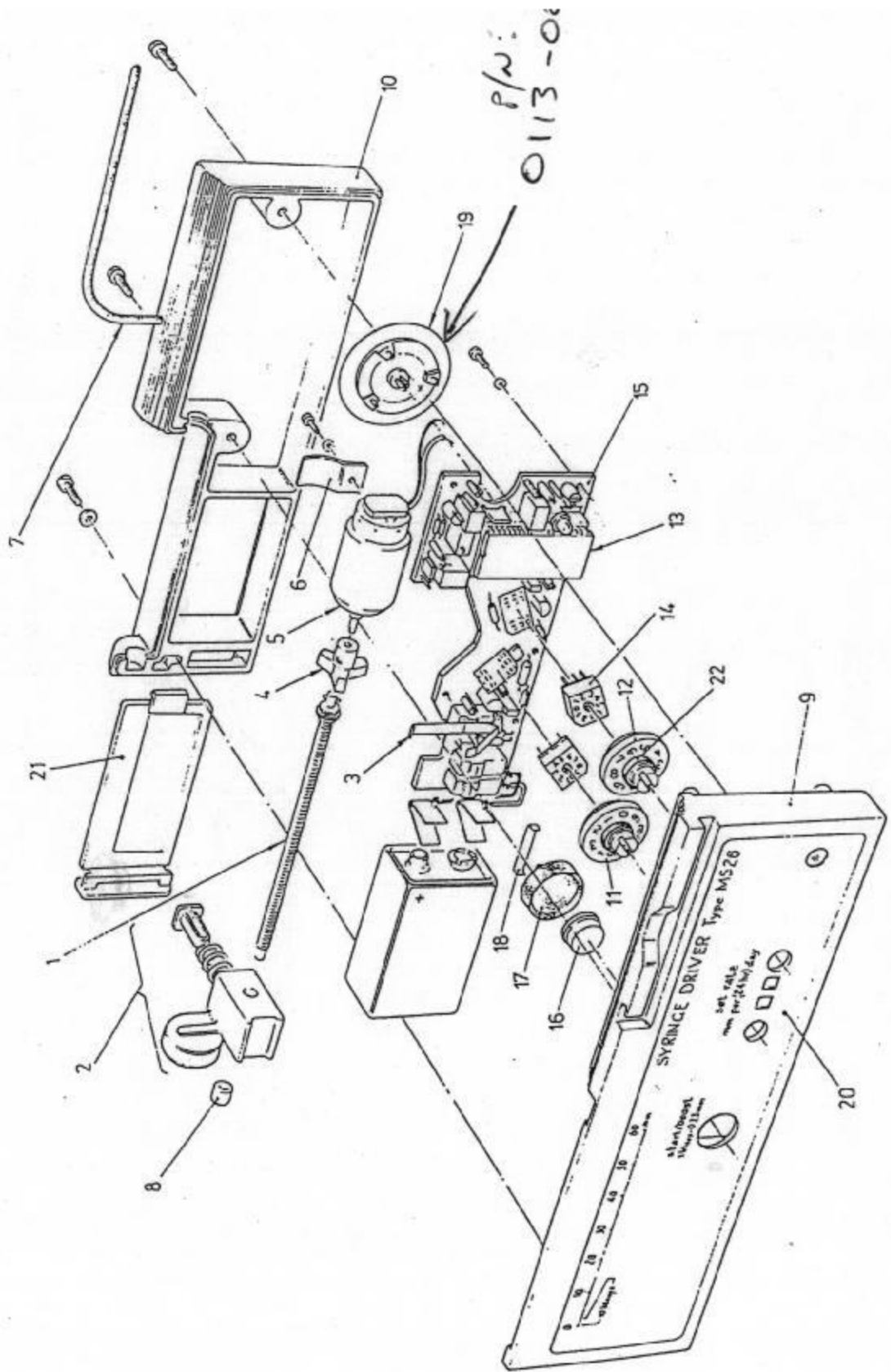


Figure 6 - Exploded View of Syringe Driver MS26

## TESTING

### 39. General

Tests should be carried out in the order printed (paras.40 - 44). If the unit has not been dismantled, the tests in paras.42 and 43 are optional.

