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(14) FVRDE Memorandum - 5040

FIGHTING VEHICLES RESEARCH AND DEVELOPMENT ESTABLISHMENT

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F.V.R.D.E. MEMORANDUM 5040

FIGHTING VEHICLES GUN CONTROL EQUIPMENT No.7 Mk.4

SETTING-UP PROCEDURE

[C-MHA]

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FIGHTING VEHICLES GUN CONTROL EQUIPMENT NO.7 I.K.1.

SETTING UP PROCEDURE

(NOTE: This edition supersedes and replaces edition dated 14th January, 1966).

1. Introduction

1.1 The purpose of this document is to act as a guide to setting up FV/GCE No.7 I.K. 4, as fitted to the Chieftain (FV.4201) AFV, with the maximum ease and safety. It is recommended that, wherever possible, the procedure as detailed in this document is followed.

See The various checks and adjustments called for in this procedure describe the performance of a correctly functioning system. The tests should be carried out with the vehicle standing on level ground except where otherwise specified. If the equipment does not react as described, it should be ascertained that the units involved are correctly installed and cabled before assuming that they are defective.

2. Check Limit Switches

2.1 Traverse the turret to Dead Astern with gun elevated. Using gunner's handwheel depress the gun until the thermal jacket around the barrel touches the rubber bump strip without compressing it. If no thermal jacket is fitted allow half an inch clearance between barrel and strip. Remove socket TV9 from control panel. Elevate the gun by four rotations of the gunner's elevation handwheel and using an Avo 8 or 9 on ohms range, check that an open circuit exists between pins D and E of TV9 socket. Depress the gun and check that a short circuit appears at the end of two rotations plus or minus half a rotation. If desired results cannot be obtained, remove cover from limit switch assembly on elevation gearbox and adjust switch 3 (bottom travel) and the main cam.

2.2 Check that an open circuit exists between pins C and F of TV9 socket. Elevate the gun by 22 rotations of the handwheel. Check that a short circuit now exists between pins C and F of TV9. If necessary, adjust switch 1 (top travel) to obtain desired results. Do not adjust main cam as it has been correctly positioned in clause 2.1.

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- 2.3. Elevate the gun to its mechanical end stop. Depress the gun by 6 rotations of the handwheel and check that an open circuit exists between pins A and H of TV9 socket. Elevate the gun and check that a short circuit appears at the end of 2 rotations plus or minus half a rotation. If necessary, adjust switch 2 (top) and first subsidiary cam to obtain desired results.
- 2.4. Traverse the turret to the offside and depress the gun to its mechanical end stop. Elevate the gun by 6 rotations and check that an open circuit exists between pins B and G of TV9 socket. Depress the gun and check that a short circuit appears at the end of 2 rotations plus or minus half a rotation. If necessary, adjust switch 4 (bottom) and second subsidiary cam to obtain desired results. Replace socket TV9 and remove socket TV4 from control panel. (It is possible to use JM6 instead of TV4).
- 2.5. Traverse the gun towards the rear of the hull with the gun in full depression until the thermal jacket around the gun barrel touches the rubber strip without compressing it. Using an Avo 8 or 9 on ohms range check that a short circuit exists between pins G and H of TV4. Zero the traverse indicator and traverse the gun 100 mils towards the front of the hull. Check that an open circuit exists between pins G and H. Traverse towards the rear of the hull and check that the short circuit reappears at a reading of 60 mils plus or minus 10 mils on the traverse indicator. If necessary adjust traverse limit switch and cam to obtain desired results.
- 2.6. Repeat 2.5 from the nearside.
- 2.7. Traverse the gun across the rear of the hull checking that a short circuit is maintained between pins G and H TV4 inside the limits set by tests 2.5 and 2.6. Replace TV4 socket.

3. Preliminary Checks

- 3.1. Check that all units are secured, all cables correctly connected, particularly main input leads. Check that the auxiliary generator is running and has the necessary cooling.
- 3.2. Ensure that there is a clearance to rotate the turret at all angles of gun elevation. Check that rotary switch S.B. on switch unit and Master switch are both "off". Release and stow Gun Clamp, then move Driver's and Loader's Safety Switches to the live position.
- 3.3. Remove Control Panel cover. On the monitor unit in the Control Panel set switch S.5 to position 11 (D.C. supply volts), switch S.4 to "D.C. normal". On meter M.1 (0 - 30 volts) check that a positive reading of $28 \pm 3v$ is obtained. Return switch S.5 to "off".

4. Check Battery Control and Motor and Tacho Polarities

- 4.1. Check that gun is unclamped, that Driver's and Loader's Safety switches are in the 'live' position, that Master Switch in 'on' and that Monitor Unit switch S1 is in the 'Run position'.
- 4.2. Set switch S.A. on the Control Panel to 'Battery'. Rotate Commander's Controller fully clockwise with the grip switch operated. Check that the turret rotates to the right. Release grip switch while controller is still hard over and check that turret stops abruptly. Re-operate grip switch then return Controller to centre. The turret should again stop abruptly. With controller hard over and grip switch operated, set Master switch to "off". Turret should again stop abruptly. Return Master switch to "on" and check that turret re-starts.

