The Facit CA2-16

Electro-Mechanical Calculator

Restoration Manual

Detailed Photographic Record

FEATURES OF THE FACIT CA2-16 CALCULATOR

Add, Subtract, Multiply & Divide
Automatic Back-Transfer Mechanism
11 Digit Setting Register
9 Digit Counter Register
16 Digit Accumulator Register
8 Digit Internal Memory Register
10 Key Numeric Keyboard
Die-Cast Cover with Molded-Through Keys
Fully Automatic Operation
240V AC Electro-Mechanical Mechanism
Manufactured in Sweden
Serial Number: 1512491
Chassis Number: 158984
Date of Manufacture: 1964
Original (1964) Purchase Price: 3,200 Kr
Size: 27 x 34 x 19 cm. Weight: 15 kg.

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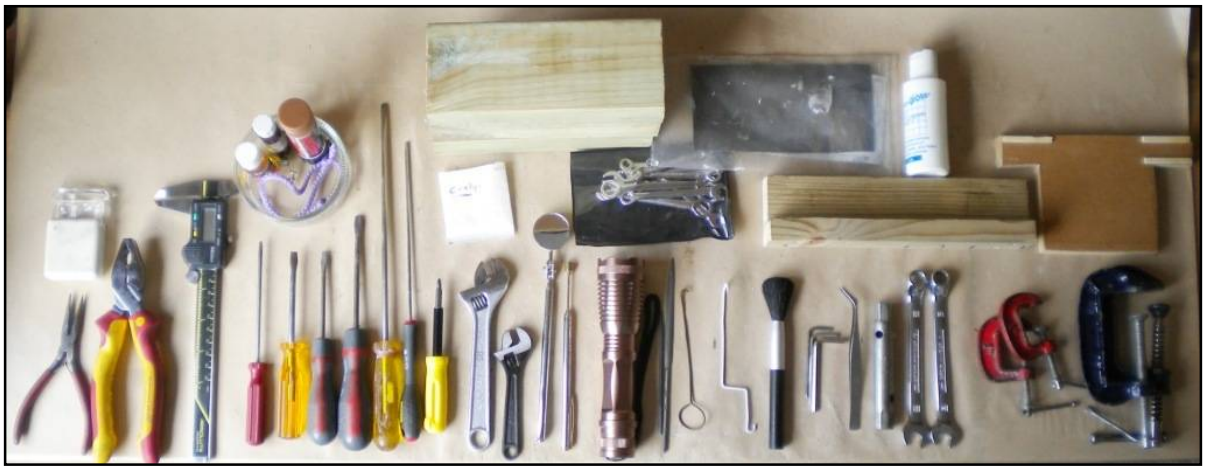
PREPARATION

Before embarking on any restoration project of this kind, especially one similar to the CA2-16, it must be stressed that the working area must be large, clean, dust and dirt free and adequately equipped to deal with all aspects of the project in hand.

Below are shown just some of the tools required to dismantle, adjust and replace the major components related to this machine (not shown here are the cleaning and washing equipment needed to restore each individual module and parts of the machine back into factory fresh condition).



From left to right are shown: magnifiers, various pliers, vernier, various grades of lubricants, selection of screwdrivers (no cross-heads needed), spare circlips of various sizes, adjustable spanners, mirror, magnets, metric spanners, powerful torch, needle files, wire spring-pullers, various grades of emery paper, dusting brush, allen keys, tweezers, box spanner, polishing liquid, G-clamps and various temporary mounting blocks.

Other items needed but not shown here: plastic holding bags, tape, notepaper, pens, pencils, lighting equipment, digital camera, (many photographs need to be taken during the project's life), service frame, manual crank and trays and magnets to retain loose parts.

Restoration of any machine of this kind may take upwards of 6 months to 2 years depending on the complexity of the machine and the severity of the restoration work required, so a large and dedicated area must be set aside in order to carry out this task in an orderly manner for the duration of the project. Note that, although this machine has a volume of much less than one half cubic foot, it contains upwards of a thousand parts and so this needs to be taken into consideration when any dismantling, cataloguing, storing, cleaning and reassembly work is undertaken.

The Facit CA2-16 is one of the most intricate machines of its time and was one of the last of its type to be manufactured prior to the advent of the electronic desk calculator.

REMOVAL SEQUENCE OF THE FACIT CA2-16 MODULES

The following modules (1 to 11) must be removed from the calculator body in the order as given in the table below and installed again in reverse order. After removal, any cleaning and lubricating of the modules should then be carefully done. These individual modules may also require further disassembly to part level for detailed inspection and cleaning, so ensuring that all pivots, pinions, gears, levers, springs and flat adjacent sliding parts operate freely - the latter being most important. Prior to re-installation, any module-specific adjustments must be carried out and any broken or worn parts replaced with new.

Keep all cleaned components in new clean plastic bags to prevent dust and dirt collecting on the newly cleaned and oiled parts. These operations should be carried out with extensive reference also to the service manual, parts manual and part locations document. Most part names in this manual are those as listed in the part locations document by John Wolff.

Extensive notes and photographic records should be maintained throughout the removal and disassembly process in order that all components and sub-assemblies are correctly reassembled and reinstalled to working order for this very complex and intricate machine.

Cleaning and lubricating notes are to be found in appendices B & C on pages 173 - 176.

Also extensive reference should be made to John Wolff's Web Museum at *http://www.johnwolff.id.au/calculators/index.htm* for general guidance on restoration and notes relevant to this particular model.

MODULE REMOVAL SEQUENCE		
Sequence Number	Module Name	Page Number
1	Housing and Keyboard Cover Plate	5
2	Registers I & II Sub-Assembly	7
3	The Motor and its Base Plate	8
4	Tens Carry Rotors	9
5	Bottom Sub-Assembly	10
6	Right-Hand Transmission Sub-Assembly	12
7	Setting Rotor	13
8	Back Corner Panel	14
9	Left Transmission Sub-Assembly	16
10	Back Transfer Sub-Assembly	17
11	Front Corner Panel & Function Keyboards	18

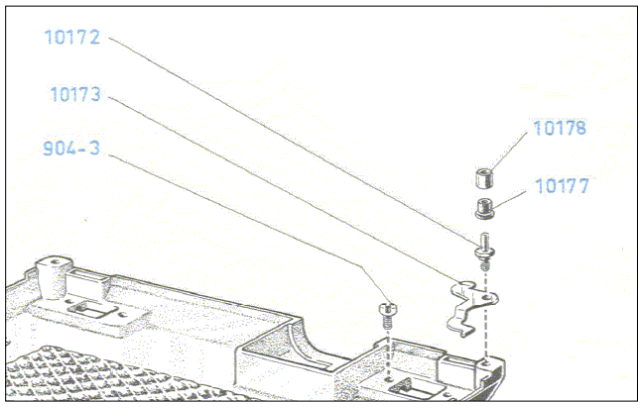
These notes have been compiled from the above-mentioned documents with photographs taken concurrently during the removal, adjusting and reinstallation of the modules into the calculator. It is hoped that this document, along with the others mentioned above, will go some way in helping to restore this truly remarkable feat of compact mechanical design back into fully working order.

Grateful thanks go to John Wolff for expert advice during various aspects of this restoration project.

1 - REMOVAL OF THE HOUSING AND KEYBOARD COVER PLATE

The housing is attached to the base plate with four cover retaining clips 10173 & 10174. These must be swung to the side in order to be able to lift off the housing.

Location of cover retaining clip 10173.



The keyboard escutcheon plate is fastened with four screws 904. Remove the screws and lift off the plate. Use a magnetic screwdriver, especially for the two screws on the right to prevent these dropping into the mechanism.

Any cleaning of the register's windows 10113 & 4 and decimal locator pointers 10112-2 could be carried out at this stage.

Replace any old sound-proofing material in the base and inside the housing with thick felt as necessary.

Unscrew the four dished washers 10115 and lift the machine off its base.

The machine may now be placed flat onto a work surface resting on its four fixing studs although it must not be placed in any other orientation for fear of bending or otherwise damaging any of the system's levers due to its weight.

Remove the two old rubber feet 10116 at the front of the base and, if corroded, replace with new.



Remove the two roller feet 10120 at the rear of the base and clean the pivot bars 1512-4.

Replace the two dried and cracked wax plugs with rubber grommets.

Retain the four large flat washers 10242 from the top of the rubber shock-absorbers.

Clean any accrued debris from the inside of the base and repaint the outside if necessary.

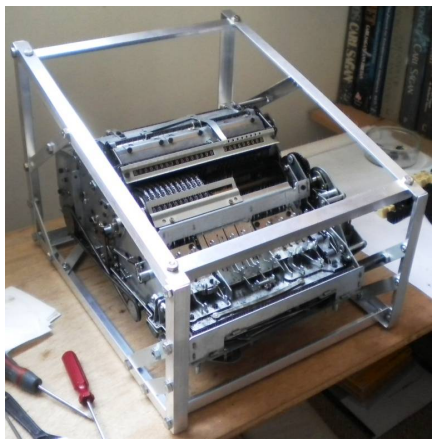
Repaint or replate the four cover retaining clips 10173 & 10174.

Remove any old sound-proofing rubber which may have become deteriorated and affix new thick felt sound-proofing material to the bottom of the base plate.

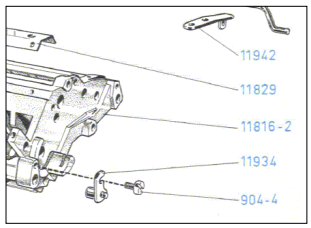
2 - REMOVAL OF THE REGISTERS I & II SUB-ASSEMBLY

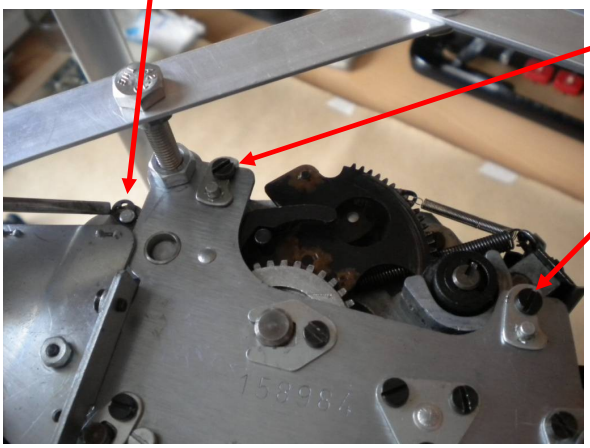
Firstly, fabricate a service frame and install the machine into it. This will ensure that the machine can be placed in any orientation without the fear of damaging any component parts due to its own weight.

NB: The machine cannot be worked on adequately without this frame.

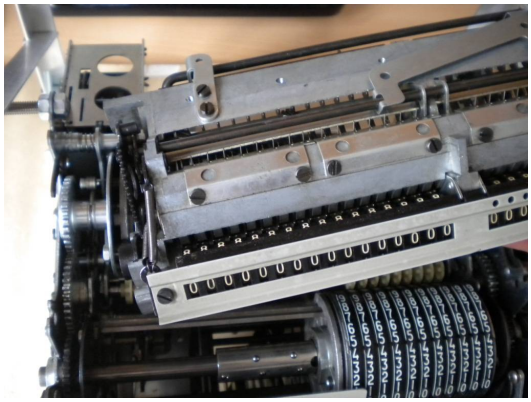


Loosen the four screws 904-4 and remove the four retainers 11934. In addition remove circlip 2099-1 from the accumulator register III clearing link 12583.



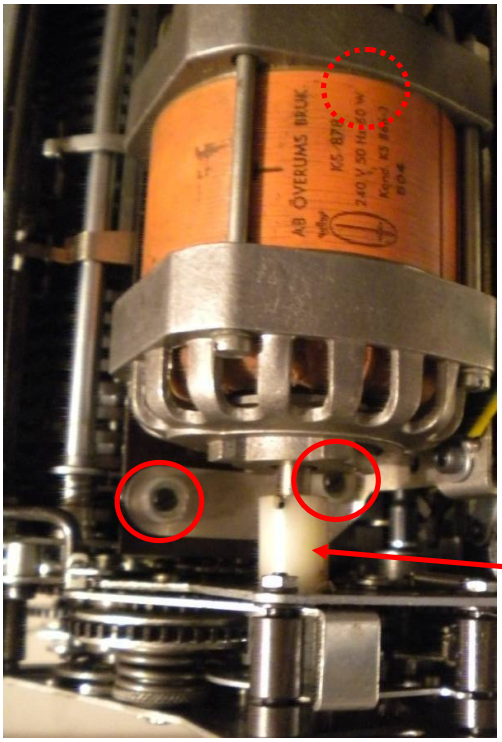


Now the mechanism can be pulled straight up.



3 - REMOVAL OF THE MOTOR FROM THE BACK OF THE MACHINE

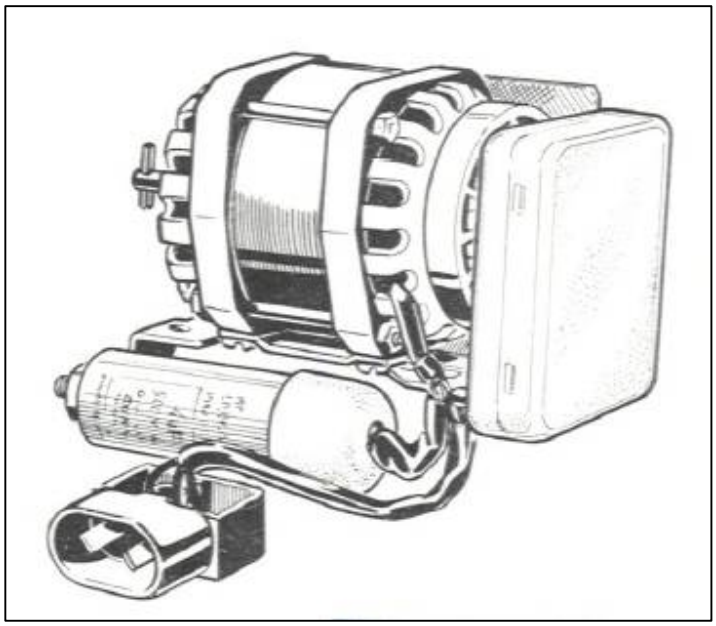
The motor's base plate is fastened with three screws 904-1.



When removing the motor it is best to place the machine onto its right side so that the compression spring inside the motor's coupling doesn't drop into the machine.

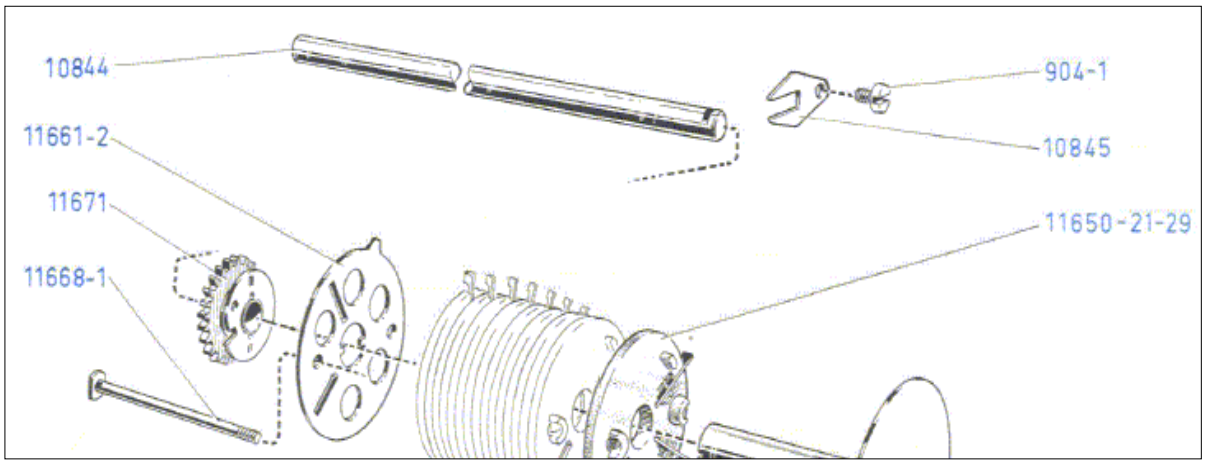
The motor coupling 12290 is spring loaded and must be moved (downwards when the machine is on its side) when removing the motor.

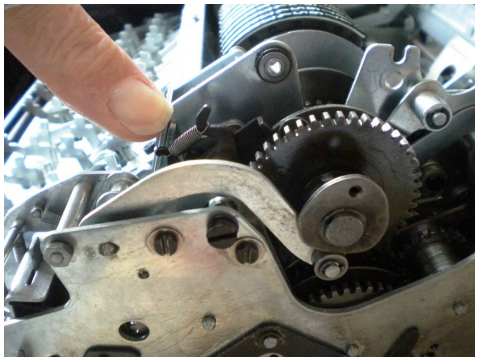
Remove 3 screws 904-2 and washers, move the motor coupling and lift out the motor unit.



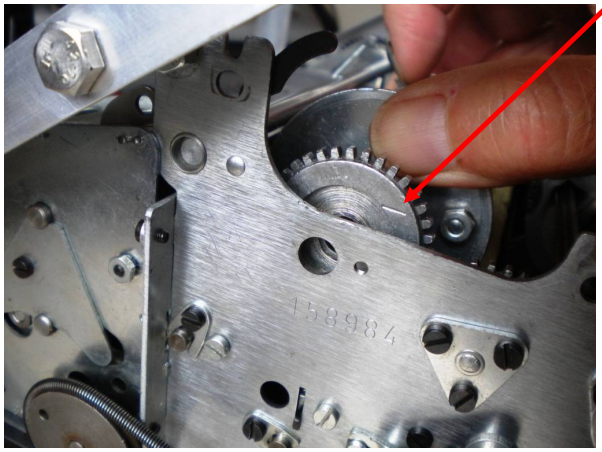
4 - REMOVAL OF THE TENS CARRY ROTORS

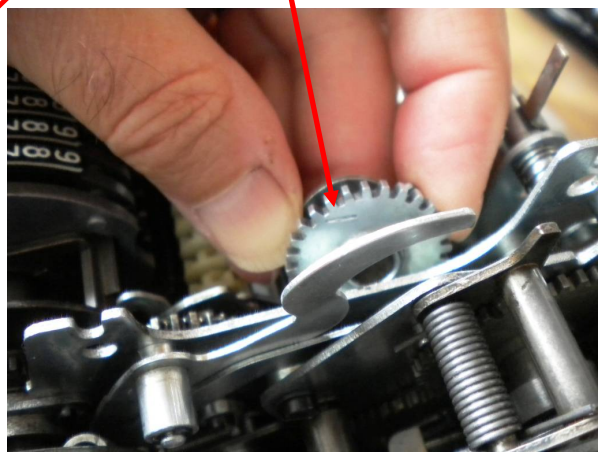
Unfasten screw 904-1 of shaft retainer 10845 and pull out tens carry rotor shaft 10844. Both rotors including gear wheel 11671 can now be lifted out of the machine.





Note that, if the setting rotor is held in its stationary position captured by the two rotor locking hooks 10977 & 10979 (see left), then the two gear wheels at each side of the tens carry rotors will have their datum marks lined up horizontally with the top of the frame.



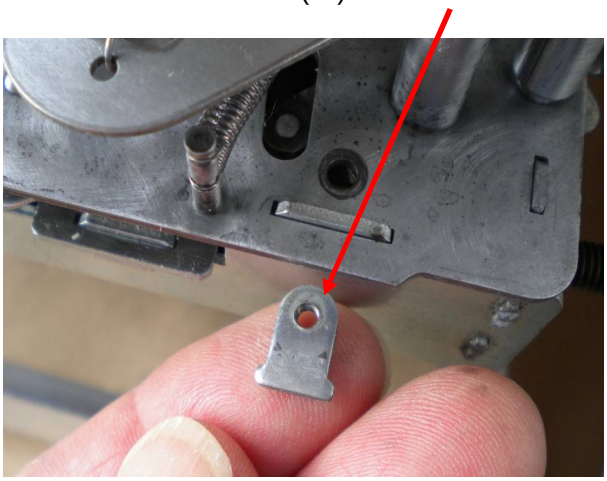


NB: During removal, adjustments and reinstallation operations, the numerical indicators are mostly referred to as rotors. When test calculations are being carried out, they are given their proper names as setting, counter and accumulator registers I, II and III respectively.

5 - REMOVAL OF THE BOTTOM SUB-ASSEMBLY

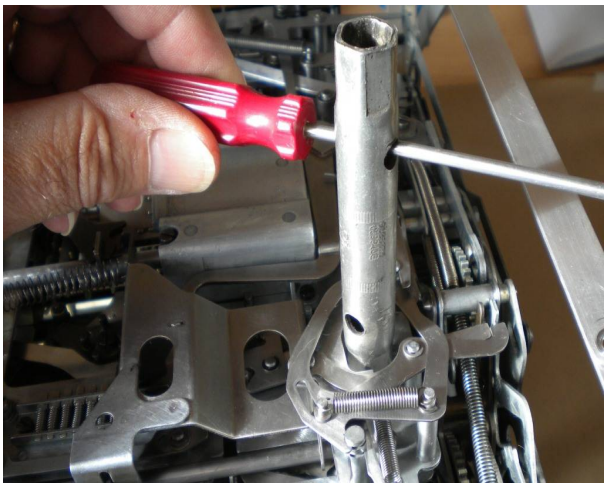
With the calculator in the service frame, invert the machine.
(numbers in parentheses refer to diagram on next page)

Unfasten 6 screws 904-1 (14) and 2 retainers.



Unfasten 1 screw 906-5 and its keeper 10863.

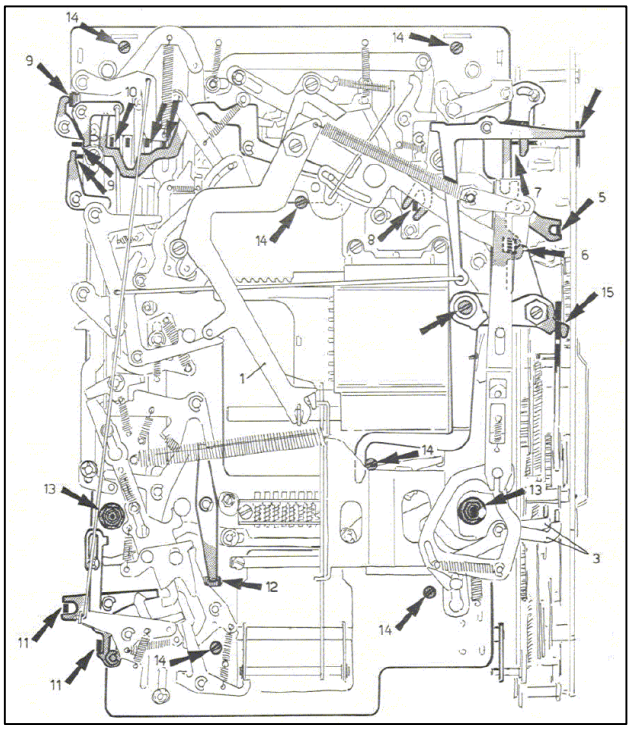
Unfasten 2 nuts 905-8 (13) and washers with an 11 mm box spanner.



Unhook register I rotor clear/return link 12187 (15).

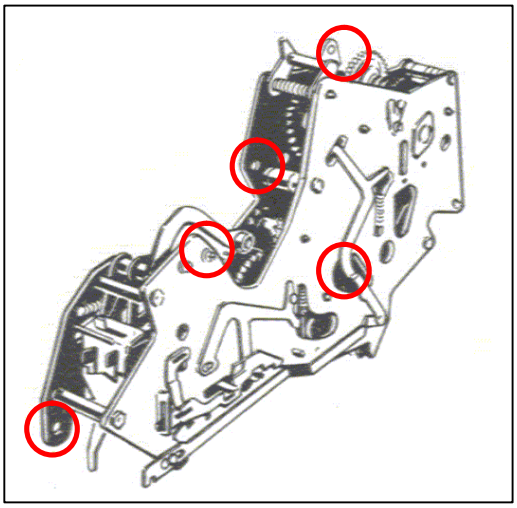
The bottom sub-assembly can now be lifted straight upwards.

Diagram of the bottom sub-assembly showing positions of fixing nuts 13, screws 14, and register I rotor clear/return link 12187 (15).

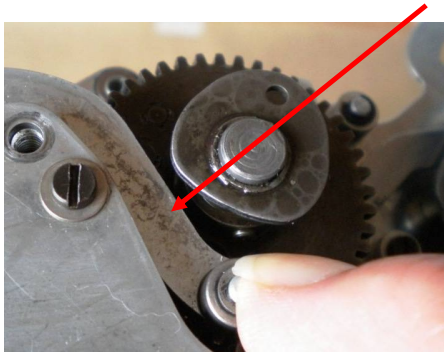


6 - REMOVAL OF THE RIGHT-HAND TRANSMISSION SUB-ASSEMBLY

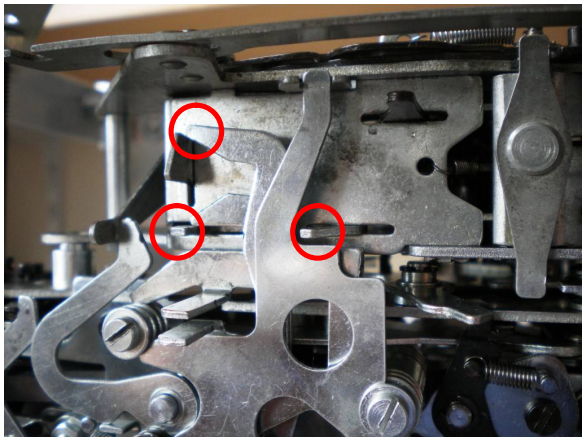
Unfasten 5 screws 906-5 where shown.



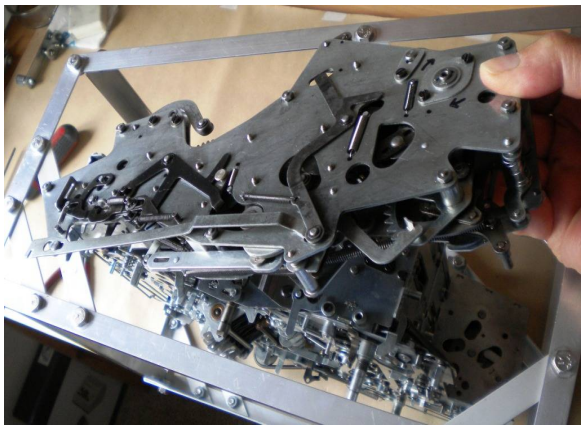
Release the register I clearing lever 12148.



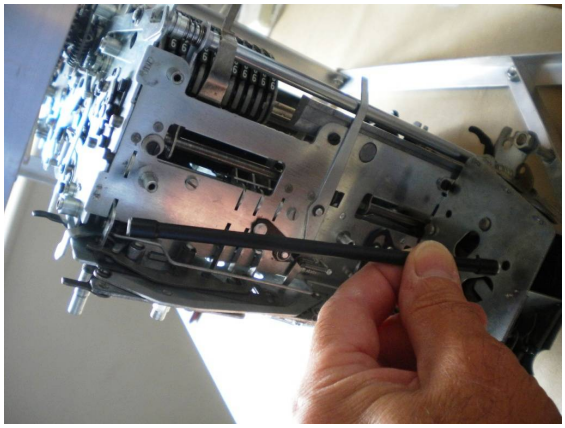
When lifting the unit off, ensure that all levers and gear teeth are free.



Lift off the unit.

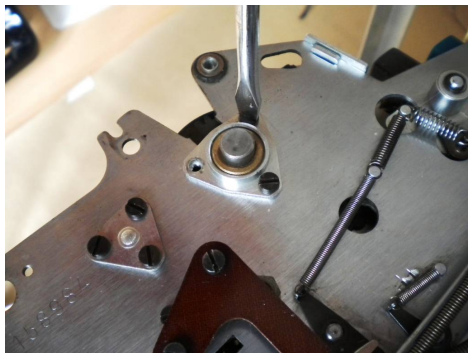


Pick up drive shaft 12602.

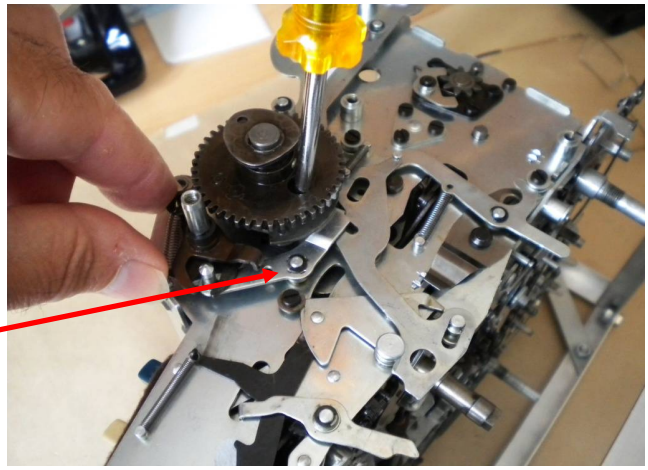


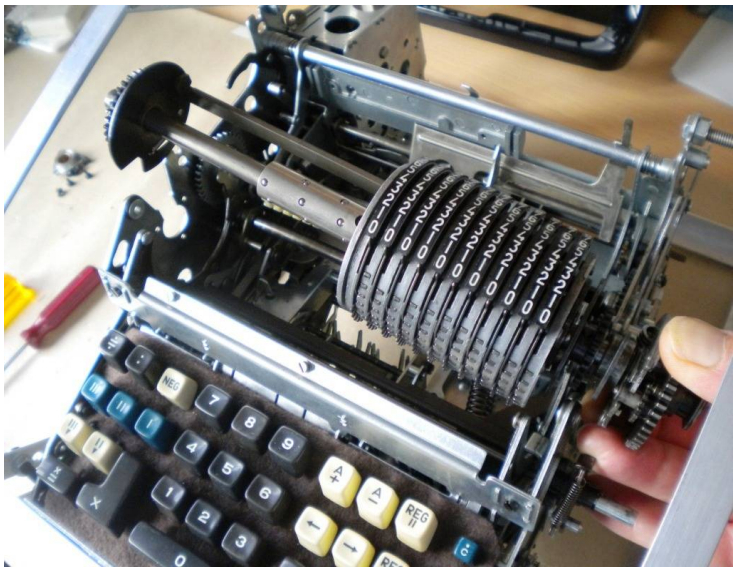
7 - REMOVAL OF THE SETTING ROTOR

Unfasten 3 screws 904-1 from the left bushing 10820 and remove the bushing.



In order to be able to remove the screws from the right bushing, rotor locking hooks 10977 and 10979 must be moved to the side with lift lever 10981. This frees up the rotor which can then be rotated to align the hole in gear 11490 with each screw in turn.



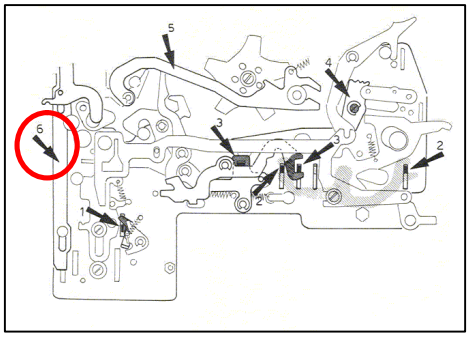


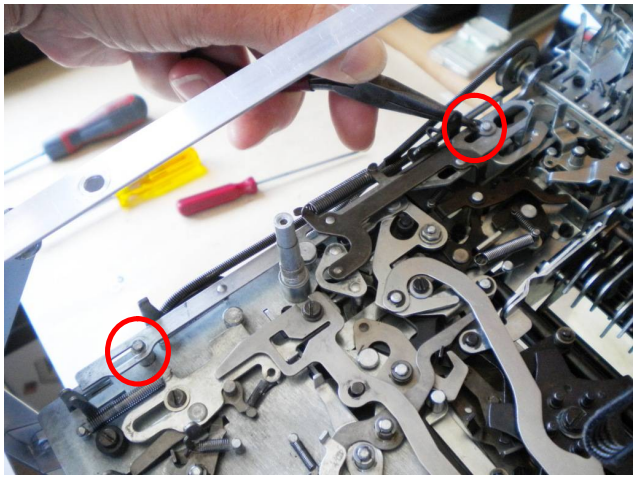
Slide the right-hand bushing to the right and, with a lot of manoeuvring, the unit will lift out.

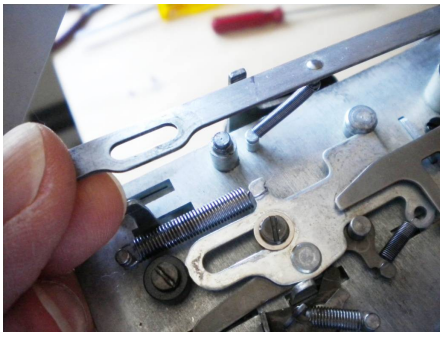
Note: Keep any loose screws/circlips etc. safe on a magnet before and after bagging as the loss of these could be disastrous especially if eg. a small circlip would become caught on an oil film between gear teeth.

8 - REMOVAL OF THE BACK CORNER PANEL

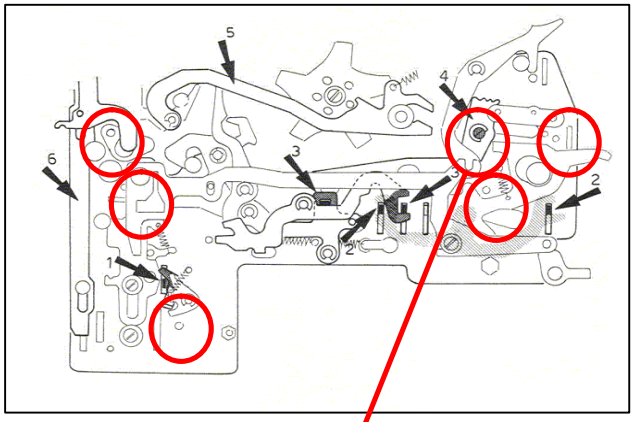
Remove start carriage 12989 (6)
by releasing two circlips and washers.



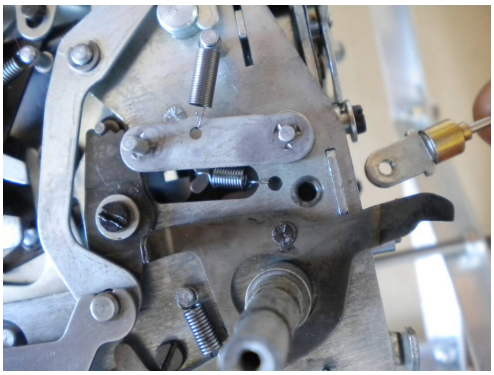


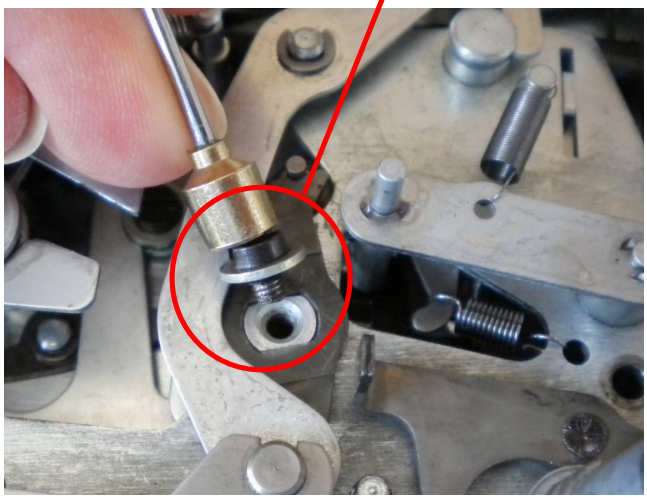


Unhook the spring beneath.

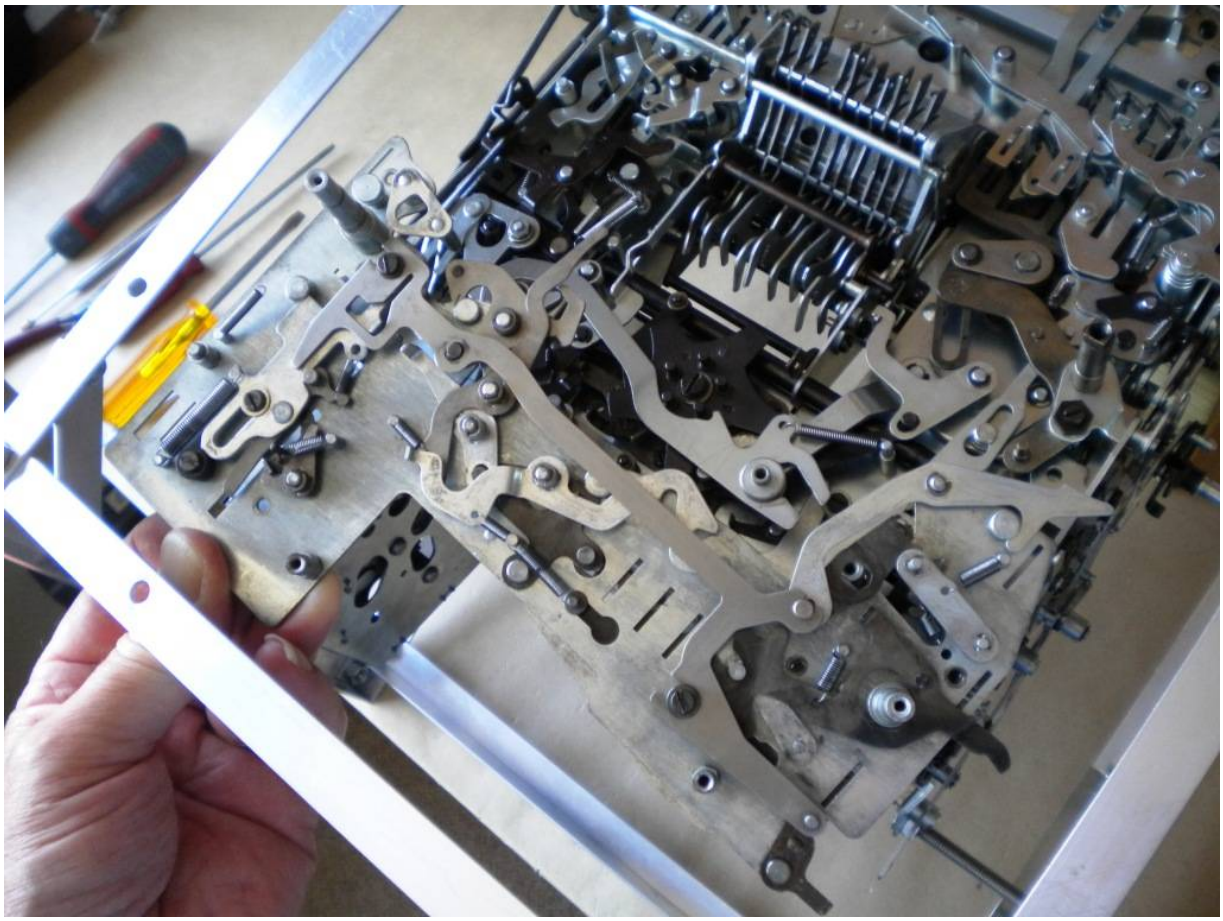


Unfasten 6 screws 904-1 and 4 retainers.

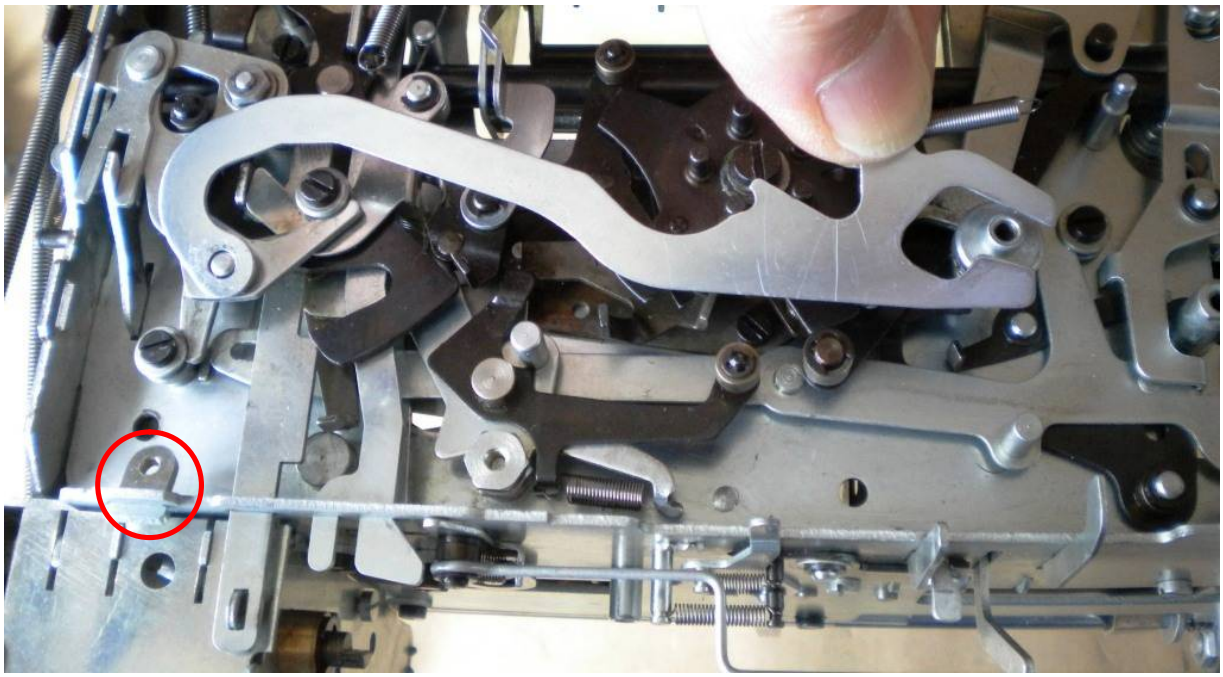




Lift off the unit (back of machine is at the bottom of the picture).



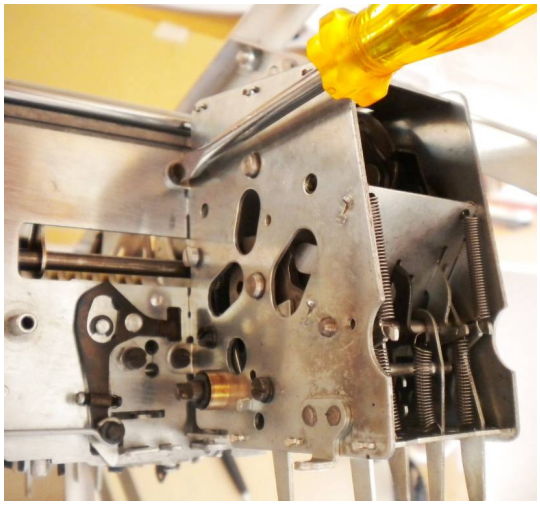
Take off right step link 10948 by removing its circlip and unhooking its spring. Don't lose the retainer!



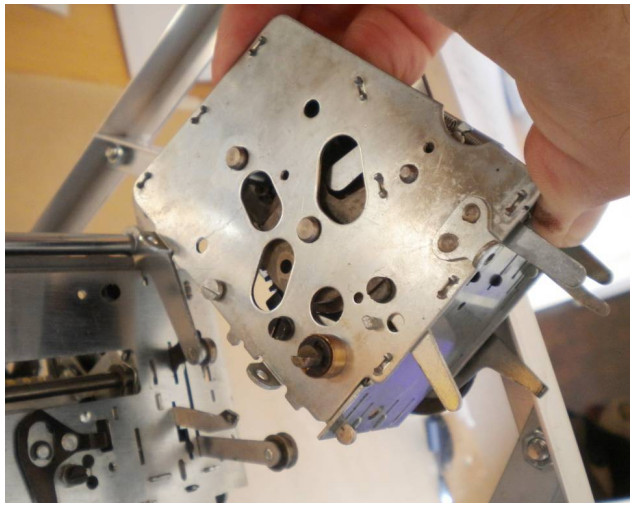
9 - REMOVAL OF THE LEFT TRANSMISSION SUB-ASSEMBLY

Remove drive belt 10216-41.

Unscrew 4 screws 904-1.

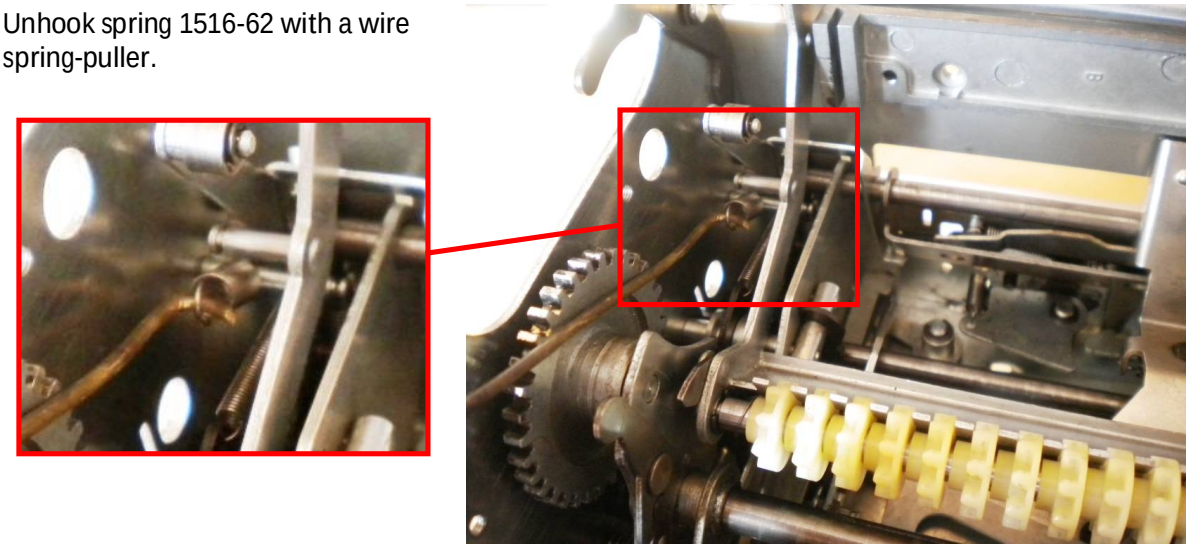


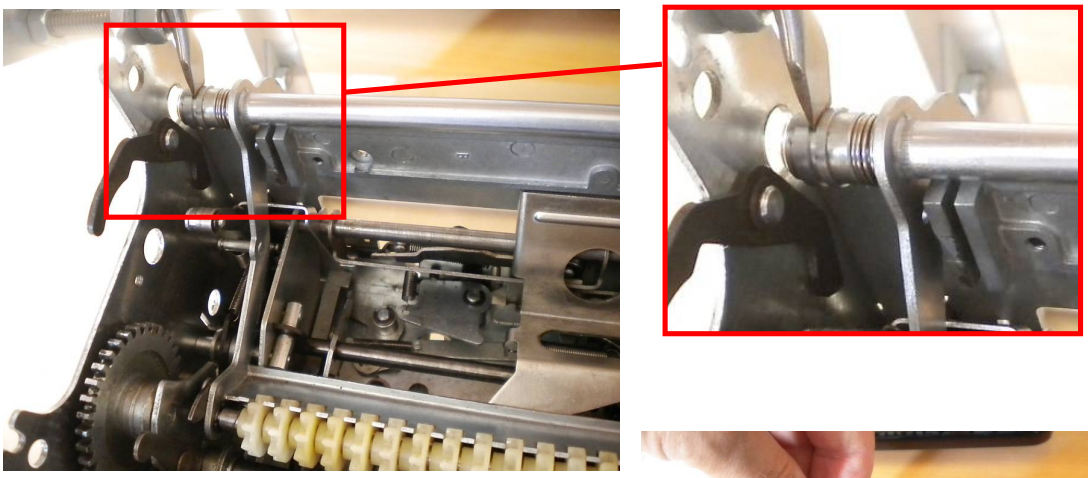
Lift off the unit.