### 40. Rate Tests

1. Remove the battery from the battery compartment, and connect a variable d.c. supply to the connector springs. Adjust the supply to 9V and slide the actuator to the rear (maximum travel available).
2. Press and release the START/BOOST pushbutton. Check the LED flash rate, which must be 1 flash every 25 +/- 0.5 seconds. If necessary, adjust variable resistor R9 to achieve this.
3. Set the rate switches to the rates stated below. In each case check that the elapsed time between successive motor pulses is as stated:

RATE SETTING	TIME
99mm/24hr	97-107 secs. 1:27 - 1:47
66mm/24hr	146-161 secs. 2:26 - 2:41
36mm/24hr	267-295 secs. 4:27 - 4:55

[Useful formula TIME BETWEEN PULSES =  $\frac{168}{\text{RATE}}$  minutes ]

4. Set the rate switches to 96 and check that the actuator moves forwards by 4mm (+/-5%) every hour.
5. Set the rate switches to 00 and check that the LED is flashing. After 3 hrs or more the actuator must still be in its original position, showing that there have been no motor pulses during this time.

NOTE: If variable resistor R5 (see para. 43) and/or R9 (this para.) require to be adjusted, peel back the front panel label from the right-hand side (nearest the LED). This exposes the access holes to the resistors; variable resistor R9 is located directly above the LED, and variable resistor R5 near the top.

When adjustments have been completed, it may be necessary to replace this front panel label should it fail to adhere when pressed back into position. Make certain that the small clear plastic 'window', is in its recess, over the rate dials, when replacing the label.

41. Guard Circuit, Alarm/Boost and 'Low Battery' Tests

1. Hold the START/BOOST pushbutton down. The motor must start to run, and cut out after an interval of 8 - 10 seconds. Check that motor operation is accompanied by 3 audible 'bleeps' per revolution and that the alarm tone sounds for a few seconds after the motor stops (but see Appendix 2 - Continuous Alarm Conversion).
2. Release the pushbutton.
3. Reduce the variable d.c. supply to 5.5V and observe that the LED ceases to flash. Restore the supply to 8V and check that the LED resumes flashing.

42. Cam Adjustment

The motor must run so as to rotate the leadscrew by one revolution for every six motor pulses, although the two conditions of the cam switch (i.e. 'on' or 'off') may result in different motor run times. Alternate motor pulses are permitted to be of slightly different lengths but must not differ by more than 20%. If necessary adjust the motor run time by slight bending of the cam follower lever, using tool Part No 0105-0079 (see Fig.7). To do this the rear case half will need to be removed and then refitted before proceeding to para 43.

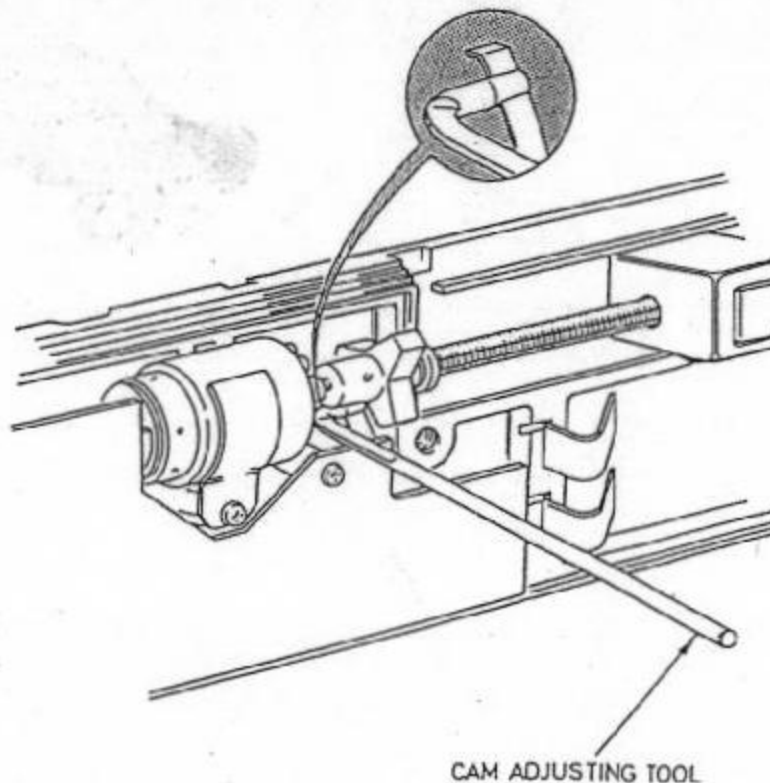


Figure 7 - Adjustment of Cam Follower

43. Thrust Adjustment

(RV5)

1. Set the rate switches to 99.
2. By suspending weights from the actuator (item 2, Fig. 6) or by using a 'Spring Test Gauge Assy', Part No. 0105-0083, which is temporarily fitted in place of a syringe. Check :-

- A) For actuators fitted with a cream or blue coloured plunger :-

The cut-out thrust (LED stops flashing) is not less than 3 kg with the supply voltage at 7V, and not more than 5 kg at 9V.