- 4.3. Repeat test 4.2, but rotate Controller anti-clockwise for leftward rotation of the turret.
 - 4.4. Repeat tests 4.2 and 4.3, using Gunner's Controller.
 - 4.5. Set Monitor Unit Switch S5 to position 23 (Traverse Motor Current). Meter M2 (scale 100 - 0 - 100A) should deflect right for clockwise rotation of the Commander's Controller and left for anti-clockwise rotation. Record the value of steady current in each direction. This should not exceed 15 amps.
 - 4.6. Set Monitor Unit Switch S5 to position 25 (Hull Tacho Output). Check that meter M2 deflects as in Test 4.5.
 - 4.7. Set Monitor Unit Switch S5 to position 27 (Traverse Motor Tacho Output). Check that Meter M2 deflects as in Test 4.5.
 - 4.8. Set Monitor Unit Switch S5 to position 3 (Elevation Motor Tacho Output). Raise and lower gun by means of Gunner's Elevation Handwheel. Meter M2 should deflect right for upward motion of the muzzle and left for downward motion. Return switch S5 to "off".
 - 4.9. With Gunner's Controller rotated to the right and turret traversing right, check that rotating Gunner's Elevation hand wheel will raise or lower the muzzle. Repeat, traversing to the left. Return switch S.A. to 'Metadyne'.
5. Set-up and Check Amplifiers

- 5.1. Check that switch S.A. on the Control Panel is set to 'Metadyne'. Set the Master Switch to "on". On the Switch Unit set rotary switch B to "Non-stab". 1LP.1 on the Power Supply Unit should light within 30 ± 10 seconds of switching to "Non-stab".

NOTE: In tests 5.2 - 5.9 M1 reads 0 - 30v., M2 100 - 0 100ma except where indicated.

- 5.2. In the Control Panel, set Traverse and Elevation Coupling Amplifier 'Gain' switches to Position 7, Monitor Switch S.1. to 'Trim S.A.', S.4 to 'D.C, Normal, S.3 to 'Normal' and switch S.5 to position 29. Holding switch S.2 in the 'H.T. Trav'. position, read Traverse Output Valve grid voltage on M.1. and Traverse Variator Differential Current on M.2. Adjust Traverse Servo Output Amplifier 'Trim' and 'Output Level' potentiometers to give a zero reading on both M.1. and M.2. (N.B. Adjustment of each potentiometer will affect both meter readings). Set switch S.4 to 'Meter Reverse' to ensure that a true zero reading has been obtained on M.1. Release switch S.2. Set switch S.1 to "trim C.A." Holding switch S2 in "H.T. Trav" position, adjust Traverse Coupling Amplifier 'Bias' potentiometer to give a zero reading on M2. Release switch S2.
- 5.3. Set switch S1 to "Trim SA". Set switch S.5 to position 1. Holding switch S.2 in the 'H.T. Elev.' position read Elevation Output Valve grid voltage on M.1. and Elevation Variator Differential Current on M.2. Adjust Elevation Servo Output Amplifier 'Trim' and 'Output Level' potentiometers to give zero reading on both M.1. and M.2. (N.B. Adjustment of each potentiometer will affect both meter readings). Set switch S.4 to 'Meter Reverse' to ensure that a true zero reading has been obtained on M.1. Release switch S.2. Set switch S1 to "Trim C.A." Holding switch S2 in "H.T. Elev". position, adjust Elevation Coupling Amplifier 'Bias' potentiometer to give a zero reading on M.2. Release switch S2. Return switch S5 to position 29.

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- 5.4. Set switch S.1. to 'Left'. Holding switch S.2 in the 'H.T. Trav.' position, check that M.2. reads not less than 70mA deflection left and the L.H. lamps brighten on Traverse Servo Output amplifier Set switch S.1. to 'Right'. With switch S.2. as before check that M.2 reads not less than 70mA deflection right and that R.H. lamps brighten. Release switch S.2.
- 5.5. Set switch S.5 to position 23 (Traverse Motor Current). Depress Traverse Metadyne 'Start' button or operate switch S.D. on Switch Unit until Metadyne is heard to reach a constant speed; this should not take more than six seconds, then release start button. If the metadyne has not been heard to start by the time six seconds have elapsed, a fault condition exists. Button or switch must be released immediately and must not be re-operated until fault has been cleared. Hold switch S2 momentarily in the 'H.T. Trav.' position and check that M2 (100 - 0 - 100A) reads not less than 80 amps. to the right.
- 5.6. Set Switch S.1. to 'left' and operating switch S.2. as before, check that M2 reads not less than 80 amps. to the left. Release switch S.2., and depress Traverse Metadyne 'stop' button or operate Switch S.A. on Switch Unit.
- 5.7. Set switch S.5., to position 27 and switch S.3. to 'Normal' M.1 (0 - 100v) should read $52.5 \pm 27.5v$. Set switch S.1. to 'Right' and switch S.3. to 'Meter Reverse'. M.1. should again read $52.5 \pm 27.5v$. This is the output of the P.C.R. in the Traverse Coupling Amplifier.
- 5.8. Set switch S.5. to position 1, switch S.1. to 'Down'. Holding switch S.2. in the 'H.T. Elev.' position, check that M.2. reads not less than 70mA deflection left and that L.H. lamps brighten on Elevation Servo Output Amplifier. Set switch S.1. to 'Up'. With switch S.2 as before, check that M.2. reads not less than 70mA deflection right and that R.H. lamps brighten. Release switch S.2.
- 5.9. Set switch S.5 to position 5, (Elevation Motor Current). Depress Elevation Metadyne 'Start' button or operate switch S.D. on switch Unit until metadyne is heard to reach a constant speed; this should not take more than six seconds, then release 'Start' button. If the metadyne has not been heard to start by the time six seconds have elapsed a fault condition exists. Button or switch must be released immediately and must not be re-operated until fault has been cleared. Hold Switch S.2 momentarily in the 'H.T. Elev.' position and check that M2 (100 - 0 - 100A) reads not less than 80 amps. to the right.
- 5.10 Set switch S.1. to 'Down' and operating switch S.2 as before, check that M.2. reads not less than 80 amps to the left. Release switch S.2 and depress Elevation Metadyne 'Stop' button or operate Switch S.A. on Switch Unit.
- 5.11 Set Switch S.5 to position 3 and switch S.3 to 'Normal'. M.1 should read $15 \pm 10v$. Set switch S.1 to 'Up' and switch S.3 to 'Meter Reverse'. M.1 should again read $15 \pm 10v$. This is the output of the P.C.R. in the Elevation Coupling Amplifier. Return switch S.5 to 'off', switch S.1 to 'Run'. Set Traverse and Elevation Coupling Amplifier 'Gain' switches to position 1.