10 - REMOVAL OF BACK TRANSFER SUB-ASSEMBLY

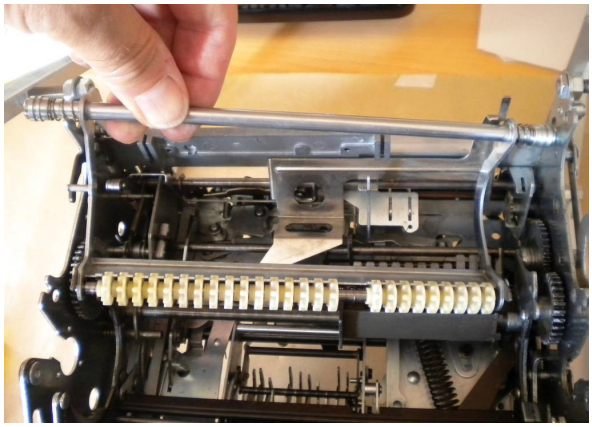
Unhook spring 1516-62 with a wire spring-puller.





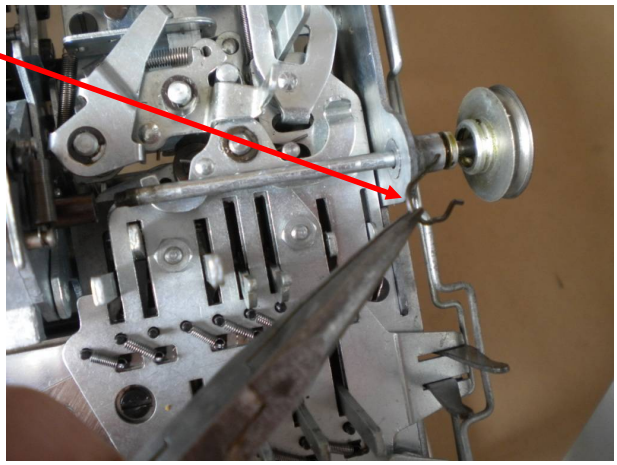
Push out the bushing from the left side wall.

Lift out the cradle without losing the bushing and spring on the opposite side.

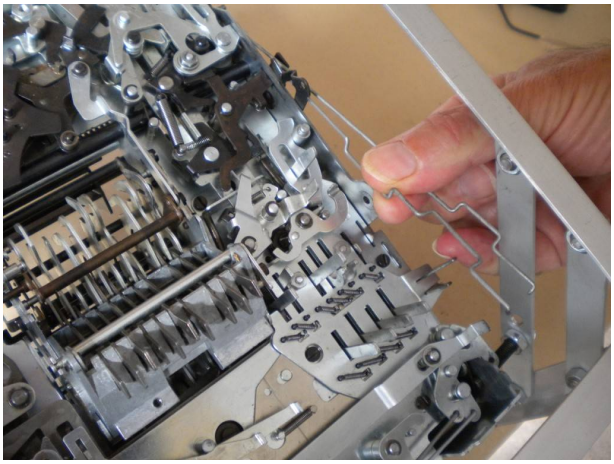


11 - REMOVAL OF THE FRONT CORNER PANEL & FUNCTION KEYBOARDS

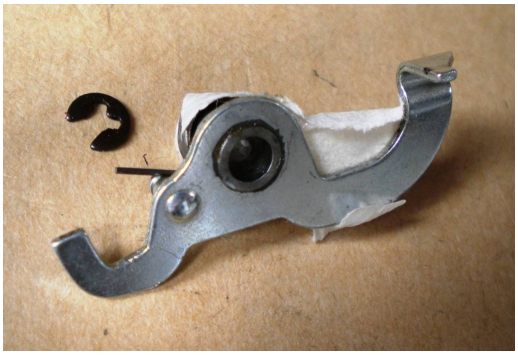
Invert the machine then take off retainer 11215 and pull out drive shaft and pulley 11206.

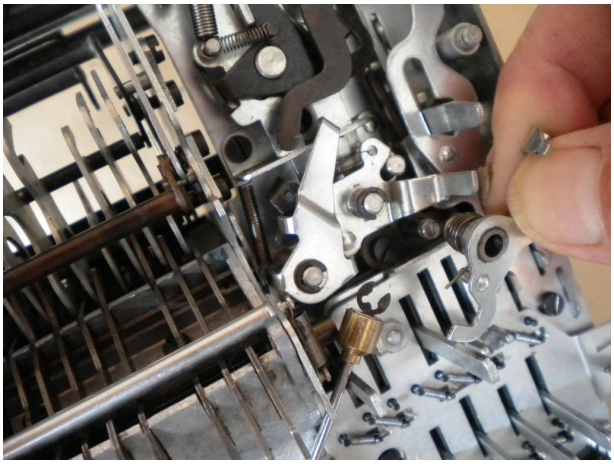


Unhook and remove wire links 10246-10 and 10246-11.

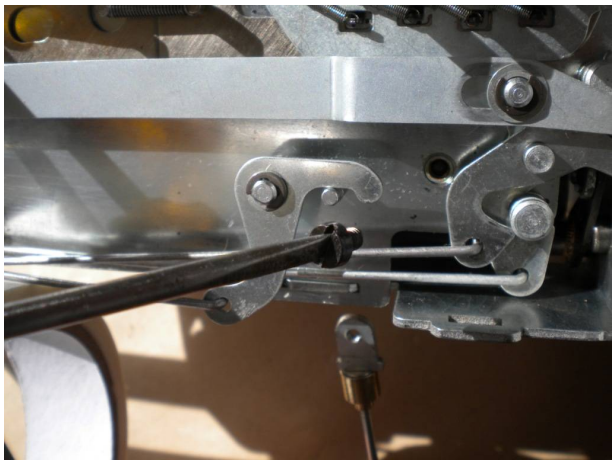


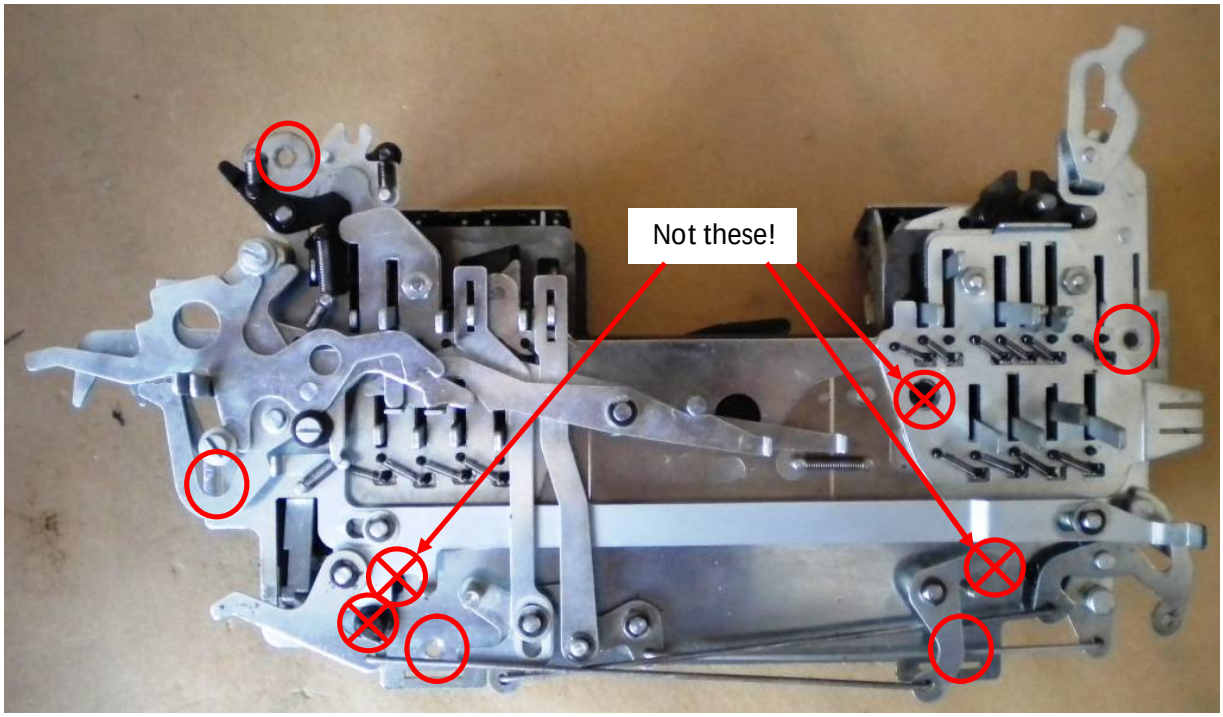
Remove circlip and swing link 12981.
Ensure the spring is kept in place with tape.





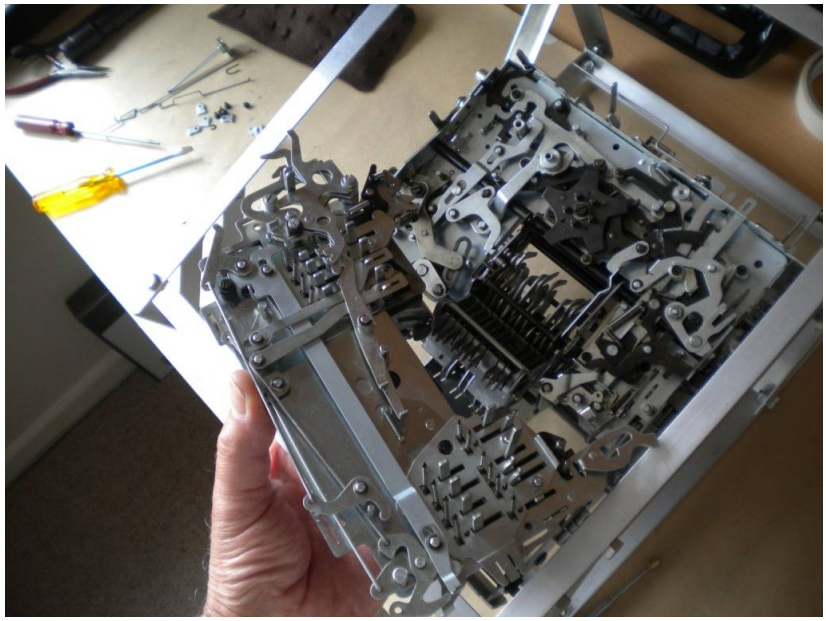
Unfasten 5 screws 904-1 and 4 retainers where shown by the uncrossed circles.

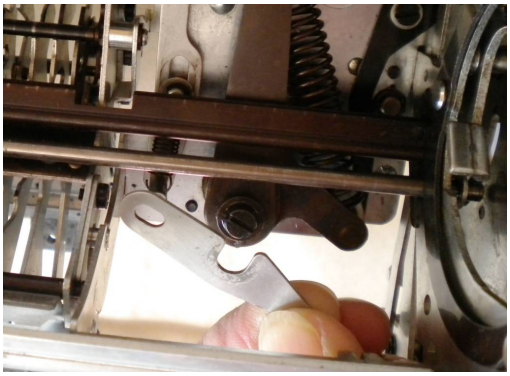




Take off all keytops if any dust-ingress cover is fitted to enable the removal of the front corner panel and function keyboards from the underside of the machine (leave the keytops on if there is no dust-ingress cover fitted).

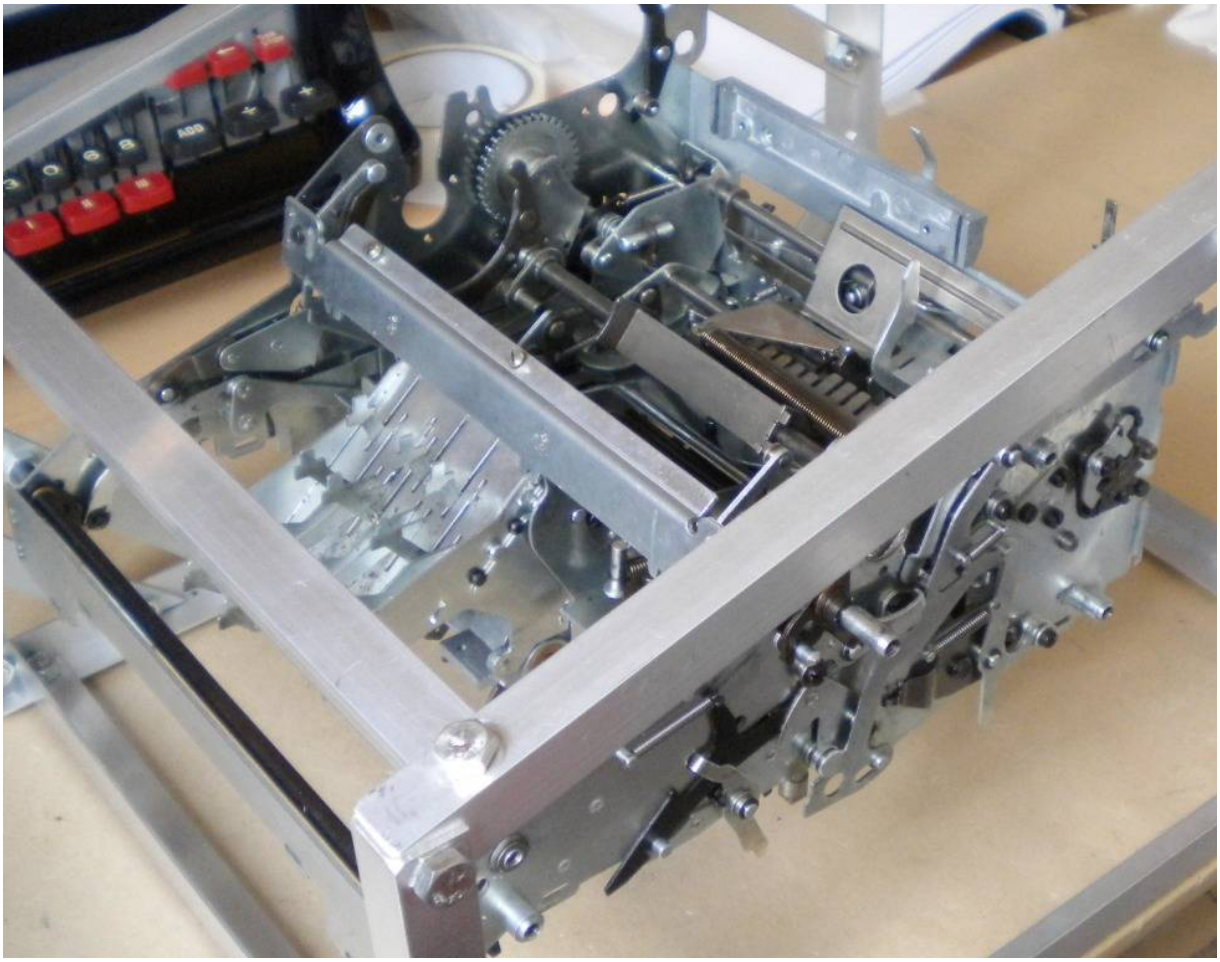
Invert the machine and lift the front corner panel and function keyboards upwards.





Lift out counter register II link lever 11020 from the main body of the machine.

The main body of the calculator with all main modules removed. A Facit CA1-13 is in the background.



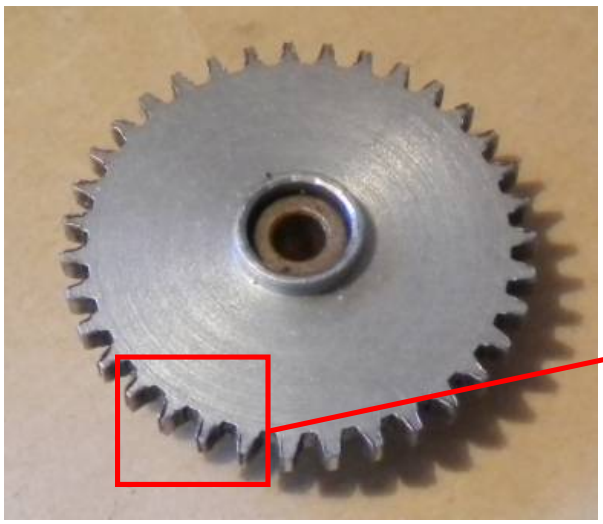
All the modules previously removed have been bagged and labelled.

It will now be assumed that all component parts of the calculator and of each module have been cleaned and lubricated, so ensuring that all pivots, pinions, gears, levers, flat sliding parts and springs operate freely (possibly by disassembly of the modules to their individual part level).

At this stage in the restoration, it may be necessary to replace any worn or broken parts in the various sub-systems of the machine. Close inspection may reveal broken, bent or worn parts through past usage which would need careful rectification before any further assembly work is carried out.

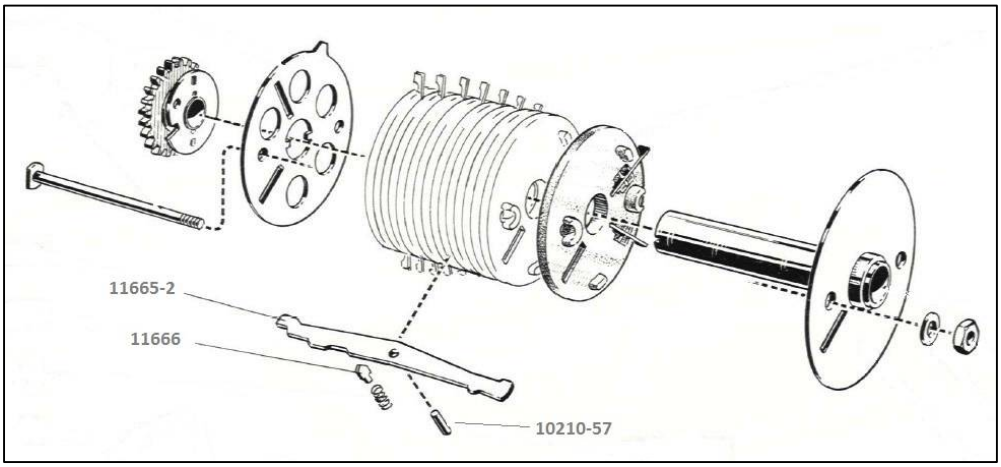
The following photograph shows a replacement for the broken counter direction lever 11025.

The photographs below show wear on the teeth of spur gear 10830 through lack of adequate lubricant. This would cause greater and unnecessary backlash in the gear train resulting in out-of-phase relationships between the various sub-systems driven by these gear trains.



A new gear with the same ID, OD, PCD, MOD, face width and number of teeth was machined and fitted as a replacement so ensuring minimal gear train backlash.

Further work had to be undertaken on the counter register II tens carry rotor as carry rotor coupling link 11665 would not move satisfactorily into each of its detent positions. It was found that old hardened grease had to be removed from pivot 10210-57 and detent plunger 11666 to alleviate this problem.



Photographs showing the buildup of old grease preventing the free movement of rotor coupling link.

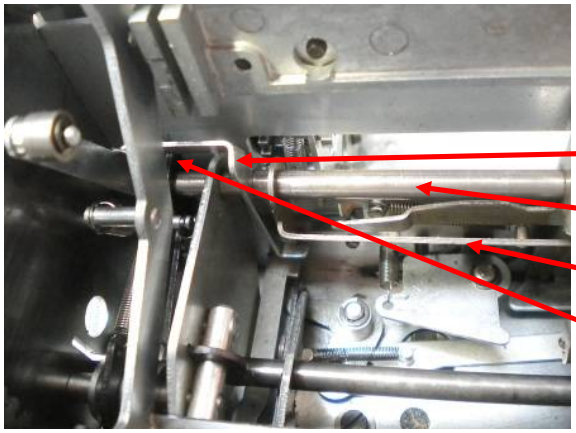
Parts after cleaning. Note the area where the detent plunger slides against segment 23 which has also been cleaned and smoothed from its initial rough surface.

The cleaned parts of the counter register II tens carry rotor prior to reassembly.

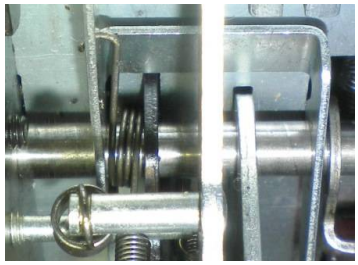
It may not be necessary to dismantle any further components from the machine as most parts here are protected from dirt and grime being located deep within the main body of the machine. On the present machine undergoing restoration, it was found necessary to remove both quotient coupling shafts 10624 for cleaning related parts and, if this should become necessary then, upon reinstallation of these parts, careful consideration must be given to the relative positions of the following components:

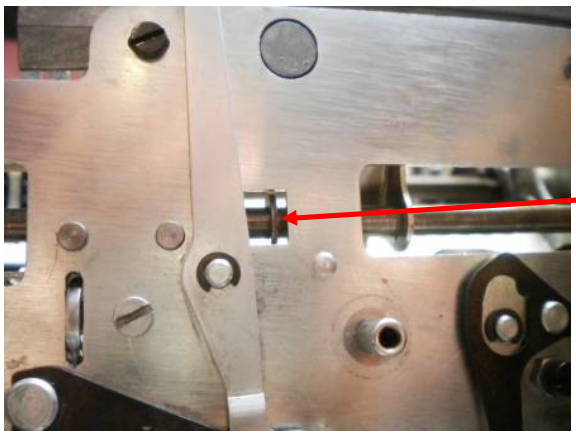
The upper quotient coupling shaft 10624 must pass through (in order) the pivot holes in: offset lever & roller 13024 and its torsion spring 10217-13, start arm 10613, sliding plate 13008 and quotient coupling indicator 10795.

The lower quotient coupling shaft 10624 must pass through (in order) the pivot holes in: collar 10625, carriage stop plate 11001-1 and quotient coupling 10788-2.

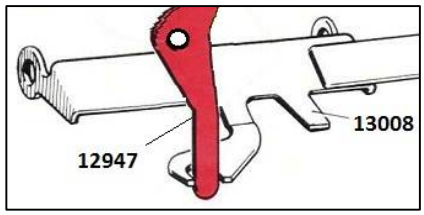


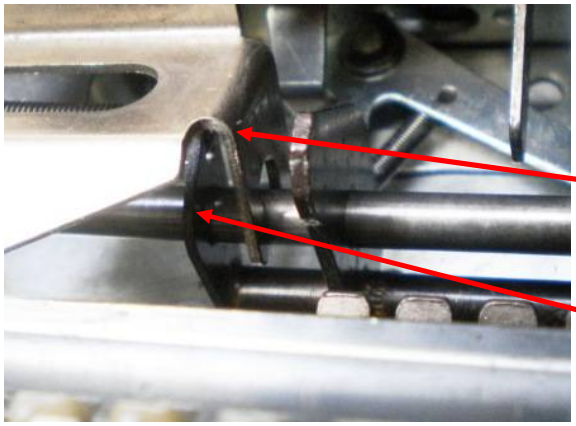
Shown at left are the relative positions of offset lever & roller 13024, start arm 10613 and sliding plate 13008.



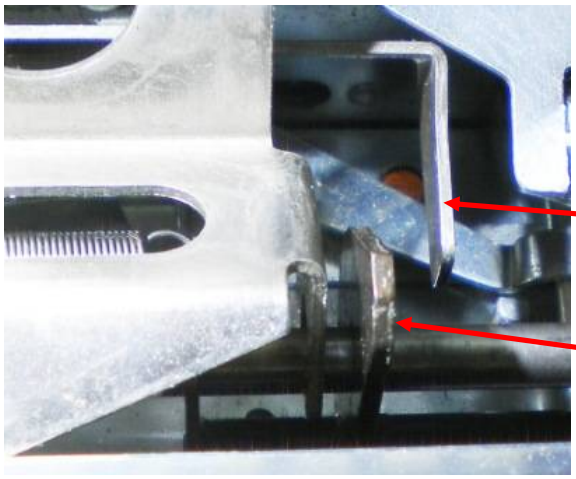


Ensure that sliding plate 13008 protrudes through the small square hole in the rear framework of the machine and its forked end engages changeover bracket 12947.

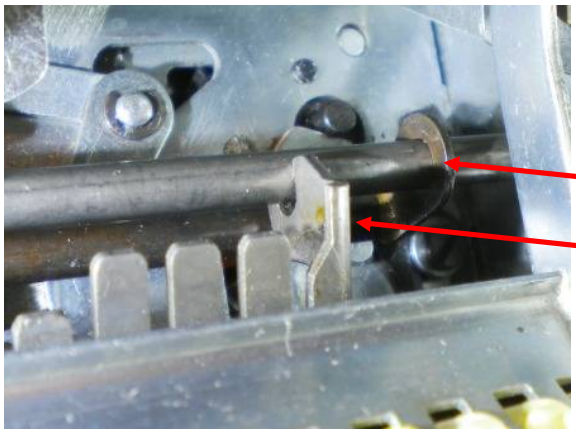




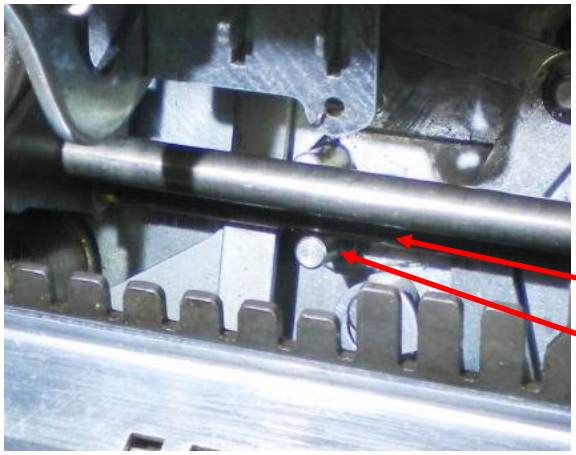
Note the positional order of the left-hand pivot hole of quotient coupling 10788-2 and quotient coupling indicator 10795's right-hand slot.



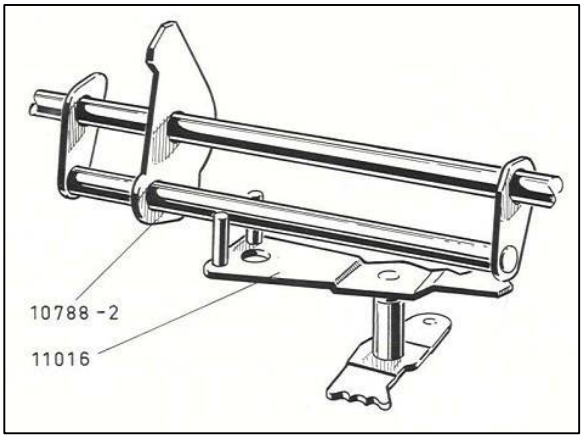
The large effecter on quotient coupling 10788-2 must lie to the left of the angled protrusion on sliding plate 13008.



Note the positional order of rotor carriage 10997 and the right-hand pivot hole in the end of quotient coupling 10788-2.



Ensure that the connecting bar of quotient coupling 10788-2 lies between the two vertical studs on quotient-switch lever 11016

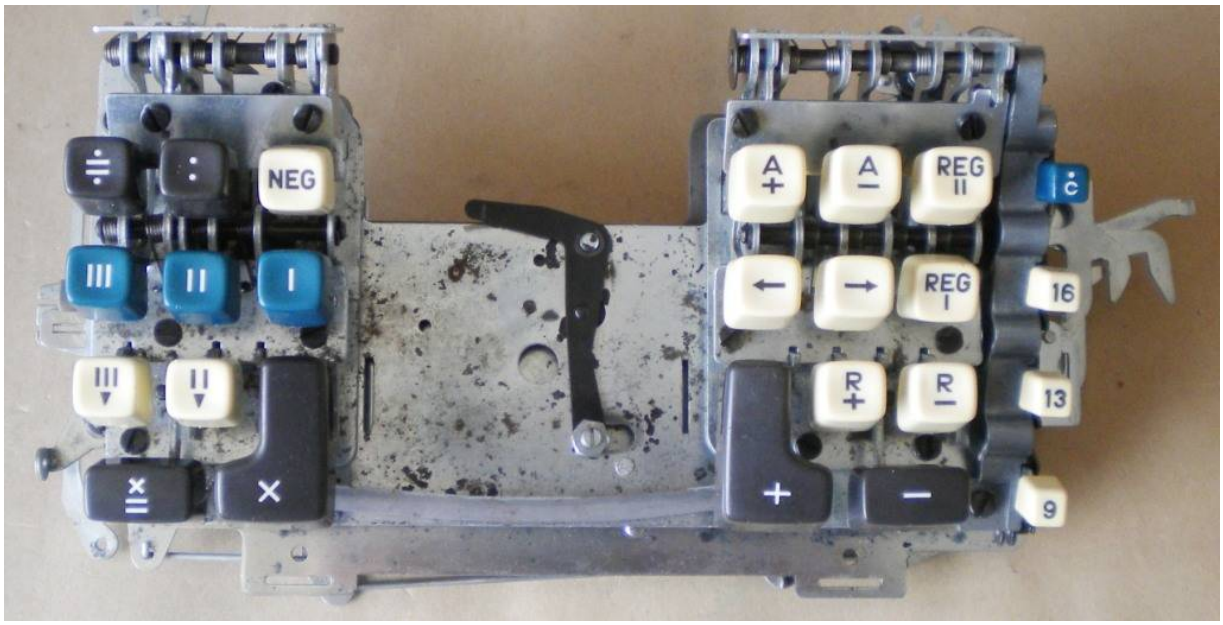


Failure to observe the positional order of these components will result in non-functionality of some of the machine's sub-systems and may result in breakage or locking up.

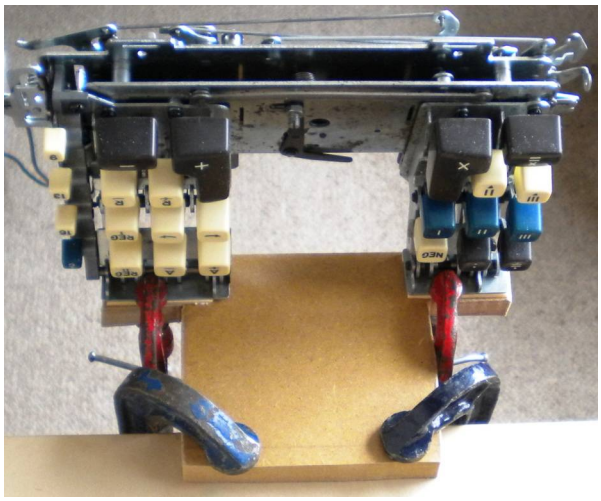
INSTALLATION OF THE FRONT CORNER PANEL AND FUNCTION KEYBOARDS

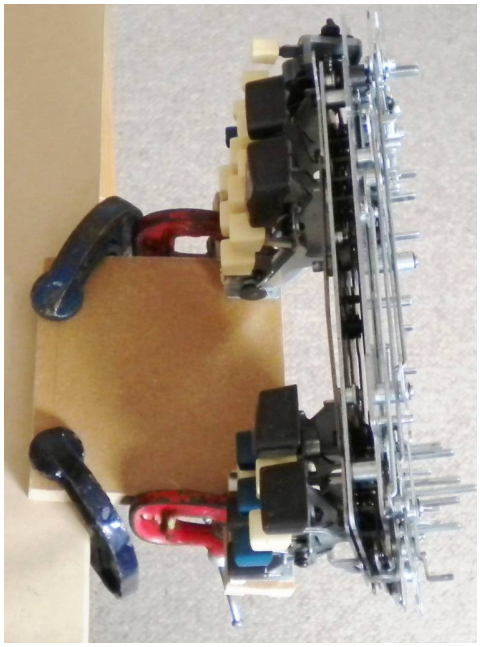
Functionality check of the front corner panel and function keyboards prior to installation

Replace the keytops onto the two function keyboards.



Fabricate a temporary mounting and hold the unit by clamping or other means such that all levers and pivots can freely move.

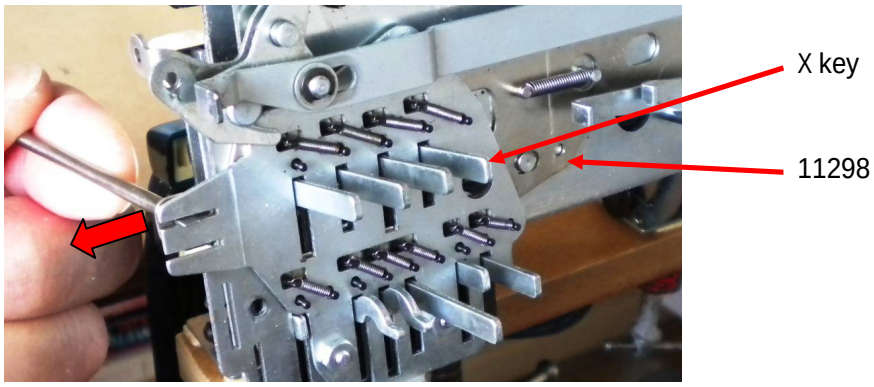




Check the following functionality:

In the following steps, check that all key levers are easily movable and bounce back quickly and easily with no sticking. Also check that all keystem latches 11300, 11301 and 11312 (see exploded diagrams below) block the key levers and release them accordingly.

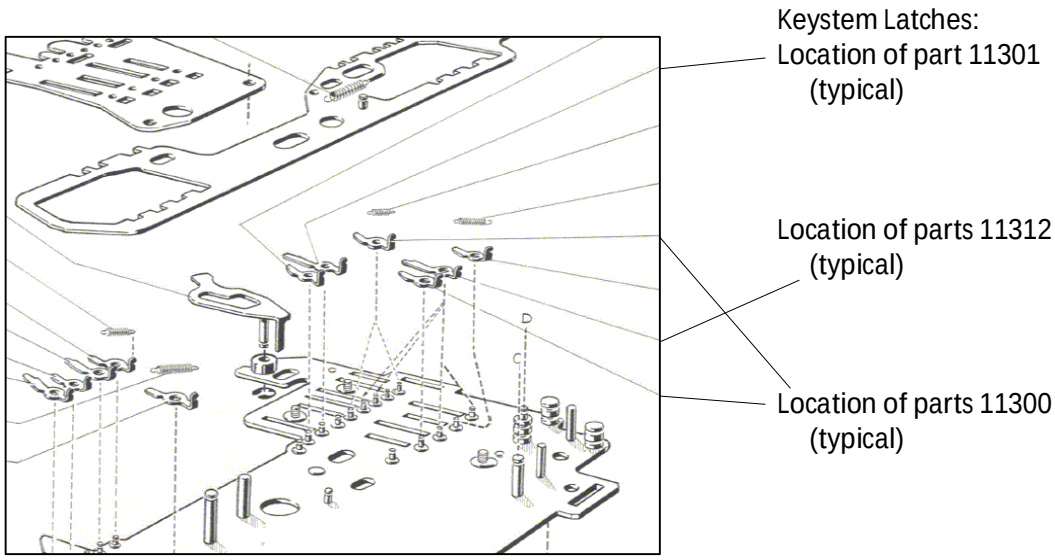
1. Depress the "X" key and check that all keys, with the exception of "II", "III", "REG I", "REG II", "ċ", rounding down keys "9", "13" and "16", are blocked. Release the "X" key by moving keystem latch release plate 11298.



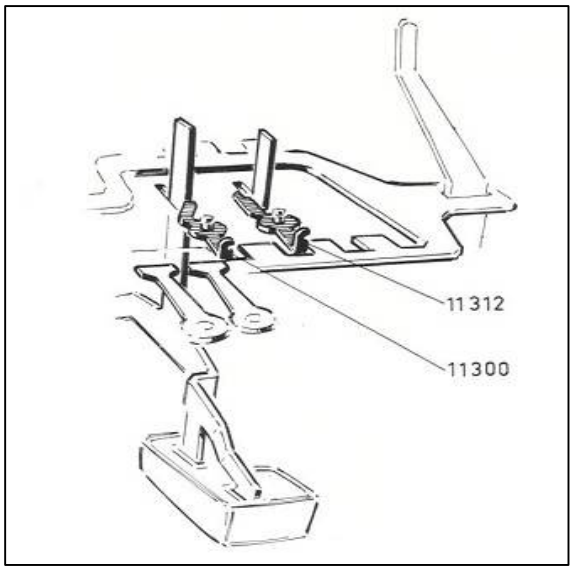
2. Depress key "←" and check that all keys, with the exception of "REG I" and "REG II", "ċ", "9", "13" and "16", are blocked. Release the "←" key by moving keystem latch release plate 11298 as before.

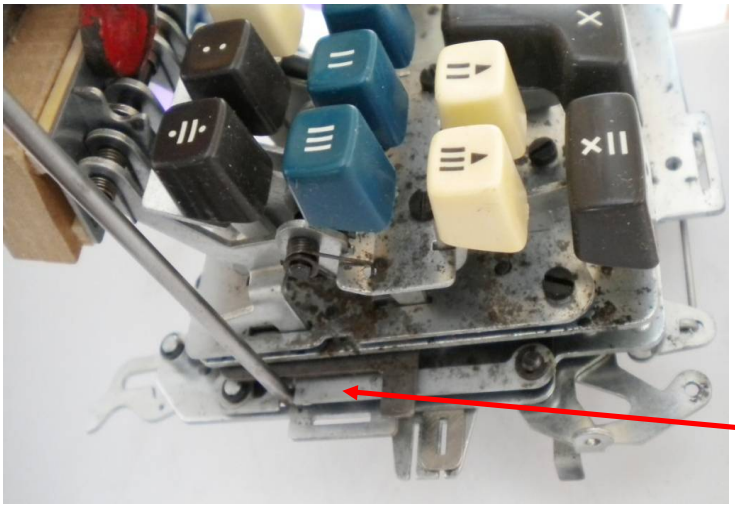
3. Depress rounding down key "9" and check that keys "A+" and "A-" are blocked. Release rounding down key "9" by pressing the "ċ" key.

4. Depress key "REG II" and check that keys "A+" and "A-" are again blocked. Release by pressing the "ċ" key.



Location of keystem latches 11300 and 11312



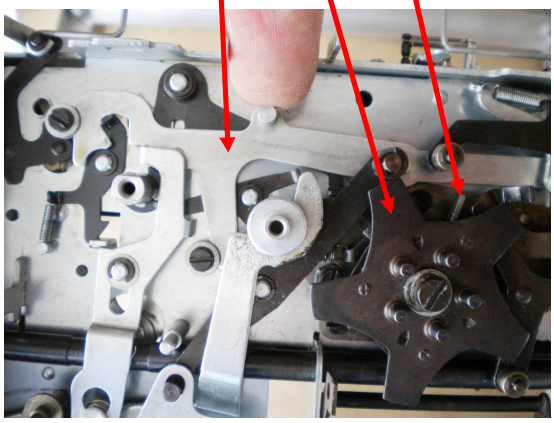


Also ensure that lever 11308 and link 11310 operate freely in releasing key "IIv".

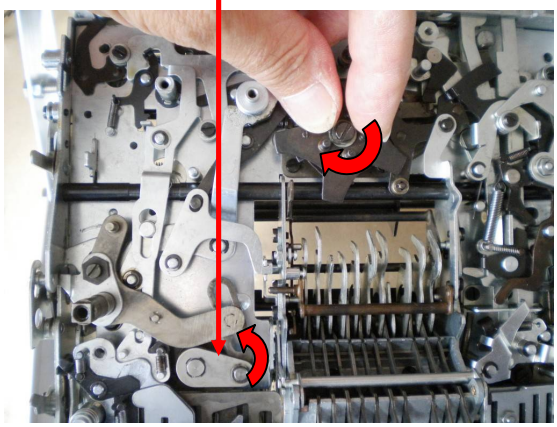
Installation of the front corner panel and function keyboards back into the calculator

Firstly, place the machine inverted and push escapement release lever 12904 towards the front so that outer escapement hook 10964 is able to ratchet onto escapement wheel 10955. By rotating escapement wheel 10955 manually clockwise, rotor return lever 12920 is moved clear so allowing the front corner panel to be installed easier.

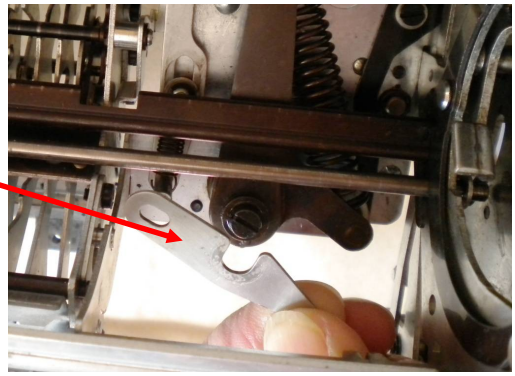
12904 10955 10964



12920

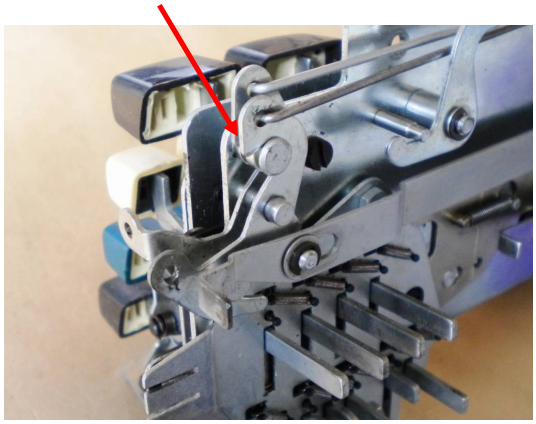


Place the machine upright and attach counter register II link lever 11020.

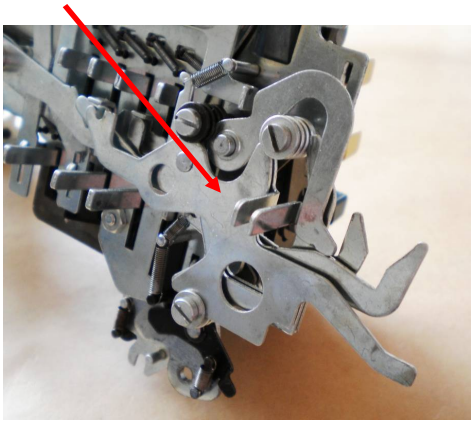


Reset all keys and install the front corner panel ensuring that swing links 11085, plus levers 11350 & 11352 and minus levers 11351 & 11355 remain in their respective guide slots.

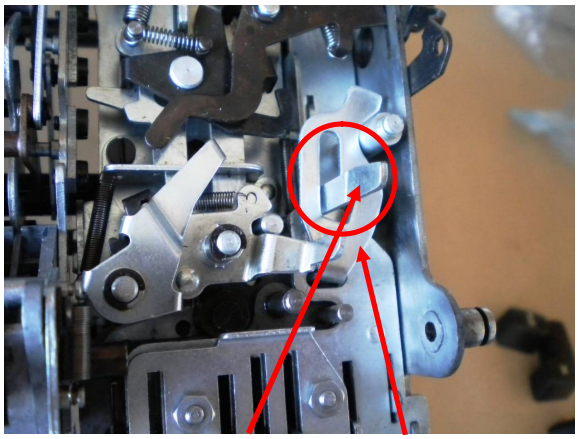
11085

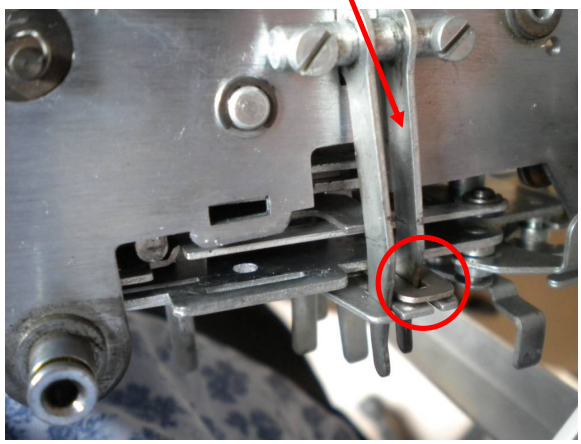


11352, 11350, 11351 & 11355

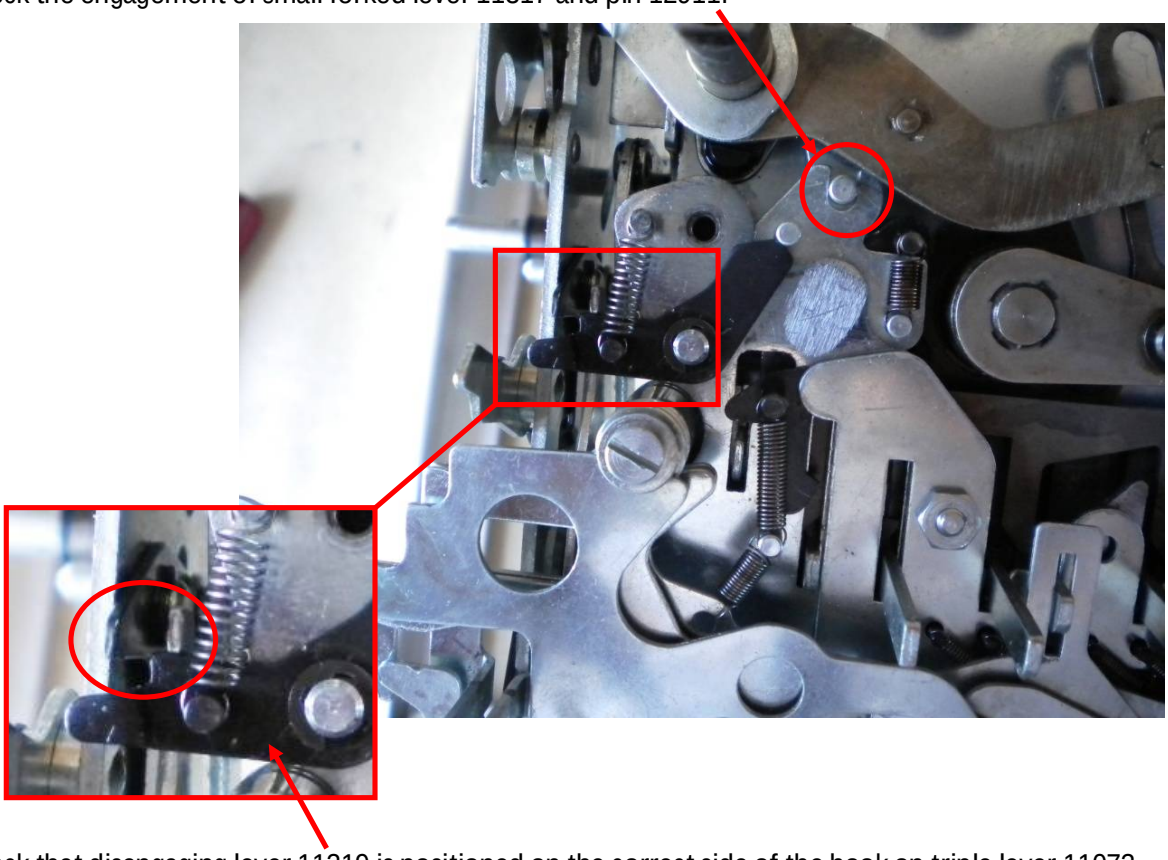


Check that lever 10610 goes through arrester hook 13000 and that drive lever 11099 goes through keystem latch release plate 11298



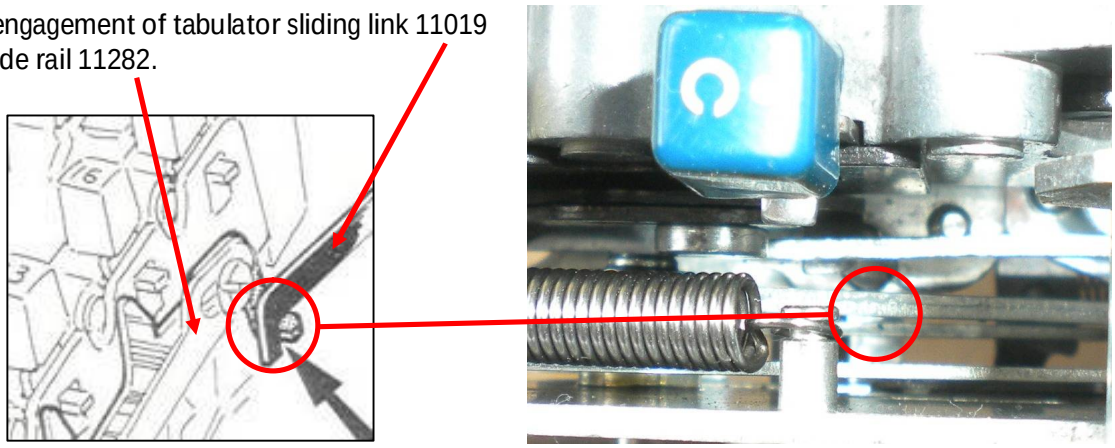


Check the engagement of small forked lever 11317 and pin 12911.