- B) For actuators fitted with a black coloured plunger :-

The cut-out thrust is not less than 2.5 kg with the supply voltage at 7V, and not more than 3.5 kg at 9V.

If necessary adjust variable resistor R5 (see NOTE para.40) so condition A) or B) is satisfied.

NOTE: Since manufacture of these syringe drivers began, three types of actuator plunger have been used. They can be identified by their colour; black, cream or blue. The colour of the actuator plunger shows around the edge of its white button. Because of their age the black type are likely to be worn by now and are best replaced if still fitted. If possible fit the newest design (blue), when replacing them.

44. End of Travel

This test checks that the syringe driver is able to switch itself off when the actuator reaches the end of its travel. The test should be carried out at least twice.

1. Move the actuator up close to the casing at the end where the syringe is normally strapped. Make sure the actuator plunger is fully engaged with the leadscrew.
2. Press and hold down the START/BOOST pushbutton. The motor will run for a few seconds and then stop.
3. Release the button, then press and hold it again for a few seconds. Keep doing this (three times is usually enough), and then the motor should not run at all when the button is re-pressed. If it does run every time and the actuator is pushing against the case, then the plunger is probably damaged so it is slipping on the leadscrew. The plunger should be replaced (see para.31 and 36), then the thrust rechecked (see para.43).

This completes the TESTING.

SERVICING REQUIREMENTS

45. Tools and Equipment

Standard Tool Kit (i.e. selection of screwdrivers, soldering iron etc).

Cam Adjusting Tool Part No. 0105-0079

Spring Test Gauge Assy. Part No. 0105-0083  
or

Weights - 2.5kg & 3.5kg, 3kg & 5kg.

Stop Watch

Variable Power Supply, 0-10V d.c.

Vernier Calipers

MIN ORDER \$100

46. Spare Parts

*CLEAR WINDOW.*

0105-0035.

<u>ITEM</u>	<u>PART NO</u>
	<i>Perspex Cover</i>
[2] Actuator Assy	0105-0529 cost \$38.75
Actuator Plunger (less button)	0105-0041-0
[8] Back Bearing	0105-0002
[21] Battery Cover	0105-0011
Button (for actuator plunger)	0112-0023
Case complete	0105-0008
[13] Custom IC	0113-0026
[20] Front Label	0105-0416
[1] Leadscrew & Bearing Assy	<del>0113-0012</del> 0113-0012
Microswitch	0105-0031
[5] Motor & Gearbox Assy	3560-0021
[15] P.C.B. Assy	0105-0059
[19] Piezo-transducer Assy (X1)	0113-0003
Rate Adjusting Tool	0113-0017
[11] Rate Dial Left	0113-0023
[12] Rate Dial Right	0105-0430
[22] Rate Dial Seal	0105-0429
[14] Rate Switch	0105-0016
[7] Securing Strap	3571-0000
[3,4] Switch-lever & Cam Spares Kit	0105-0040-C
Cam Adjusting Tool	0105-0432
Spring Test Gauge Assy	0105-0079
<i>Battery terminals</i>	0105-0083
	0105-0069

For prices and the availability of other parts not included in this list, please contact Graseby Medical directly.

[ ] Ref nos in Fig.6

## APPENDIX 1.

### Case Sealing Instructions (Optional)

If a sealed case assembly has to be dismantled, the seal will break-up and lose any further effectiveness. So fresh sealant should be used to form a new barrier against liquid entering the case, when it is re-assembled. If this is undertaken, make sure all work needing access to the inside of the case is completed before starting to seal it.

The case halves should be sealed using a non-corrosive silicone sealant, such as LOCTITE Tempflex 544.

1. Clean off any old sealant still present.
2. The sealant is best applied in a continuous, thin bead, around the inner lip of the front case half (item 9). Starting at the top by the motor, following the lip along to the bottom of the case and finishing by going across the partition wall by the battery connector springs. The area around the cam and bearing should be kept free of sealant. Sealing around the battery compartment is ineffective and so is unnecessary.
3. Fit the rear case half (item 10) and clean off any excess sealant which may be squeezed out of the joint, before it begins to set. The sealant recommended will take about 30 minutes, in a normal room environment, to solidify appreciably.
4. Re-opening the case after this will almost certainly mean having to repeat the whole sealing procedure.

## APPENDIX 2.

### Continuous Alarm Conversion

If a continuous alarm tone is required when the syringe driver stops (eg at the end of an infusion), the circuit board should be modified as follows:-

1. Remove the capacitor C5.
2. Move the resistor R17 across to the position previously occupied by C5.
3. Test the unit as described under TESTING, but now the alarm tone should not stop after a few seconds following the motor stopping, but sound continuously.

After this, only by removing the battery or starting an infusion can the alarm be silenced.