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6. Trim and Polarity Checks

- 6.1 Ensure that gun is unclamped, positioned dead ahead at approximately 0° elevation, that Driver's and Loader's Safety Switches are in the 'Live' position, that Battery/Metadyne switch is in the 'Metadyne' position, that Monitor Unit Switch S.1. is in the 'Run' position. Set Master Switch to 'on', set Rotary Switch B to 'Non-Stab.' and observe that LLP.1 on the Power Supply Unit lights within 30 ±10 secs. Set switch S.5 on Monitor Unit to position 29. Pull 'On' switch S.6 in Monitor Unit.
- 6.2 Operate Gunner's Controller grip switch and rotate Traverse 'Non Stab' Trim control on Trimming Unit fully clockwise. Note that M2 deflects to the right and that right hand lamps brighten on the Traverse Servo Output Amplifier. Rotate Trim control fully anti-clockwise and note that M2 now deflects to the left and that left hand lamps brighten. Set Trim control to give a zero reading on M2 and a balance in lamp illumination on Traverse Servo Output Amplifier.
- 6.3 Set switch S.5 on Monitor Unit to position 1. Remove fuse FS.3 from control panel. Operate Commander's controller grip switch and proceed as in clause 6.2 adjusting Elevation 'Non Stab' Trim control on Trimming Unit and observing lamps on Elevation Servo Output Amplifier.
- 6.4 With grip switch operated, rotate Commander's Duplex Controller Handle clockwise in Traverse. Observe the right hand lamps brighten on Traverse Servo Output Amplifier. Rotate the Controller Handle anti-clockwise and observe that left-hand lamps brighten. Repeat this test with the Gunner's Controller. The same results should be obtained.
- 6.5 With grip switch operated, move Commander's Controller handle backwards in Elevation. Observe that the right-hand lamps brighten on the Elevation Servo Output Amplifier. Move Controller Handle forwards and observe that the left-hand lamps brighten.
- 6.6 Set rotary switch S.B. to 'Stab' on the Switch Unit. Set Elevation 'Stab' Trim control on the Trimming Unit to mid travel position and, operating Gunner's Controller grip switch, adjust Elevation Gyro Trim potentiometer to give a zero reading on M2 and a balance in lamp illumination on Elevation Servo Output amplifier. Then proceed as in clause 6.2 adjusting Elevation 'Stab' Trim Control and observing lamps on Elevation Servo Output Amplifier.
- 6.7 Proceed as in clause 6.5 using both Commander's and Gunner's Controllers in turn.
- 6.8 Set switch S.5. on Monitor Unit to position 29. Set Traverse 'Stab' Trim control on the Trimming Unit to mid travel position, and operating Gunner's Controller grip switch, adjust Traverse Gyro Trim potentiometer to give a zero reading on M2 and a balance in lamp illumination on Traverse Servo Output amplifier. Then proceed as in clause 6.2 adjusting Traverse 'Stab' Trim Control.
- 6.9 Repeat clause 6.4.
- 6.10 Set Loader's Safety Switch to 'Safe' and check that movement of the Controllers with the grip switch operated does not produce illumination of the lamps in either channel. Return switch to 'Live' position and repeat the test with the Driver's Safety Switch. Push 'Off' switch S.6 in Monitor Unit. Return switch S.5 to 'Off'. Replace fuse FS.3.

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7. Check Traverse Servo Operation

WARNING

Before commencing this section it is essential to realise that, should the equipment prove to be faulty, a very real danger to the technician exists, as well as the possibility of extensive damage to equipment.

It is, therefore, imperative that the most stringent measures should be carried out to ensure that,

- (a) Outside the turret no personnel or equipment are in the area which can be covered by the gun barrel.
- (b) Inside the turret, operating personnel must be kept to the minimum. Loose clothing should not be worn. Personnel must ensure that they and their clothing are well clear of hull mounted items, the gun breech and any other moving parts. The person carrying out the tests should operate from the Commander's seat until he is absolutely certain that the equipment is functioning correctly.
- (c) It is also important to realise that certain faults, e.g. Tacho or Gyro feedback reversed or missing, may not manifest themselves immediately the Metadyne is run up, but only after a demand has been placed on the system. In this event an apparently stable system may suddenly become violently unstable. If this occurs the Master Switch should be set to 'Off' immediately.

7.1 Check that the gun is unclamped and clamp stowed, that Full Battery Master switch is on, that Driver's and Loader's Safety Switches are in 'Live' position, that Battery/Metadyne switch is in the 'Metadyne' position, that Monitor Unit Switch S.1 is in the 'Run' position and that Traverse Coupling Amplifier Gain switch is set to position 1. Set Master Switch to 'on'. Set Rotary Switch S.B. on Switch Unit to "Non-Stab" and observe that LL.1 on Power Supply Unit lights within 30 ±10 seconds. Pull 'on' switch S.6 in Monitor Unit. Set switch S.5 to position 29. Ensure that the gun is elevated above 0°.

7.2 Operate Commander's Controller Grip Switch. Check that Traverse Servo Output Amplifier lamps are balanced in illumination, indicating that the system is trimmed in Traverse, depress Traverse Metadyne 'Start' button or operate switch S.D. If lamps give an indication that 'Trim' is not maintained, release 'Start' button immediately. Assuming that 'Trim' is maintained, continue to depress 'Start' button until Traverse Metadyne is heard to reach a constant speed; this should not take more than 6 seconds, then release 'Start' button. Push 'Off' switch S.6 in Monitor Unit.

7.3 With Commander's Controller grip switch operated, slowly rotate the Controller clockwise and check that the Turret rotates to the right and speed increases smoothly until the Controller is nearly at the end of its travel, when an abrupt increase of speed should occur. Release the grip switch with the Controller hard over and allow Turret to regain speed then return the Controller slowly to its centre position and check that there is an abrupt decrease in speed followed by a gradual return to rest. Repeat this rotating the Controller anti-clockwise and observing rotation of the Turret to the left.