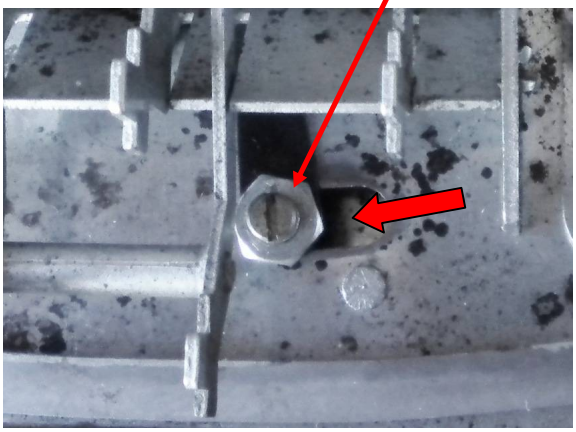


Check that disengaging lever 11319 is positioned on the correct side of the hook on triple lever 11073.

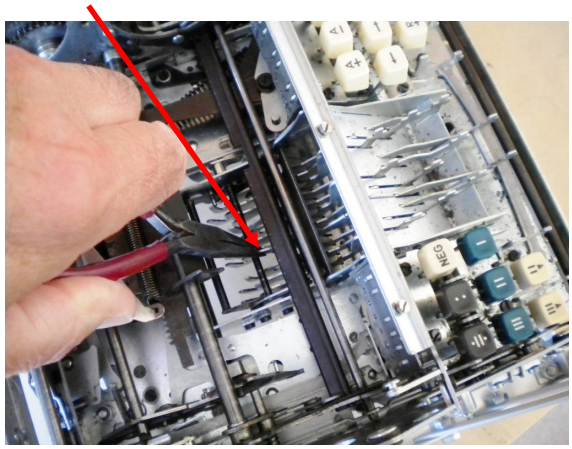
Check engagement of tabulator sliding link 11019 and guide rail 11282.

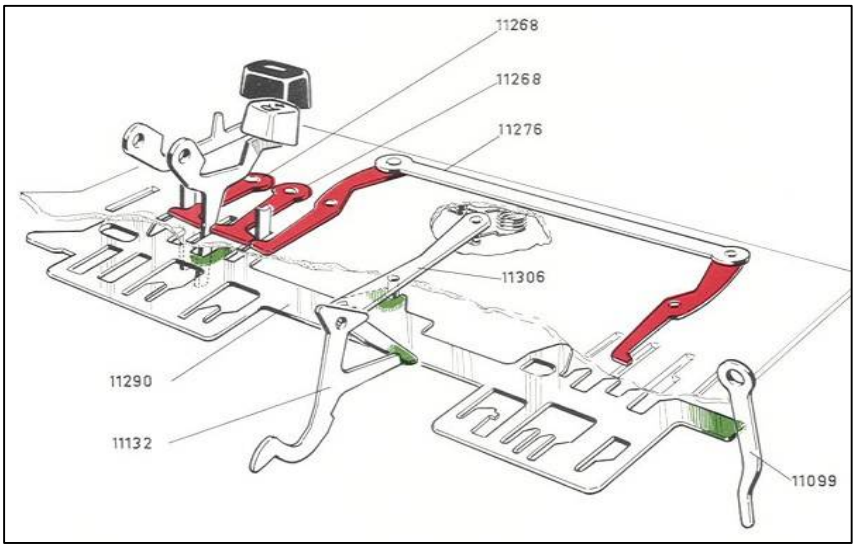


Ensure that switch plate toggle 11306 is in the position shown.

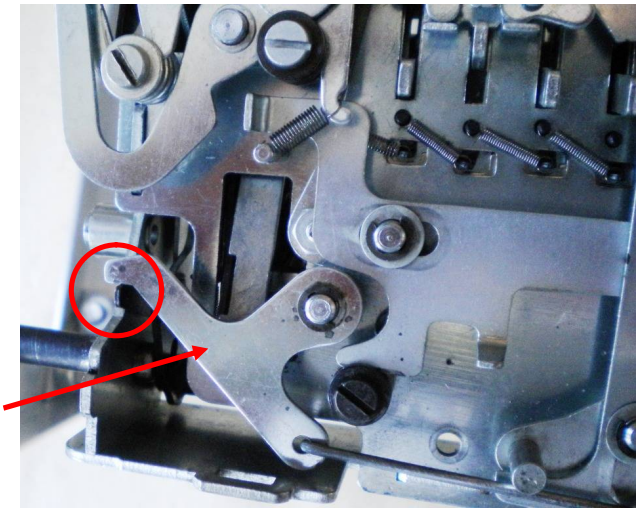


Pull up number keyboard lock lever 11132 to facilitate this.





Ensure that lever 11083 is at the correct side of the actuating end of triple lever 11073

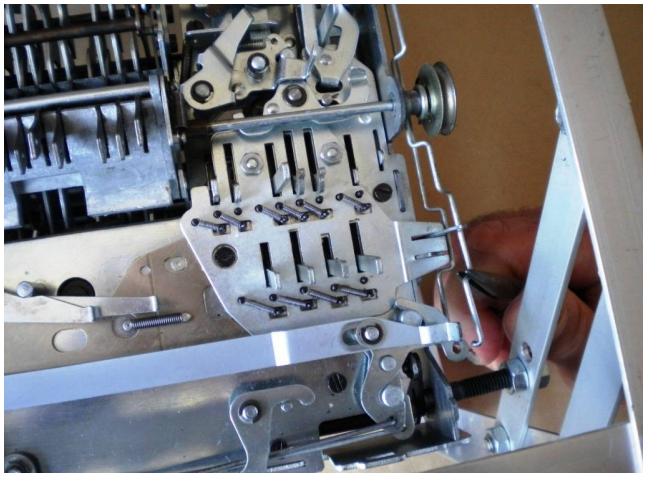


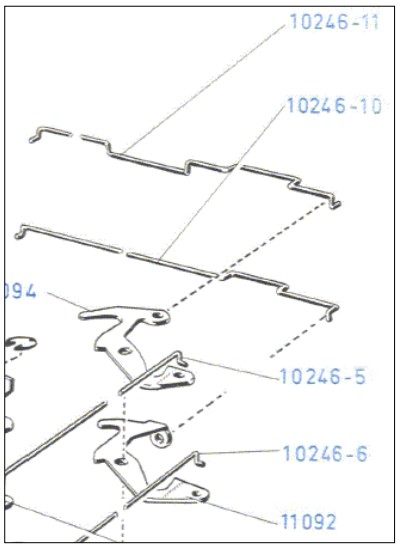
Install the 4 retainers and 5 screws 904-1.

Install swing link 12981 with the torsion spring.

Install drive shaft and pulley 11206 and retainer 11215.

Install the two wire links 10246-10 and 10246-11.





As previously, recheck the following after the keyboard is installed into the machine:

In the following steps, check that all key levers are easily movable and bounce back quickly and easily with no sticking. Also check that all keystem latches 11300, 11301 and 11312 block the key levers and release them accordingly.

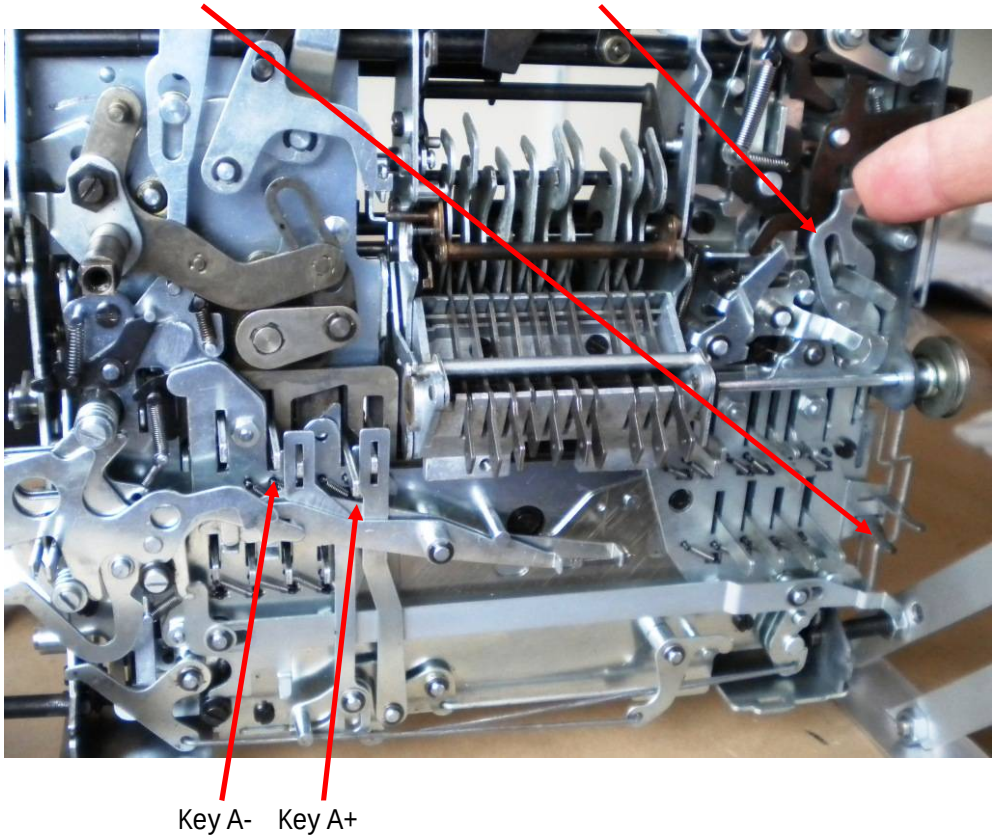
a) Depress the "X" key and check that all keys, with the exception of "II", "III", "REG I", "REG II", "ċ", rounding down keys "9", "13" and "16", are blocked. Release the "X" key by moving keystem latch release plate 11298 with drive lever 11099.

b) Depress key "←" and check that all keys, with exception of "REG I" and "REG II", "ċ", "9", "13" and "16", are blocked. Release the "←" key by moving keystem latch release plate 11298 as before.

c) Depress rounding down key "9" and check that keys "A+" and "A-" are blocked. Release rounding down key "9" by pressing the "ċ" key.

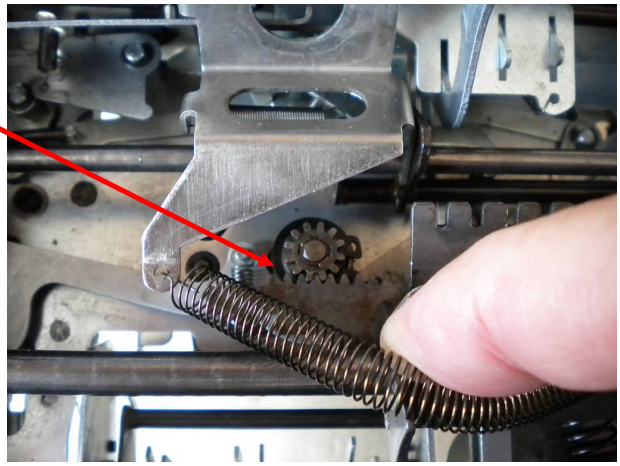
d) Depress key "REG II" and check that keys "A+" and "A-" are again blocked. Release by pressing the "ċ" key.

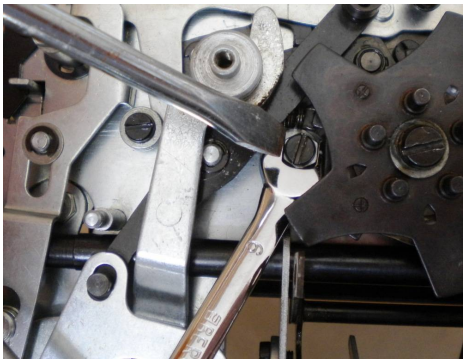
e) Depress key "A+" and ensure that it is freely released by moving keystem latch release plate 11298 with drive lever 11099 and pressing arrester hook 13000. Repeat with the "A-" key.



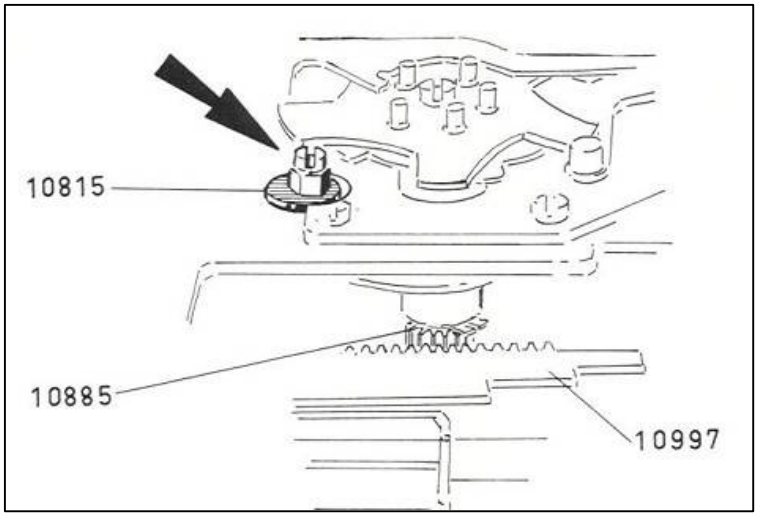
MACHINE SETTING CHECKS

Check that the clearance between the toothed rail on rotor carriage 10997 and escapement gear wheel 10885 is as small as possible without the parts sticking. Check along as much of the length of the rail as possible by rotating the escapement wheel 10955 by hand then pressing the "0" key to index the toothed rail.



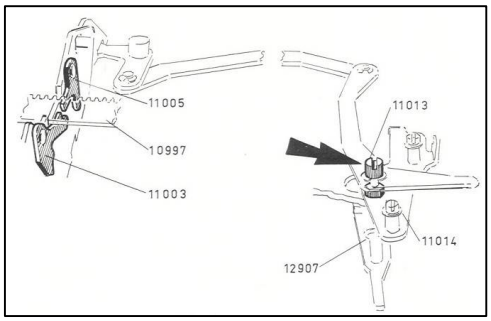


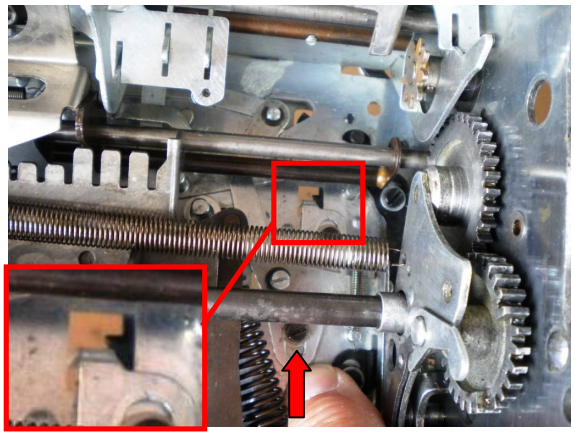
Adjust by moving the stepped switching mechanism by first backing off the tension on escapement mounting plate 10960-2's fixing screws 904-1. Then rotate eccentric 10815 using a 6 mm spanner after first slightly loosening screw 904-3.

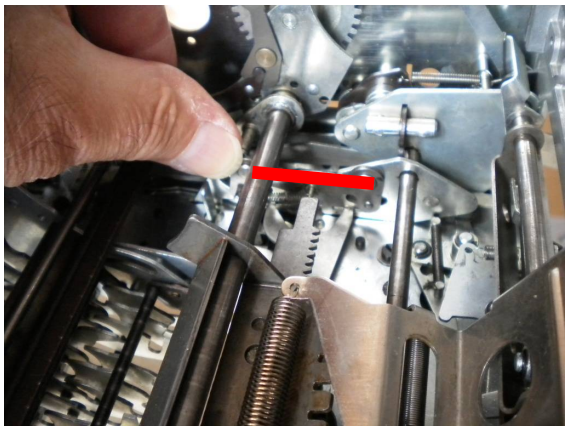


In order to ensure the best possible engagement of hooks 11003 & 11005 in rotor carriage 10997, the position of the hooks must be set as follows:

Press rounding key "16" and then push back intermediate lever 11014 by hand until it locks into its rearmost position. In this position check that the top edges of the hooks 11003 & 11005 are aligned at the same height.

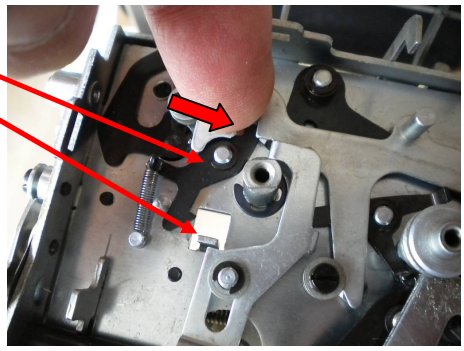




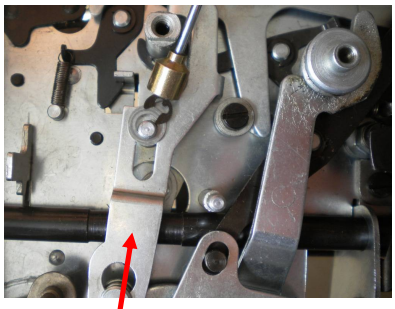


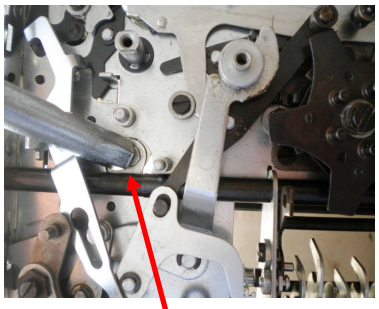
Reset key "16" by first pushing detent lever 12906 to the side so releasing intermediate lever 11014.

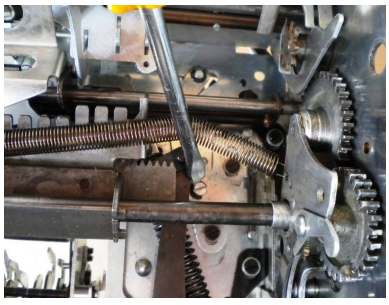
Rounding key "16" can then be reset by pressing the "ċ" key.



Remove sliding link 12907 and loosen the nut with a 6 mm box spanner for eccentric 11013 to facilitate the adjustment. By turning the eccentric with a screwdriver, the hooks 11003 & 11005 can be adjusted to the correct position. The nut must be properly tightened afterwards.

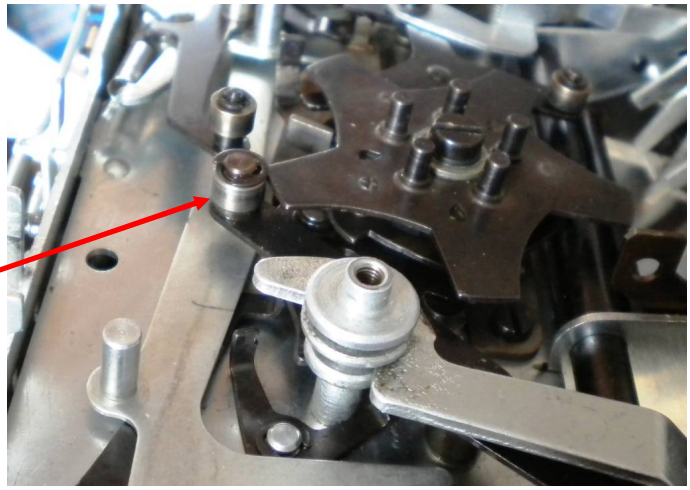




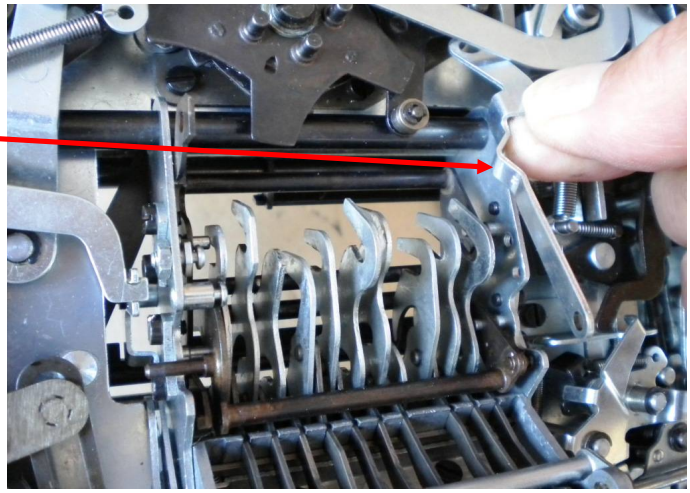


12907 11013

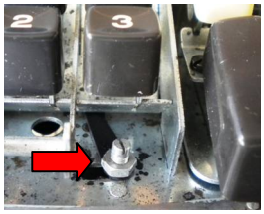
Ensure that roller 10235 rests on escapement wheel 10955 without clearance, but nevertheless doesn't brake the switch wheel. This must be checked with all five wings. If there is any discrepancy, then a smaller or larger roller must be substituted.

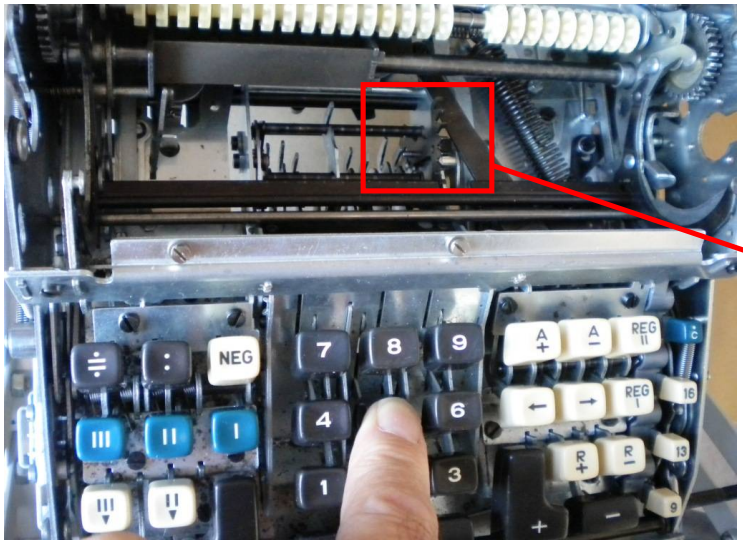


In order to check the free movement of the levers and pivots associated with the numeric keypad, first remove 2 circlips and escapement link 10959.



Next ensure that switch plate toggle 11306 is in its rightmost position.

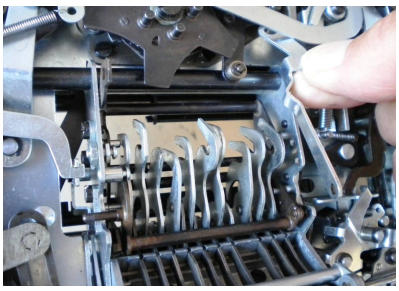




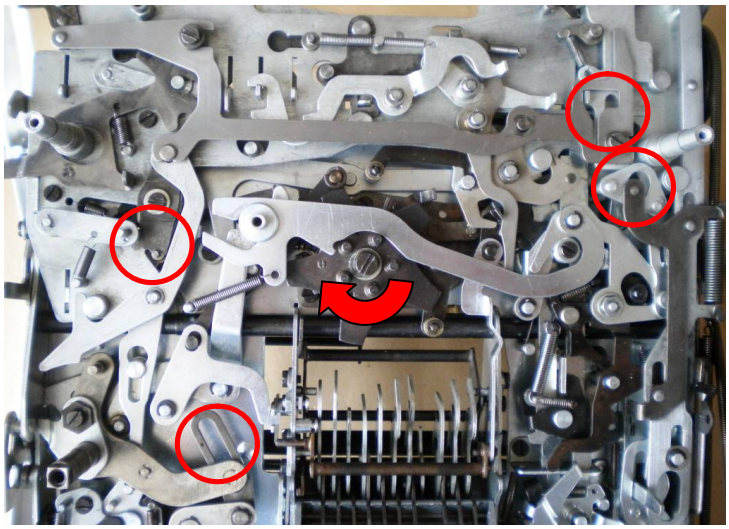
Check the free movement of each key in turn and ensure that rotor setting segment 11181 is turned by the appropriate amount depending on the value of the depressed key.

Enable the functionality of the numeric keyboard by the following steps:

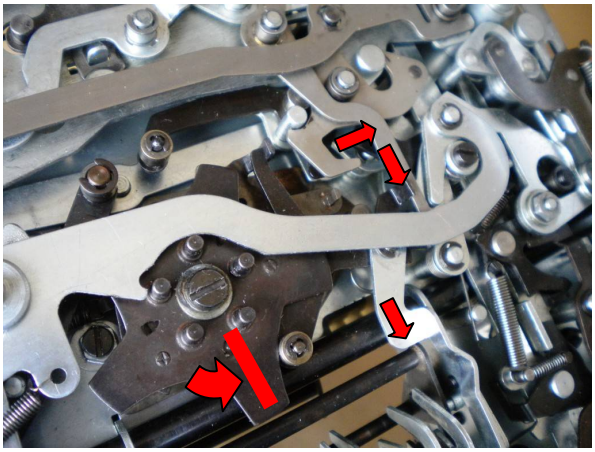
Invert the machine and replace escapement link 10959 and its 2 circlips.



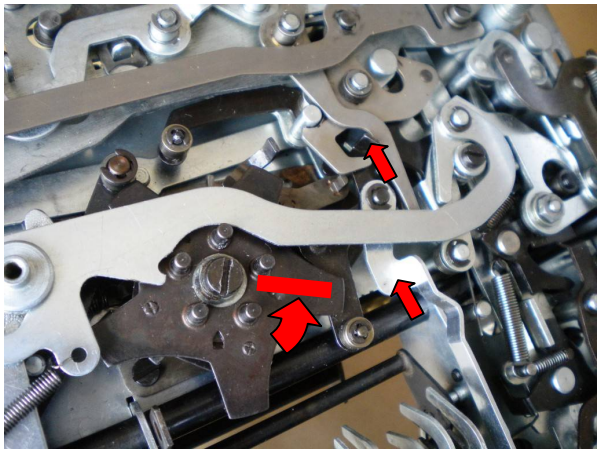
Wind up escapement wheel 10955 manually clockwise a few turns to tension the mechanism then, after ensuring that levers (ringed) are in the positions shown (and have not been left inappropriately set by previous assembly operations), press each numeric key in turn and note the operation of all attendant mechanisms.



Numeric key pressed



Numeric key released



MODULE INSTALLATION, CHECKS AND ADJUSTMENTS

INSTALLATION AND ADJUSTMENT SEQUENCE		
Sequence Number	Module Name	Page Number
1	Back Transfer Sub-Assembly	39
2	Left Transmission Sub-Assembly	40
3	Back Corner Panel	41
4	Setting Rotor	47
5	Module Adjustments - 1	49
6	Right Transmission Sub-Assembly Functionality Checks	57
7	Right Transmission Sub-Assembly	72
8	Right Transmission Sub-Assembly Cam Checks	77
9	Module Adjustments - 2	82
10	Pinbox and Feeler Functionality Checks	97
11	Bottom Sub-Assembly	102
12	Tens Carry Rotors	115
13	Registers II & III Sub-Assembly	118
14	Module Adjustments - 3	122
15	Motor Installation	149
16	Module Adjustments - 4	155

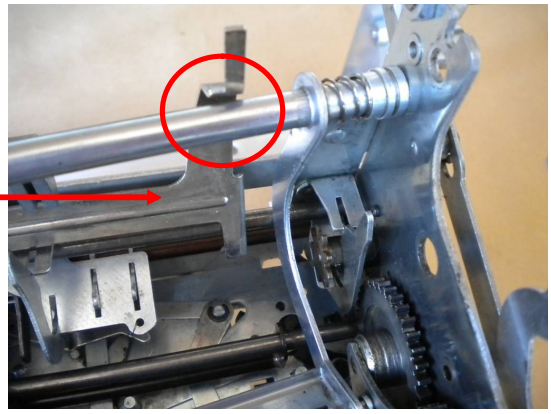
Install the above listed modules into the body of the calculator in the order given in the table above.

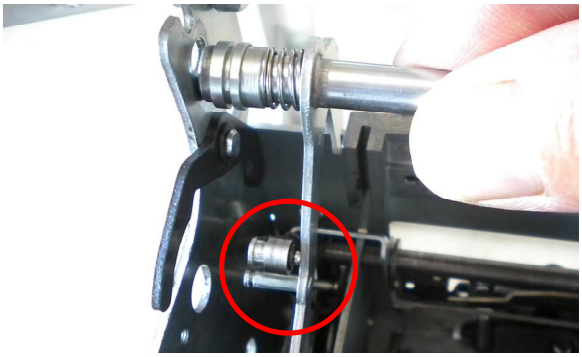
Carry out further adjustments in the sequences given in the main body of the document.

1 - INSTALLATION OF THE BACK TRANSFER SUB-ASSEMBLY

Mount the right bushing on the back transfer sub-assembly's pivot and install the cradle in the right side wall first.

Ensure that the back transfer frame's pivot 10747 is located beneath quotient coupling indicator 10795 and counter disable lever 11030.

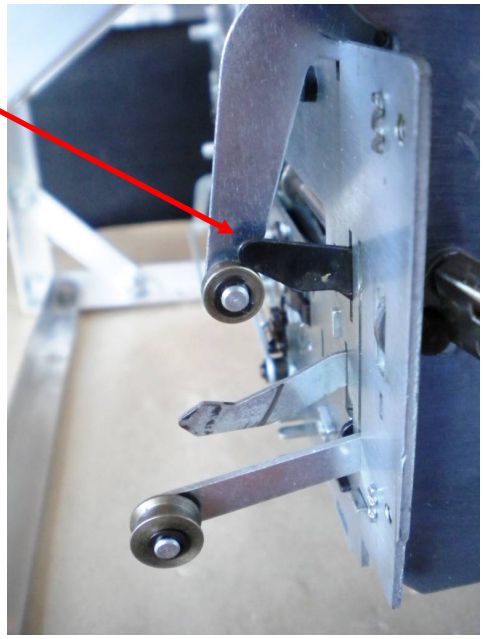


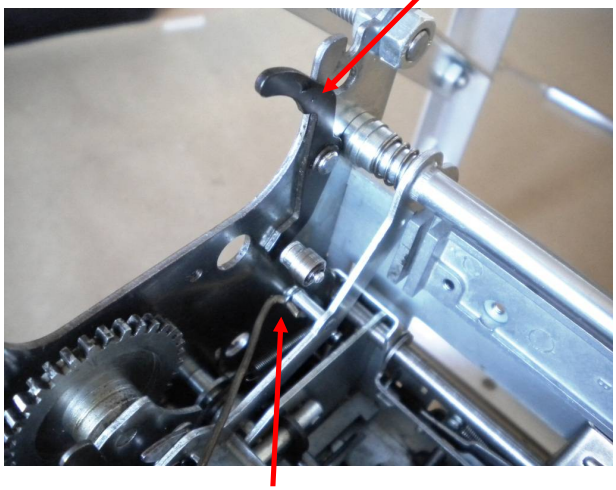


Mount the left bushing then, as it is slid towards its pivot hole in the left side wall, ensure that roller 10958 on lever 13024 rides above the spring peg.

With the left bushing in place in its pivot hole, ensure that roller 10235 is positioned below start arm 10613.

Do not trap the pivot shoulder of lever 11098.

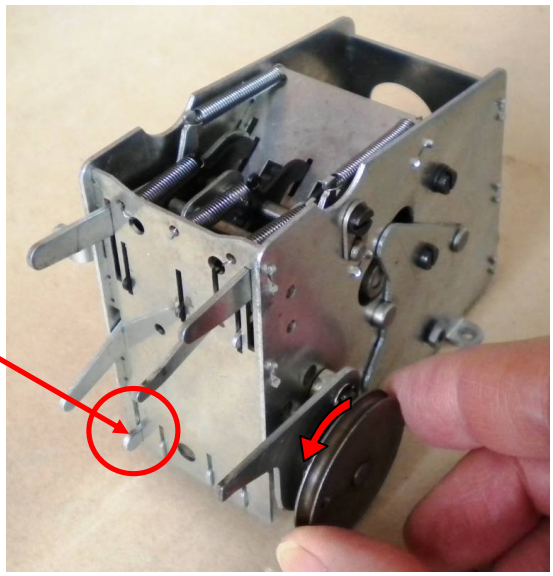




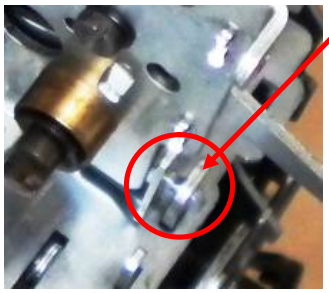
Lastly, hook in spring 1516-62 with a wire spring puller and check that the unit freely pivots.

2 - INSTALLATION OF THE LEFT TRANSMISSION SUB-ASSEMBLY

Spin pulley 12590 CCW by hand until cam follower lever 12593 is at the bottom end of its slot.



Place the unit into position ensuring that lever 12593 is engaged into the slot in left/right shift sliding link 12941.

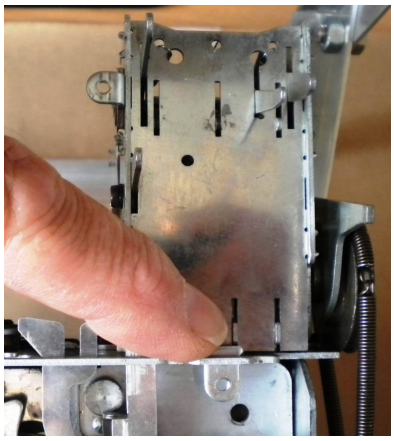


Spin pulley 12590 by hand again and check that the back transfer sub-assembly does not lift then screw in 4 screws 904-1 to secure the left transmission sub-assembly to the machine's back frame.

Emplace the drive belt 10216-41 as shown, ensuring that it passes to both sides of the fibre silencer.

3 - INSTALLATION OF THE BACK CORNER PANEL

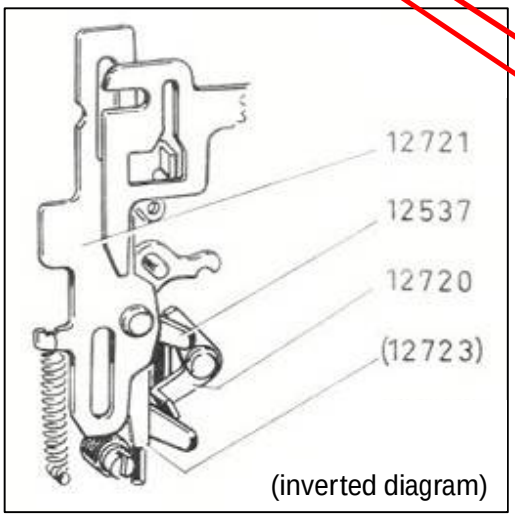
(back of machine is at the top of the pictures)

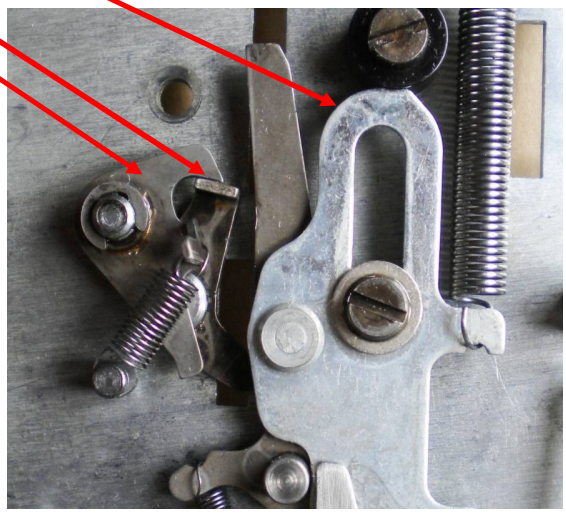


Prior to installation of the back corner panel, invert the machine, then firstly, insert a retainer 10838 into the slot near the left transmission sub-assembly (during the next operations, do not tip the machine onto its back or this retainer will fall out).

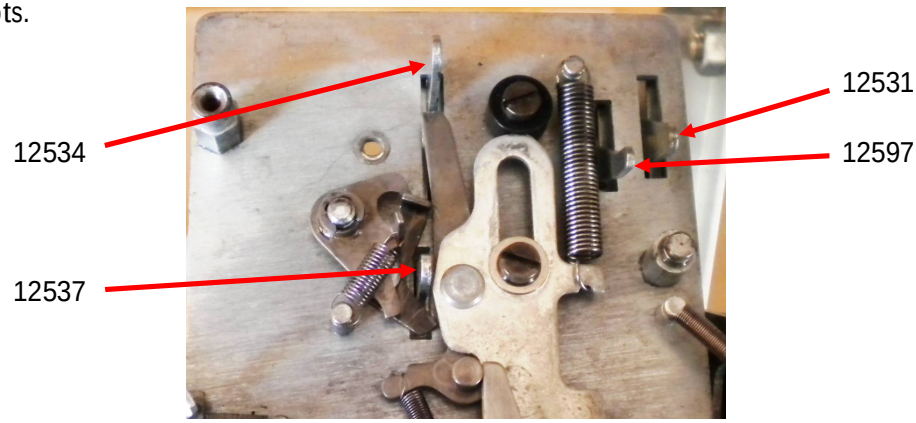
Spin the hard rubber buffer 180° to present a new face to division sliding plate assembly 10840.

Check the position of swing link 12720 and the small lever 12710.



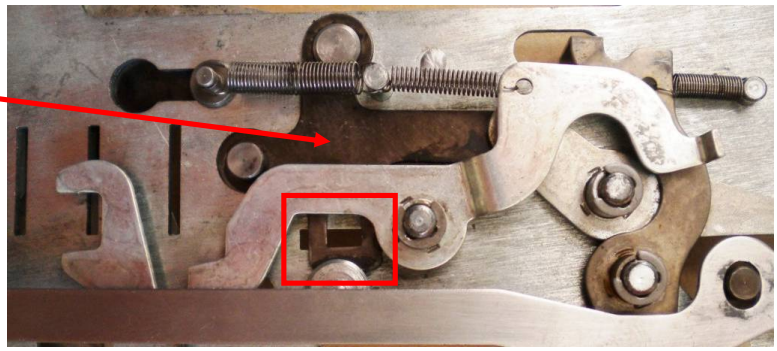


Install the corner panel and check that lever 12531, offset lever assembly 12597, division cam follower 12534 and division setup cam follower 12537 from the left transmission sub-assembly are located into their corresponding slots.

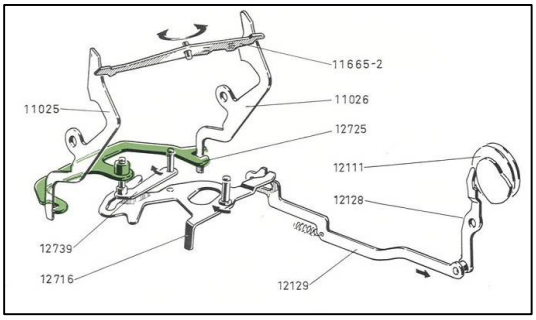


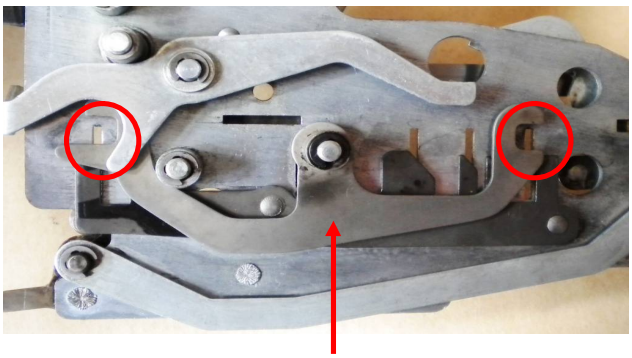
Switch lever 12537 is to reside between the legs of swing link 12720.

Counter disable lever 11030 should engage into the square slot in quotient switch piece 12712.



Counter direction levers 11025 and 11026 should engage in counter +/- rocker 12725.

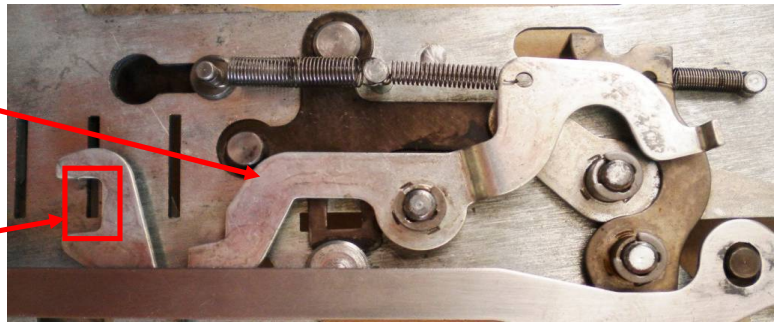




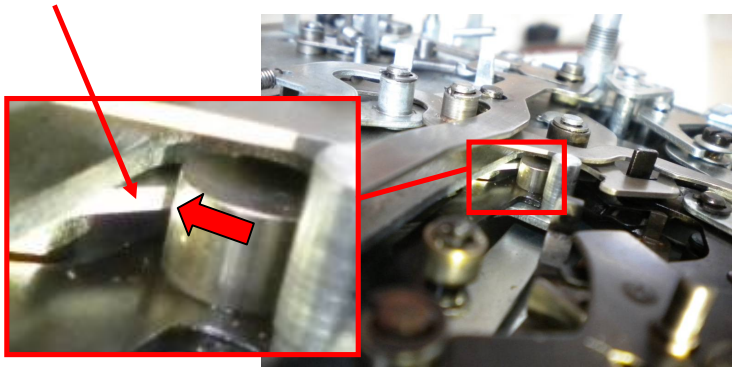
Underside of corner panel showing location of counter +/- rocker 12725.

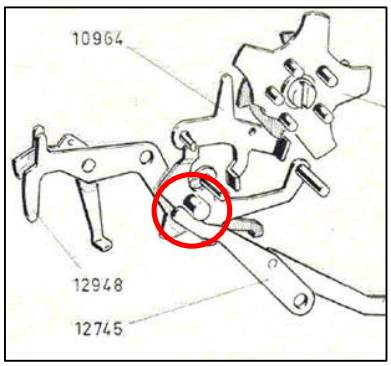
Check the position of division indent lever 12727.

Lever 13015 must pass through the slot and between the forks of counter +/- select lever 12727.

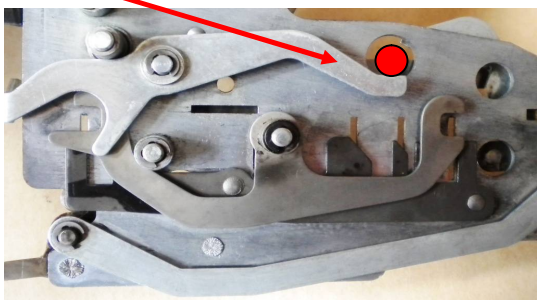


Lever 12745 must pass to the side of the boss on turn hook 12952.

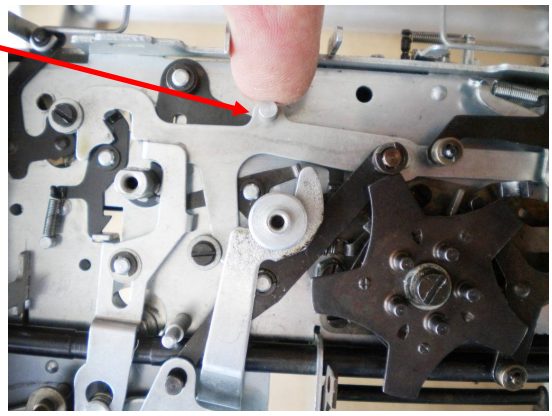




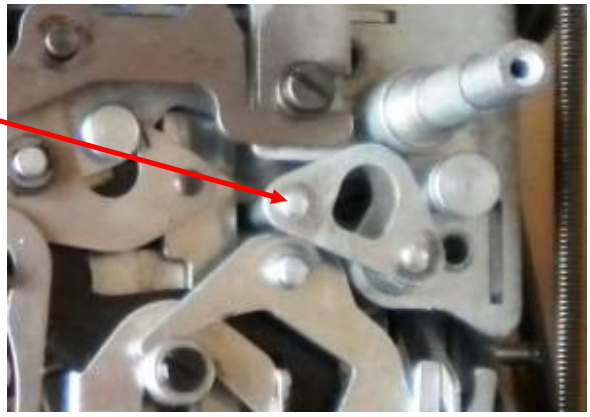
The pin on escapement release lever 12904 should engage with the end of lever 12735.



(hidden top view when mounted)



The pin on total trigger 12993 should project through the hole in escapement release lever 12904.



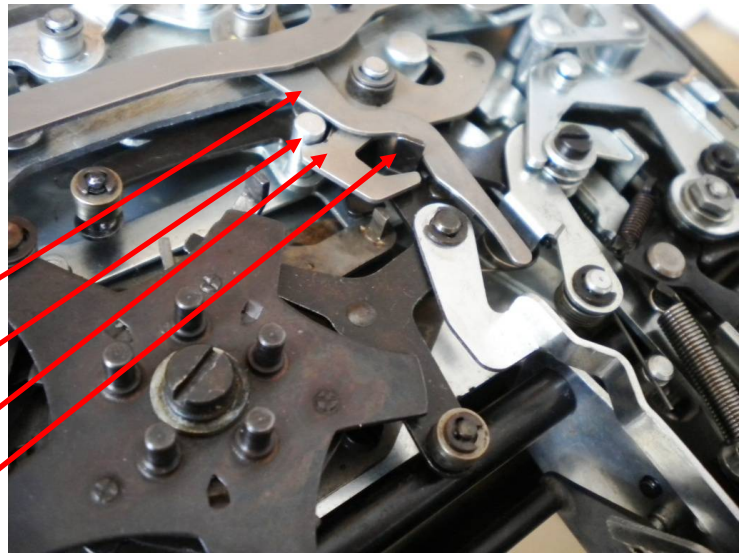
The angled protrusion on escapement trip lever 12961 must pass between motor switch lever 12748 and quotient coupling linkage 12963. Make sure also of the positioning of the pin on left stage lever 12948.

12748

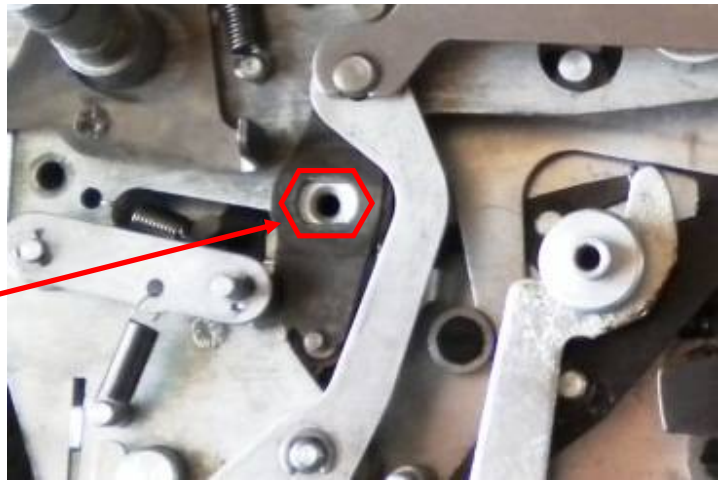
12948

12963

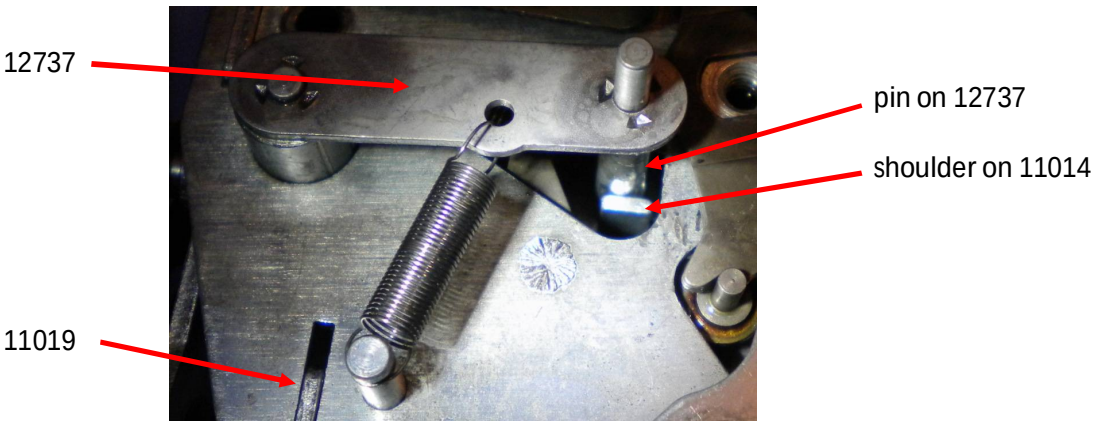
12961



The pivot on quotient switch lever 11016 must protrude through the shaped hole in quotient coupling detent lever 12731 and must be flush with the surface prior to being fastened with a screw.

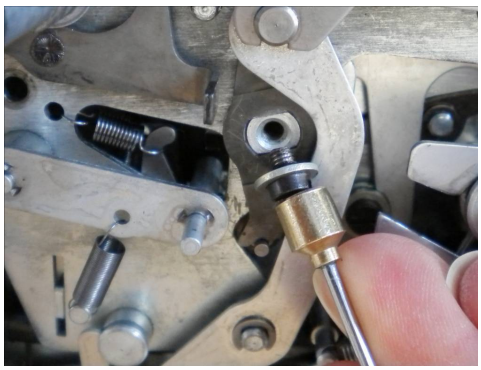


When placing the back corner panel into position, the pin on swing link 12737 should be in the rearmost position relative to the angled shoulder on intermediate lever 11014 and that the flange on tabulator sliding link 11019 protrudes through its slot (this slot is to prevent any lateral sway of link 11019).



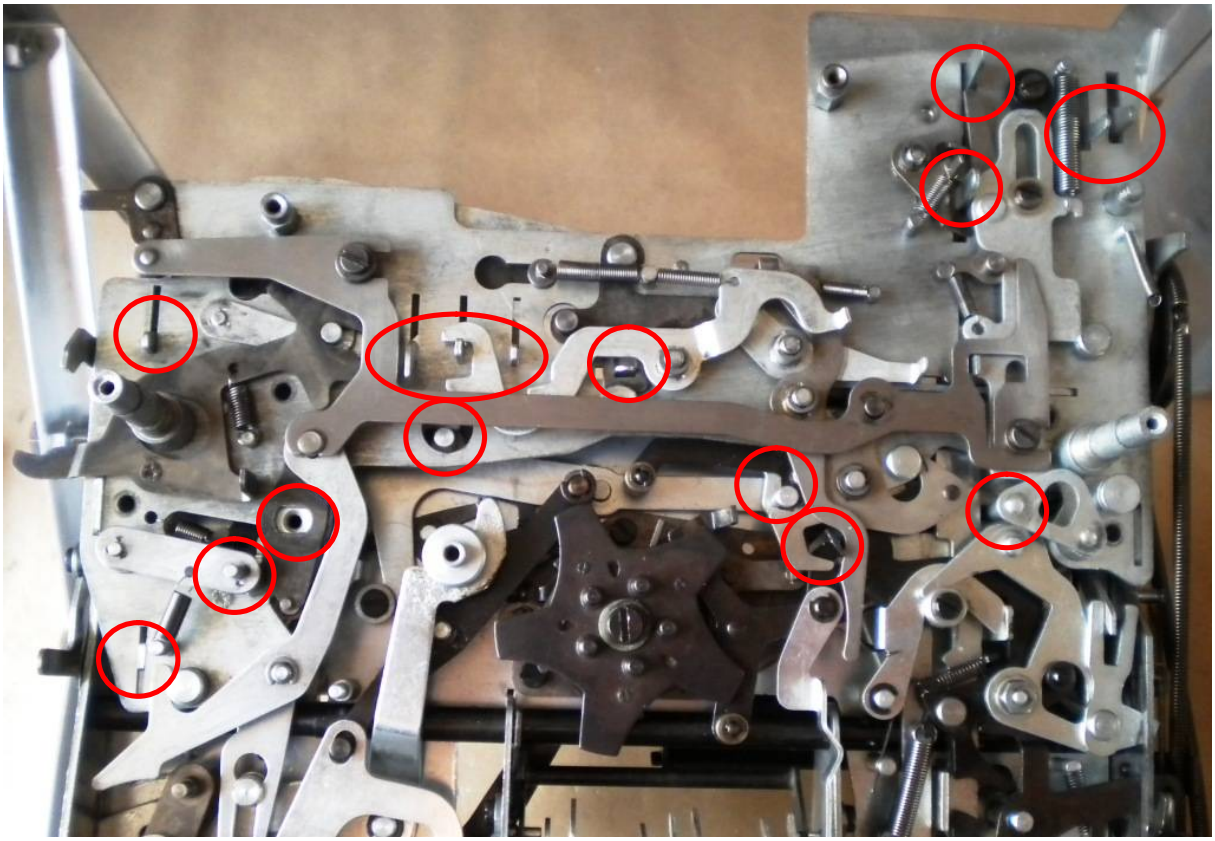
NOTE: Do not force the module down - when all levers are correctly engaged, the module will sit down easily. If the module should rock slightly, then this indicates that one or more of the levers are not yet in place.

Insert the remaining 3 retainers 10838 and screw in 5 screws 904-1 to affix the base plate.

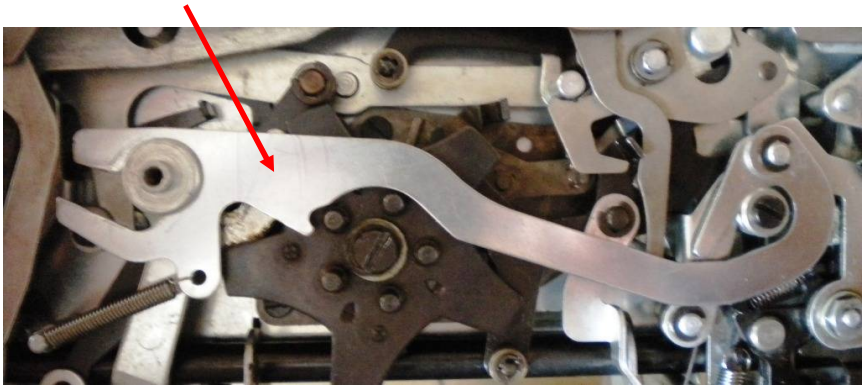


Screw down quotient switch lever 11016 to quotient coupling detent lever 12731 with 1 screw 904-1 and a washer.

Location of check points on previous pages.



Install right step link 10948 with its circlip and spring.



Install start carriage 12989 with 2 circlips & washers and hook in the spring beneath.

Check that the rearmost part of 12989 pushes against lever 12531

12989

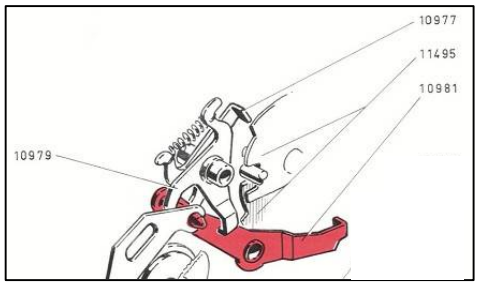
Check that the pin on total carriage 12991 passes through the hole in total trigger 12993

12991

Check that the frontmost part of 12989 pushes against swing link 12981

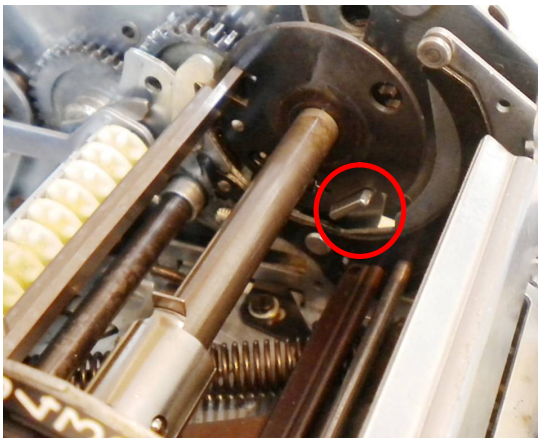
4 - INSTALLATION OF THE SETTING ROTOR

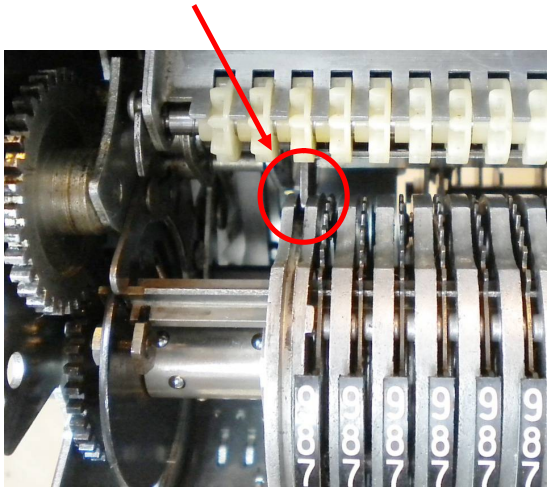
Move rotor locking hooks 10977 and 10979 to the side with lift lever 10981.



Start to emplace the rotor with the cams in this position. Then rotate the rotor to the position shown below.

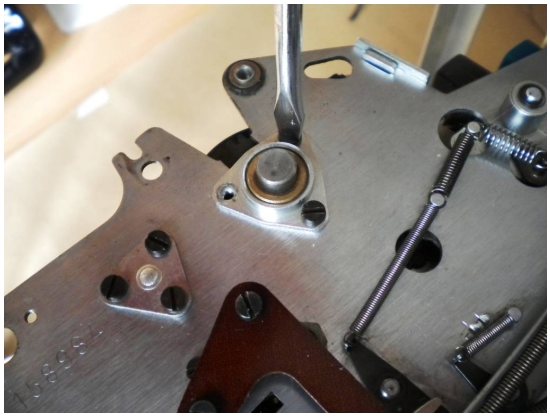
Prior to placing the setting rotor's bearings in place, ensure that rotor lock lever 10848 (which is moved by orientation lever 12908) lies in the cam disk cutout and that the flange on rotor carriage 10997 lies in the slot at the left of the setting disc assembly 11405.



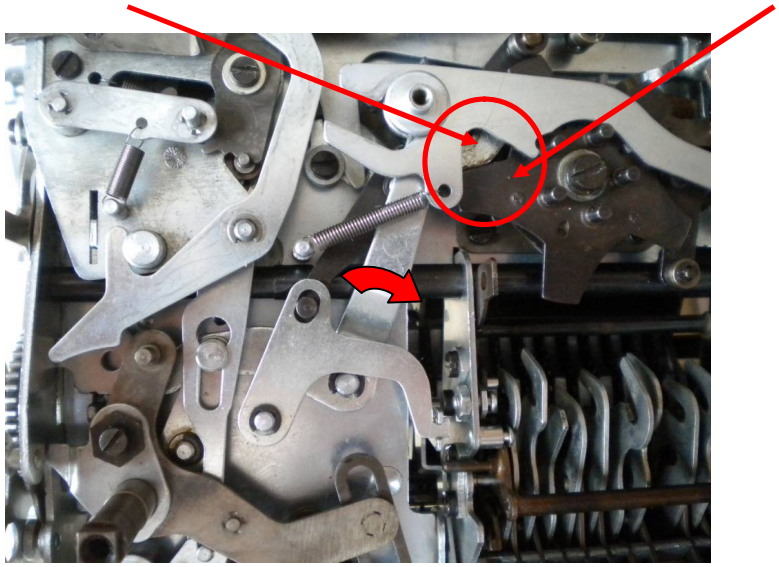


Fix the left-hand bushing to the side wall with 3 screws 904-1.

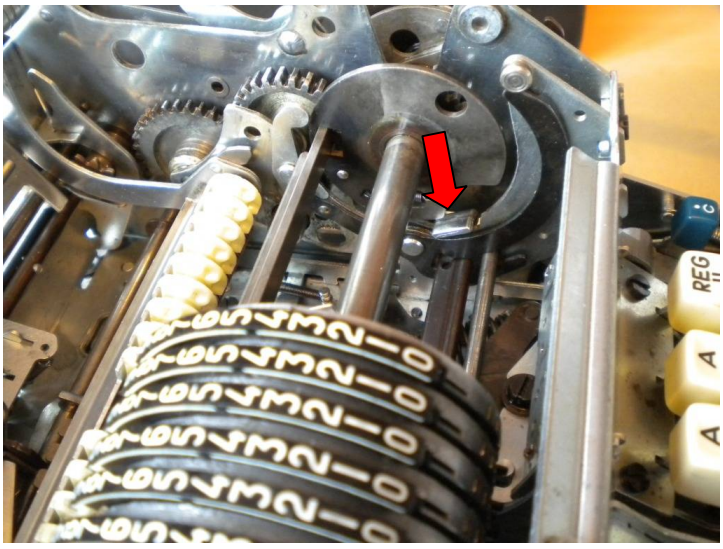
The position of the gear wheels need not be taken into account during assembly (provided the tens carry rotors are not installed).



In order to rotate the unit so that the right-hand bushing may be affixed, rotor lock lever 10848 (which is moved by orientation lever 12908) needs to be dropped out of the cam disk cutout. To facilitate this, rotate the orientation lever 12908 into place between the wings of escapement wheel 10955.

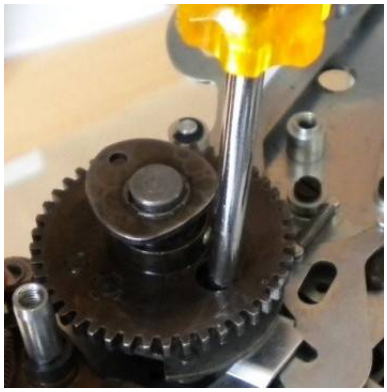


In this position, rotor lock lever 10848 can by moved down and out of the slot in the cam disk cutout.



Now the setting register's rotor can be rotated to allow a screwdriver to line up with the screws.

Fix the right-hand bushing to the side wall with 3 screws 904-1.



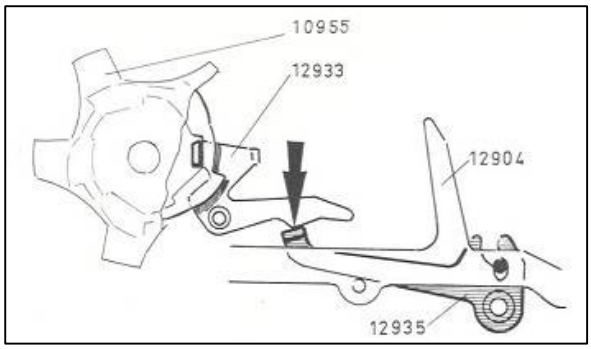
5 - MODULE ADJUSTMENTS - 1

Escapement Wheel Latching

Invert the machine and, with the back of the machine nearmost, check the following:

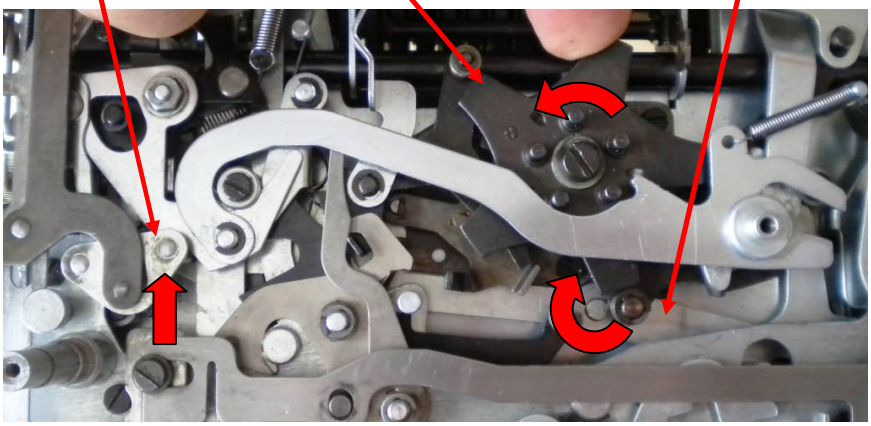
In its first position, inner escapement lever 12933 must latch as securely as possible with escapement wheel 10955. In its second position, it must pass completely freely by the ratchet teeth of the escapement wheel.

The different positions can be controlled by manually swivelling escapement release lever 12904 by using total trigger 12993.

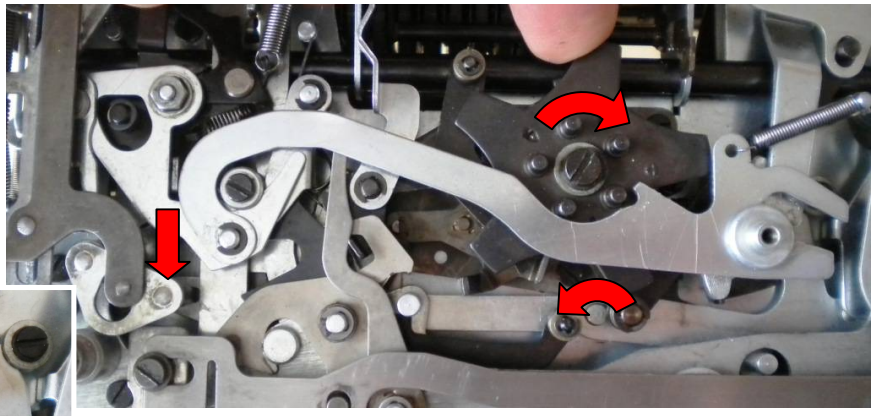


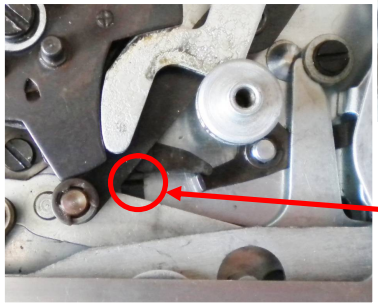
12993 10955 12904

First position: Escapement wheel can only turn CCW. Total trigger 12993 latches the inner escapement lever 12933 onto the escapement wheel 10955.



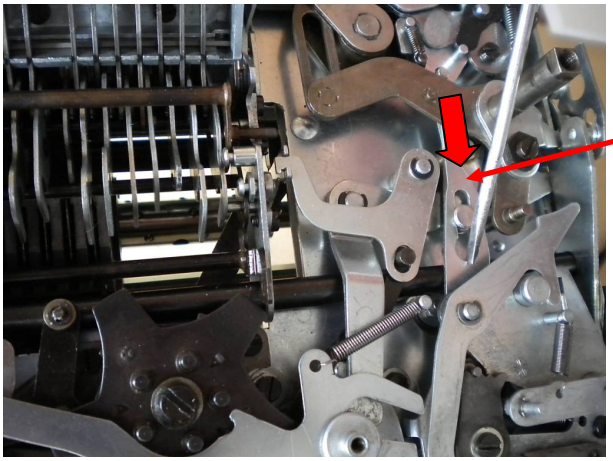
Second position: escapement wheel can only turn CW. Escapement wheel is free to pass inner escapement lever 12933.



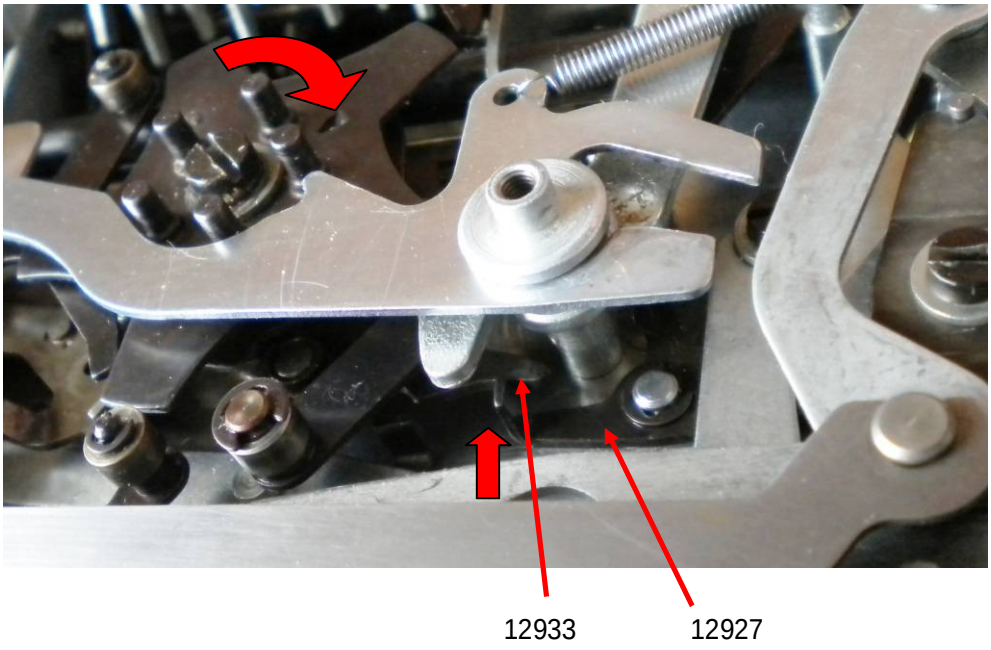


Adjustment is carried out by bending the angle on lever 12935 (beneath right step link 10948 and escapement release lever 12904).

Depress sliding link 12907 with a suitable tool to check the correct release of inner escapement lever 12933 via lever 12927 from escapement wheel 10955. When thus released, escapement wheel 10955 can freely turn CW.



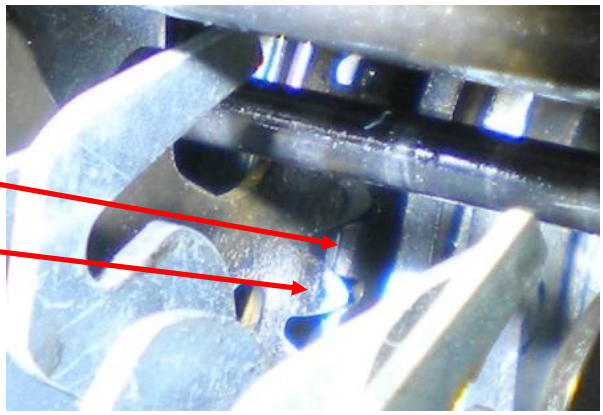
The flange on sliding link 12907 must disengage inner escapement lever 12933 from escapement wheel 10955 via lever 12927.



Adjustment is carried out by bending the angle on lever 12927.

Rotor Setting Segment Alignment

Rotor setting segment 11181 must be positioned in such a way that its left side aligns with the left side of the setting discs 11461.



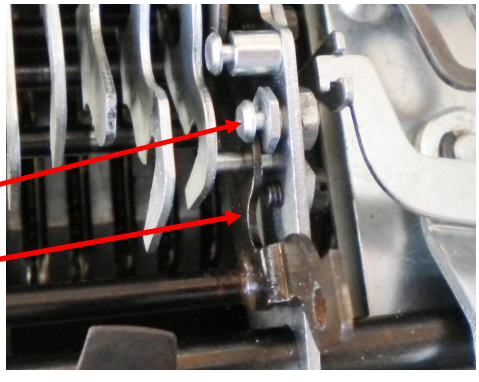
It also has to be checked whether the segment passes freely past blocker 11447.

The position of the segment must be checked in relation to all the setting discs.

It is also advantageous at this point to employ a mirror to check that rotor setting segment 11181 is fully in mesh with the teeth on setting discs 11461.

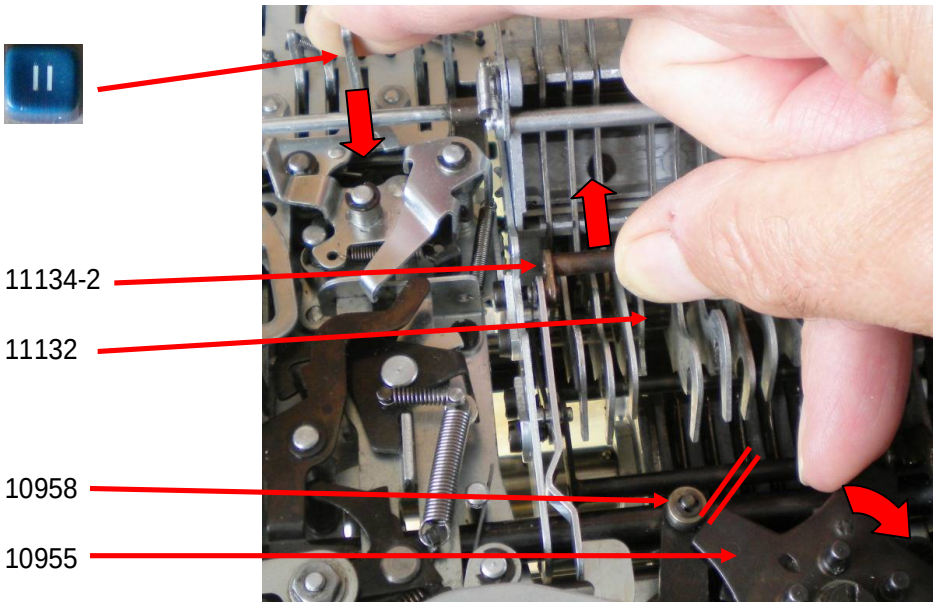
Move rotor setting segment 11181 slowly by hand whilst checking this.

The lateral position of rotor setting segment 11181 is set with guide 10223-13. Note that if the position of the segment is thus changed, the position between the lower extension of the segment and the pins of the scan mechanism must also be controlled.



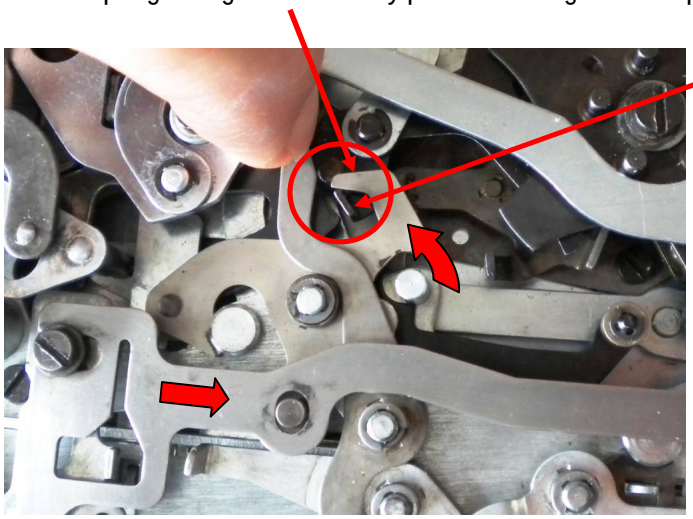
Escapement Wheel Clearance

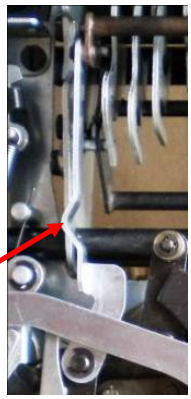
Whilst reset key "II" is depressed, hold trigger bridge 11134-2 against number keyboard lock lever 11132. Check that in this position, the roller 10958 has a clearance of 0 – 0.1 mm compared with escapement wheel 10955.



Quotient Coupling Linkage Clearance

Check that quotient coupling linkage 12963 freely passes the angle of escapement trip lever 12961.

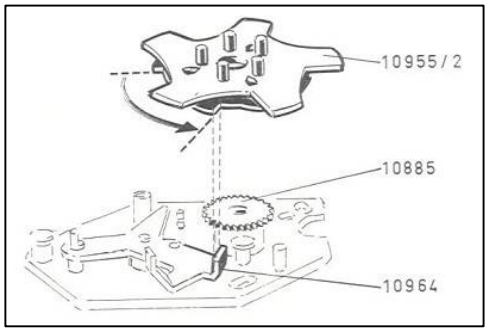




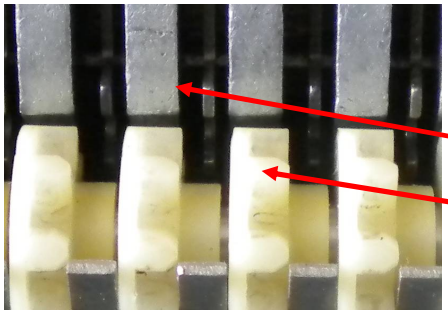
Adjustment is carried out by shortening or lengthening escapement link 10959.

Setting Rotor Latch Position

Check that the setting register's rotor (when in its rightmost position and latched by outer escapement hook 10964) is positioned correctly laterally (left-right) by loosening and adjusting the phasing of escapement wheel 10955 in relation to escapement spline wheel 10885 and outer escapement hook 10964.

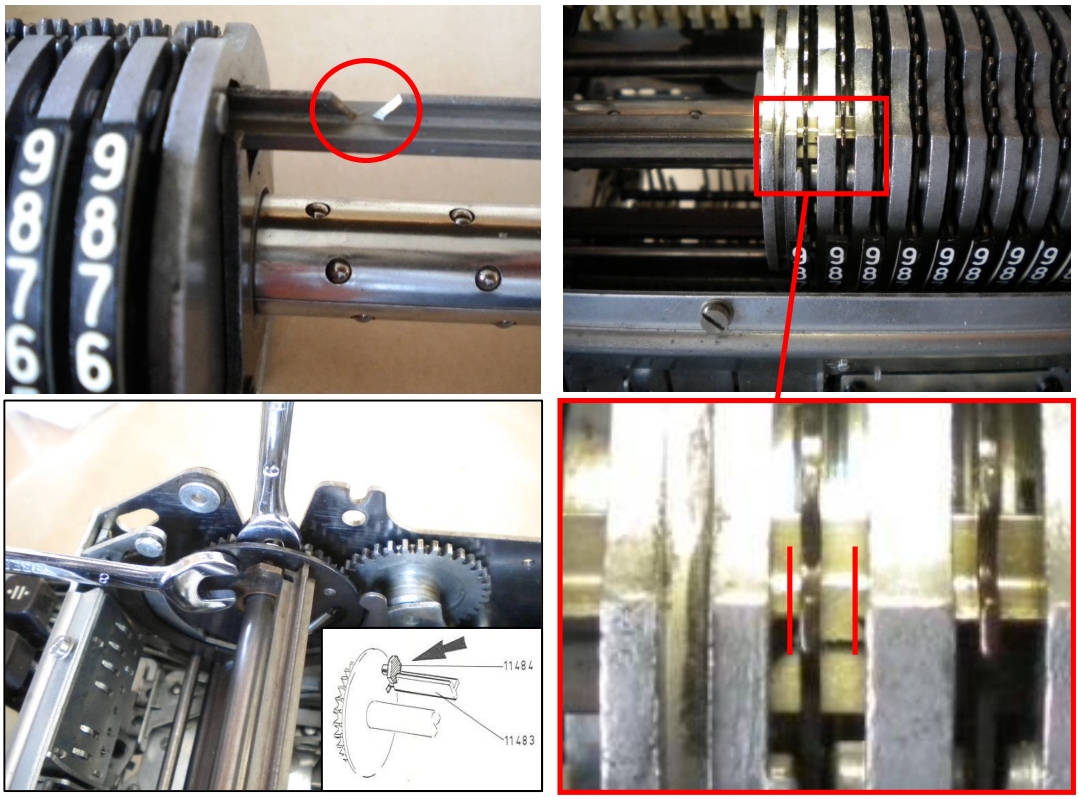


A detailed adjustment procedure for the phasing of escapement wheel 10955 can be found in appendix A on page 171.



When the setting register's rotor is thus latched, the relative positions of back transfer gears 10731 and setting discs 11461 should be as shown at left.

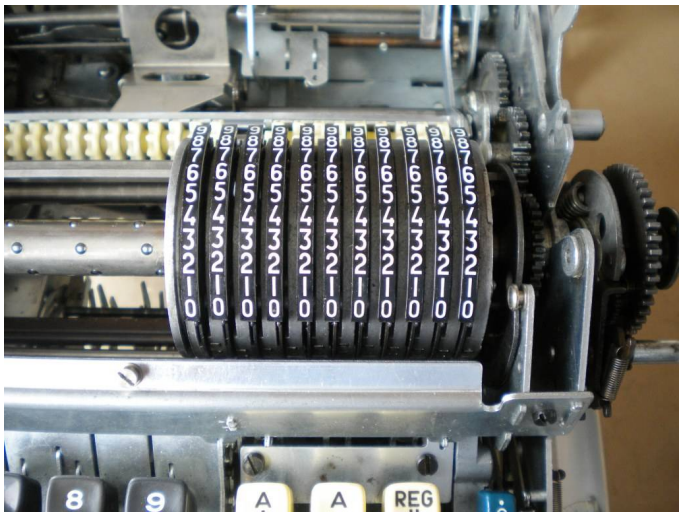
With the setting register's rotor in its latched position, the notch on rail 11483 must lie in such a way that the setting discs 11461 are positioned in the left of the opening without chafing on the rail.



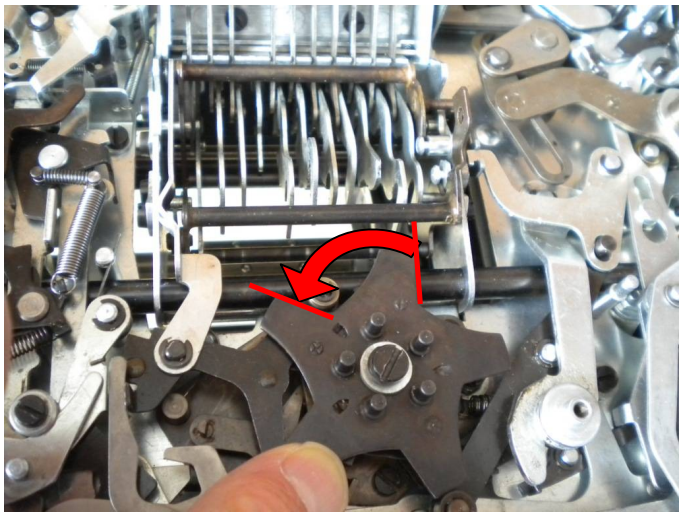
The position of the rail is adjusted with screw 11484 using 6 & 8 mm spanners.

Setting Disc Indexing

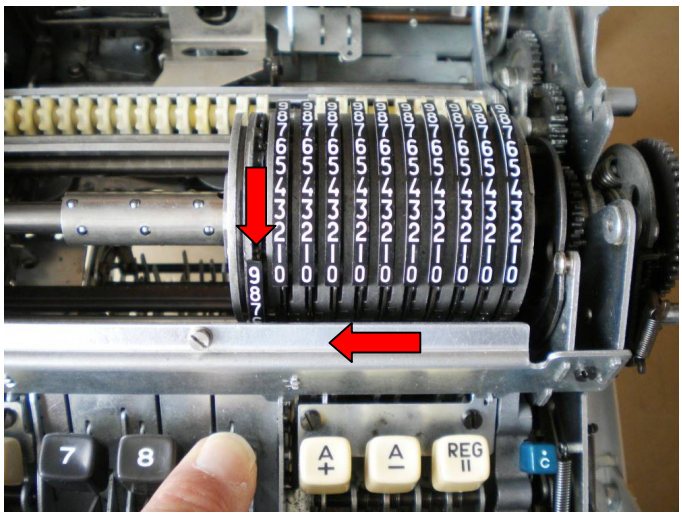
Start this next check with the setting register's rotor in its rightmost position by manually turning escapement wheel 10955.



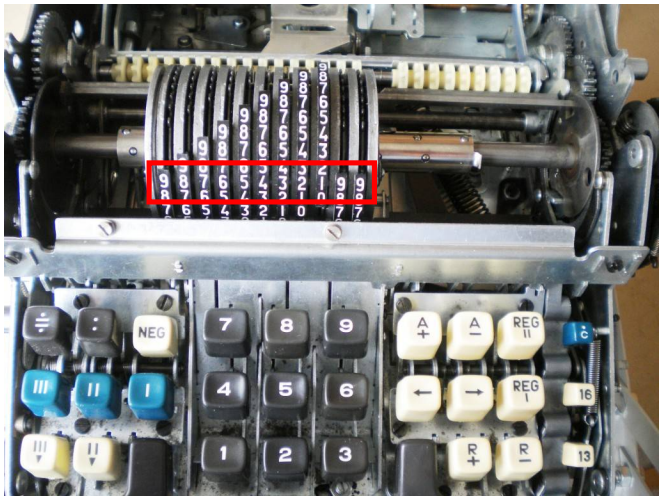
Hold escapement wheel 10955 and depress key "9" then manually turn escapement wheel 10955 slowly CCW.



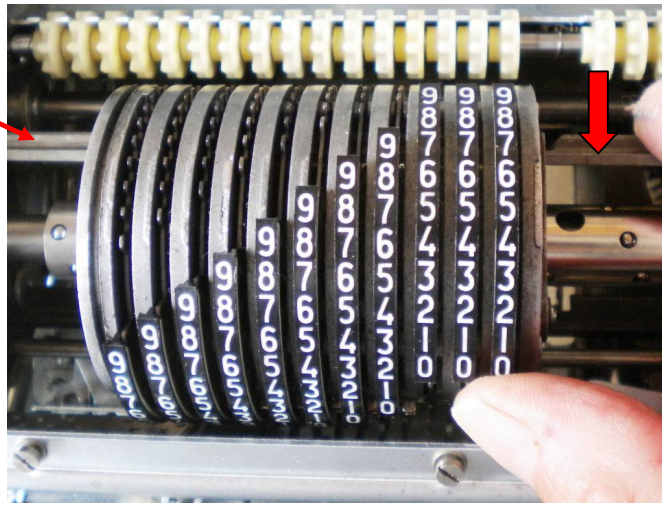
Check that the setting disc is turning to the number 9 before the setting register's rotor carries out its left step.



Carry out the same check on all number keys. Adjustment is carried out by bending the angle on outer escapement hook 10964 (see diagram on page 53).

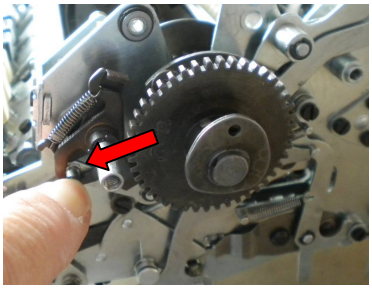


Reset all the setting discs back into their zero position by lifting rail 11483.

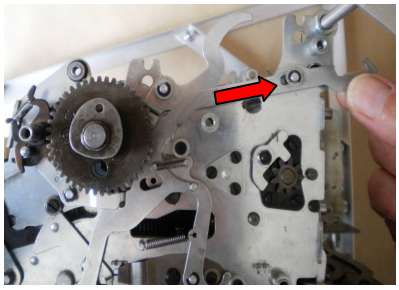


NB: The setting rotor can be rotated out of its zero position by (A) pulling the pin on lever 10981 thereby releasing rotor locking hooks 10977 & 10979 then turning the rotor. (B) Pull stop lever 10983 towards the back of the machine to prime rotor locking hooks 10977 & 10979 then (C) rotate the setting rotor back into its zero position. The rotor will then lock back into place with the rotor locking hooks.

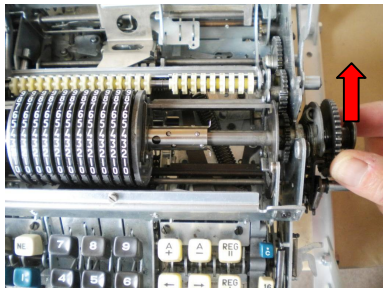
A



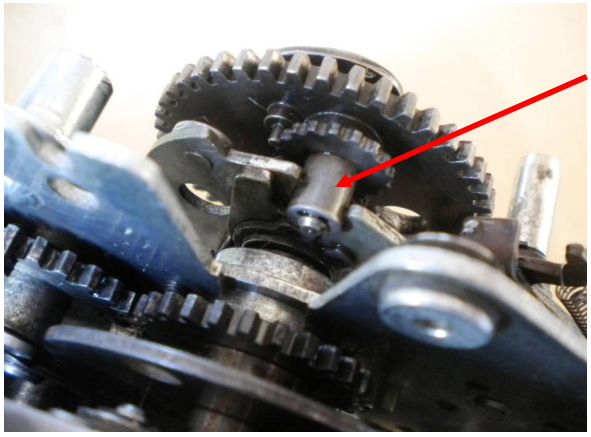
B



C



Setting Rotor Stop Position

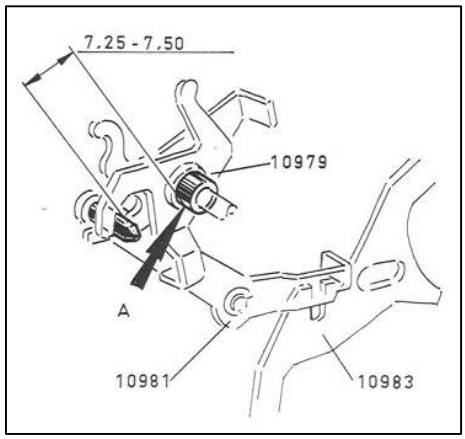


The stop position of the setting register's rotor can be changed by removing the circlip, pulling out and turning eccentric 11498.

Setting Rotor Locking Hook Position

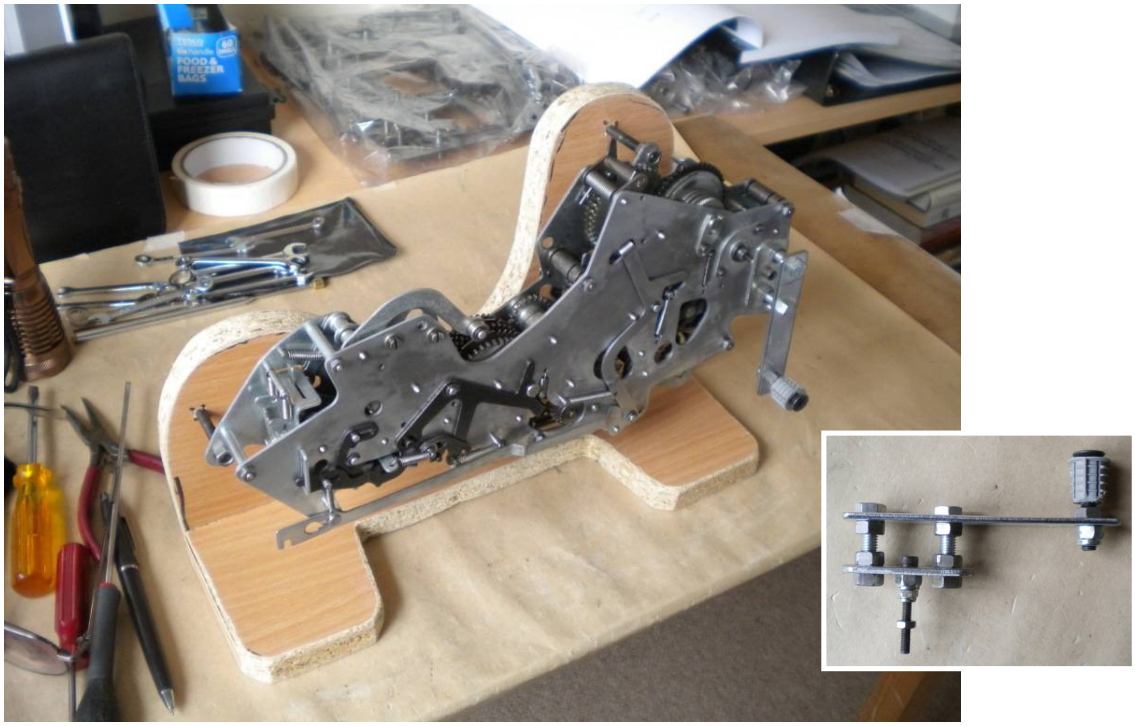
Depress lift lever 10981 and then release it, so that its angle rests on stop lever 10983. In this position check that the distance between the pin on the lift lever and the hub on rotor locking hook 10979 is 7.25 – 7.50 mm. The distance must be measured from the outer part of the hub. See point A on the drawing.

Adjustment is carried out by dismantling lift lever 10981 and carefully bending it straight, whereby the above-stated measurement is increased.

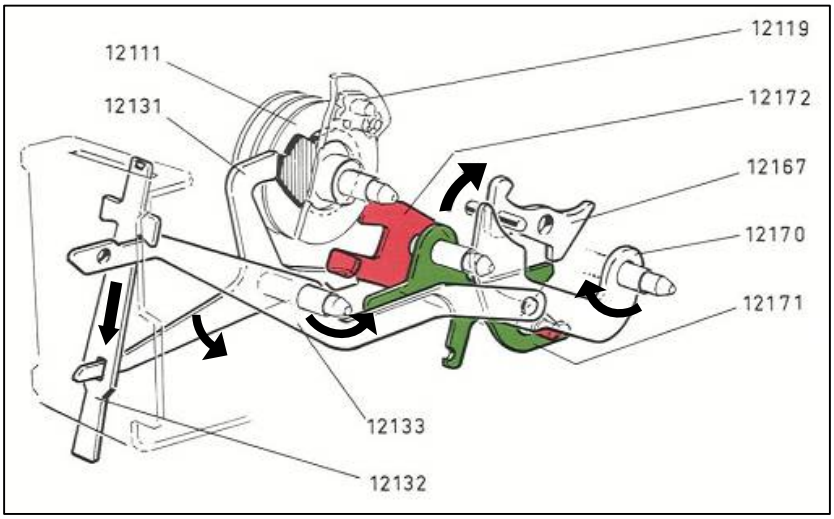


6 - RIGHT TRANSMISSION SUB-ASSEMBLY FUNCTIONALITY CHECKS

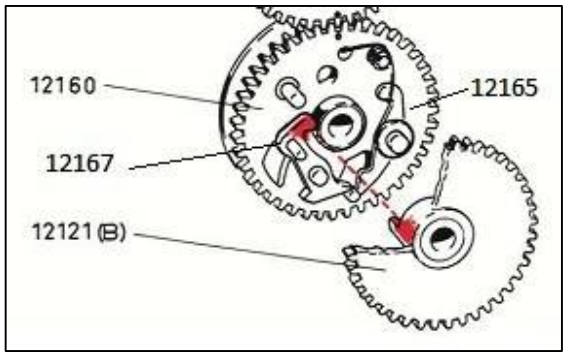
Firstly, fabricate a temporary mount to hold the unit vertically for ease of working and construct a manual hand-crank with a 3 mm central screw thread and screw this into drive gear 12301. When constructing the hand-crank, make sure that the handle can be rotated past the service frame when the right transmission sub-assembly is mounted onto the machine.