7.4 Repeat 7.3 using Gunner's Controller.

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- 7.5 With the turret traversing at 'slew' speed, depress Traverse Metadyne 'Stop' button or operate switch S.A. Check that turret halts abruptly. Allow Metadyne to run down. Set rotary Switch S.B. to 'Stab'. on the Switch Unit. With switch S.6 pulled 'on', and Commander's Controller grip switch operated, check that there is a zero reading on M.2 and a balance in lamp illumination on Traverse Servo Output Amplifier indicating system is trimmed in traverse.
- 7.6 Proceed as in tests 7.2, 7.3 and 7.4, then depress Traverse Metadyne 'Stop' button or operate switch S.A. and allow Metadyne to run down.

8. Check Elevation Servo Operation

WARNING

Before commencing this section, it is essential to realise that, should the equipment prove to be faulty, a very real danger to the technician exists, as well as the possibility of extensive damage to equipment.

It is therefore imperative that the most stringent measures should be carried out to ensure that:-

- (a) Outside the turret no personnel or equipment are in the area which can be covered by the gun barrel.
- (b) Inside the turret, operating personnel must be kept to the minimum, loose clothing should not be worn. Personnel must ensure that they and their clothing are well clear of hull mounted items, the gun breech and any other moving parts. The person carrying out the tests should operate from the Commander's Seat until he is absolutely certain that the equipment is functioning correctly.
- (c) It is also important to realise that certain faults, e.g. Tacho or Gyro feedbacks, reversed or missing, may not manifest themselves immediately the Metadyne is run up, but only after a demand has been placed on the system. In this event an apparently stable system may suddenly become violently unstable. If this occurs, the Master Switch should be set to 'off' immediately.
- 8.1 Check that gun barrel is not positioned within the zone covering the rear of the hull as laid down in test 2.7. Check that the gun is unclamped and the clamp stowed, that Hull Battery Master Switch is on, that the Driver's and Loader's Safety Switches are in the 'live' position, that Battery/Metadyne switch is in the 'Metadyne' position, that Monitor Unit switch S.1 is in the 'Run' position and that Elevation Coupling Amplifier Gain switch is set to position 1. Set the Master Switch to 'on' and rotary switch S.B. to 'Non-stab.' Check that LLF.1 in the Power Supply Unit lights within 30 ±10 secs. Set 'Speed Grading' potentiometer in the Elevation Coupling Amplifier and 'Non-stab' 'speed grading' potentiometer in the Elevation Relay Unit fully anti-clockwise. Pull 'on' switch S.6 in Monitor Unit.
- 8.2 Set switch S.5 to position 1. Operate Commander's Controller Grip Switch and check that Elevation Servo Output Amplifier lamps are still balanced in illumination, indicating that the system is trimmed in elevation, then depress Elevation Metadyne 'Start' button or operate switch S.D. If lamps give an indication that trim is not maintained, release 'start' button immediately. Assuming that trim is maintained, continue to depress 'start' button until the elevation metadyne is heard to reach a constant speed; this should not take more than 6 seconds. Then release 'start' button and push 'off' switch S.6.

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- 8.3 Operate Commander's Controller grip switch, slowly move the Controller backwards and check that the gun elevates and that speed increases smoothly. With the gun elevating at maximum Controller Deflection check that if the grip switch is released, the gun immediately stops. Also with the gun elevating at maximum Controller Deflection check that if the Controller is returned to its central position the gun immediately stops. Repeat this, moving the Controller forwards and observing depression of the gun muzzle.
- 8.4 With gun elevating at maximum controller deflection, depress Elevation Metadyne 'stop' button or operate switch S.A. and check that gun stops abruptly. Allow Metadyne to run down. Set rotary switch S.B. to 'Stab.' on the Switch Unit. Pull 'on' switch S.6. With Commander's Controller Grip Switch operated, check that there is a zero reading on M.2 and a balance in lamp illumination on Elevation Servo Output Amplifier, indicating system is trimmed in elevation.
- 8.5 Proceed as in tests 8.2, 8.3. Repeat 8.3, using the Gunner's Controller. Then depress Elevation Metadyne 'stop' button or operate switch S.A. and allow Metadyne to run down.
9. Dynamic Check of Limit Switches
- 9.1 In the Traverse and Elevation Coupling Amplifiers set 'gain' switches to position 1 and the 'Speed Grading' potentiometers to mid position. Set rotary switch S.B. to 'Stab' and run up Traverse and Elevation Metadynes.
- 9.2 Ensure that the gun barrel is not positioned within the zone covering the rear of the Hull as laid down in Test 2. In the Monitor Unit, set Switch S.5 to position 1 to read Elevation Variator Differential Current 100 - 0 - 100mA on M.2. Operate Commander's Controller grip switch and move the Controller backwards in elevation until it rests against its end stop. When the gun muzzle is at its maximum elevation note that the reading on M.2 is 20mA \pm 20mA to the right. Continue holding Controller handle on its stop, but set Rotary switch S.B. to "Travel". Observe that the muzzle immediately depresses to approximately +10° and hunts about that point. Return rotary switch S.B. to 'Stab.'. Move Controller forwards until it rests against the other end stop. When the gun reaches its maximum depression, check that the reading on M.2 is 20 \pm 20mA to the left. Continue holding Controller handle on its Stop, but set rotary switch S.B. to "Travel". Check that muzzle elevates to approximately 0°, and hunts slowly about this point. Return rotary switch S.B. to 'Stab'.
- 9.3 Using Commander's Controller traverse the gun towards the rear of the Hull with the muzzle in full depression. As the barrel approaches the rubber bump strip reduce speed. Observe that as the barrel reaches a clearance of some two or three inches from the end of the strip, it elevates to clear the rear of the Hull. Traverse the gun in the opposite direction and check clearance at the other end of the rubber bump strip. Repeat the above at 'slew' speed and note that gun does not damage strip.
- 9.4 In the event of either 9.2 or 9.3 giving incorrect results carry out the appropriate procedure detailed in Tests 2.1 to 2.7.