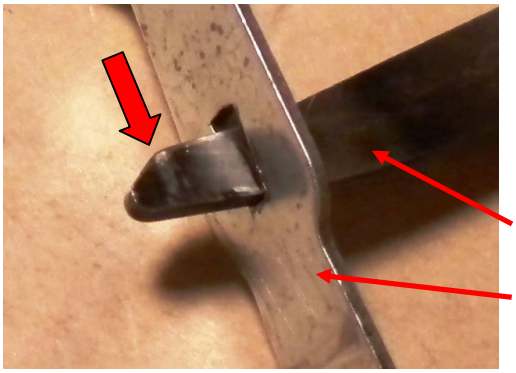
When the unit is partially disassembled, make sure there is no wear in the slot of +/- pulldown link lever 12132 where +/- cam follower 12131 protrudes through and impacts at the bottom of this slot. If this wear is excessive through past usage, then both +/- clutch pawls 12167 will not be fully actuated via +/- clutch operating levers 12133 & 12134 and +/- clutch trip levers 12170.

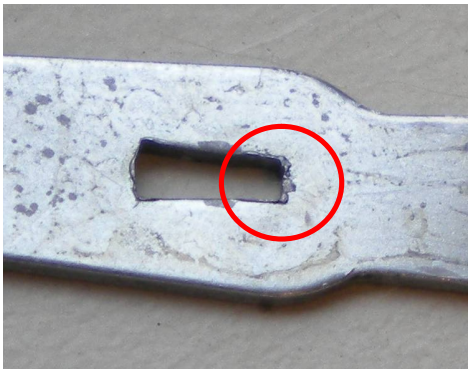


If either clutch pawl 12167 is not fully actuated then this would result in +/- clutch drive gear 12160 not being turned by either of the transmission drive gears 12121 A or B (CW or CCW).

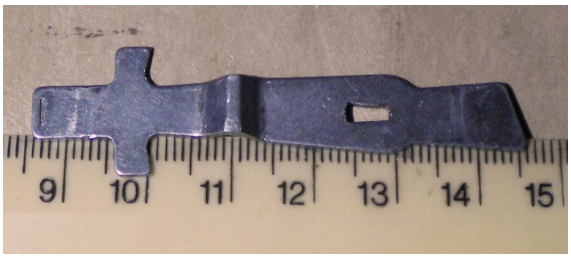


The following photographs show the location of possible excessive wear in the slot of +/- pulldown link lever 12132 from the repeated impact of +/- cam follower 12131.

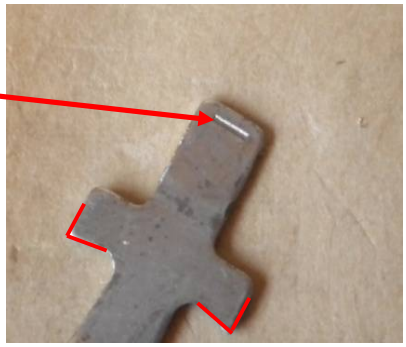




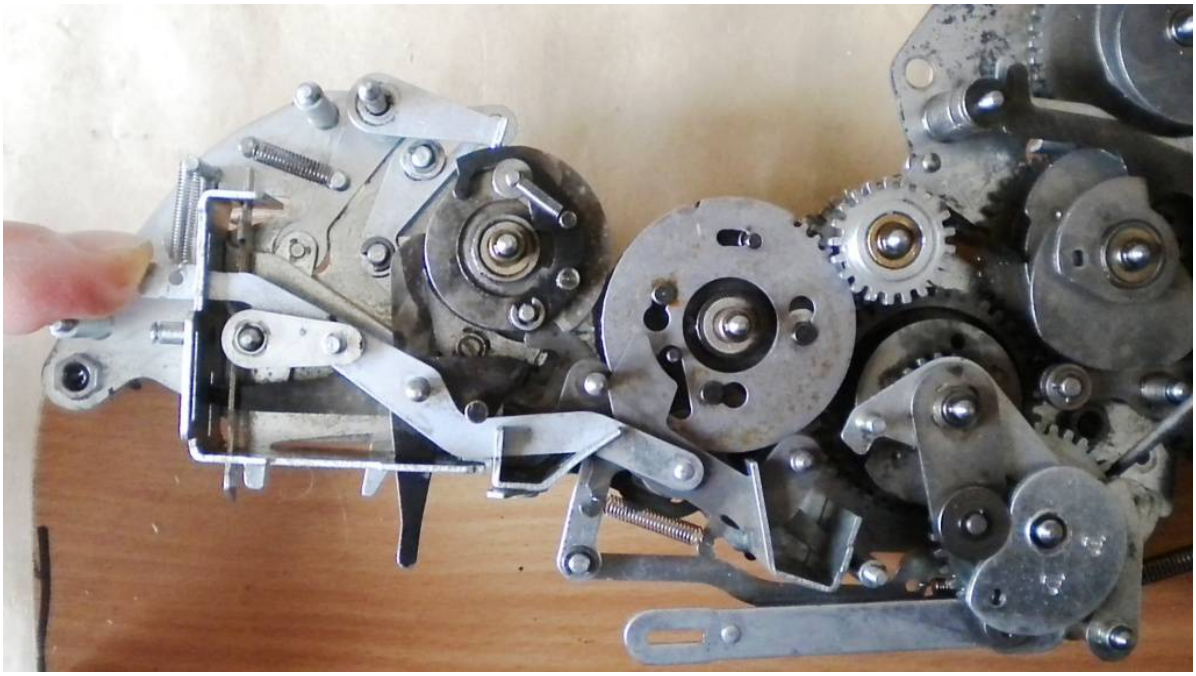
If this is found to be so, then the material around this slot needs building up or the lever can be shortened overall by introducing a kink. The following photographs show how the lever has been manually shortened by approx. 1 mm from its original length to compensate for this wear and tear.



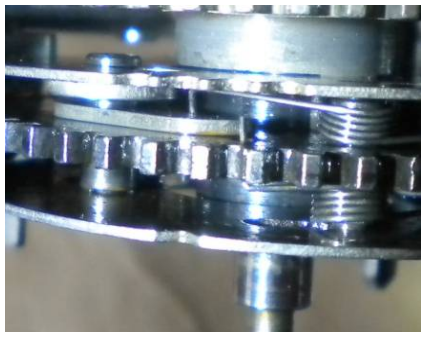
Note that when reinstalling this lever, the embossed sign on the upper part is at the front of the machine and that the two 'wings' can easily pass over levers 12133 & 12134.

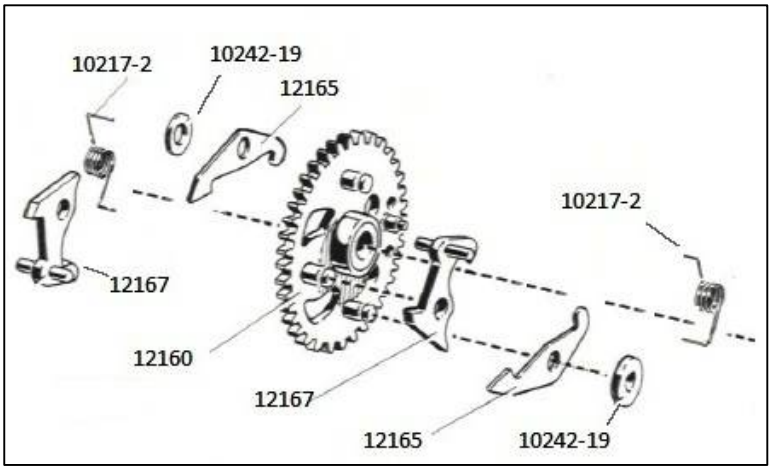


Ensure at this time that all levers, pivots, gear trains and clutch items associated with the above parts are free and fully functional and that no old grease is present - especially on adjacent flat sliding parts. Also check that all spring end loops are correctly formed (this applies to all springs on this machine).

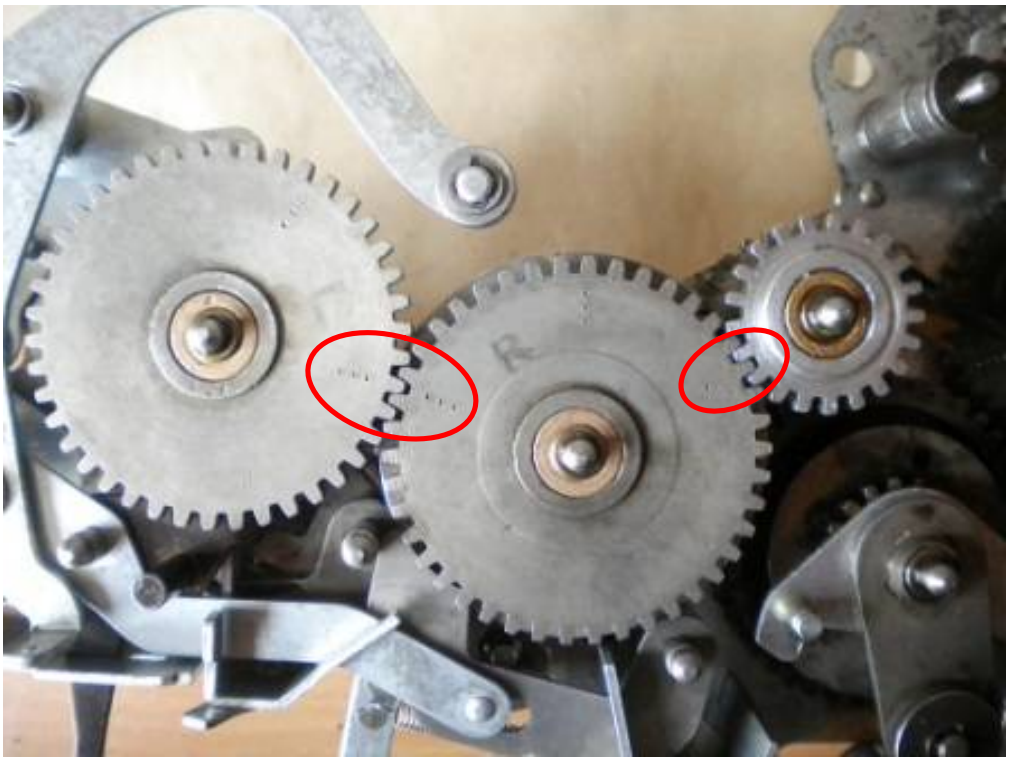


It is also important that both +/- clutch pawls 12167, their +/- detent levers 12165 and associated return torsion springs 10217-2 are adequately lubricated and free to pivot.

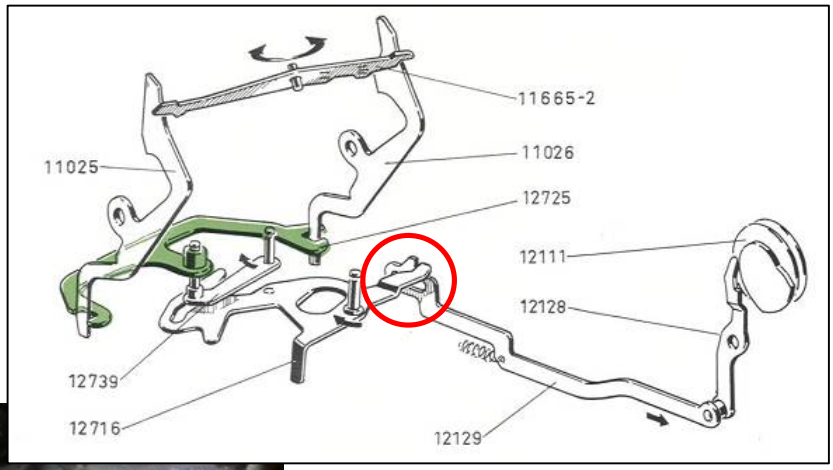


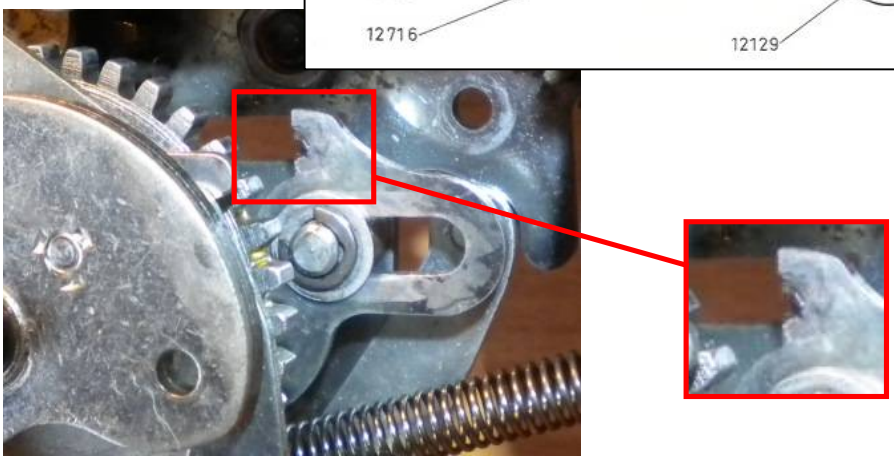


NB: Take note of the datum marks when reinstalling gear sets (this applies to all gears on this machine).

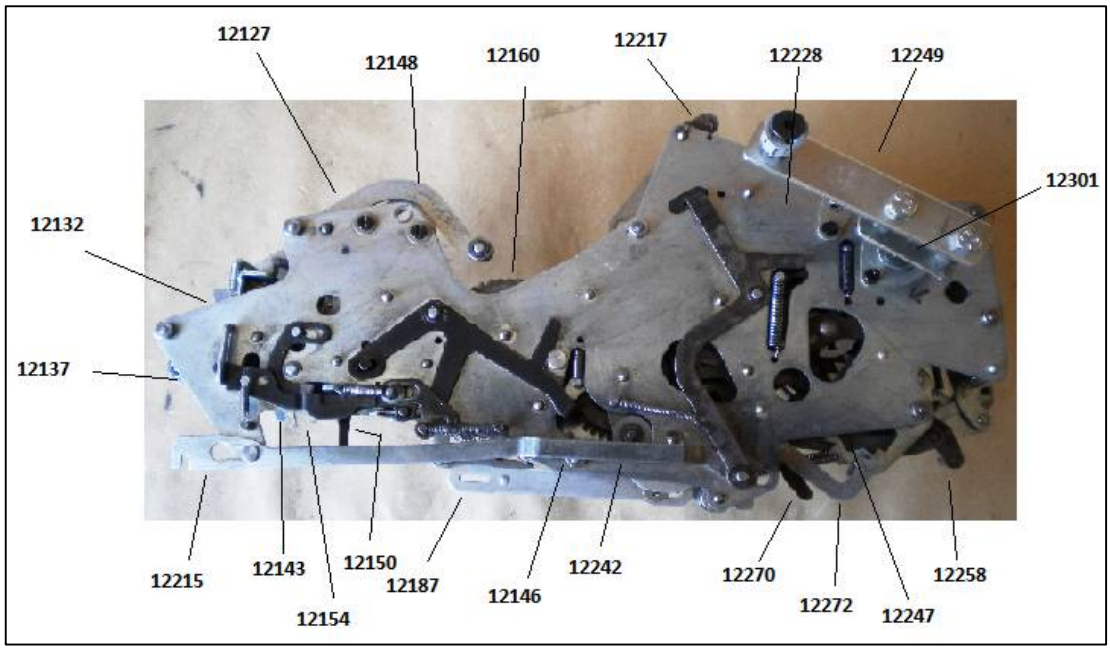


An additional source of wear may be evident on counter +/- sliding link 12129 where the raised profile is used to actuate calculation direction lever 12716. This wear can be compensated for by the adjustment (6) as detailed on page 133.





The right transmission sub-assembly performs a number of functions via various levers, cam sets and gear systems, the locations of which are shown in the following photograph and table.



The following table lists the major input and output parts in ascending part numerical order. Their approximate locations are given with reference to the sub-assembly when mounted on the machine.

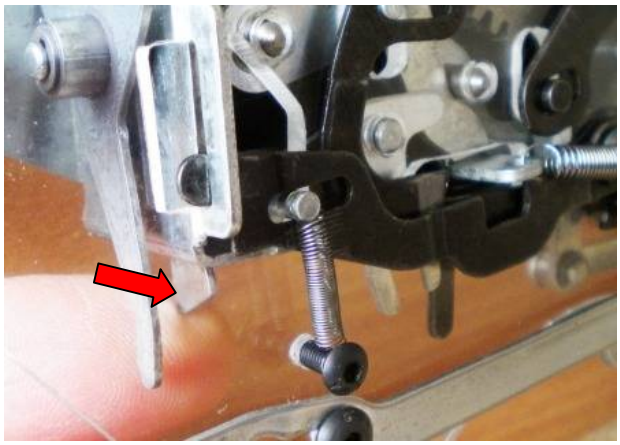
Part Number	Description	Function	Location
12127	Register I unlock slider	Output	Middle
12132	+/- pulldown link lever	Input	Front
12137	Lever	Input	Front
12143	Clutch release lever	Input	Left
12146	Register I clearing lever	Input	Middle
12148	Register I clear lever	Input	Middle
12150	Start lever	Input	Left
12154	Forked 3-arm lever	Input	Middle
12160	+/- clutch drive gear	Output	Middle
12187	Register I clear/return link	Output	Bottom
12215	Register II clearing clutch sliding link	Input	Bottom
12217	Register II clearing lever assembly	Output	Top
12228	Countback gear assembly	Input	Left
12242	Sliding link	Input	Left
12247	Stage hook	Output	Left
12249	Countback end lever	Output	Top
12258	Feeler shaft rocker lever	Output	Back
12270	Shortcut select lever	Input	Bottom
12272	Shortcut select quadrant hold lever	Input	Bottom
12301	Motor input gear	Input	Left

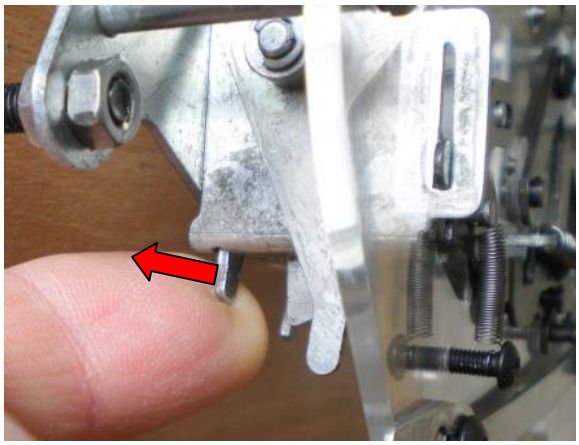
It is both instructive and necessary to observe the various mechanisms in action when the unit is under test. To this end, a perspex side panel can be substituted for the right-side steel plate so enabling the correct functionality to be observed for each sub-system when tested in turn.

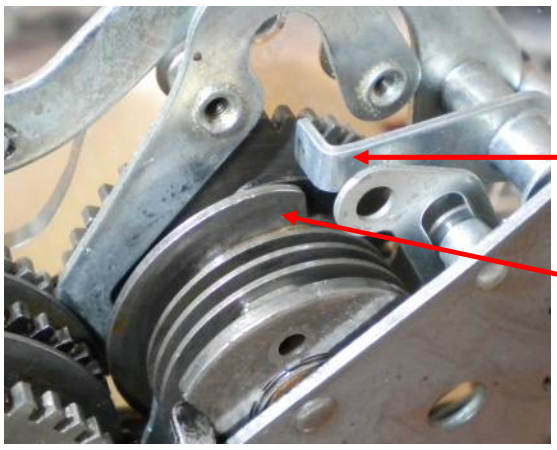
Prior to each functionality check being carried out, manually crank (CW) a number of turns to make sure that all cam sets are not engaged.

Plus and Minus Start

Push +/- pulldown link lever 12132 to the right then pull clutch release lever 12143 to the front.



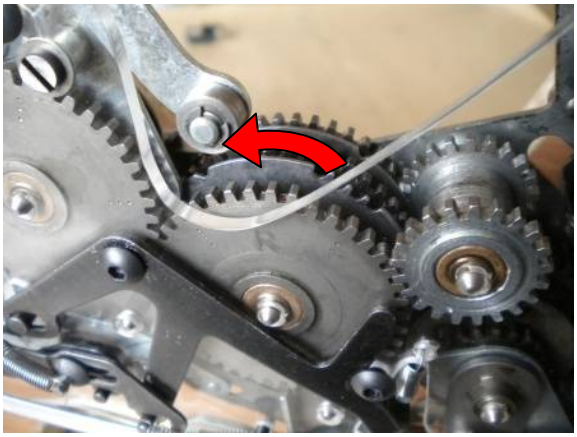




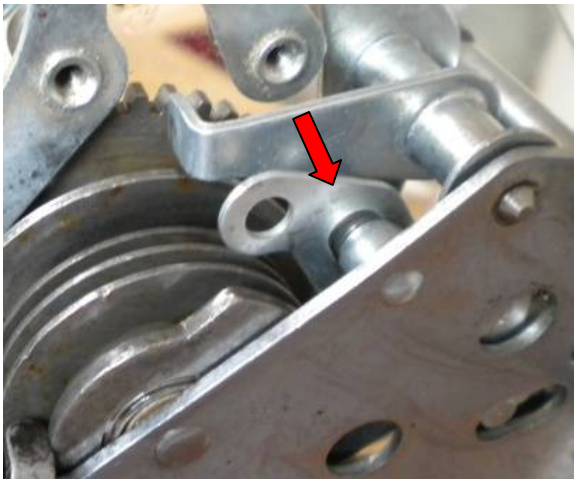
Ensure that clutch release lever 12140 has disengaged from cam assembly 12111.

12140

12111

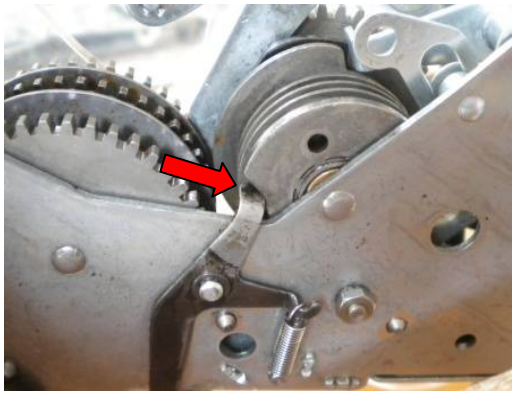


Manually crank and observe that +/- clutch drive gear 12160 rotates CCW when viewed from the right side of the assembly (the hand-crank side).



Further cranking moves setting register I unlock slider 12127 downwards.

At the end of the cycle, start lever 12150 should engage in cam assembly 12111 and +/- clutch drive gear 12160 should have returned to its initial position with the single vee notch in plate 12169 at the top (the four semi-circular notches in these plates were used as locators in the manufacturer's jig when this component was originally assembled).

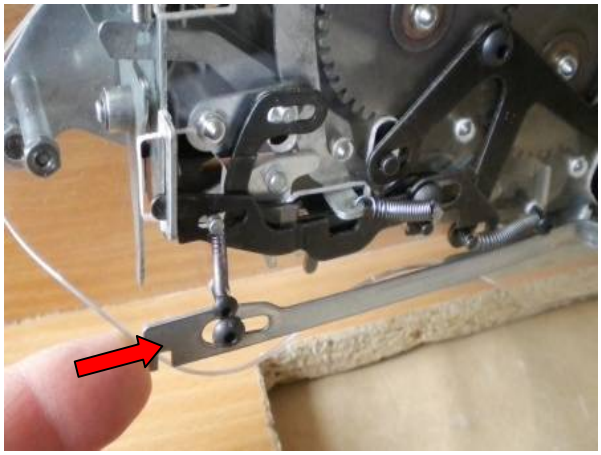


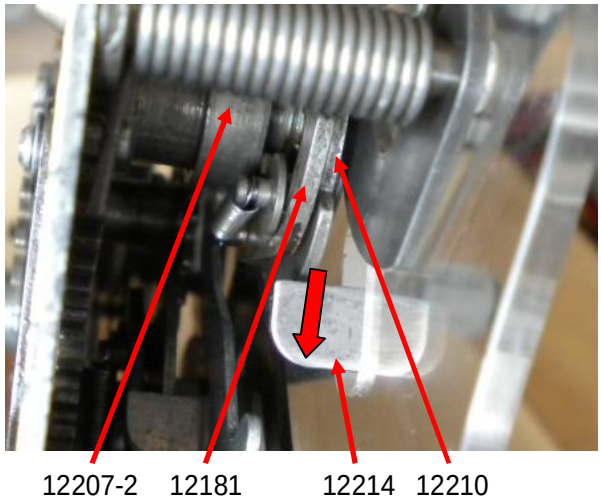
Repeat this sequence with +/- pulldown link lever 12132 pushed to the left whereupon +/- clutch drive gear 12160 should rotate CW and again stop with the vee notch in plate 12169 at the top.

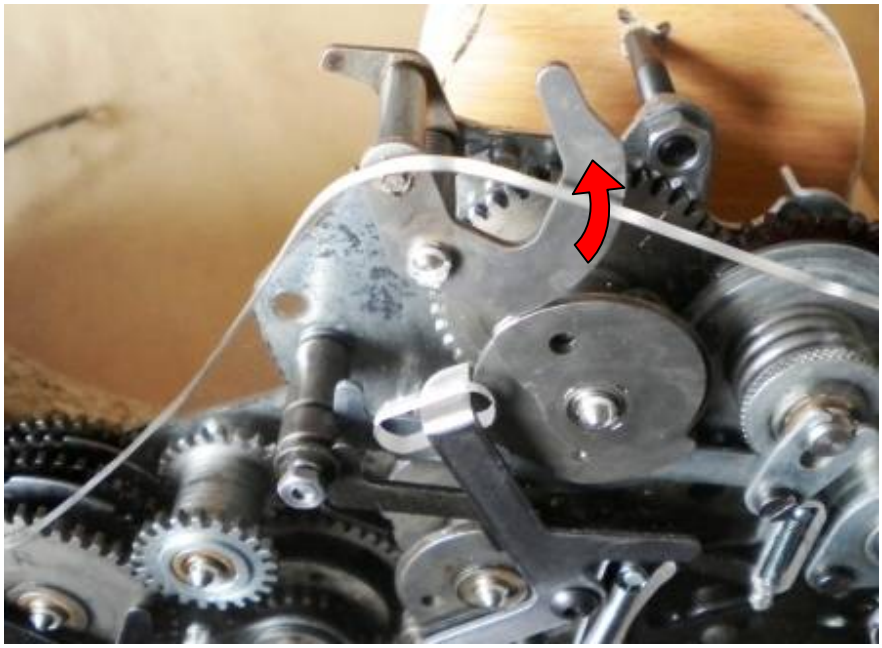
This and subsequent checks should be carried out a number of times to ensure correct and continuously repeatable functionality.

Counter Register II Clearing

Push counter register II clearing clutch sliding link 12215 to the back of the unit and observe that counter register II clearing clutch lever 12214 has released pawl 12181 on counter register II clearing cam & clutch 12210. Pawl 12181 should now engage with counter register II clearing clutch gear 12207-2 so turning the cam set 12210 when hand-cranking.



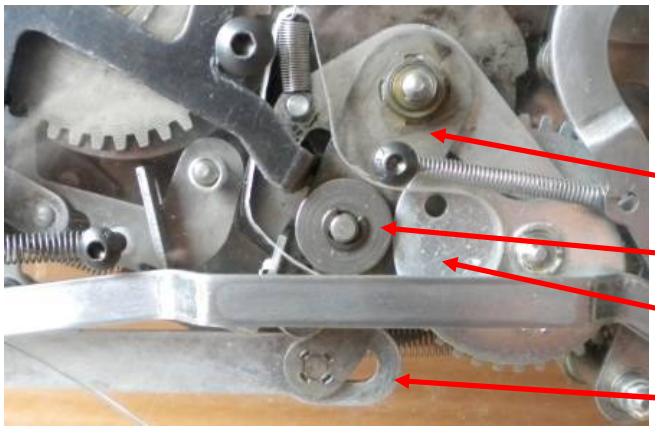




Cam set 12210 should easily raise counter register II clearing lever assembly 12217 against its torsion spring 10217 then let it fall back positively at the end of the cycle.

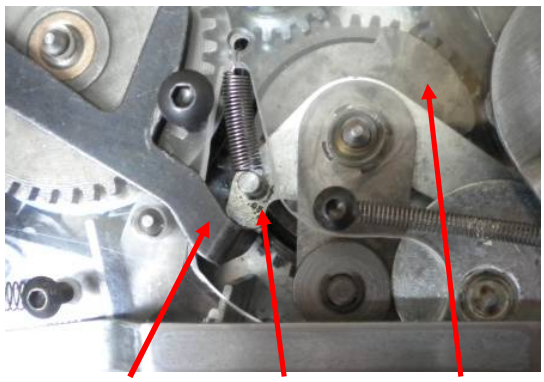
Setting Register I Clearing

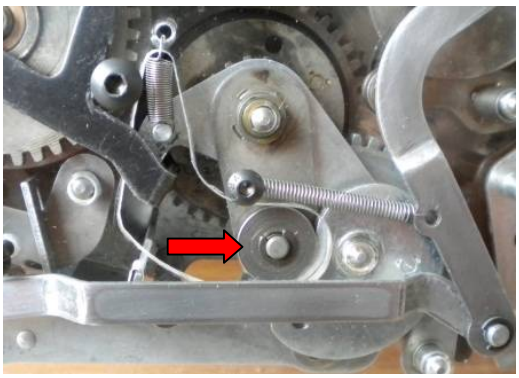
Push start lever 12150 to the right (towards the back of the right transmission sub-assembly) so actuating rotor clearing clutch lever 12192. This action should now freely release pawl 12181 on setting register I clear/return cam 12177.



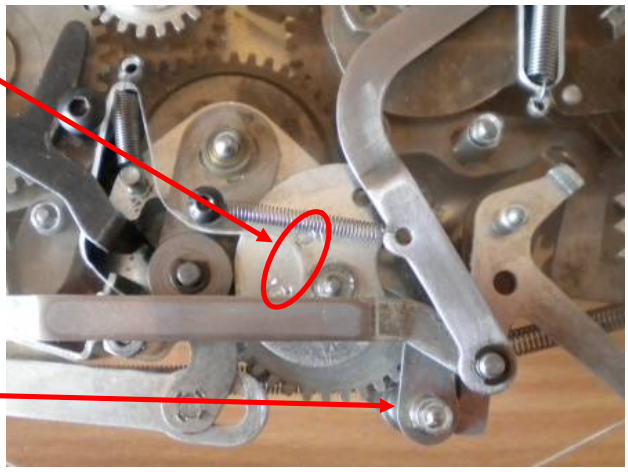
Roller 10235 should smoothly rotate as rotor clear/return gear & cam 12189 pushes roller and rotor clear/return arm 12184 so taking register I rotor clear/return link 12187 with it.

Also observe during this action, that retaining lever 12182 prevents the premature return of rotor clearing clutch lever 12192 so allowing setting register I clear/return cam 12177 to rotate twice and that, at the end of the cycle, roller 10235 and arm 12184 are pulled fully towards the back of the unit by means of return spring 1516-67.



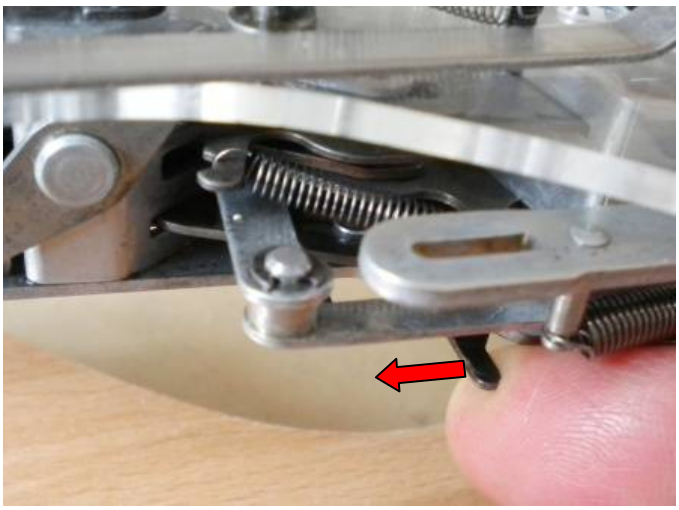


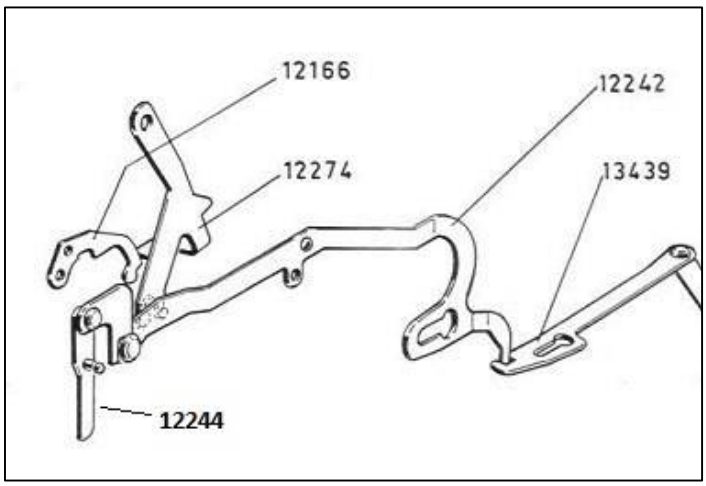
During this cycle a secondary function moves 2-arm offset lever 12196 by means of two spigots on rotor clear/return gear & cam 12189.

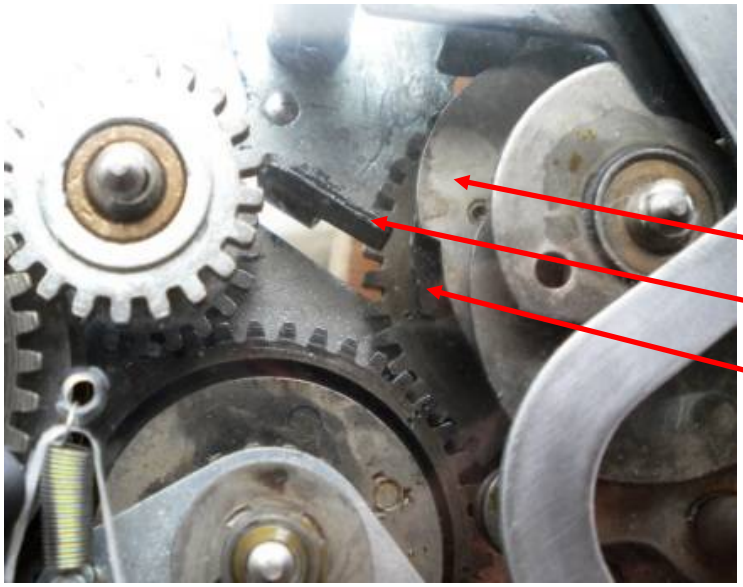


Multiplication & Countback

Push sliding link 12242 to the front of the unit and observe the free movement of 2nd trip lever 12274, double lever 12244 and stage hook 12247



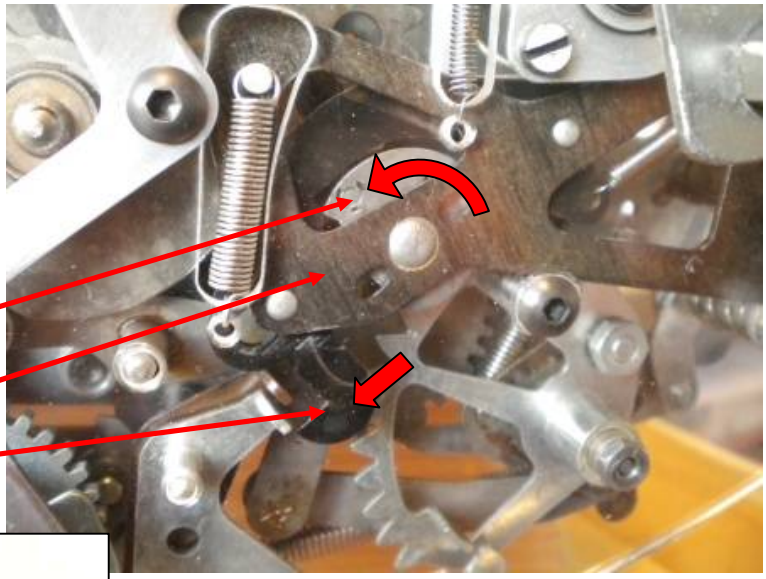


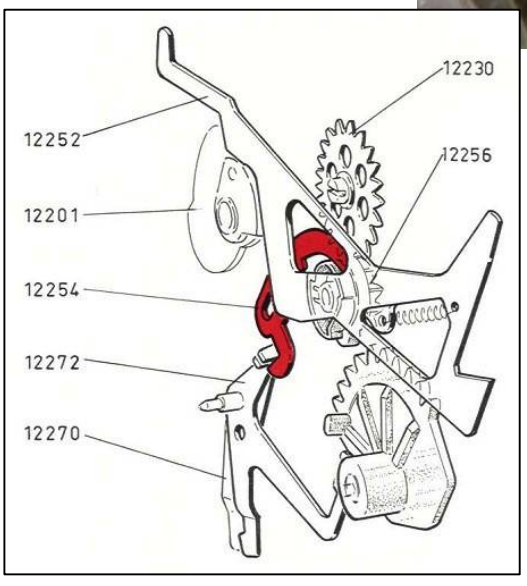


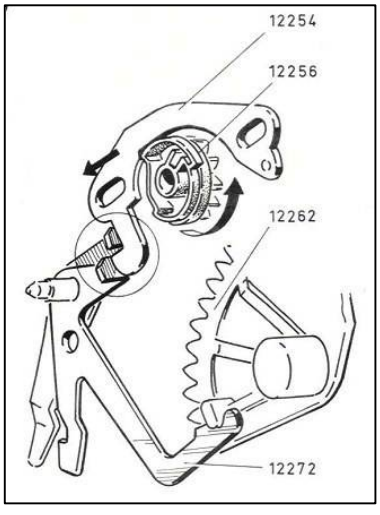
2nd trip lever 12274 should easily release pawl 12166 on countback cam and clutch 12201, so allowing the cam set to turn when hand-cranked.

Note: Keep 2nd trip lever slightly free of countback cam during the cycle so allowing the cam to freely rotate whilst slowly hand-cranking.

As the cam set begins to rotate, shortcut selector 12254 should slide downwards along the pins of countback slider plate 12252 by means of the rotation of countback transfer gear 12256. This movement should be totally free and uninhibited.







As the cam set continues to rotate, ensure that there is free movement for the following parts:

Countback transfer gear 12256

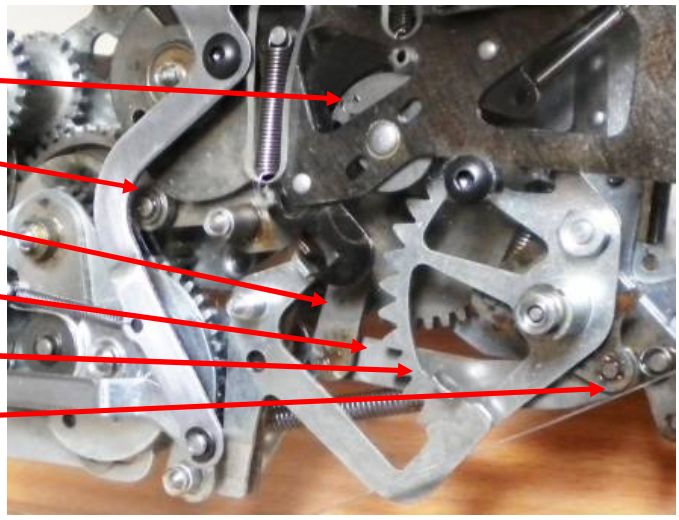
Roller 10235

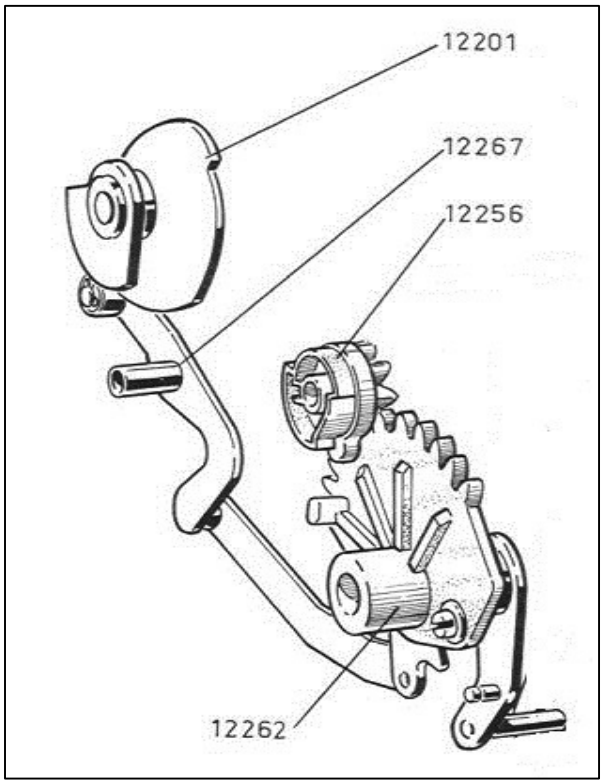
Feeler cam follower lever 12267

Feeler drive link 12266

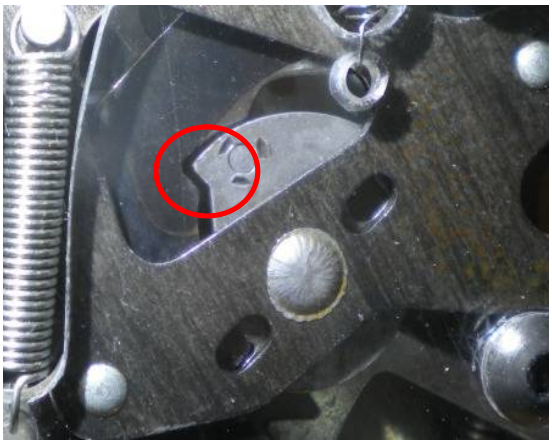
Quadrant gear 12262

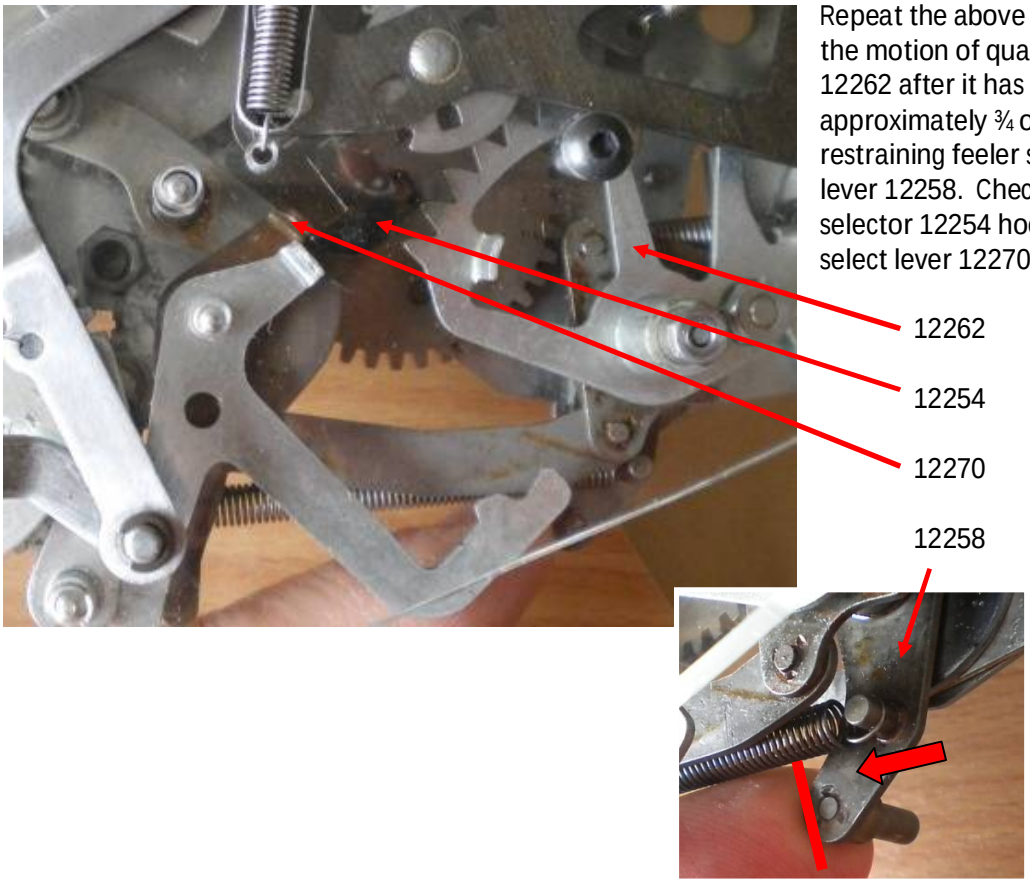
Feeler shaft rocker 12258





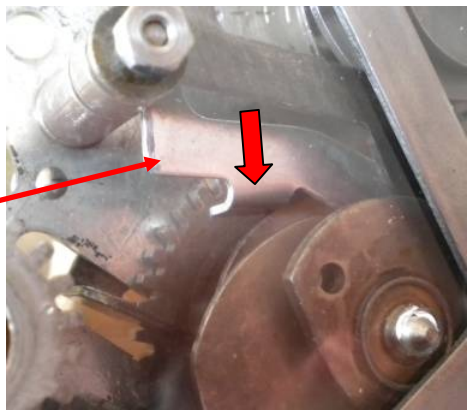
At the end of the cycle, the distance between countback transfer gear 12256 and shortcut selector 12254 should be approx. 0.5 mm.

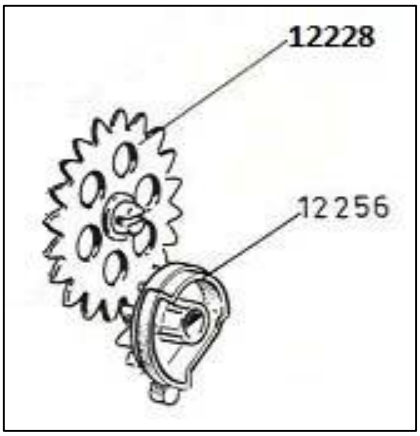




Repeat the above cycle but arrest the motion of quadrant gear 12262 after it has turned through approximately ¾ of its motion by restraining feeler shaft rocker lever 12258. Check that shortcut selector 12254 hooks shortcut select lever 12270 only.

Continue hand-cranking until the quadrant gear has returned to its initial position whereupon countback clutch hold lever 12250 should have engaged pawl 12166 and prevented countback cam and clutch 12201 from further rotation.





At this point, countback slider plate 12252 should have raised countback transfer gear 12256 into mesh with countback gear assembly 12228.

Rotate countback gear assembly 12228 by hand so that the pin on countback transfer gear 12256 raises countback end lever 12249.

This in turn should raise countback clutch hold lever 12250 so allowing countback cam and clutch 12201 to rotate when further cranking is carried out and, at the same time, shortcut selector 12254 should be released to return to its initial position by tension spring 1516-17.

12250

12254

Continue to hand-crank to reset countback cam and clutch 12201 back to its starting position.

Repeat the above cycle but this time arrest the motion of quadrant gear 12262 after it has only turned through approximately ¼ of its motion by again restraining feeler shaft rocker lever 12258. Check that shortcut selector 12254 this time hooks both shortcut select levers 12270 & 12272.