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- 9.5 Set rotary switch S.B. to "Travel". With the turret slewing and the gun moving in elevation, set Master Switch to 'off'. Check that the turret and gun come to a controlled halt, that the Metadyne and Power Supply unit cease to function. Return the Master Switch to 'on' and check that LLP.1 on the Power Supply unit comes on after 30 ± 10 seconds. Check that the Metadynes can be re-started as detailed in clauses 7.2 and 8.2.

10. Set-up Elevation Channel

- 10.1 Ensure that gun is not over rear of hull. Set rotary switch S.B. to 'Stab' and run up Elevation Metadyne. Set Monitor Switch S.5 to position 3, read Elevation Motor Tacho Output (30 - 0 - 30v) on M.2. Set Elevation Coupling Amplifier 'Gain' switch to position 7. The system will probably be unstable at this setting when the gun is disturbed by means of the Commander's Controller and the gain should be turned down one position at a time until the instability ceases. Note the final position.
- 10.2 Operate the Commander's Controller grip switch, check that the system is still trimmed by the fact that the gun is stationary, then move the Controller handle sharply backwards in elevation until it rests against one end stop. Note reading on M.2 while gun is responding to Controller demand. Adjust 'Speed Grading' potentiometer on Elevation Coupling Amplifier to give a steady 10 Volts deflection on meter. Due to the restricted travel in elevation, it will be necessary to elevate and depress the gun several times in order to get an accurate reading on M2. Return the Commander's Controller to the centre position at the end of the test and release grip switch.
- 10.3 Set rotary switch S.B. to 'Non-Stab' and Gain Switch on Elevation Coupling Amplifier to position 1. Repeat test 10.2 but adjust 'Non-Stab. Speed Grading' potentiometer on Elevation Relay Unit to obtain the desired 10V on M2.
- 10.4 Set the Gain Switch on Elevation Coupling Amplifier to position 7. The system will probably be unstable at this setting when the gun is disturbed by means of the Commander's Controller and the gain should be turned down one position at a time until the instability ceases. Note the final position. Compare this setting with that obtained in 10.1. Record the lower of the two, and set the 'Gain' switch to this position.

11. Set up Traverse Channel and Measure Stiffness

- 11.1 System should be fully operating in the stabilised condition. Set 'Gain' switch on Traverse Coupling Amplifier to position 7. The system will probably be unstable at this setting when the gun is disturbed by means of the Commander's Controller and the gain should be turned down one position at a time until the instability ceases.
- 11.2 Lay the gun on a target at not less than a thousand yards. Adjust 'Stab' trim controls to ensure that gun does not drift off target. Instruct the driver to carry out a neutral turn, at maximum speed. Set 'Divided Reset' potentiometer on Traverse Relay Unit to give a finishing position within ± 50 mils ($\pm 3^\circ$) of starting position. It is probable that adjusting the 'Divided Reset' potentiometer will affect the gain setting. Therefore repeat the appropriate part of test 11.1 and note final setting.

NOTE:- On a vehicle with rubber tracks fitted the vehicle will be laterally displaced from its original position at the completion of a neutral turn. This only introduces an error of 1 mil for each yard of displacement and can be ignored.

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- 11.3 Set Monitor Unit switch S.5 to position 27, read Traverse Motor Tacho output (300-0-300V) on M.2. Rotate the Commander's Controller fully clockwise. Operate the grip switch and slowly return the Controller anti-clockwise. At approximately 40.5 degrees of Controller angle, the slew micro-switch will be de-energised and an abrupt decrease in turret speed will occur. At this point, adjust 'Speed Grading' potentiometer on Coupling Amplifier Traverse to give a reading of 100 volts deflection right on M.2. Return Controller to centre position then slowly rotate anti-clockwise. Note that M.2. now indicates a reading of 100 volts deflection left immediately prior to the slew switch operating to give the abrupt increase in turret speed.
- 11.4 Set rotary switch S.L. to 'Non-Stab' and Gain switch on Traverse Coupling Amplifier to position 7. The System will probably be unstable at this setting when the gun is disturbed by means of the Commander's Controller and the gain should be turned down one position at a time until the instability ceases. Note the final position.
- 11.5 Repeat test 11.3 but adjust 'Non-Stab. Speed Grading' potentiometer on Traverse Relay Unit to obtain desired 100 volts on M.2. It is probable that adjusting the 'Non-Stab. Speed Grading' potentiometer will affect the gain setting. Therefore repeat the appropriate part of test 11.4 and note the final setting. Compare this setting with that obtained in 11.2. Record the lower of the two and set the 'Gain' switch to this position.
- 11.6 Set rotary switch S.L. to 'Stab.'. In the Monitor Unit pull 'On' switch S.6. Set switch S.5 to position 29 and switch S.1 to 'Trim S.A.' Holding switch S.2 in the 'H.L. Traverse' position check that the readings on M.1. and M.2. are at zero; if necessary, adjust 'Trim' and 'Output level' potentiometers on Traverse Servo Output Amplifier to obt in this. Return switch S.1. to the 'Run' position and with Commander's Duplex Controller grip switch operated, adjust Traverse Stab. trim control on Trim Unit to give a zero reading on M.2. Reading 'Traverse Variator Differential Current' on M.2. (100-0-100mA) and keeping Commander's Controller grip switch operated, rotate Traverse Servo Output Amplifier 'Trim' potentiometer very slowly clockwise. Note the reading on M.2 when turret just commences to rotate to the right. Press the Traverse Metadyne 'Stop' button or operate switch S.A. and wait for metadyne to run down. Then, still keeping Commander's grip switch operated, rotate 'Trim' potentiometer further in the clockwise direction until M.2 reads 40mA greater than the current measured above. Release grip switch and run up Traverse Metadyne. Re-operate Commander's grip switch and record time taken for turret to rotate 500 mils. Release grip switch, press metadyne 'Stop' button and allow metadyne to run down. Check that with grip switch re-operated reading on M.2 is still 40mA greater than current originally observed. If this is not the case, repeat the test and record again. Return Traverse Servo Output Amplifier 'Trim' potentiometer anti-clockwise to the point where a zero reading is obtained on M.2. Release Commander's Controller grip switch and push 'Off' switch S.6.
- 11.7 Repeat test 11.6 in the opposite sense, 'Trim' potentiometer rotated anti-clockwise, turret rotating to left.
- 11.8 Reduce times recorded in 11.6 and 11.7 to mils per second, add the results arithmetically to obtain average rate error for full drive. This depends largely on Traverse Coupling Amplifier gain switch setting but should not exceed 30 mils per second at gain setting 1.

N.b. Higher gain settings will give lower rate errors.

11.9 With system fully operating rotate Commander's Controller fully to the right, operate the grip switch, and record time taken for turret to complete one revolution to the right at 'Slew' speed. Repeat with Controller fully over to the left, again recording time. This should not exceed 18 seconds. If incorrect results are obtained first check that tests 11.3 and 11.5 have been carried out correctly.

12. Turret Mounting Friction Test

- 12.1 Position the vehicle on a 15° incline. Run up the Gun Control Equipment for Stab. operation. Set Traverse Stab. Trim control fully clockwise leaving Elevation Stab. trim in the balanced position, with the gun elevated approx. 3°. Operate Commander's Controller Grip switch and allow turret to traverse 360° observing that the turret traverse smoothly without 'Stick/slip' or 'judder'. Any points at which this does take place should be noted.
- 12.2 Proceed as in 12.1 but set Stab. trim control fully anti-clockwise. Return Traverse 'Stab'. Trim control to trimmed position.
- 12.3 Set Loader's Safety Switch to 'Safe'. Press Traverse 'Stop' button. Press Elevation Motadyne 'Stop' button. Set rotary switch S.B. and Master Switch to 'Off'.

13. Set-up Contra-Rotation "Line-Up" Facility

WARNING

The gun control system must be correctly set up before commencing this section. It is essential to realise that, should the equipment prove faulty, a very real danger to the technician exists, as well as the possibility of extensive damage to equipment.

It is therefore imperative that the most stringent measures should be carried out to ensure that:-

- (a) Outside the turret no personnel or equipment are in the area which can be covered by the gun barrel.
- (b) Inside the turret, operating personnel must be kept to the minimum. Loose clothing should not be worn. Personnel must ensure that they, and their clothing, are kept well clear of the Hull mounted items, the gun breech and any other moving parts. The person carrying out the tests should operate from the Commander's seat.

It is important to realise that certain faults e.g. a jammed relay or faulty micro-switch may not manifest themselves until after Contra-Rotation has been selected and a demand placed on the system. In this event the turret may rotate out of control. If this occurs the G.C.E. Master Switch should be set to 'off' immediately.

13.1 Preliminary Checks No. 11 Cupola (Gearbox No. 1 Mk. 1) and No. 15 Cupola (Gearbox No. 2 Mk. 2 - 10th Vehicle onwards).

13.1.1. Cupola Direction Sensing Switch S.W.3

Remove Socket TGC2 from the Contra-Rotation Gearbox upper plate. Using an Avo 8 on ohms range, check that, with the cupola wound off to right of 'Line-up', a short circuit exists between pins A and B of Socket TGC2 free end and that an open circuit exists between pins A and C. With the cupola wound off to the left of 'Line-up', a short circuit should exist between pins A and C and an open circuit between pins A and B of Socket TGC2. Replace TGC2.

13.1.2 Check Master Switch S.W.1 and Set Adjustable Cams

Remove TX1 from Direction Sensing Switch. With the cupola wound to the left of 'Line-up', slacken the two 7/16 ins. A/F stiff nuts securing the two Adjustable Cams to the locating peg and move both cams fully outwards, i.e. away from the peg, then tighten both stiff nuts. Remove the socket from TGC1 situated on the right hand side of the gearbox. Push the Contra-Rotation Selection Lever fully forward. A short circuit should now exist between pin A on TX1 free end and Pin C on TGC1 fixed end. Release the Selection Lever by operating the Release Pawl situated above the guide ramp and check that an open circuit appears.

13.1.3 Check 8° Switch S.W.2

Wind the cupola to a position where the striker is half way across the left hand slope of the guide ramp and hold the Contra-Rotation Selection Lever fully forward. Check that an open circuit exists between pin A on TX1 free end and pin C on TGC1. Release the Selection Lever and wind the cupola into 'Line-up'. Check that the open circuit is maintained. Now wind the cupola to a position where the striker is half way across the right hand slope of the guide ramp again holding the Selection Lever fully forward and checking that the open circuit is still maintained. Bring the cupola into 'Line-up' and replace TX1 and TGC1 connectors.

This completes the preliminary checks.

13.2. s (Gearbox No. 1 Mk. 1 and No. 2 Mk. 2)

13.2.1. Adjusting the 8° Cams for Optimum

(a) Set the equipment fully operating in "NON-STAB" condition. Switch the cupola Supply Junction Box Master Switch to "ON". With cupola locked to main turret, check that the illuminated HESH aiming circle projected into the commanders sight may be centralized in the X10 eye piece.

(b) Select a target at not less than 1000 yds. and zero the traverse indicator.

(c) Traverse the main turret 500 mils left and wind cupola back to selected target. Centralise the target in the X10 eye piece, engage contra-rotation and operate the commanders grip switch. The main turret should now slew right, cupola remaining stationary. 'Line-up' achievement will be indicated by the locating peg engaging in the slot in the guide ramp and the selection lever dropping back. (Note: Deflection of controller or trim on balance during lining-up, will affect the line-up achievement.)