At the termination of this cycle, rather than the angle on quadrant gear 12262 coming to rest at the end of shortcut select lever 12272 (photograph "A"), the quadrant gear should now be caught on the back part of shortcut select lever (photograph "B"). This action results in the quadrant gear being arrested one tooth pitch higher.

A

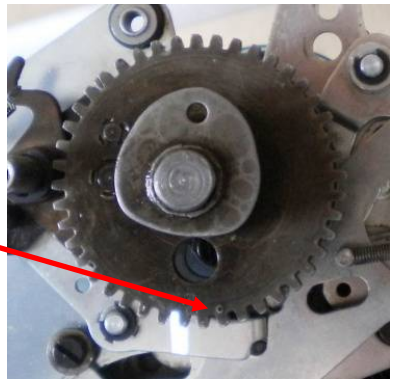
B

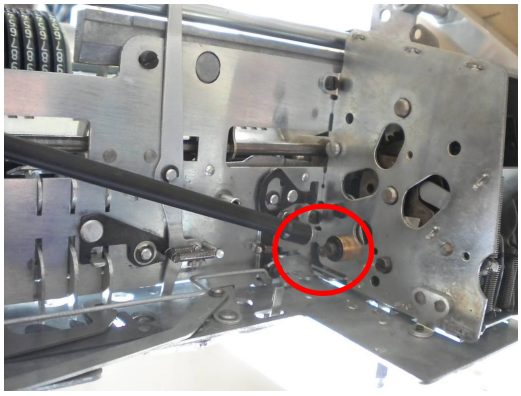
The position of the quadrant gear in photograph "A" initiates countback revolutions to process complementary numbers of the multiplicand in the range 5 - 9.

When all sub-systems of this unit are verified as working properly, the steel side plate can be bolted back on and the right transmission sub-assembly run through further repeat checks prior to installation onto the machine.

7 - INSTALLATION OF THE RIGHT TRANSMISSION SUB-ASSEMBLY

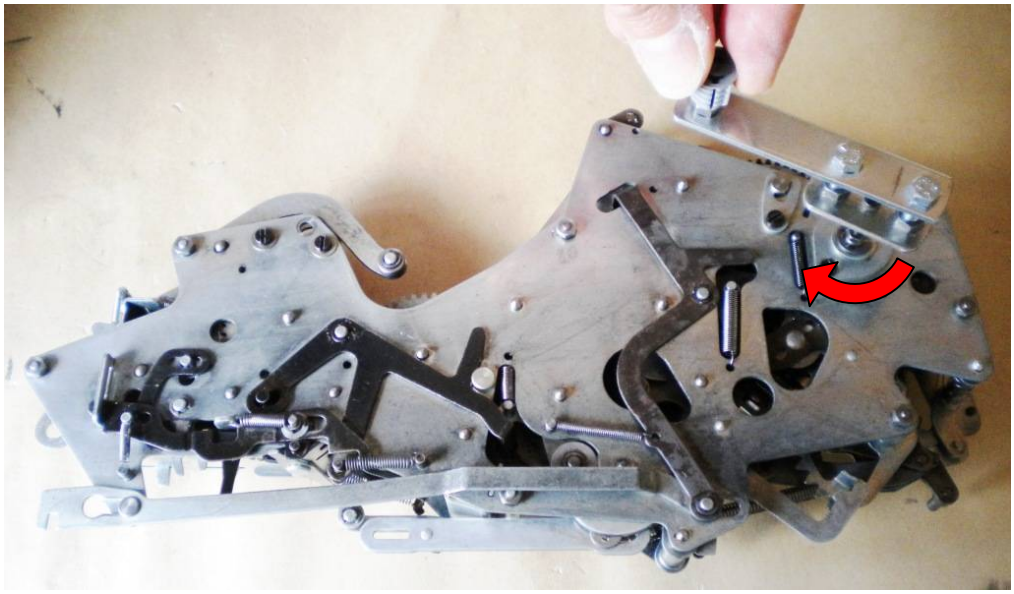
Ensure that the setting rotor is locked into its zero position so that the setting mark on gear 11490 is in its lowest position as shown.





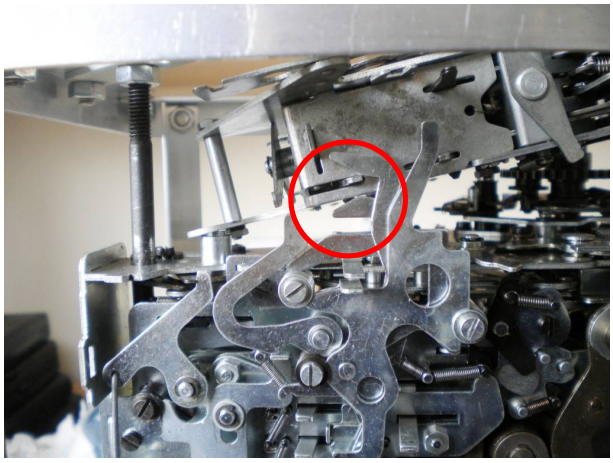
Place the machine onto its left side and install drive shaft 12602 onto the left transmission sub-assembly's drive spigot 12590.

Ensure that all cam sets are free by repeatedly hand-cranking drive input gear 12301 CW.

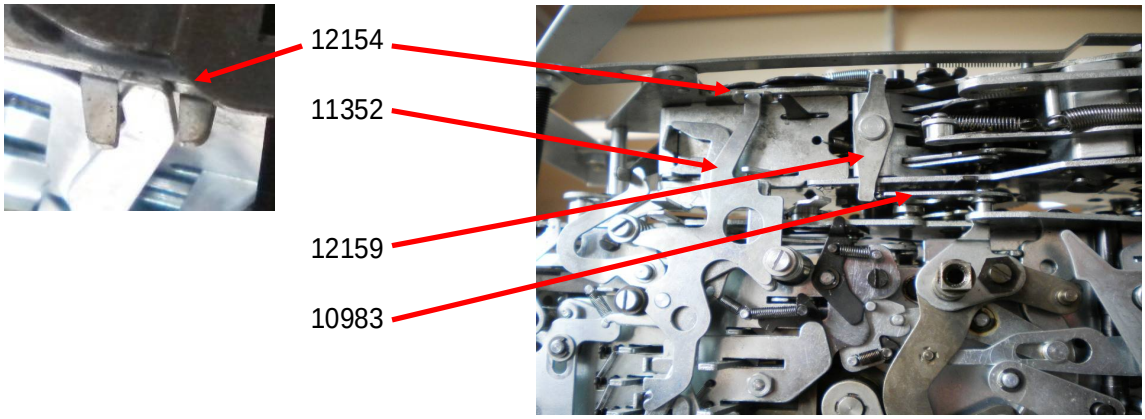


Stop cranking in a position such that the half-diameter on gear input shaft 12301 will align with drive shaft 12602.

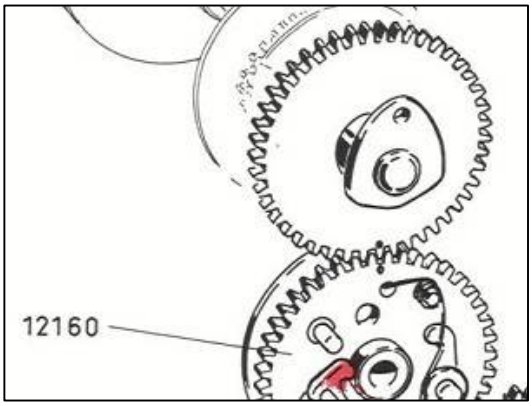
Put the machine onto its left side and lower the front of the transmission sub-assembly down first, so that offset lever 12143 engages in minus lever 11351. Try not to trip any sub-systems as the unit is lowered into place.



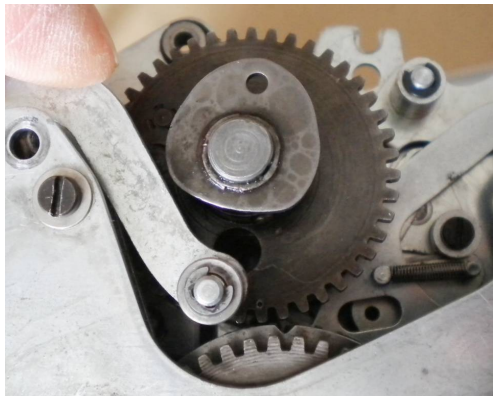
Check the engagement of forked lever 12154 and plus lever 11352, also the engagement of the lower part of stop lever 10983 with lever 12159.



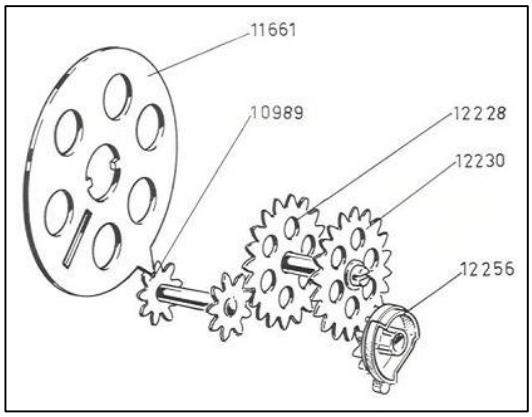
The mark on clutch drive gear 12160 must align with the mark on gear wheel 11490 of the setting rotor.

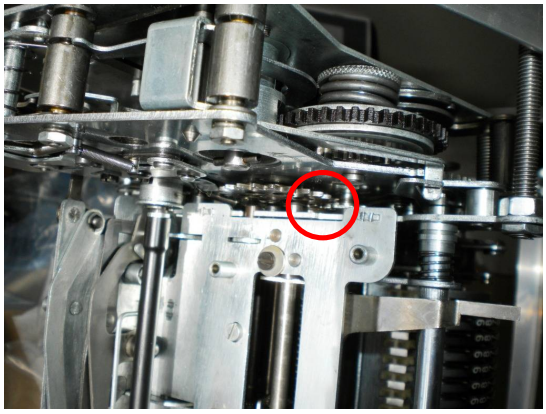


Depress setting register I clearing lever 12148 so allowing the unit to be lowered further.

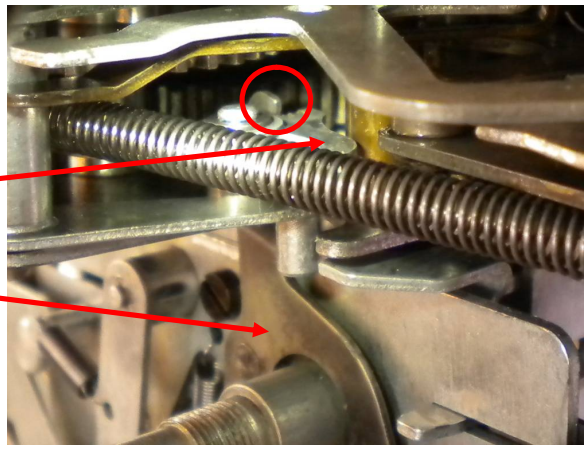


Check that countback gear wheel 12228 and multiplication star wheel assembly 10989 are engaged.

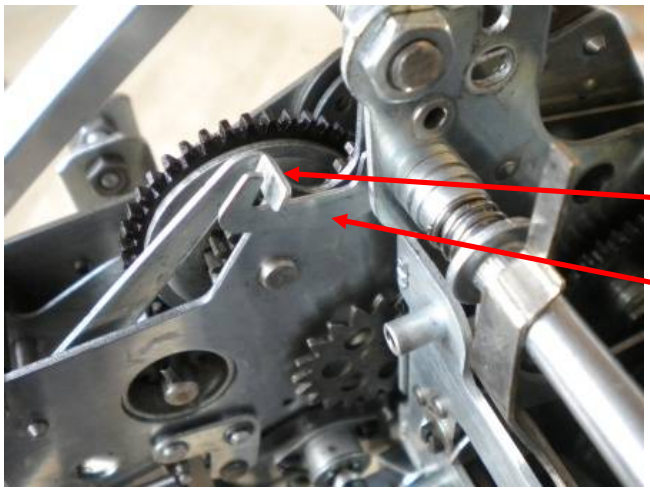




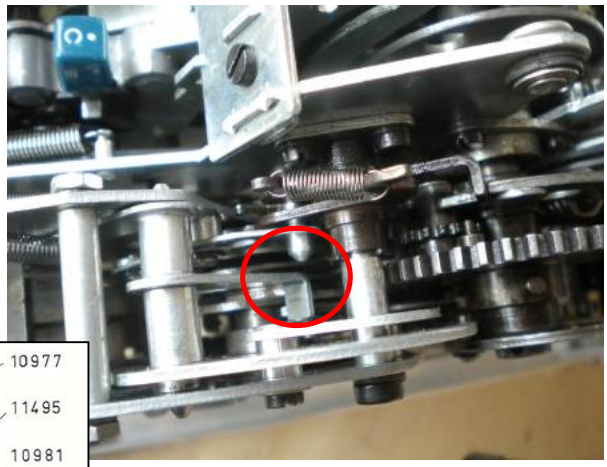
Check that calculation direction lever 12716 and counter +/- sliding link 12129 are aligned correctly.

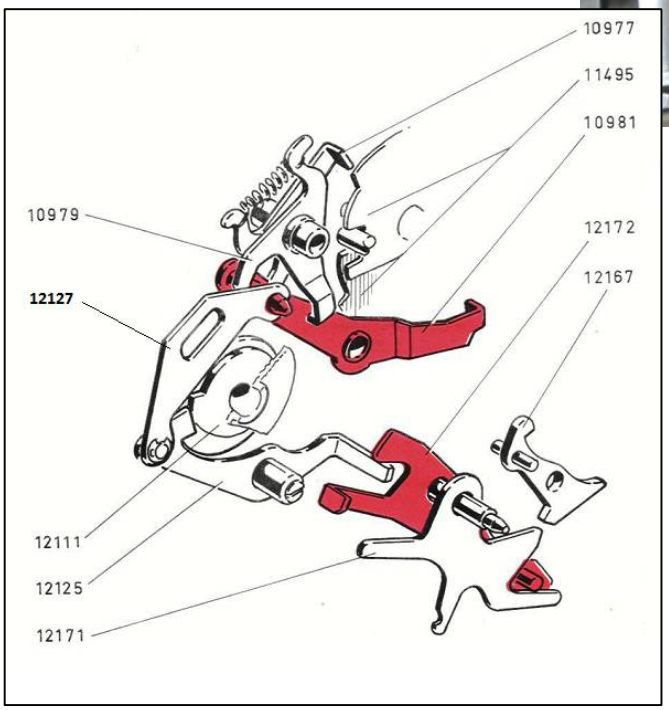


As the sub-assembly is lowered into position, check that countback end lever 12249 is hooked into the top end of stop lever 10983.



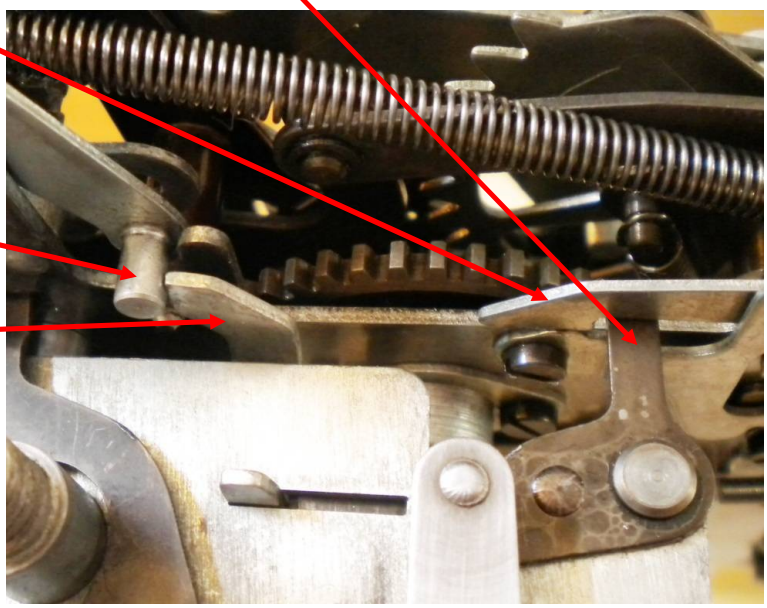
The pin on the lift lever 10981 must be located through the hole in setting register I unlock slider 12127.



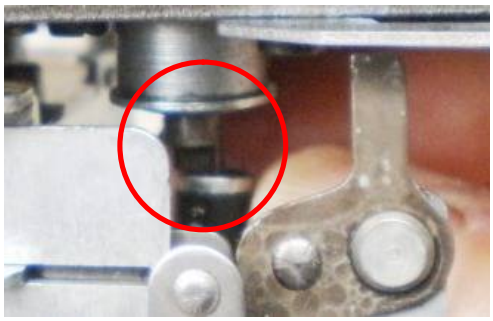


Stage hook 12247 has to hook onto swing link 12743...

...and lever 12195 should align with the end of lever 12735

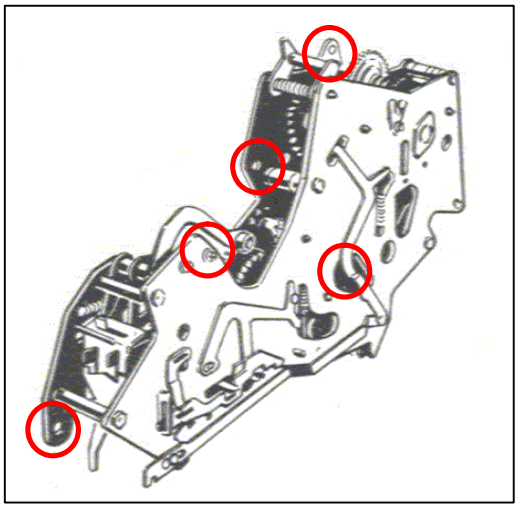


(underside view)



Finally, slot in drive shaft 12590 and fasten the unit down with 5 screws where indicated.

Do not force the unit down. When all components are correctly engaged, the unit will sit flush onto its 5 anchor points.



8 - RIGHT TRANSMISSION SUB-ASSEMBLY CAM CHECKS

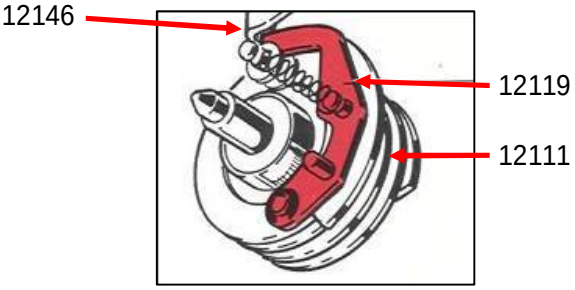
Firstly: Insert the hand-crank into drive input gear 12301 and secure. With the setting rotor locked into its zero position, all cam and gear sets in the right transmission sub-assembly should revolve freely without any inherent actions taking place when manually and continuously hand-cranked (CW - always crank CW).

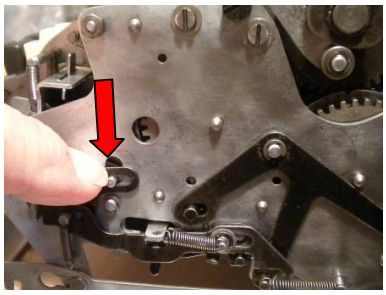
NB: There may be some initial mechanism resetting actions when initially cranking due to random tripping of various levers during the installation of this unit.

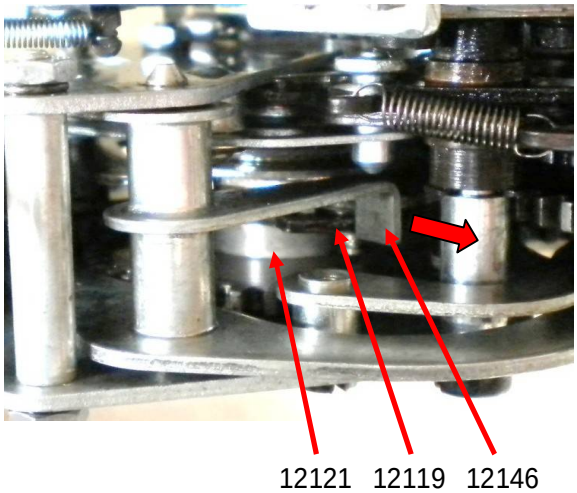
Before any adjustments are carried out, check the cam and gear sets in the right transmission sub-assembly according to the following list:

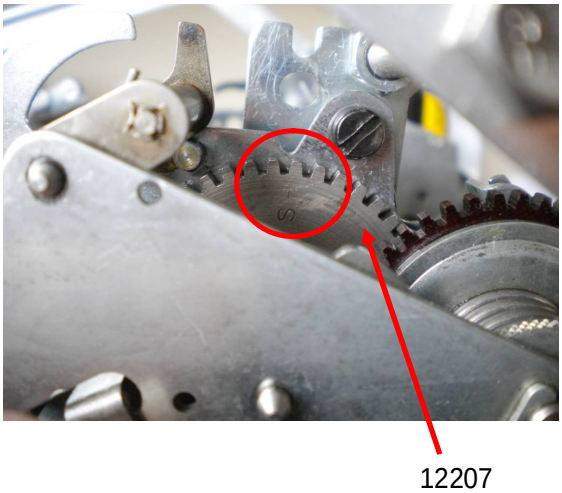
a) Start Cam Set

Manually press down on sliding link 12156 to trigger start clutch pawl 12119 on start cam set 12111 thus releasing arresting ratchet 12146.





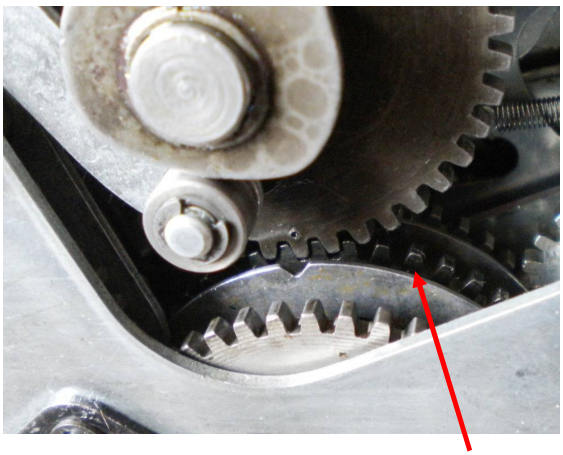




Slowly begin to hand-crank. When the start catch engages in drive wheel 12121 and starts to rotate with it, the "**S**" mark on counter register II clearing clutch gear 12207 must lie exactly opposite the flute on the side wall of the unit. Rotate the hand-crank approximately 14 more turns to reset all the mechanisms.

b) Plus and Minus Revolutions

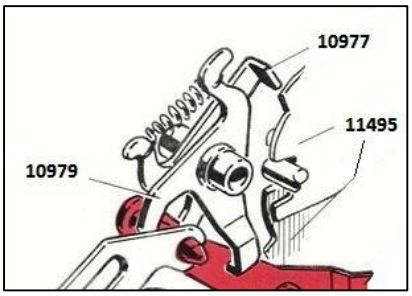
Repeat the above operation and note that, when +/- clutch drive gear 12160 begins to move, the "**+ -**" mark on register II clearing clutch gear 12207 must be positioned exactly opposite the flute in the side wall of the unit. Do this with the +/- pulldown link lever 12132 in its left and right positions as on pages 62 & 63.



12160

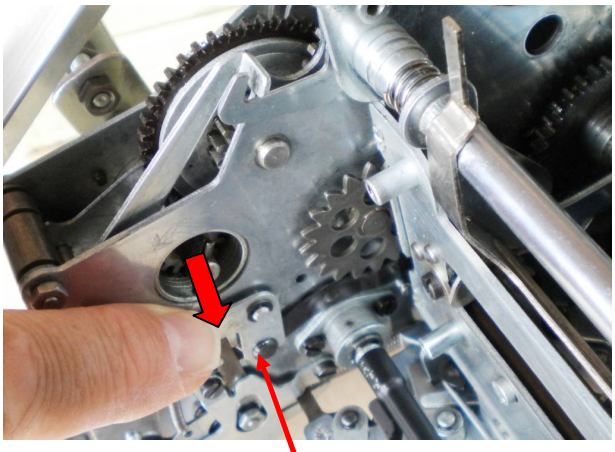
12207

During this cycle, the two rotor locking hooks 10977 & 10979 should lift out of engagement from buffer discs 11495 then later intervene back into the buffer discs to stop the setting rotor in its starting position.

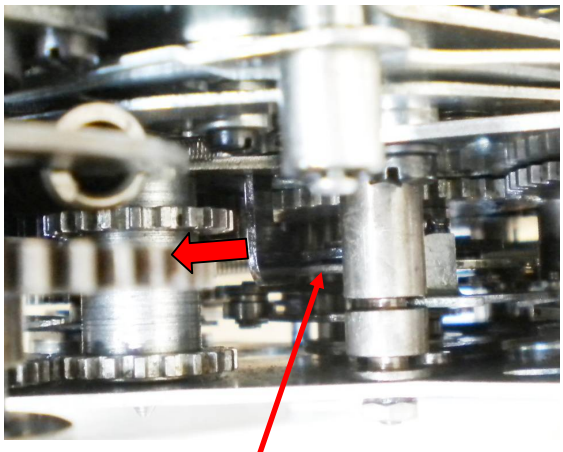


c) Multiplication Cam Set

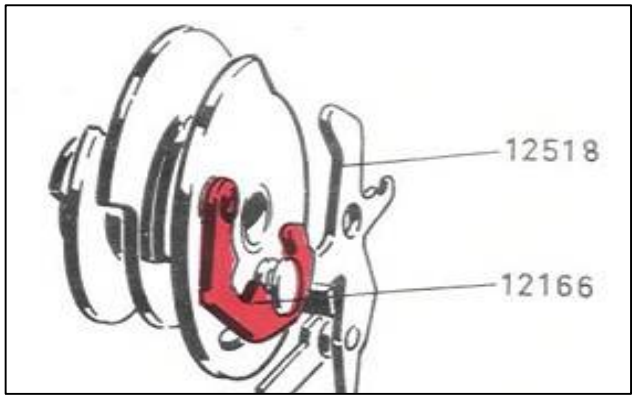
Trigger the start catch for multiplication countback cam set 12201.



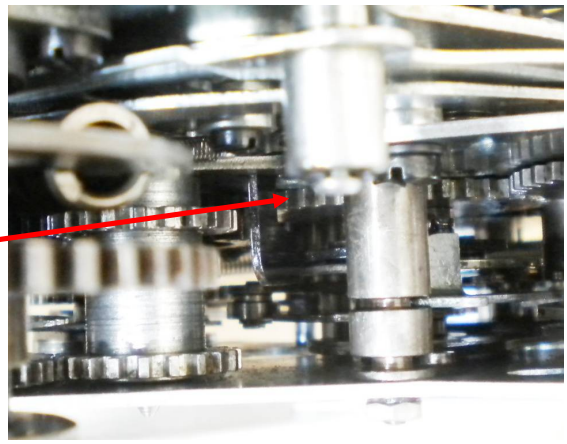
Use double lever 12244 as a trigger

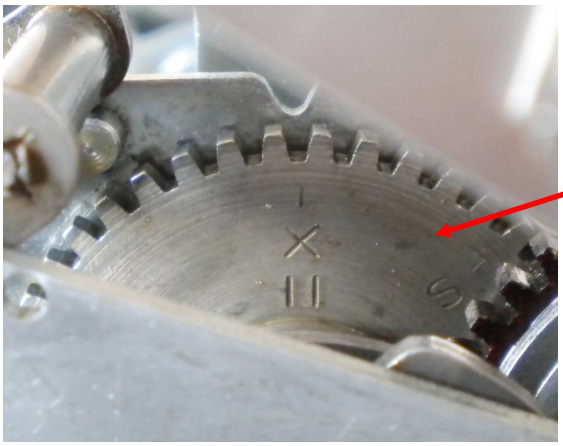


12201

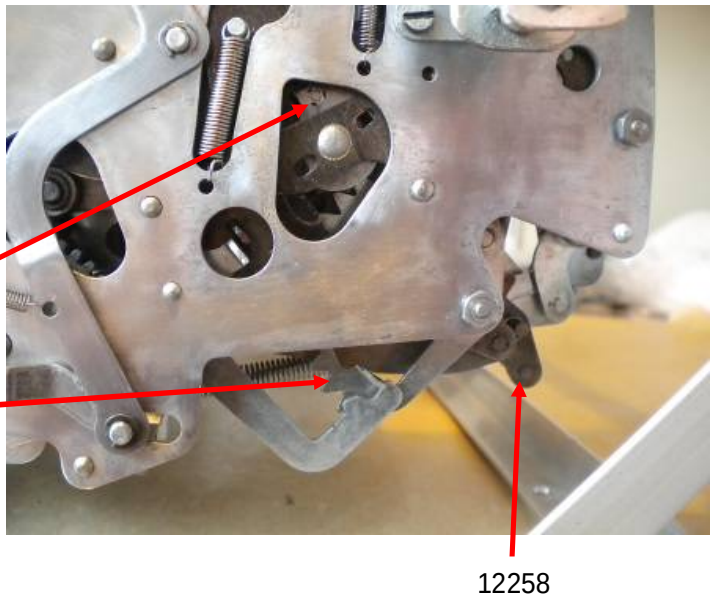


When start pawl 12166 engages in drive gear wheel 12199, the "**x =**" mark on counter register II clearing clutch gear 12207 must be positioned exactly opposite the flute in the side wall of the unit.



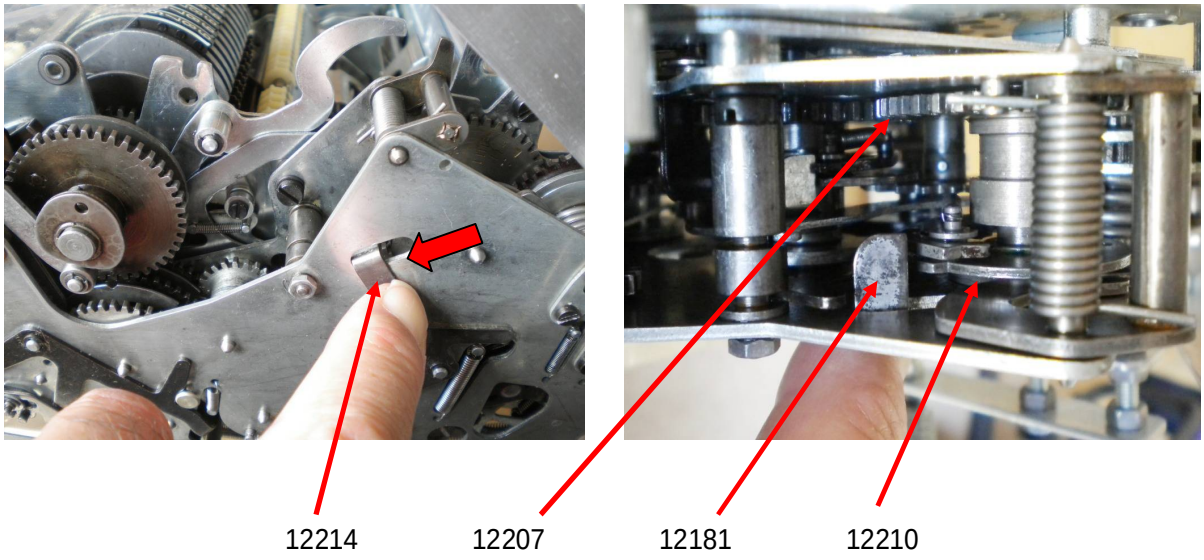


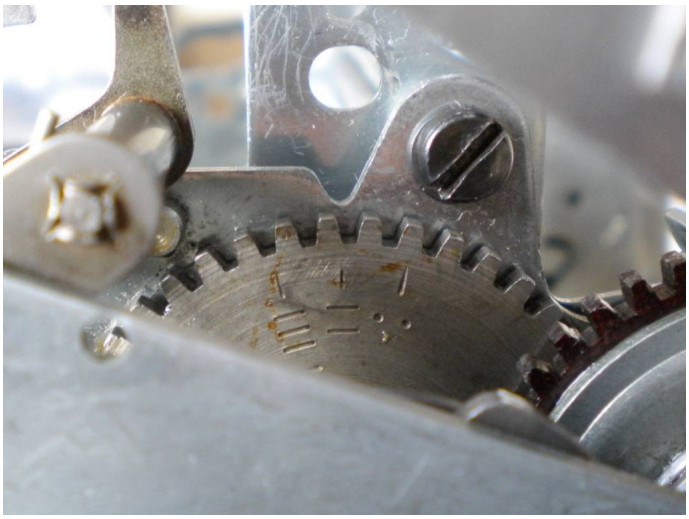
Observe the free movement of quadrant gear 12262, countback transfer gear 12256 and feeler shaft rocker lever 12258. Hand-crank 7 turns to reset the mechanisms.



d) Counter Register II Clearing Cam Set

Move counter register II clearing clutch lever 12214 to trigger the start pawl 12181 for counter register II clearing cam set 12210 and hand-crank until the start catch engages in counter register II clearing clutch gear 12207 and begins to turn the cam set. In this position, the "**II**" mark on counter register II clearing clutch gear 12207 must lie exactly opposite the flute in the side wall of the unit.

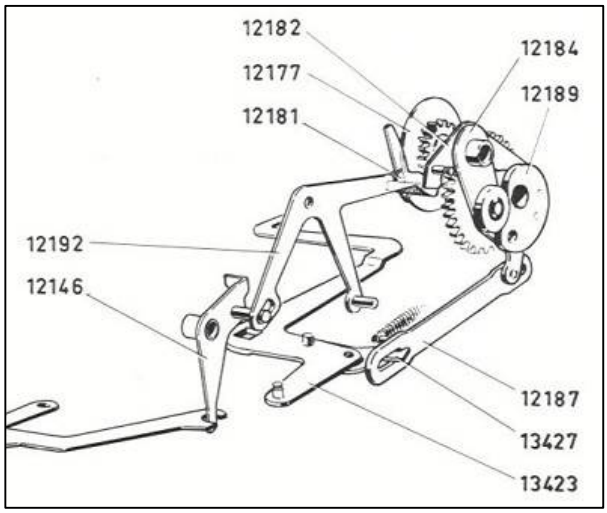


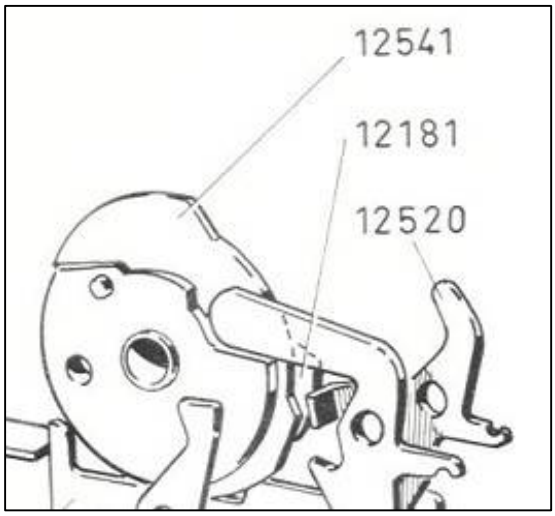


Hand-crank a further 7 turns to reset the mechanisms and ensure that counter register II clearing clutch lever 12214 has returned to its initial position.

e) Setting Register I Clear/Return Cam Set

Trigger the start pawl 12181 on setting register I clear/return cam 12177 by pressing down rotor clearing clutch lever 12192, then slowly hand-crank until rotor clear/return cam 12189 starts to move.





When rotor clear/return cam 12189 starts to move, the "**III**" and "**I**" markings on counter register II clearing clutch gear 12207 must be positioned exactly opposite the flute in the side wall of the unit.

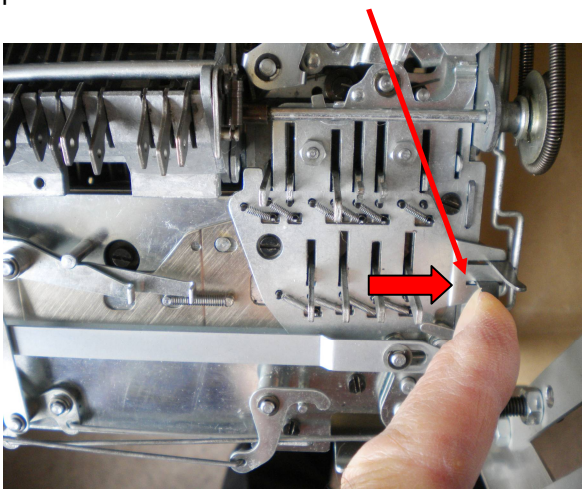
Restrain setting rotor clear/return link 12187 from dropping out of engagement with rotor clear/return arm 12184 whilst this operation in progress.

Crank a further 14 turns to reset the mechanism and ensure that rotor clearing clutch lever 12192 has returned to its initial position and roller 10235 and arm 12184 are pulled fully towards the back of the unit by means of return spring 1516-67.

9 - MODULE ADJUSTMENTS - 2

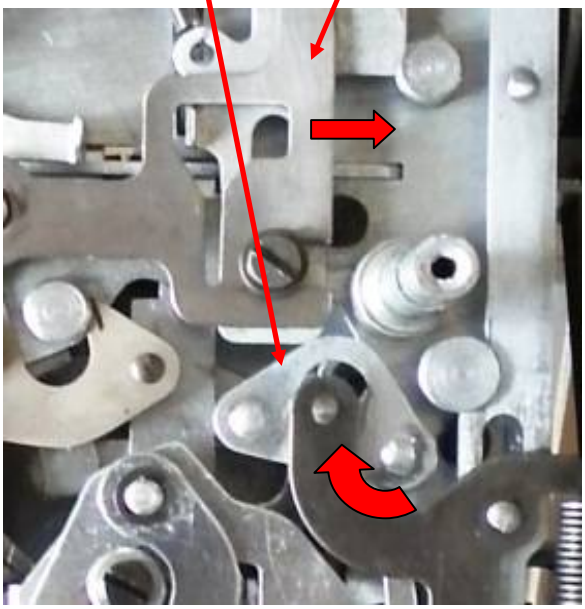
As an aid to the following operations, ensure that the mechanisms shown here are in their correct positions prior to any adjustment procedures being carried out:

Release any keys by moving keystem latch release plate 11298 with drive lever 11099.

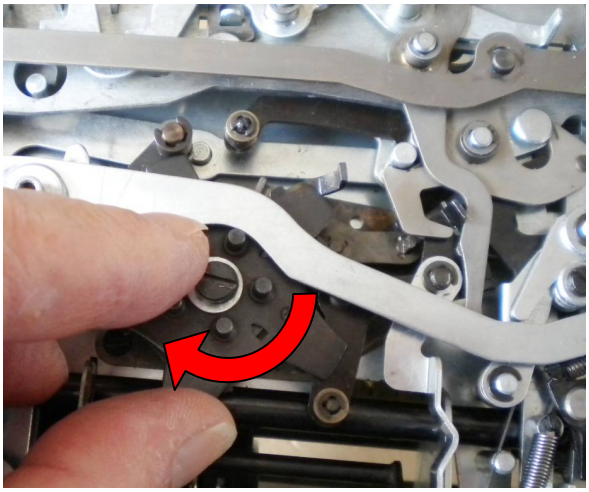


Ensure that switch plate toggle 11306 is in the position shown.

Quotient-switch carriage 12741 is fully right. Total carriage 12991 is CW.



Wind up escapement wheel 10955 CW to position the setting rotor into its rightmost position.



Underside of machine with front nearmost.

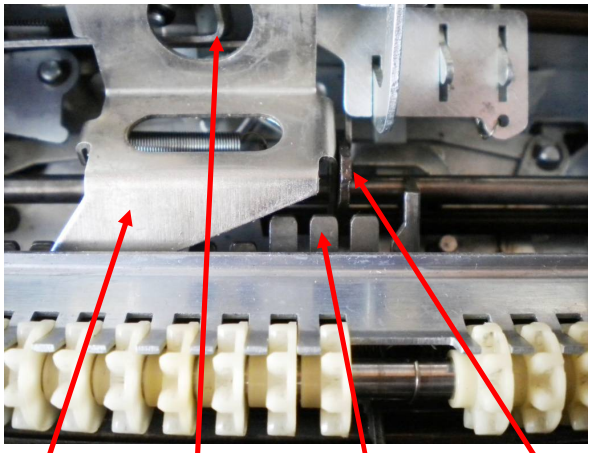
Quotient Switch Coupling Position

Key in ten zeroes and check that quotient switch coupling 10788-2 is positioned exactly opposite the flute in the rotor carriage 10997. Check at the same time that changeover sliding plate 13008 doesn't obstruct the movement. Quotient coupling indicator 10795 must lie against eccentric 10814 whilst this operation is carried out.

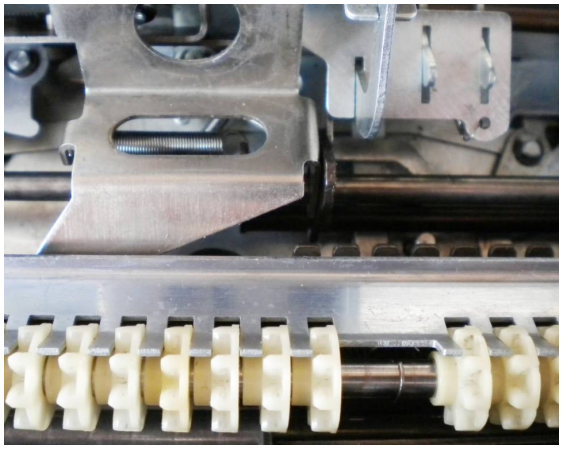
Also carry out these checks with one keyed in zero.

Position of quotient switch coupling 10788-2

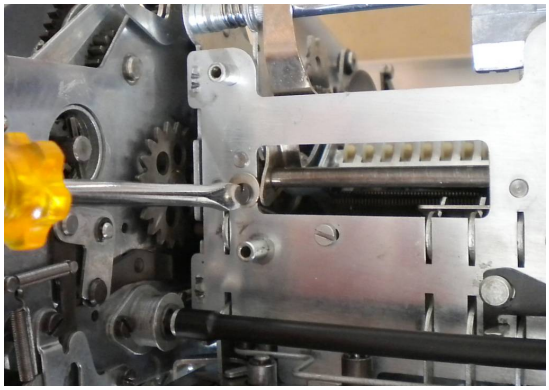
...with 10 keyed-in zeros.

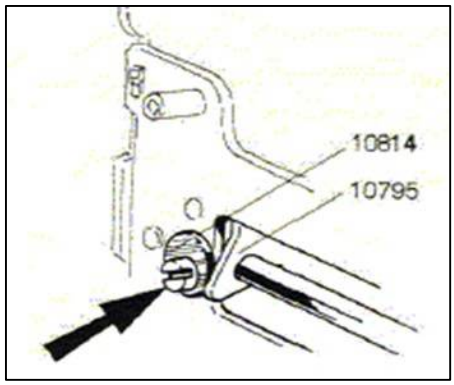


...with one keyed-in zero.



Adjustment is carried out with eccentric 10814.

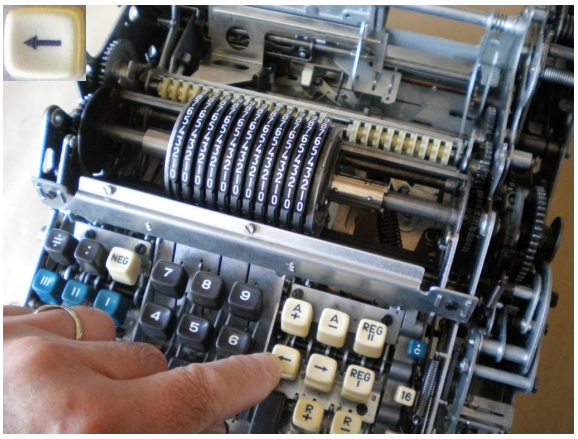




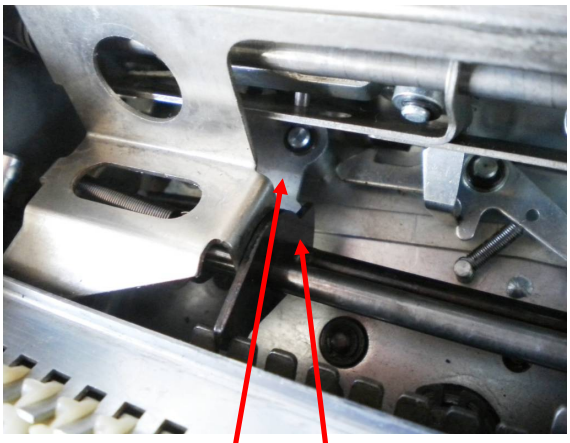
Outer Escapement Hook Clearance

Position the setting register's rotor as on page 82. Key in one zero to engage quotient switch coupling 10788-2 with the first flute of rotor carriage 10997.

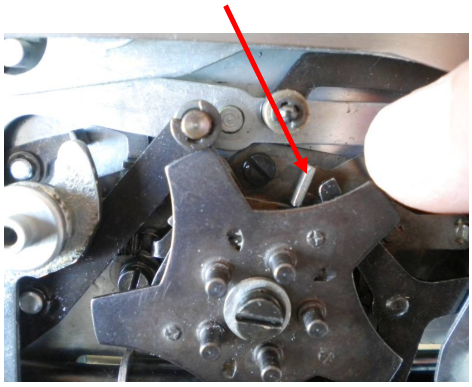
(*) Operate the "←" key whilst cranking
The rotor will step left. Crank a further 3 turns.

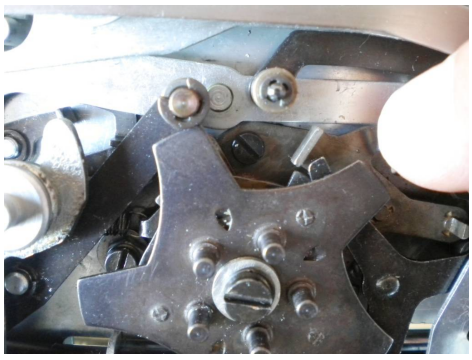


Repeat from (*) until quotient switch coupling 10788-2 is stopped at arrester 10775.

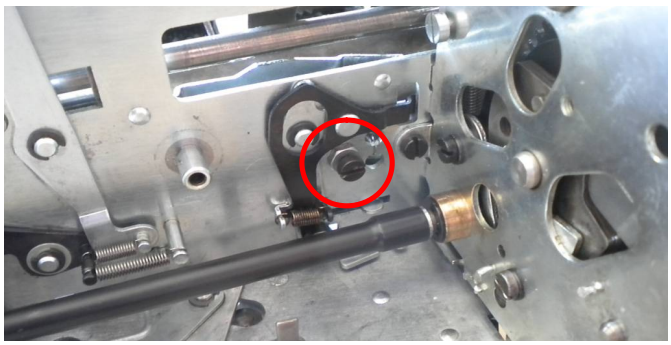


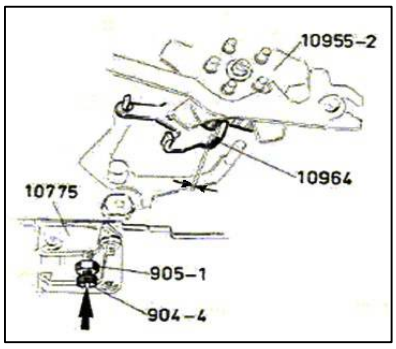
Check that in this position the outer escapement hook 10964 has the smallest possible clearance on the block disc of escapement wheel 10955. It should be possible to just feel a very slight scraping when outer escapement hook 10964 is moved.





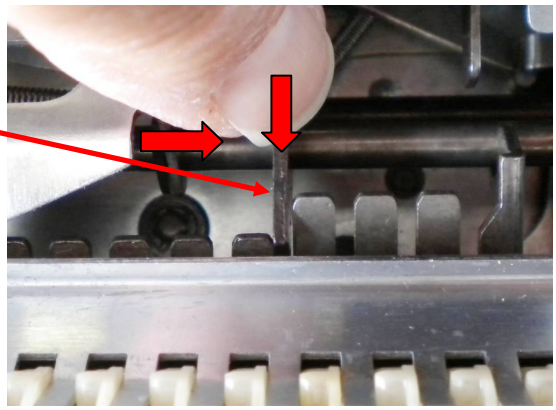
Adjustment is carried out with screw 904-4 and nut 905-1, which sets the position of arrester 10775.



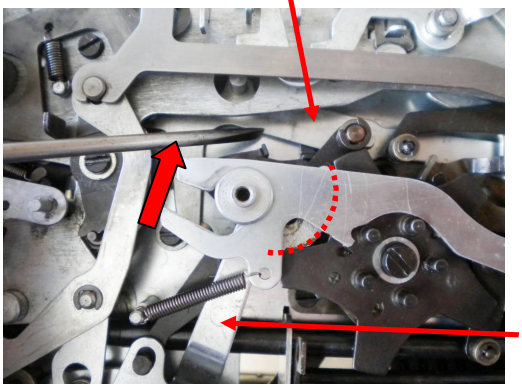


Orientation Lever Alignment

Position the setting rotor as on page 82. Move the setting rotor to position 8 by keying in 8 zeros then guide quotient switch coupling 10788-2 into the flute in rotor carriage 10997.



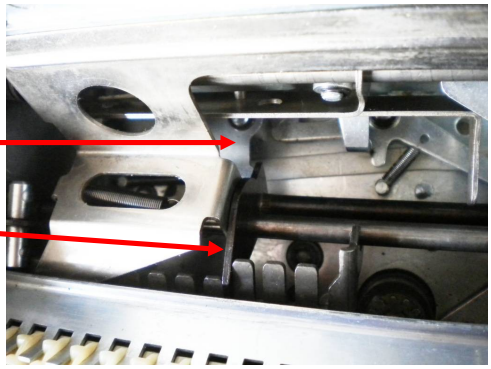
12904



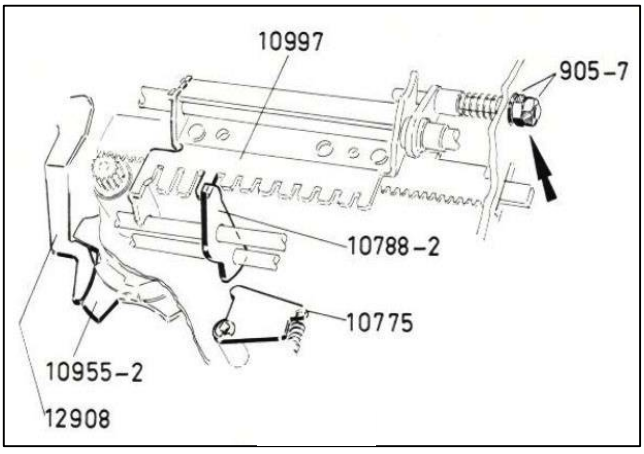
Manually swivel escapement release lever 12904 whilst restraining escapement wheel 10955 (or the setting rotor will try to fly left).

Let the setting rotor settle to its leftmost 16th position. Check that in this position, orientation lever 12908 comes into as good a position as possible in relation to escapement wheel 10955.

12908



At the same time ensure that arrester 10775 doesn't obstruct the complete activation of quotient switch coupling 10788-2.

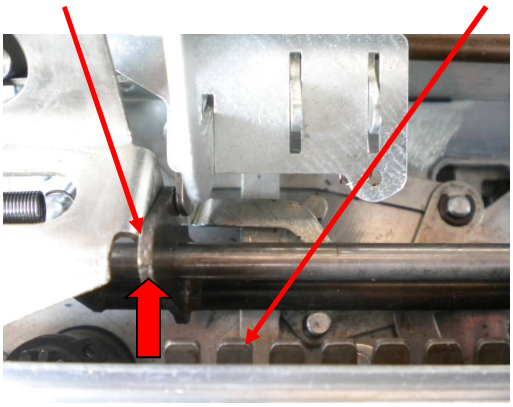


Set the stop-position of the rotor with the 2 lock nuts 905-7.

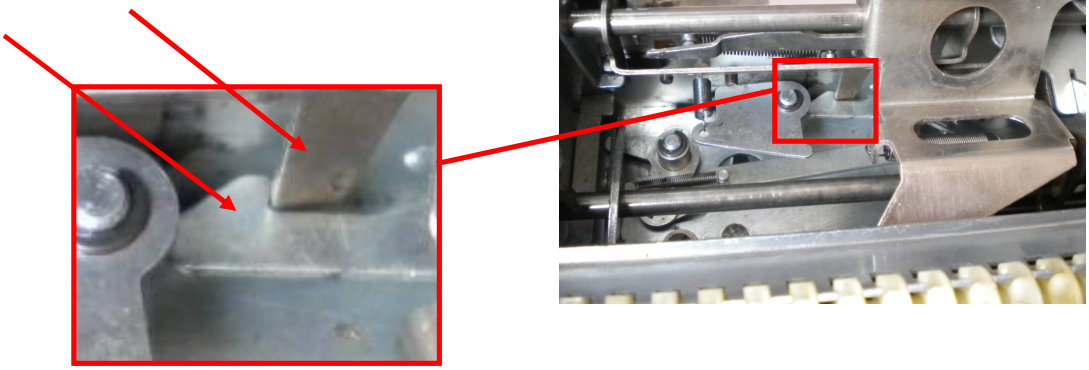
Changeover Sliding Plate Latching

Perform all the reset operations as shown on page 82.

Ensure quotient switch coupling 10788-2 is disengaged from rotor carriage 10997.

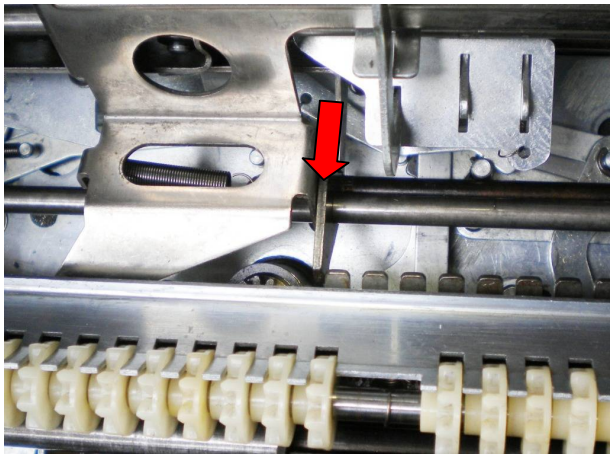


With the setting rotor at the right, changeover sliding plate 13008 will be latched by hooked lever 13011.



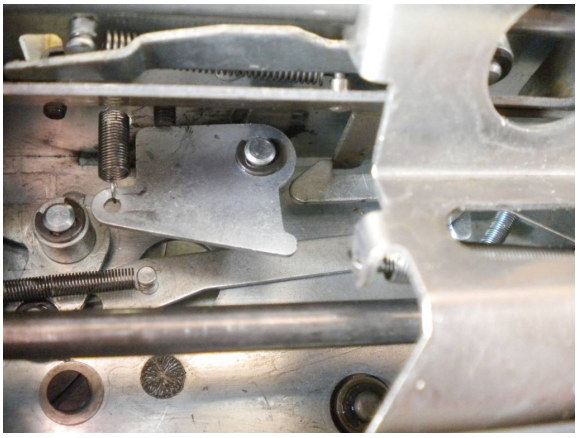
Press the "←" key whilst slowly cranking.

Quotient switch coupling 10788-2 will slowly come into engagement with rotor carriage 10997.

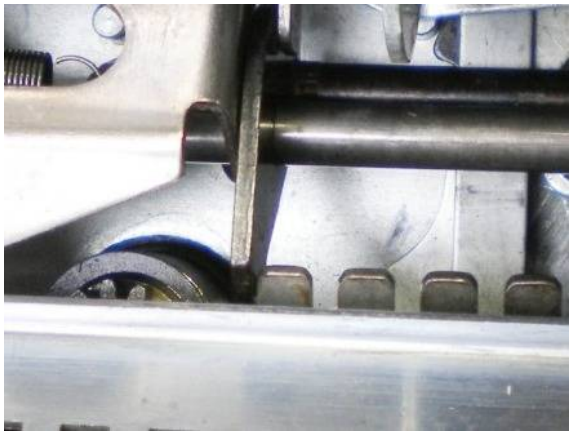


Check that changeover sliding plate 13008 isn't unlatched (1) by hooked lever 13011 before quotient switch coupling 10788-2 has firmly engaged (2) in the short toothed row on rotor carriage 10997. Later in the cycle, changeover sliding plate 13008 will then be unlatched (3) by hooked lever 13011.

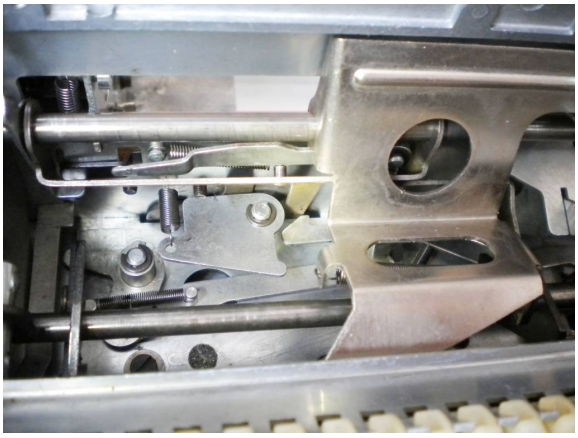
(1)



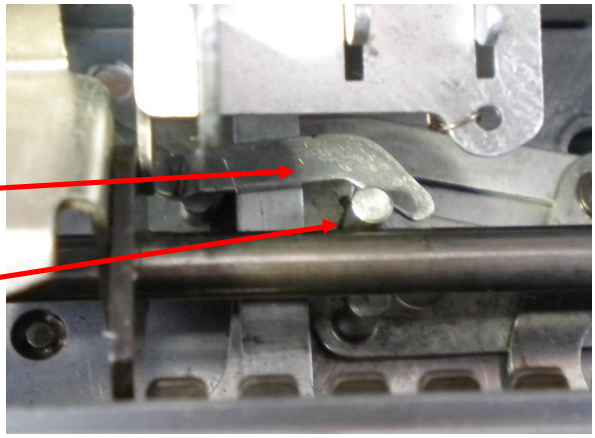
(2)



(3)



Adjustment is carried out by bending the part of hooked lever 13011 which touches on quotient coupling set lever 11016.

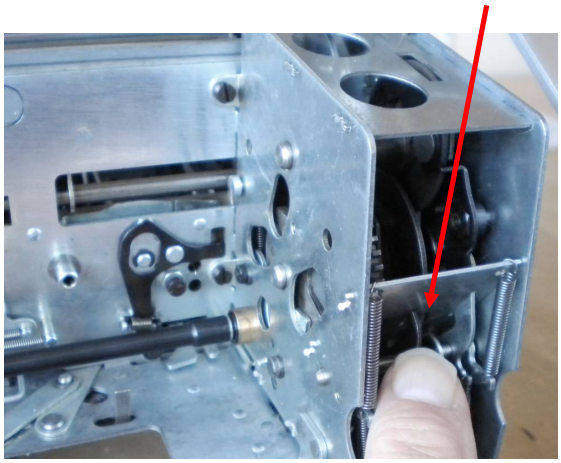


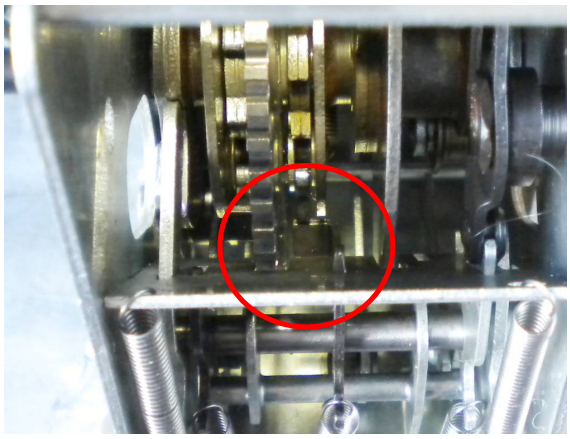
Release quotient switch coupling 10788-2 out of engagement with rotor carriage 10997.

Back Transfer Sub-Assembly Lift And Engagement

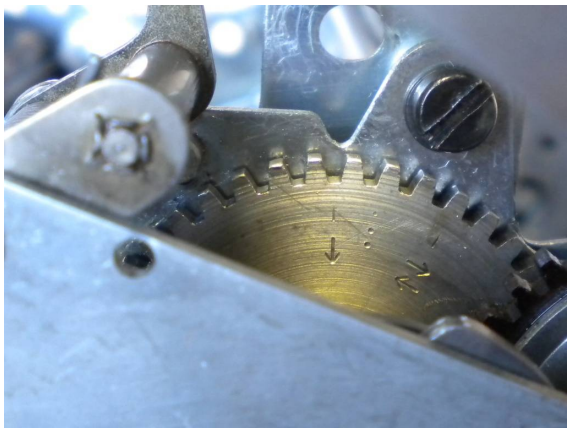
Perform all the reset operations as shown on page 82.

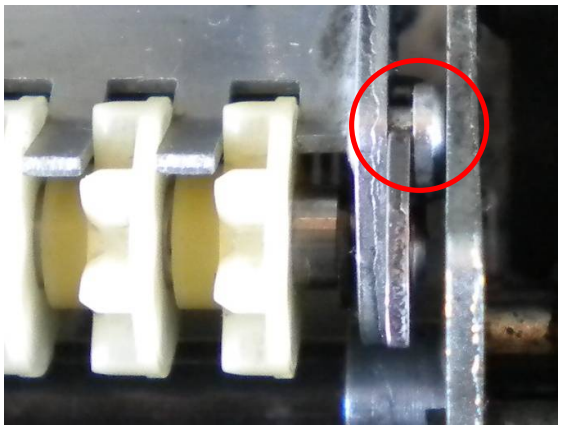
Trigger the division setup clutch trip lever 12520 for back transfer cam & clutch 12554.





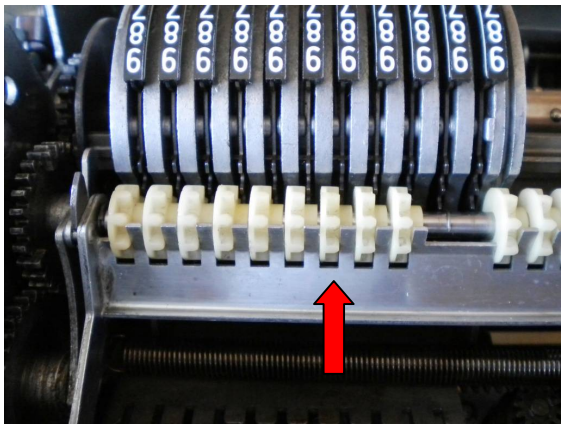
Hand-crank the machine until the back transfer sub-assembly begins to lift. Marking "↓" on counter register II clearing clutch gear 12207 should now be exactly opposite the flute in the side wall of the unit. If the marking isn't correct, a drive wheel has been installed incorrectly.

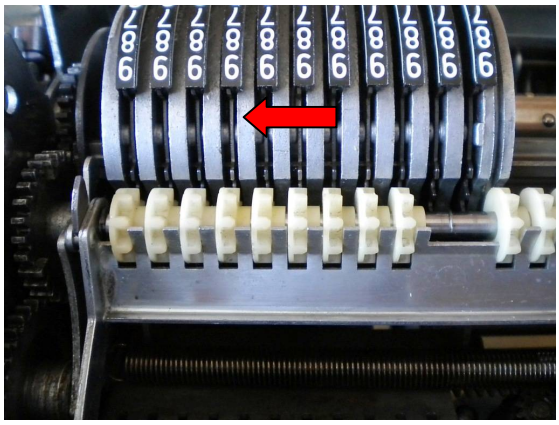


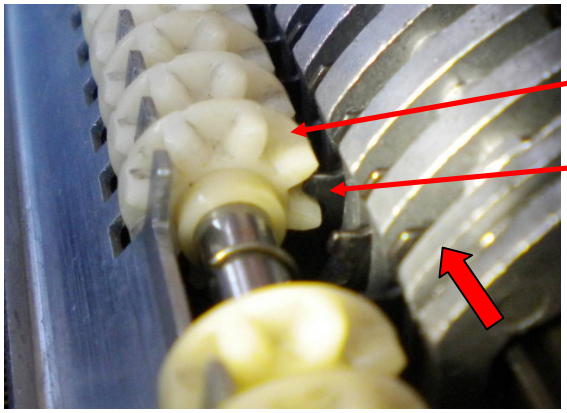


NB: It is most important that the back transfer sub-assembly moves very easily and that it passes the right guide panel with the smallest possible clearance without grinding on the panel.

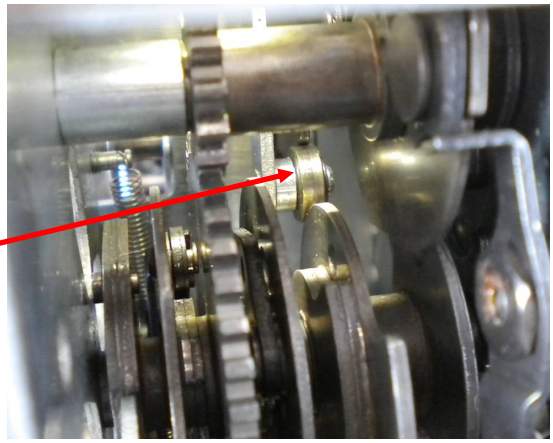
The lift movement of the back transfer sub-assembly must be set in such a way that the back transfer gears 10731 and setting discs 11461 can engage freely.





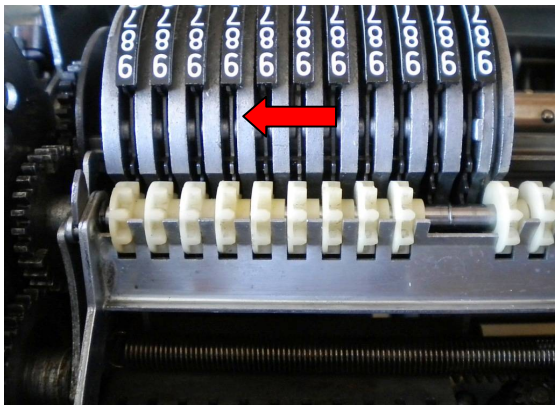


Adjustment is carried out by exchanging roller 10235 for one of smaller or larger diameter.



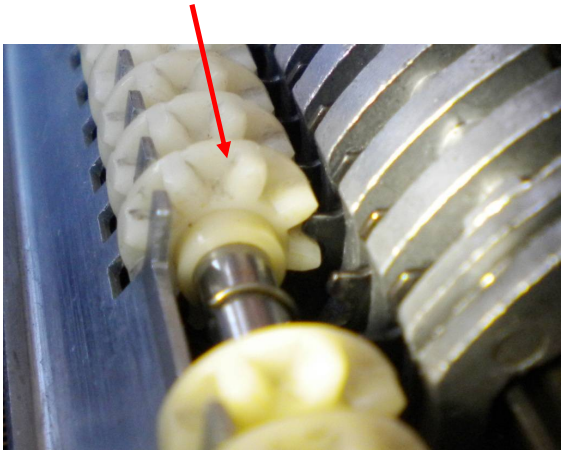
After the back transfer sub-assembly has dropped, continue hand-cranking a further 11 turns to reset the mechanism.

Trigger the back transfer sub-assembly once more with trip lever 12520 and hand-crank until the setting rotor starts to carry out the right-step movement.



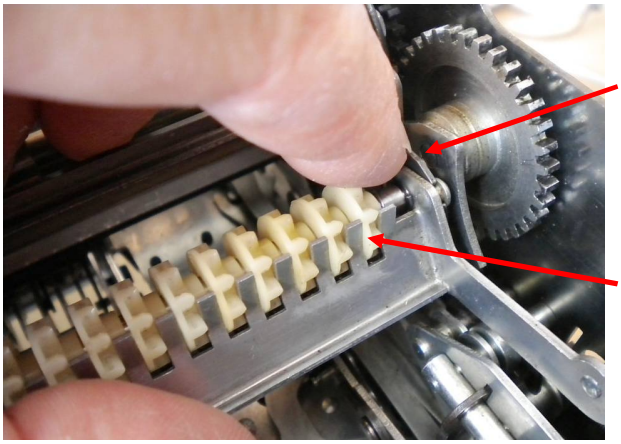
(looking from rear of machine)

10731



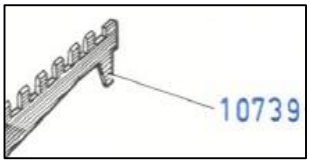
During this part of the operation, firstly check that the back transfer gears 10731 aren't turned when they engage in the setting discs and, secondly, that the right step of the setting rotor is sufficient to enable adequate intermeshing of the teeth on both gear wheels from the side.

Continue to crank as before until the setting discs are released.



Manually raise the back transfer sub-assembly slightly then press the 2 lock release levers 10742 to free the back transfer gears 10731. Now check that all back transfer gears can move very easily.

Afterwards, when the lock release levers 10742 are released, check that all back transfer gears 10731 are captured and restrained from rotating by locking bar 10739.

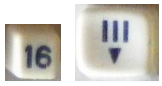


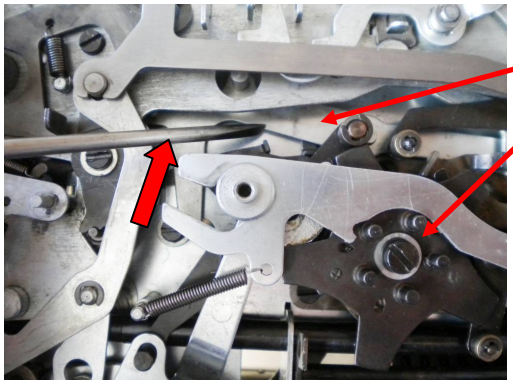
Division Setup Clutch Triggering

This next check is to verify that the division setup clutch trip lever 12520 for back transfer cam & clutch 12554 will definitely be triggered automatically. This check is to be carried out only after the procedures outlined in the preceding pages above have been completed.

1) Move the setting rotor to a centre position to gain access to intermediate lever 11014.

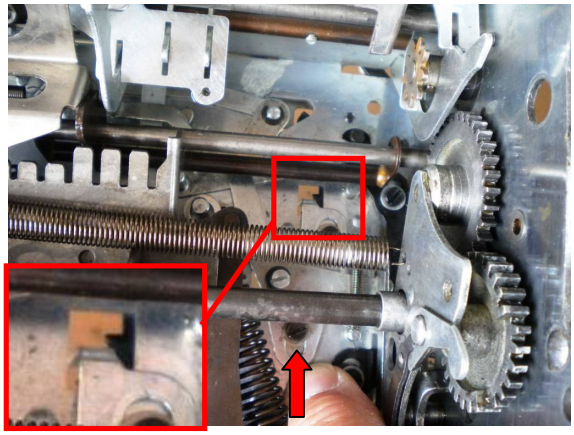
2) Depress key "16" and then key "IIIv".





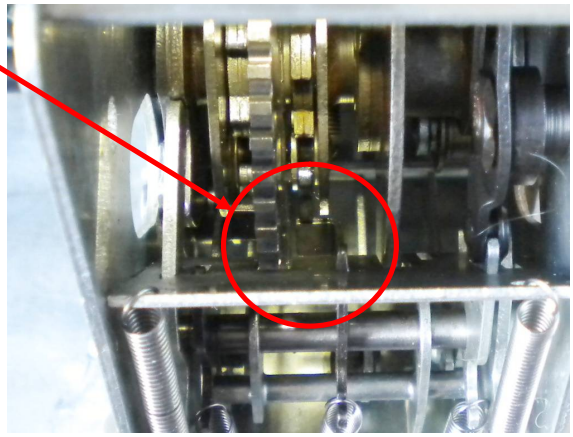
3) Manually swivel escapement release lever 12904 whilst restraining escapement wheel 10955 (or the setting rotor will try to fly left).

4) Continue to hold the escapement wheel and next push back intermediate lever 11014 by hand until it locks into its rearmost position.

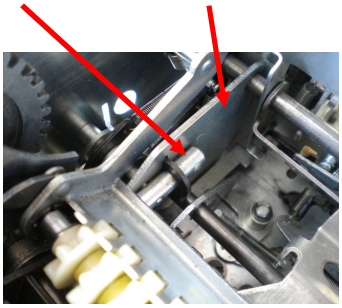


5) Release escapement wheel 10955 and let the setting rotor fly fully left.

6) Now check that trip lever 12520 was triggered.



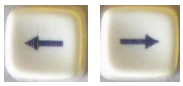
Adjustment is carried out by putting discs between shaft 10626-1 and panel 10619.

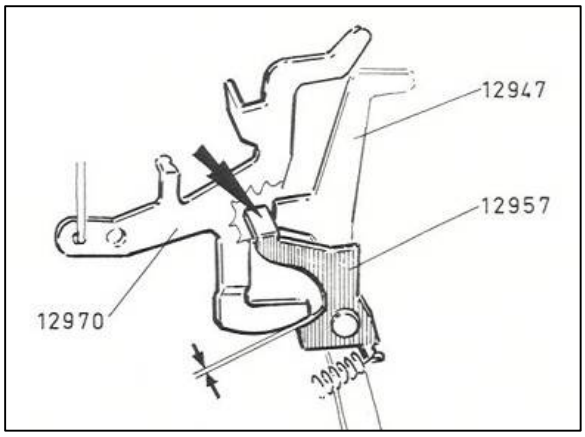


Reset the keys and manually crank the mechanisms and put the setting rotor fully right.

Indent Hook Clearance

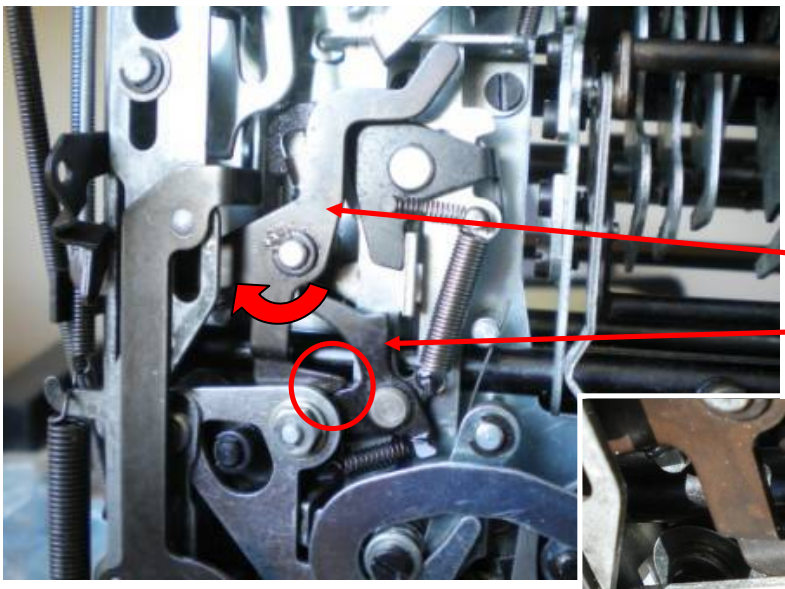
When the setting rotor sits in its last position after the last right step, there must be some clearance between the curve at the bottom of right shift linkage lever 12970 and indent hook 12957. This is most easily checked by carrying out a left step and then a right step by pressing the "←" key then the "→" key (whilst hand-cranking).



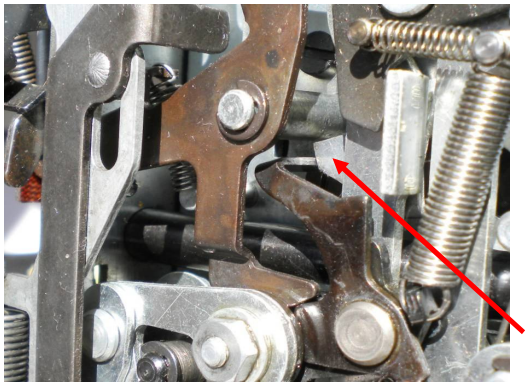


Reset all keys by moving keystem latch release plate 11298 with drive lever 11099. Ensure that switch plate toggle 11306 is in its rightmost position.

(underside view with back of machine nearmost)



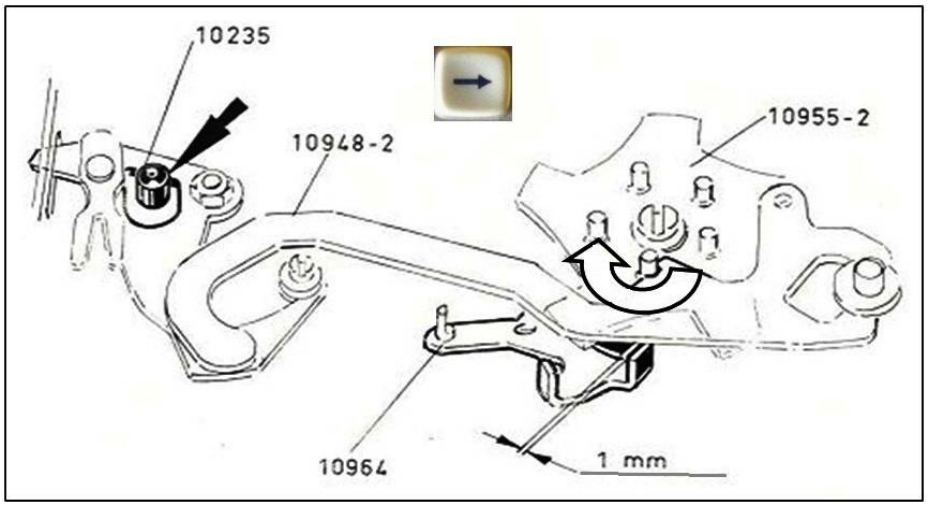
Press the right step key. As soon as it is let go, right shift linkage lever 12970 must be able to pass the angle on indent hook 12957 without touching it.

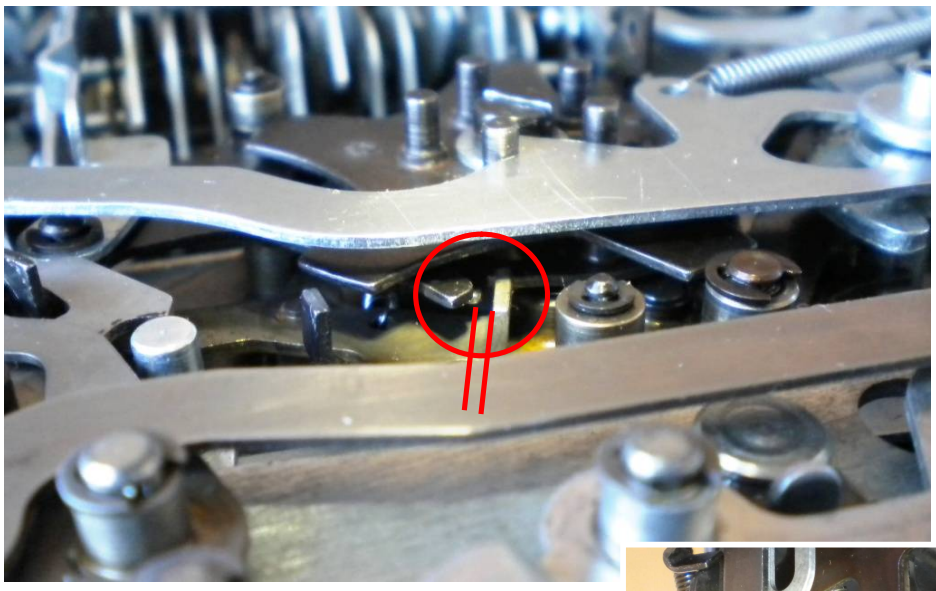


Adjustment is carried out by carefully bending the angle on indent hook 12957, which, in this position, rests on changeover lever 12947.

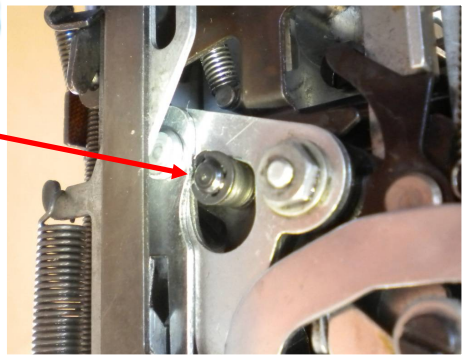
Right Step Link Operation

Carry out a few left step movements by pressing the "←" key (and cranking) then trigger the right step movement once by pressing the "→" key and slowly crank to check that right step link 10948-2 sufficiently turns escapement wheel 10955. The ratchet teeth on escapement wheel 10955 should pass by the outer escapement hook 10964 with 1 mm clearance before the escapement wheel settles back.





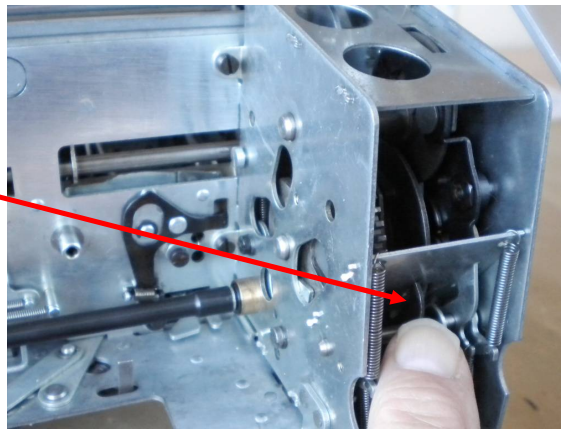
Adjustment is carried out by exchanging roller 10235 on drive lever 12953 with one of larger or smaller diameter.



As previously, after each of these checks and adjustments, reset the keys, manually crank the mechanisms and put the setting rotor fully right.

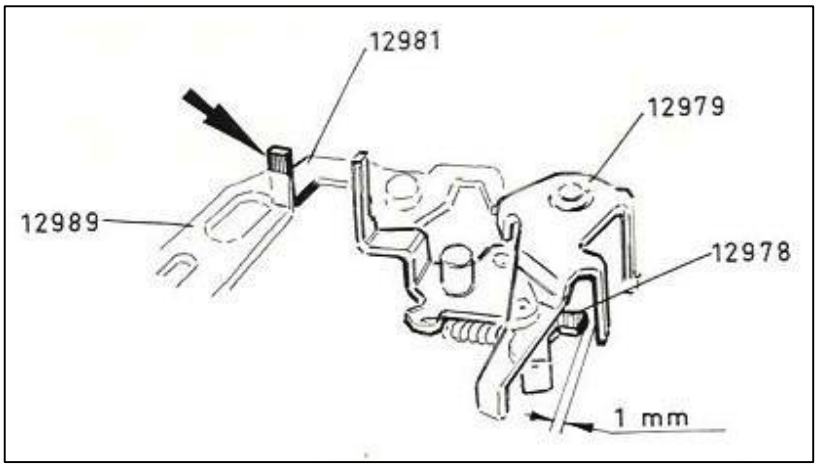
Swing Link Activation

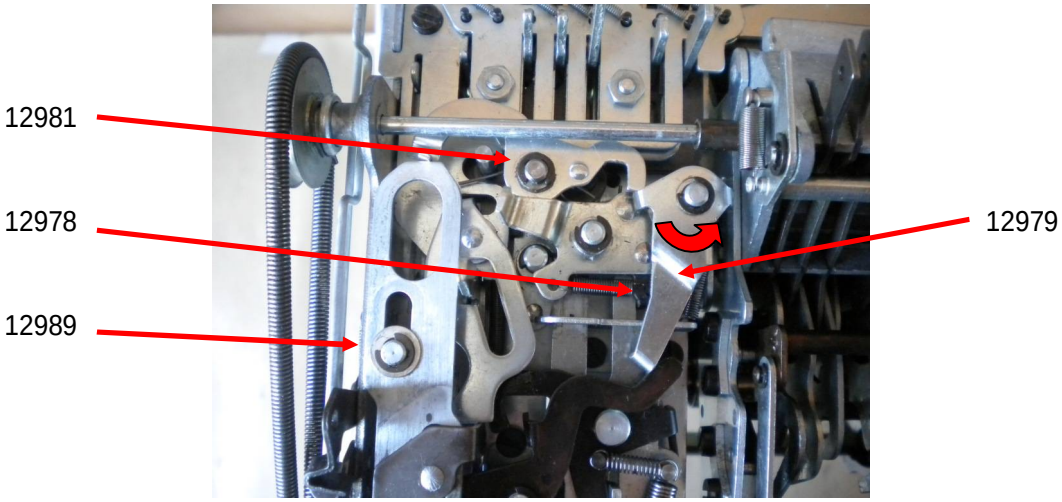
Press key "IIIv" then trigger the division setup clutch trip lever 12520 for back transfer cam & clutch 12554.

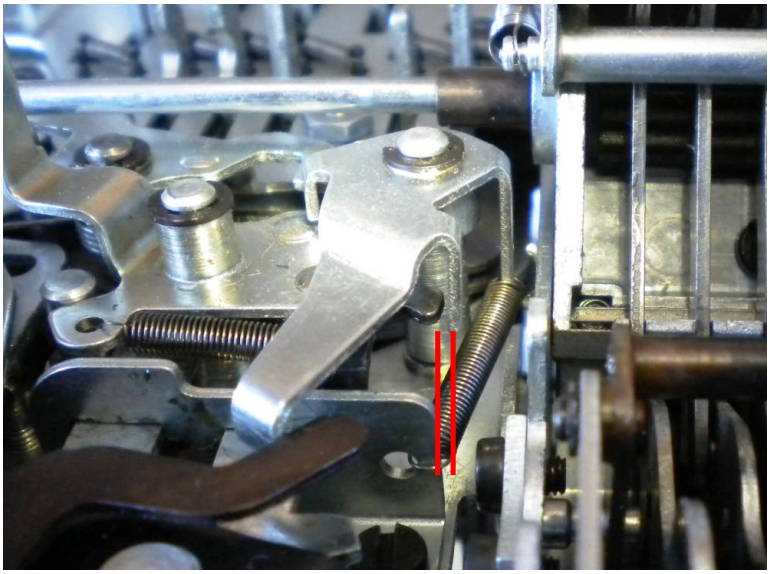


Manually crank until lever 12531 in the left transmission sub-assembly impacts on start carriage 12989.

Now, further crank to check that the movement is transferred via swing link 12981 to indent part 12979.





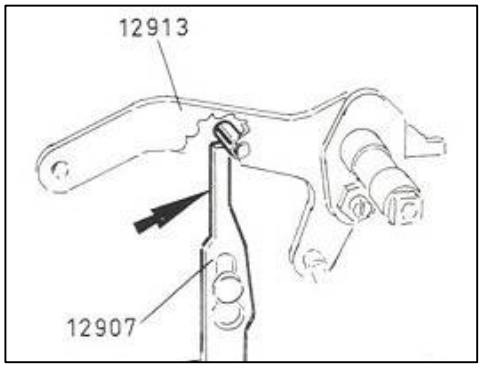


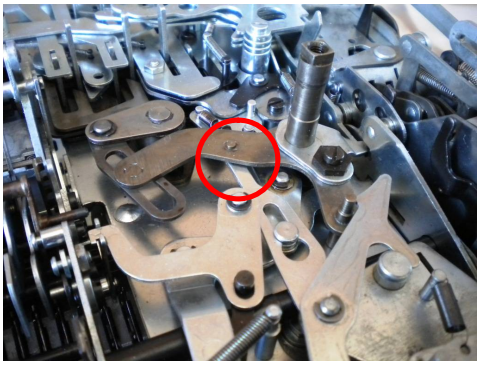
When indent part 12979 first comes to rest, check that the previous movement is sufficient to result in a clearance of 1 mm between parts 12979 and hook 12978.

Adjustment is carried out by bending the angle on swing link 12981 as indicated by the arrow in the diagram on the previous page.

Continue to hand-crank to reset the mechanisms.

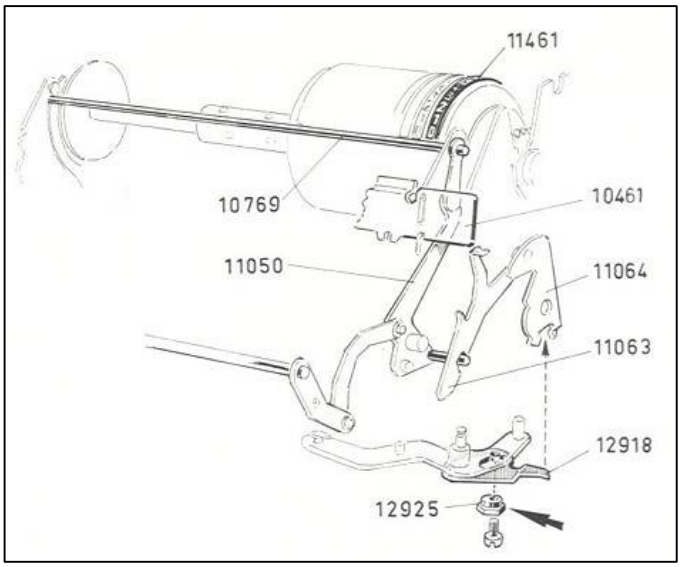
Also, on pressing down key "IIIv", check that sliding link 12907 securely engages with the pin on rotor return/clear lever 12913. Adjustment is carried out by bending sliding link 12907.

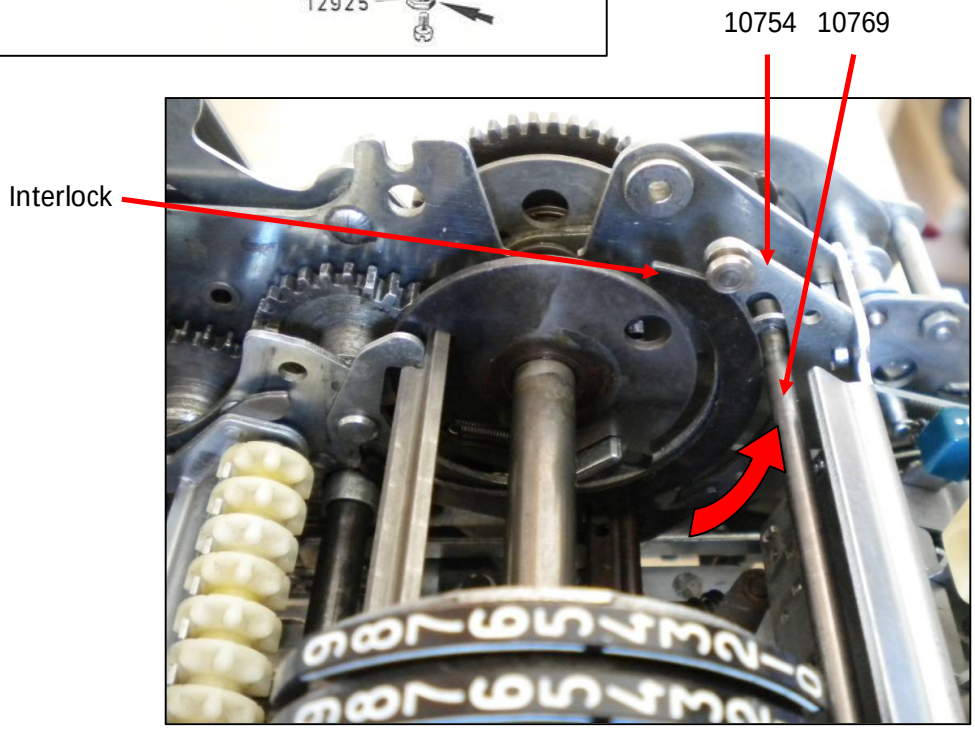




Rotor Clearing Bail Movement

As a cursory check, ensure the free movement of rotor clearing bail 10769 by first moving the 2 interlocks on side plates 10754 & 10755. In addition, check that lever 11050 doesn't knock against support 10461.



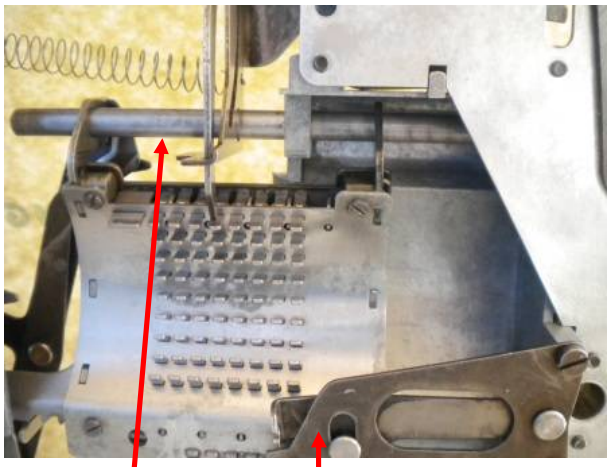


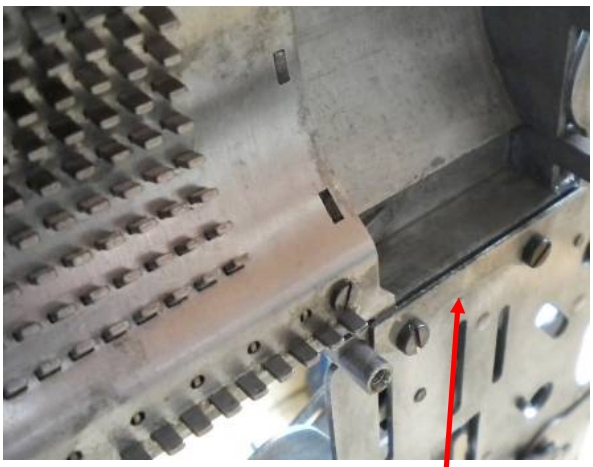
10 - PINBOX AND FEELER FUNCTIONALITY CHECKS ON THE BOTTOM SUB-ASSEMBLY

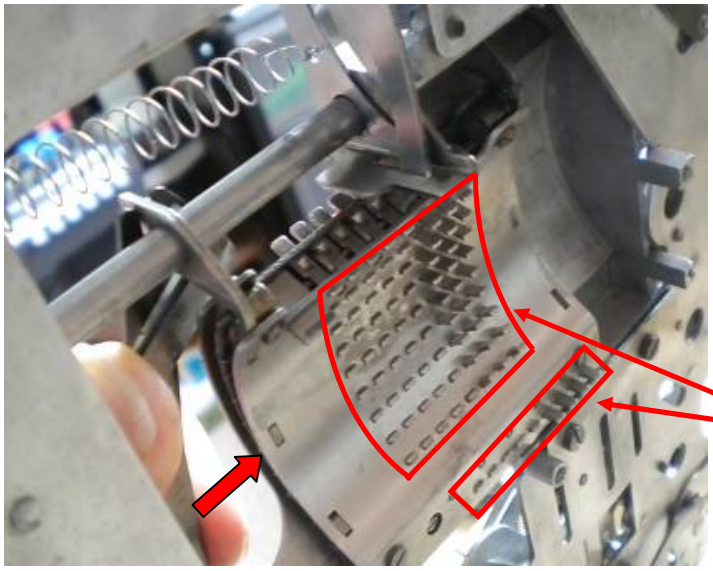
These next checks are to verify the correct functionality of the pinbox assembly 13206, its pins 13225, pinbox housing 13205, pinbox escapement assembly 13230, feeler carriage 13241, pinbox feeler lever 13246, feeler escapement holder 13250 and feeler escapement pins 13251.

Firstly, fabricate a temporary right-angled mount such that the bottom sub-assembly is held in a vertical plane. This ensures that pinbox assembly 13206 and feeler carriage 13241 are able to move laterally without putting any undue strain or otherwise on pinbox return spring 1516-79 or feeler carriage return spring 10216-26 due to the weight of the moving parts.