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- (d) If 'Line-up' is not achieved, release the selection lever by operating the release pawl and move the LEFT HAND adjustable cam by slackening the nut and tapping the cam approximately 1/16" towards the locating peg.
- (e) Repeat 13.2.1 (c) and (d) until 'Line-up' just occurs.
- (f) Repeat 13.2.1(c) and (d) traversing 1500 mils left instead of 500, note the error in mils as indicated by the traverse indicator.
- (g) Repeat 13.2.1(c) and (d) traversing 750 mils left and note the error in mils.
- (h) Repeat 13.2.1(c) and (d) traversing 250 mils left and note the error in mils.
- (k) Compare the final errors after 250 and 1500 mils displacements and if similar, lock up the left hand cam. If not, equalise the errors by further adjustment of the left hand cam. A final error of less than 50 mils after any displacement between 250 and 1500 mils should be achieved.
- (j) Repeat 13.2.1(c) to (k) for displacement right of 'Line-up'.

13.3.

Adjusting the "Line-up Delay" Potentiometer

- (g) Establish the number of mils before 'Line-up' at which the 8^o switch operates when the main turret is moving right (Appendix 1) Add 30 mils to that figure.
- (b) Select a target at not less than 1000 yds. and zero the traverse indicator. Set the LINE-UP DELAY potentiometer (RV3, traverse relay unit) to its mid position.
- (c) Traverse the main turret left by the number of mils established in 13.5(a) and wind the cupola back to the selected target. Centralise the target in the X10 eye piece, engage contra-rotation and operate the commanders grip switch. The main turret should now traverse right, cupola remaining stationary. Line-up achievement will be indicated by the locating peg engaging in the slot in the guide ramp and the selection lever dropping back.
- (d) If 'Line-up' is not achieved, turn RV3 clockwise to correct an undershoot and anticlockwise to correct an overshoot.
- (e) Repeat 13.5(a) to (d) but from the opposite direction and adjust RV3 to equalise the errors. A final error of less than 50 mils should be achieved.

13.4.

Set the Cupola into 'Line-up' position. Switch 'OFF' Cupola Supplies Junction Box Master Switch. Set Loader's Safety Switch to 'SAFE'. Operate the Traverse and Elevation Metadynes 'STOP' switch. Set rotary switch S.B. and G.C.E. Master Switch to 'OFF'. Set Driver's Safety Switch to 'SAFE'. Replace the Control Panel Cover.

WARNING - Attention is drawn to the Warning on Page 11 before proceeding with this section.

13.5. Preliminary Checks No. 15 Cupola (Gearbox No. 2 Mk. 1)

13.5.1. Cupola Direction Sensing Switch

Remove socket TGC2 from the Contra-rotation Gear Box upper plate. Using an avo 8 on ohms range, check that, with the cupola wound off right of 'Line-Up', a short circuit exists between pins A and B of TGC2 free end and that an open circuit exists between pins A and C. With the cupola wound off left of 'Line-up', a short circuit exists between pins A and C and an open circuit between pins A and B of TGC2 free end. Replace TGC2.

13.5.2 Check Cupola Control Lever Master Switch and the Cupola Isolating Switch

Wind the Cupola off to the left of line-up.
Remove TX1 from the Direction Sensing Switch.
Remove TGC1 from the right hand side of the gear box.
Push the Contra-Rotation Selection Lever fully forward.
A short circuit should now exist between pin A on TX1 free end and pin C on TGC1 fixed end.
Release the Selection Lever by operating the Release Pawl situated above the Guide Ramp and check that an open circuit appears.
Wind the Cupola into 'Line-up'.
Manually operate the Control Lever/Cupola Master micro switch and check that the open circuit still exists. If not, adjust the Isolating switch mounting until an open circuit is achieved.
Note. The Isolating switch is in series with the control lever switch and is operated by a rounded cam. at the base of the Release Pawl Shaft. The micro switch is on a mounting which can be adjusted radially to the cam by loosening the 10-24 UNC nut on the mounting. Both switches are open circuit when 'Line-up' is achieved. The Control Lever should release when the locating peg is within 1/16" of the guide ramp slot (see mechanical settings).

13.5.3 Check 8° switch, Left and 8° switch, Right

The switches are mounted in a housing to the right of guide ramp. The switch mounting securing nuts are vertically above one another on the housing side nearest to the operator. Slacken both nuts, set both switches to their middle travel position and then secure both nuts again.

Wind the cupola off to the left of 'Line-up'.
A short circuit should now exist between pin C on TX1 free end and pin E on TGC1 fixed end.
A short circuit should also exist between pin B on TX1 free end and pin D on TGC1 fixed end.
Wind the cupola into 'Line-up' and check that an open circuit exists on each of the above lines. Replace TX1 and TGC1.

13.6 Mechanical Settings

The following procedure assumes that the various switches are serviceable and that all wiring and connections are correct and satisfactory.

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(a) Control Handle Release

Adjust the Allen headed 'Control Handle release adjustment screw' on the cam lever so that after the 'Control Handle' had been moved to engage contra-rotation, subsequent movement of the 'Release Pawl' by hand, causes release of the control handle. This release should occur when the release pawl has been moved to the position it would occupy if it were being operated by the striker pin and this latter was laterally $1/16$ th inch from engagement in the guide ramp slot.

Check that after adjustment is correct for striker approaching from one direction, the same results are achieved when the striker approaches from the other direction.

It may be found that performance is assymetrical. If this is severe it may be necessary to modify the release lever which is operated by the cam at the base of the release pawl shaft.

(b) Guide Ramp Position

Check that when the 'Cupola Traverse Handle' has been pulled fully down, the 'Guide Ramp' has been pulled down sufficient to clear the striker.

N.B. It is important that this clearance is kept to a minimum and is not greater than $3/32$ inch.

Check that the striker engages with the guide ramp within $\frac{1}{2}$ inch of the guide ramp end. Any adjustment necessary should be made by shimming the striker at the cupola roof with shims FV571755.

(c) Switch Settings

(1) Isolating Switch

Set the position of the 'Isolating Switch' so that its operating arm is released, (switch open) by the cam at the base of the release pawl shaft, when the striker is just approaching line-up. Operation should be symetrical in response to movement of the striker from left and right of line-up. The switch position is determined by two adjustments (See Fig. 1)

- (1) A complete bracket pivoting about the release pawl shaft.
- (2) Micro switch support bracket pivoting about one corner screw.

(2) Initial Settings of the 8° switches and operating cams. Remove the side cover from the 8° switch box. Slacken the nuts securing the 8° switches and adjust the switches to their mid positions vertically. Tighten the securing nuts.

Traverse the cupola left until the striker is clear of the guide ramp. Manually swing the cupola back until the striker has depressed the guide ramp approximately $1/64$ inch. Adjust the 8° switch operating cam adjuster so that the vertical cam just operates the switch marked LEFT (lower, of two switches). Re-adjust the vertical cam position, allowing it to move upwards until the switch just breaks. (Switch closing and opening may be conveniently determined audibly). Continue traversing until the cupola is lined up.

Pull the traverse handle fully down. Ensure that the vertical cam does not interfere with the guide ramp downward movement. Such interference would prevent the striker from disengaging with the guide ramp slot and so prevent cupola traverse away from line-up. If the vertical cam is limiting guide ramp movement, move both 8° switches up approximately $\frac{1}{4}$ inch and repeat the setting of the vertical cams as detailed above. Re-check that guide ramp movement is not obstructed. If necessary, the 8° switch 'support bracket' can be adjusted to bring the micro switch nearer to the vertical cam.

13.7 Adjust on Target

Final setting for 8° switches and Operating Cam.
Align the gunners sight on a suitable target at a range of not less than 1000 yards. With the cupola lined up, observe the position of the target with respect to the graticule markings of the commanders' sight.

Zero the traverse indicator.

Traverse the turret RIGHT 550 mils.

Wind the cupola back to the target, as previously observed in the commanders' sight.

Engage contra-rotation and operate the commanders controller grip switch. (Note on 13.2.1. applies during lining-up)

The turret should traverse LEFT with the cupola contra-rotating.

'Line-up' achievement will be indicated by the striker engaging in the guide ramp slot and the selection lever dropping back.

The traverse indicator will give a direct reading of alignment error. An undershoot should result from the initial settings.

Assuming an undershoot results, adjust the vertical cam by unscrewing the threaded cam adjuster approximately $\frac{1}{4}$ turn so allowing the cam to move up. Repeat the functional check and note the line-up error.

Continue the adjustment of the vertical cam until line-up with minimum error occurs.

Set the RIGHT 8° switch by traversing the turret LEFT 550 mils and after winding the cupola back to the target, attempt a line-up and note the error.

Correct errors by moving the RIGHT 8° switch, (upper of the two switches) UP to correct overshoots and vice versa.

DO NOT DISTURB THE CAM POSITION.

13.8 Setting the Time Delay Potentiometer

Set RV3 on the Traverse Relay Unit (Unit T.A.T.) to its mid position. Wind the cupola away from line-up until the striker is vertically in line with the end of the guide ramp.

Attempt a 'Line-up' and observe the results.

If the striker stops short of line-up turn RV3 clockwise and re-check.

The aim should be to achieve engagement of the striker in the guide ramp slot positively, but without overdriving. RV3 should be set finally to equalise errors from left and right.

13.9 Final Functional Check

Check the operation of the line-up facility in response to initial displacements from 1500 mils down to 150 mils.

Acquisition (line-up) should be within \pm 50 mils.

13.10

Set the cupola into 'Line-up' position.

Switch 'OFF' Cupola Supplies Junction Box Master Switch. Set Loaders' Safety Switch to 'SAFE'. Operate the traverse and elevation metadynes 'STOP' switch. Set rotary switch S.B. and G.C.E. Master Switch to 'OFF'. Set Drivers' Safety Switch to 'SAFE'. Replace the control panel cover.

F.V. G.C.E. NO.7, MK.4, SETTING UP PROCEDURE

Addendum to Contra-Rotation Line-up Facility
Clause 13

Recommended method of establishing the points at which the
8° switch operates when the main armament is traversing
towards 'Line-up' (Clause 13.3a)

1. General

- (a) Tests 13.1 and 13.2 must have been satisfactorily completed
- (b) Switch 'OFF' the G.C.E.
- (c) Remove sockets TGC1 and TX1.

2. To establish the operating point of the 8° switch.

- (a) Line up the cupola and main turret.
- (b) Zero the traverse indicator
- (c) Wind cupola off to the RIGHT until the striker is clear of the guide ramp.
- (d) Manually operate the cupola master micro switch and check that a short circuit exists between TGC1, pin C, fixed end and TX1, pin A, free end.
- (e) Keeping the cupola master micro switch operated, wind the cupola LEFT until an open circuit occurs. (8° switch operation).
- (f) Without moving the cupola or turret, note any target on the centre line of the commanders sight.
- (g) Wind the cupola LEFT into line-up.
- (h) Traverse the turret RIGHT until the target noted in step (f) is again on the centre line of the commanders sight.
- (j) The Target Indicator will now give a direct reading of the number of mils before line-up at which the 8° switch operates.
- (k) Repeat the procedure 2(a) to 2(j), but from the opposite direction, to establish the point at which the 8° switch operates when the main armament is traversing LEFT towards line-up.
- (l) Reconnect sockets TGC1 and TX1.
- (m) Before continuing the setting-up procedure, allow at least 15 minutes warm-up period.



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