Remove pinbox escapement assembly 13230 then make sure that the pinbox assembly can easily slide back and forth and is not restricted by pinbox mounting shaft 13265 or pinbox retainer plate 13239.

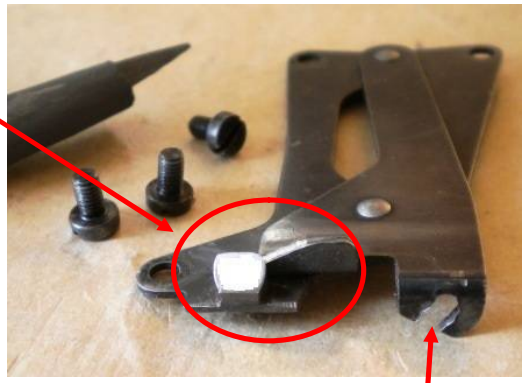


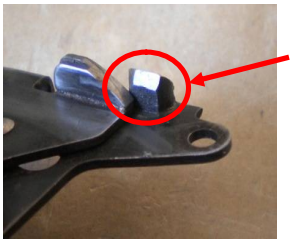




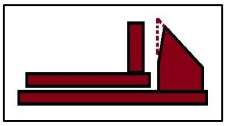
Slide the pinbox assembly out of its housing (to the left in this photograph) then manually push the pins 13225 so that they protrude out from the convex side of the assembly. Check the resetting actions of the pinbox pins as the assembly is manually moved back into the pinbox housing. There should be very little force required to carry out this action.

The two angled faces on the ratchets of the pinbox escapement assembly 13230 should be very clean and smooth. If not, bring these faces to a mirror finish with fine emery paper. This will ensure little friction when resetting the pinbox escapement pins.



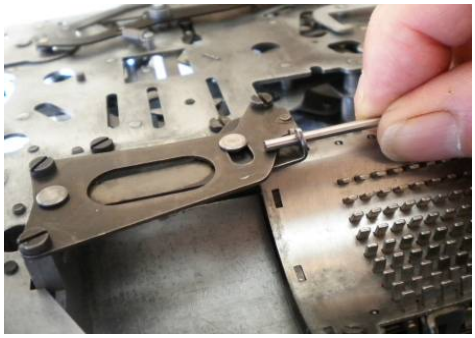


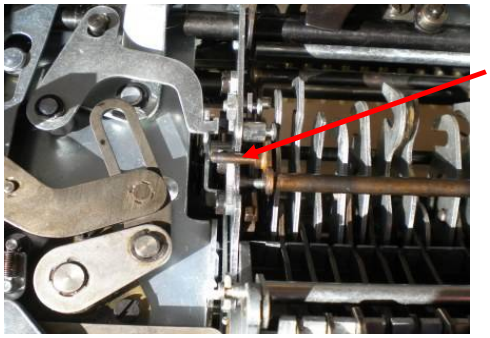
Check especially the back face of the large stationary ratchet where it will bear on the flat long edge of the pinbox pins. It may be necessary to modify the slope on this face to reduce friction with the pins.



Also check that the mechanism can freely pivot then mount the unit back onto the pinbox housing.

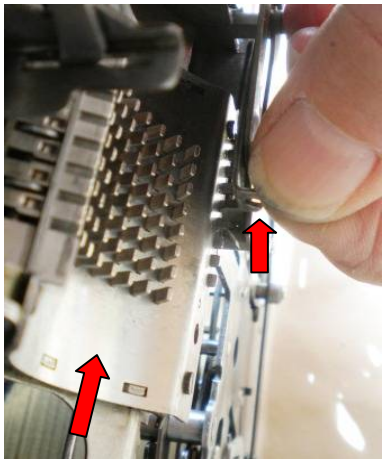
An extra check can be carried out at this time to verify the width of the slot in the fork. This slot should not be much greater than the 2.4 mm diameter of the corresponding pin on trigger bridge 11134-2. It may be found that this slot has become worn and is now too wide from past use of the machine and so should carefully be closed up and checked with a 2.4 mm drill shank to verify its size.



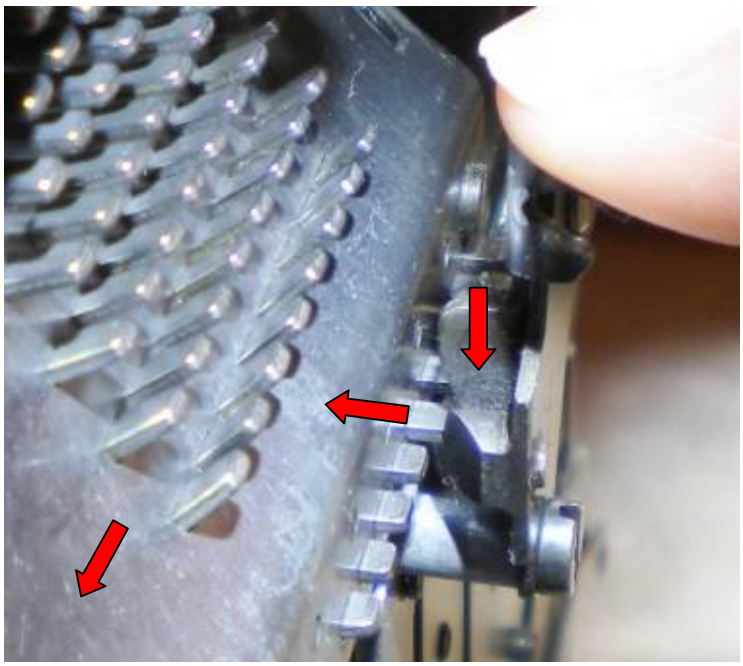


In order to fully verify the interaction of pinbox assembly 13206 and pinbox escapement assembly 13230, move feeler carriage 13241 to the side (to the left in the photograph) and temporarily restrain pinbox feeler 13246 well away from any interference with the pinbox pins.

Next, with the long angled ratchet face of the pinbox escapement assembly 13230 pulled clear of the line of 9 pins, push the pinbox assembly fully into its housing 13205.

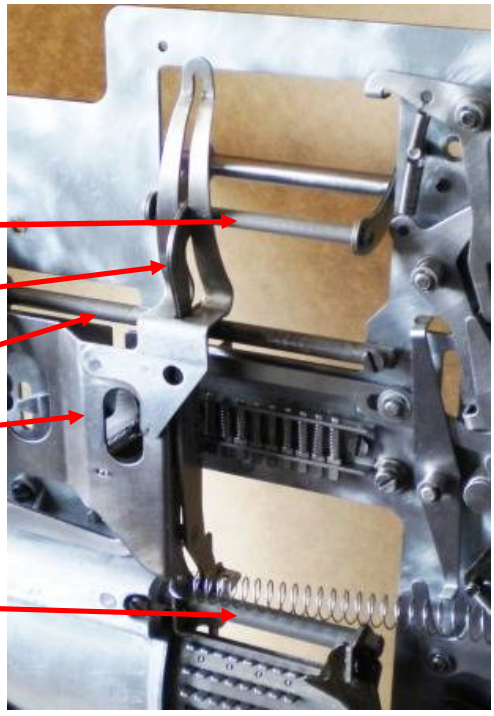


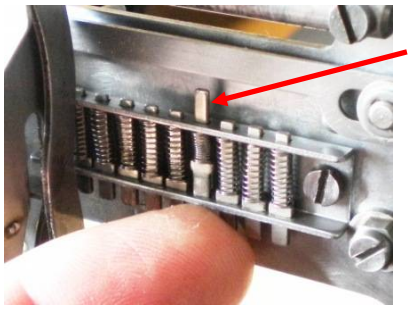
Repeatedly toggle the escapement back and forth (up and down in the photograph) and check that the pinbox assembly moves out from within the housing by means of the tension from pinbox return spring 1516-79 alone. During this operation, the force required to toggle the escapement should be minimal, ie. there should be hardly any force needed to toggle the escapement in order to push the pins into the pinbox. If too much pressure is required to carry out this motion, then the back face of the large stationary ratchet is not smooth enough and the aforementioned slot in pinbox escapement assembly 13230 will be forced open whenever a number key is pressed.



With the pinbox assembly 13206 fully out from under its housing 13205, next check the functionality of feeler carriage 13241, feeler escapement holder 13250 and feeler escapement pins 13251.

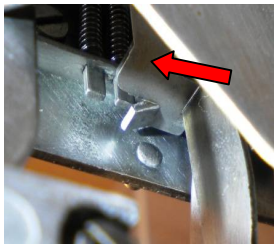
Firstly, ensure that feeler carriage 13241 does not bind and is very free to move laterally along feeler carriage shaft 13266 and pinbox shaft 13265. Also pinbox feeler lever 13246 should not bind on shaft 13267.

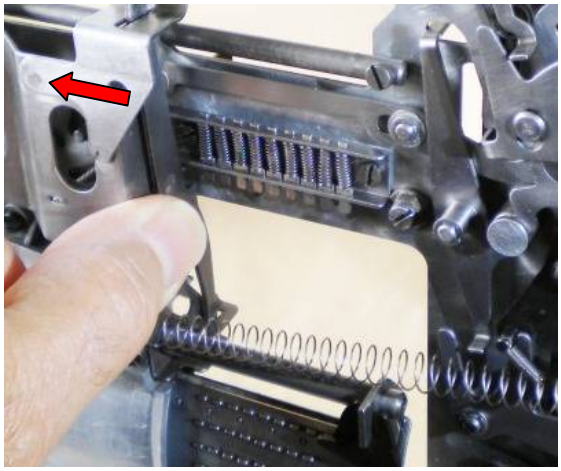




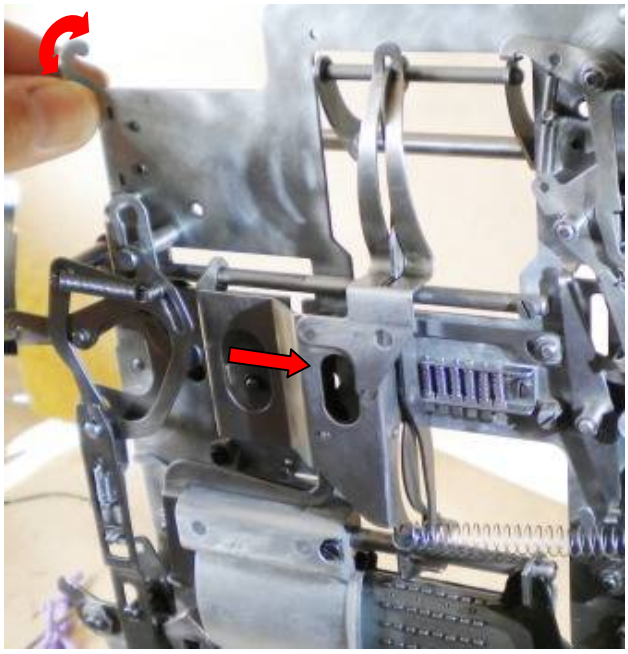
Prior to the next step, make sure that feeler escapement pins 13251 can freely move in and out of escapement holder 13250.

Push feeler carriage 13241 fully towards the pinbox housing. Whilst doing so, the angled slope beneath the feeler carriage should easily depress and pass by each escapement pin.

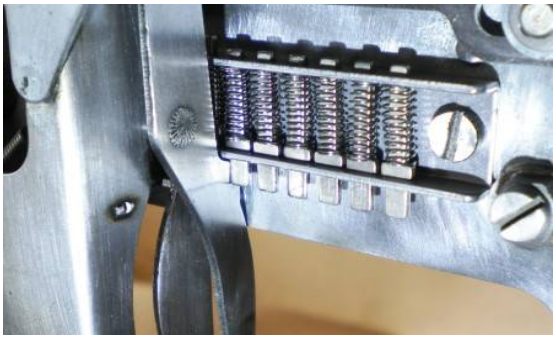


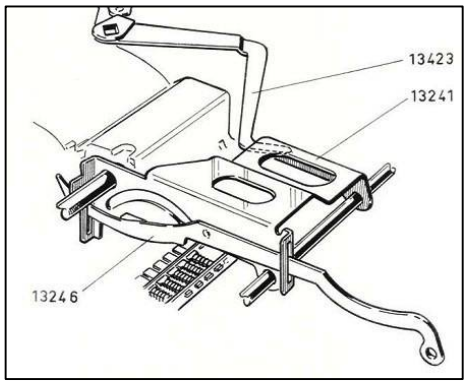


Afterwards let the feeler carriage spring back such that pinbox feeler lever 13246 comes to rest against the edge of the first feeler escapement pin.

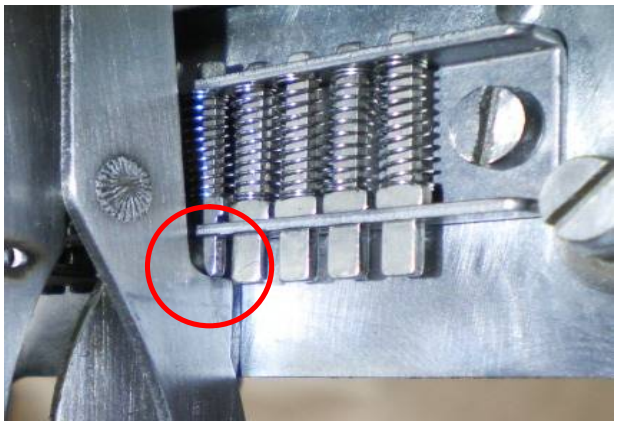


Now repeatedly toggle feeler shaft assembly 13254 whilst checking the arrested movement of pinbox feeler lever 13246 and feeler carriage 13241 as they are stopped by each feeler escapement pin in turn against the tension of feeler carriage return spring 10216-26.





During each individual toggle movement, pinbox feeler lever 13246 must strike exactly in the middle of the pins in the feeler escapement holder 13250. See page 127 to adjust this.

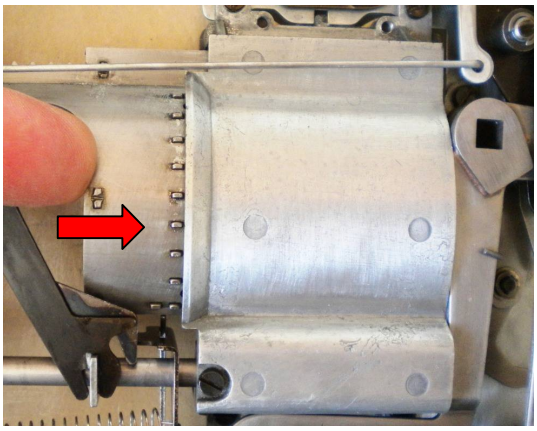


IMPORTANT: During all the checks in this section, it will be found prudent to verify the free movement of all the parts detailed above by repeated and continuous cycling of the mechanisms many, many times. These sub-assemblies must be as free as possible to ensure the correct functionality of many of the machine's co-dependent systems.

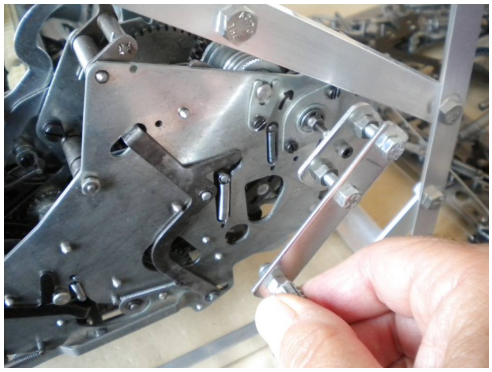
11 - INSTALLATION OF THE BOTTOM SUB-ASSEMBLY

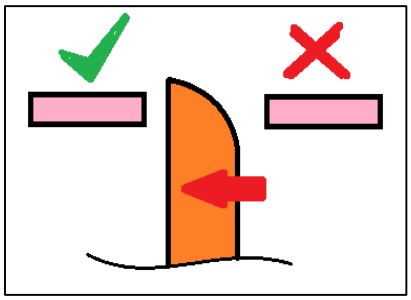
(numbers in parentheses refer to diagram on page 112)

Before the bottom sub-assembly is installed into the machine, reset the pinbox mechanism including pinbox return lever assembly 13431 (1) and pinbox feeler lever 13246.



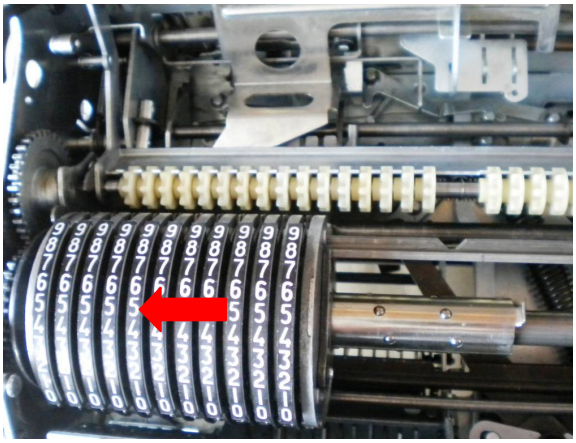
Repeatedly hand-crank so that all the gear and cam sets in the right transmission sub-assembly are reset.

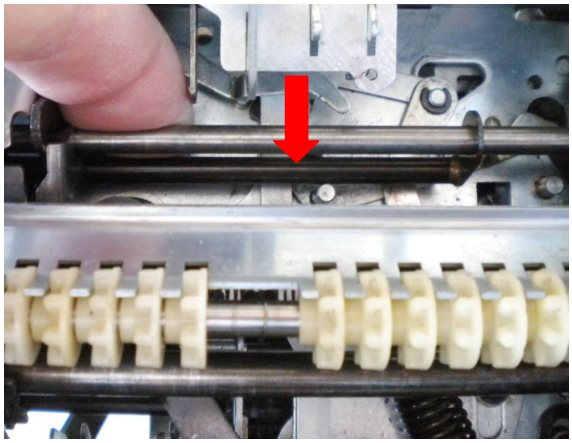


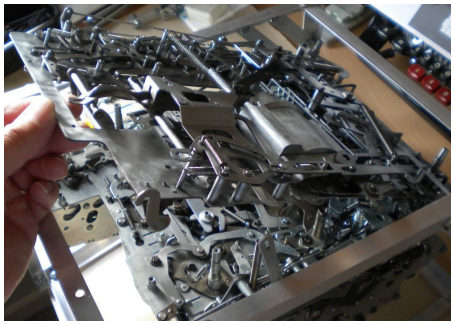


Prior to installation of the bottom sub-assembly, note that, as with most aspects of the machine's levers, some clue as to the correct side to position adjacent levers can be gleaned from the shape of each part.

Perform repeated left steps by pressing the "←" key whilst hand cranking to move the setting rotor into its leftmost position. Quotient coupling lever 10788 will need to be manually and repeatedly disengaged from the rotor carriage to facilitate this.

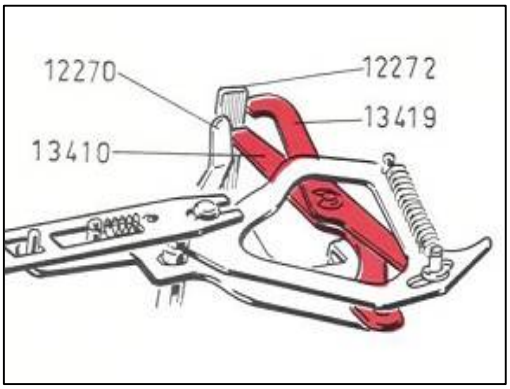


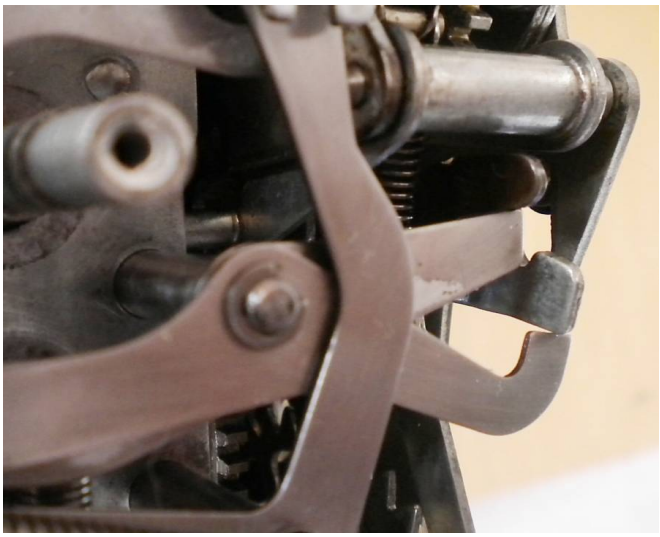




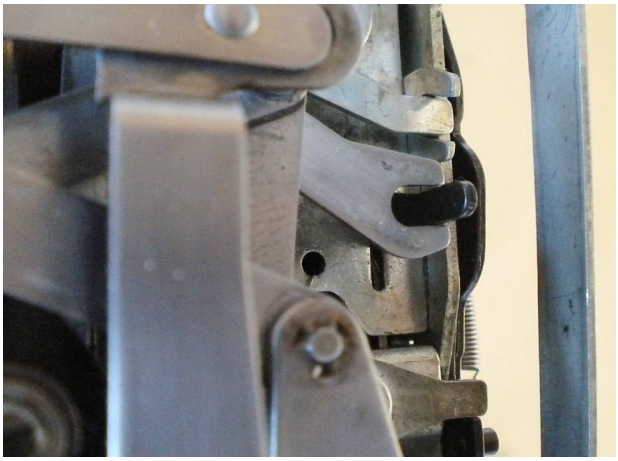
Invert the machine then, with the back of the machine nearmost, place the bottom sub-assembly directly over the bottom of the machine.

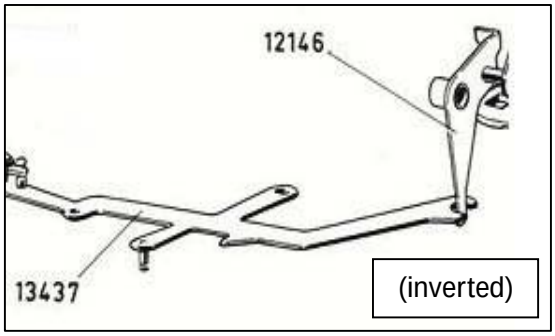
Check that start carriage 13410 lies against shortcut select lever 12270 and that first changer 13419 lies against selector lever 12272 (3).



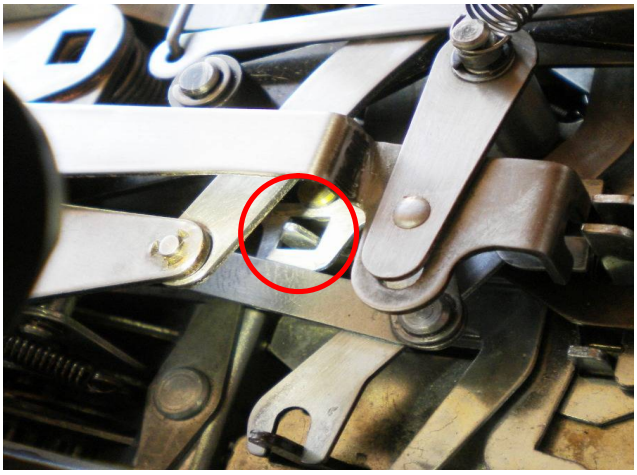


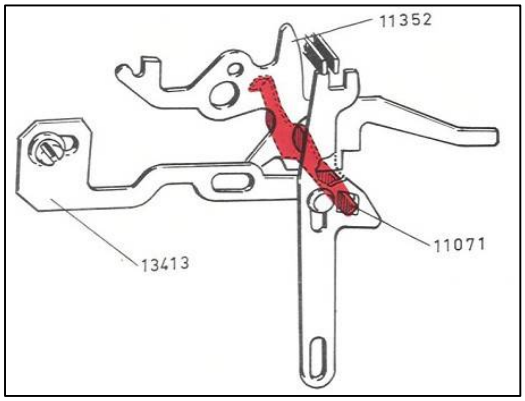
Check the engagement of setting register I clear lever 13437 and arresting ratchet 12146 (5).



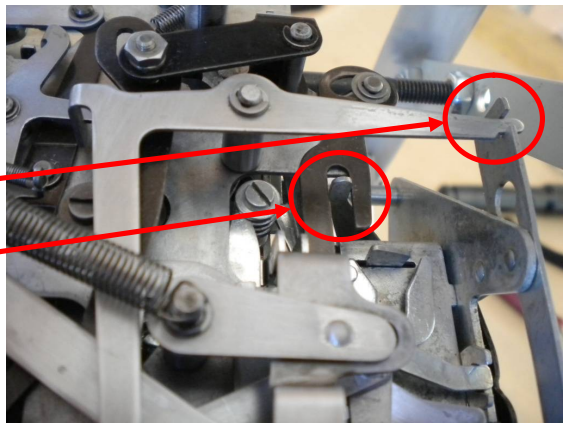


Check the position of double lever 13413 with start catch 11071 (6).

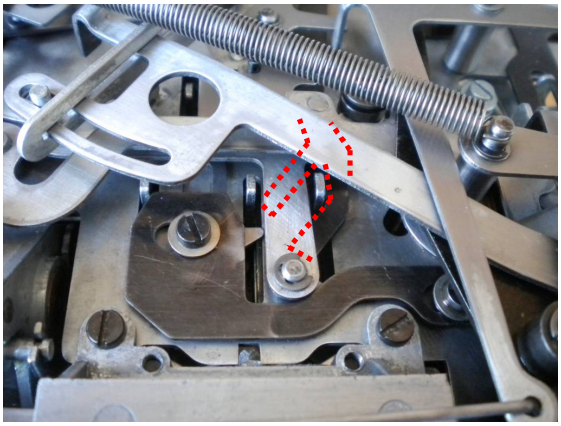


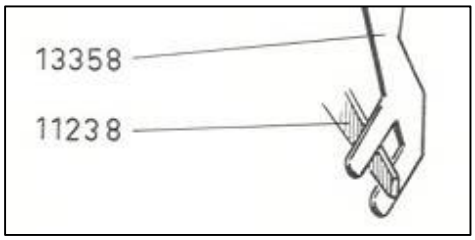


Check that start lever 13421 is engaged with changer 12137 and that counter register II clear lever 13404 is engaged with counter register II clearing clutch sliding link 12215 (7).

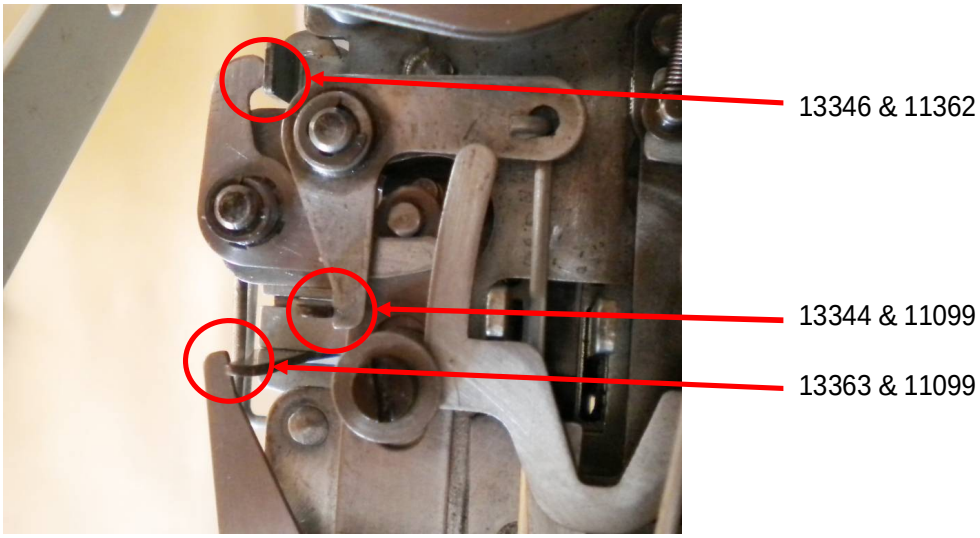


Check engagement of forked arrester lever 13358 and "REG I" key lever 11238 (8).

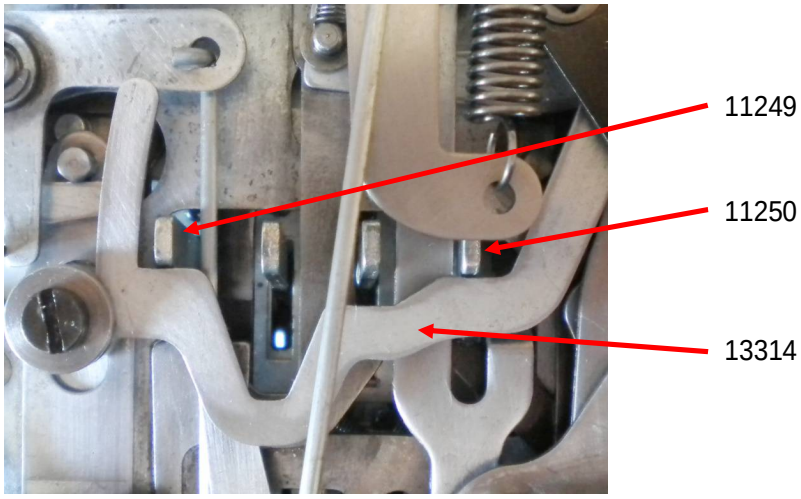




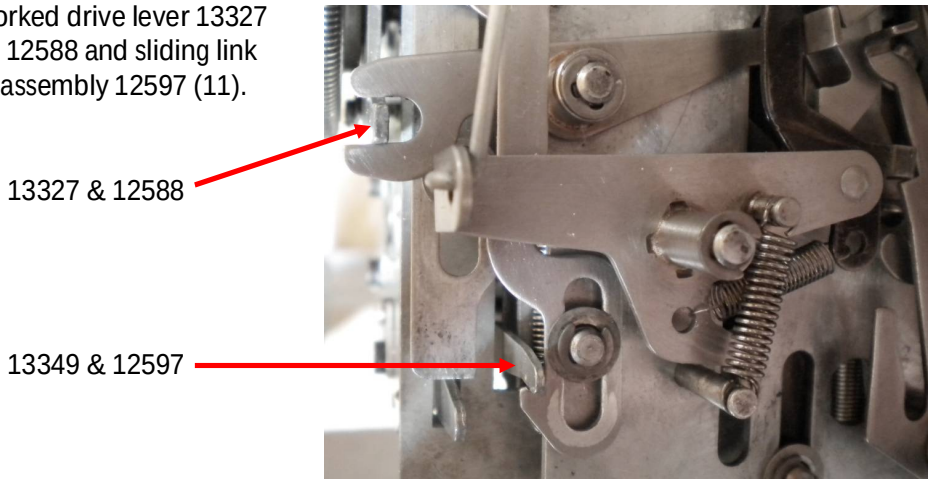
Check position of lever 13363 with drive lever 11099, switch linkage 13344 with the second drive lever 11099 and lever 13346 with rail 11362 (9).

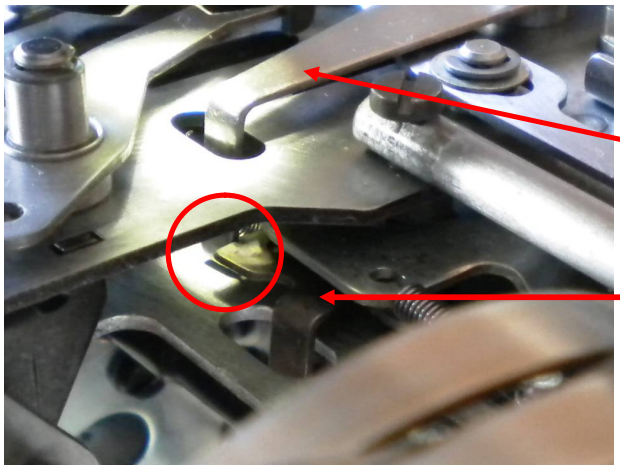


Check position of turn lever 13314 with "IIIv" key lever 11249 and "X" key lever 11250 (10).



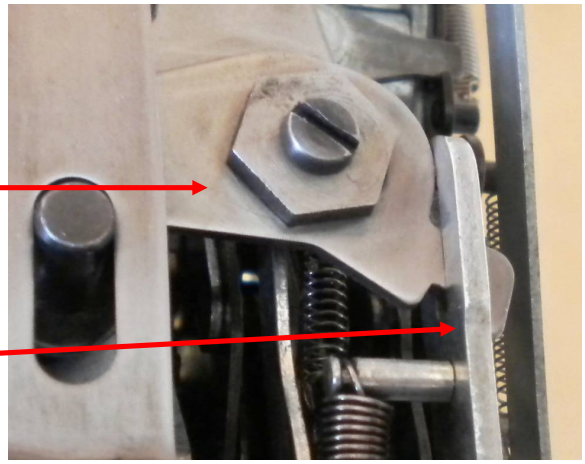
Check engagement of forked drive lever 13327 with cam follower lever 12588 and sliding link 13349 with offset lever assembly 12597 (11).



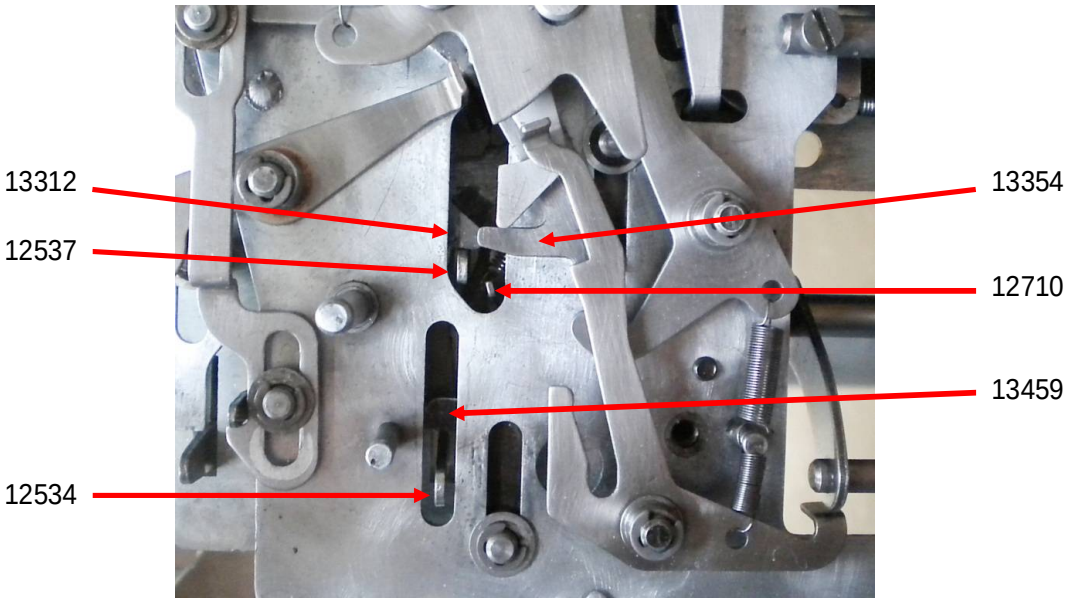


Check the position of switch operating lever 13333 and switch lever 12748 (12).

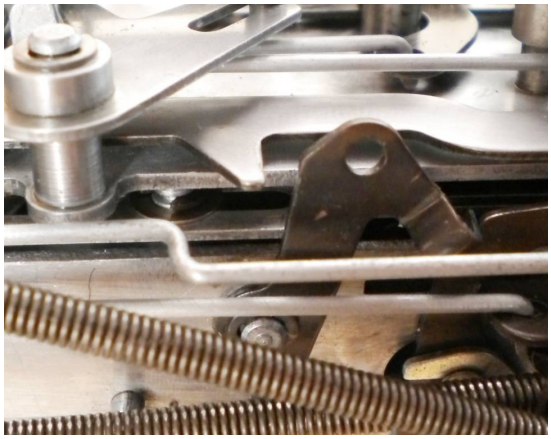
Ensure that rotor and pinbox return lever 13423 engages in the setting register I rotor clear/return link 12187 on the right drive unit (15).



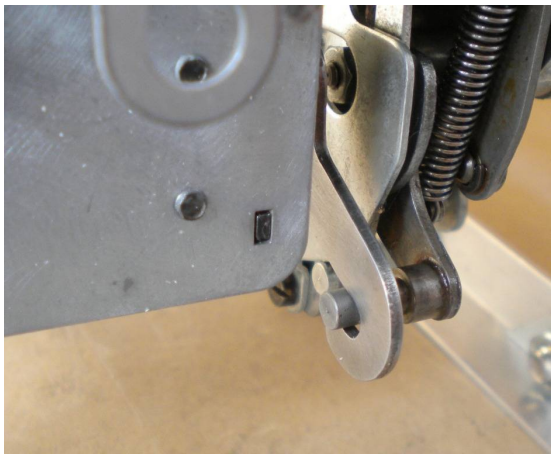
Check that riveted lever 13312 is at the right side of division setup cam follower lever 12537 and that the hook on switch-off slider assembly 13354 is at the correct side of small lever 12710 and that lever assembly 13459 is at the correct side of division cam follower 12534 (tappet assembly 13322 has been temporarily removed for clarity) (16).



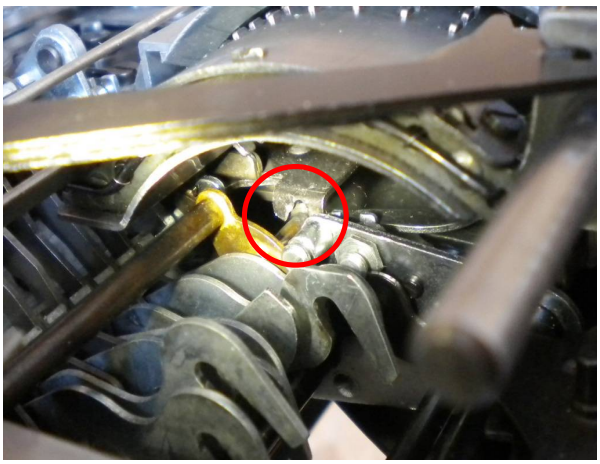
Check that sliding link 13352 actuates swing link 12937 (17).

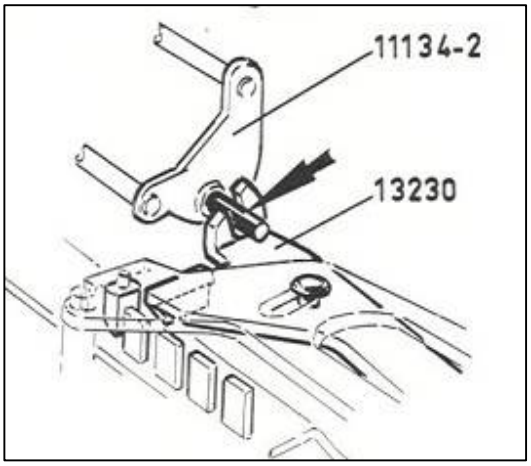


The hook on feeler shaft assembly 13254 should engage with feeler shaft rocker 12258 (18).



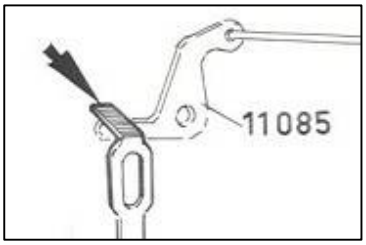
The slot in pinbox escapement lever assembly 13230 must align with trigger bridge 11134-2 (19).



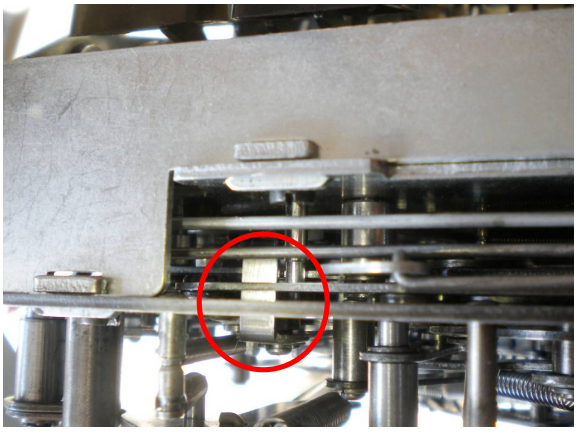


(inverted diagram)

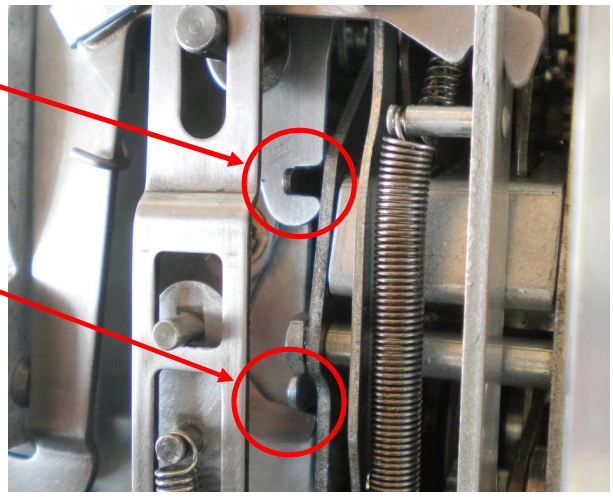
The angled end of sliding link 13378 should sit to the fore of swing link 11085 (20).

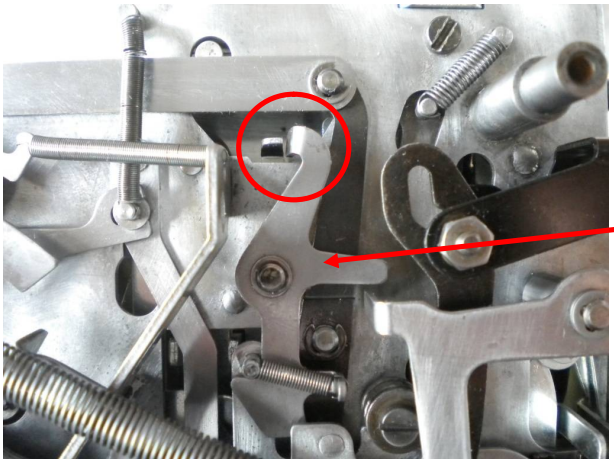


(looking at front of machine)



Ensure that the cutout in start lever assembly 13439 is hooked onto sliding link 12242 and that lever 13457 is engaged with division switch 10985 (21).





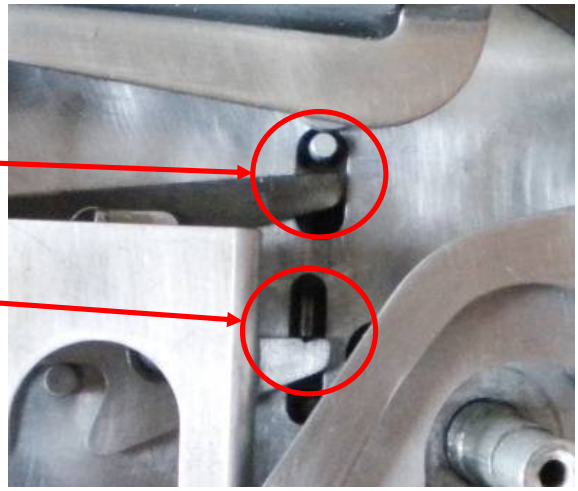
Lever 13406 should engage with sliding link 11362 (22).

13406

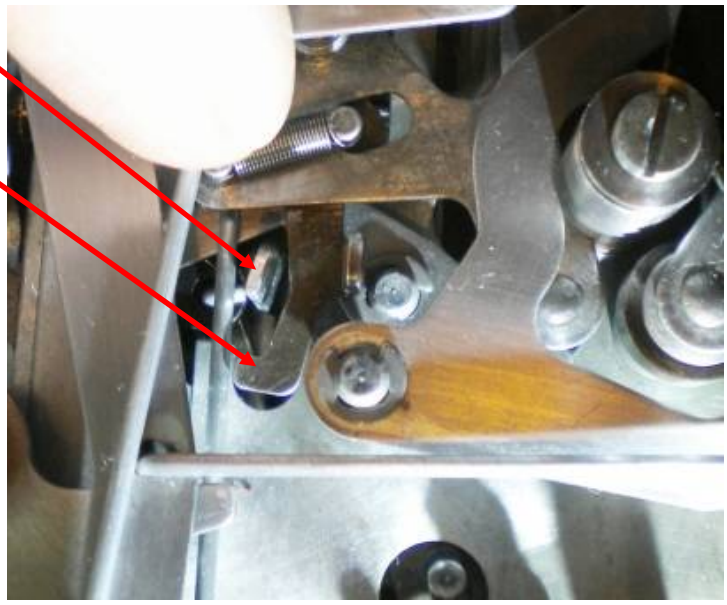
Check the relative positions of levers 13371 & 12737 and 13373 & 12716 (24).

13371 & 12737

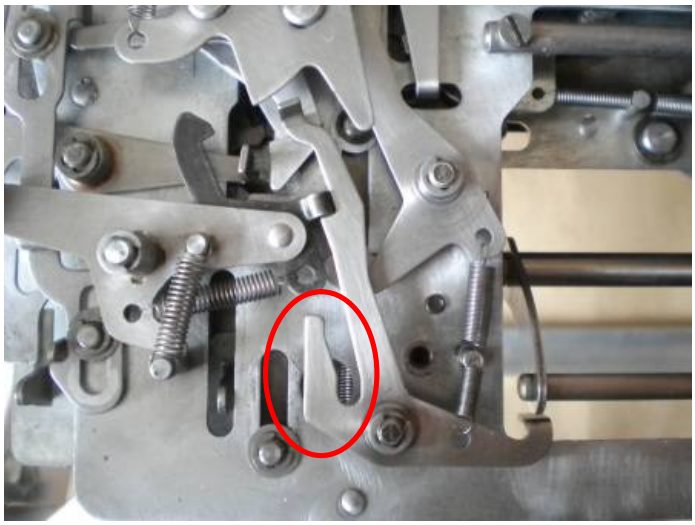
13373 & 12716



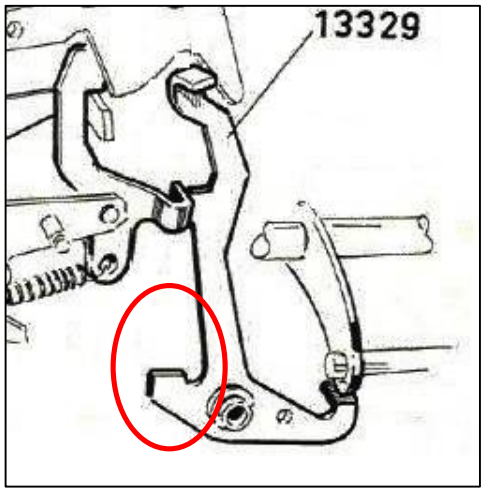
The long raised end effecter on hook 12978 must be at the correct side of the small attached lever riveted to multiply linkage lever assembly 13439 (25).



V-lever 13397 has been removed for clarity in the image at right.

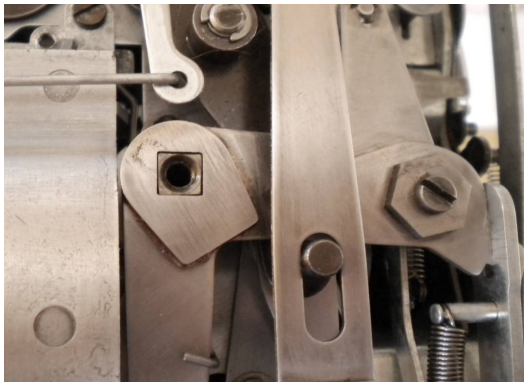


Quite a few holes and some components in this machine don't seem to have any purpose - witness the unusually shaped profile of indent lever 13329 which is completely different from that depicted in the diagram from the German Service Manual. Perhaps a legacy design or a common part from a different model.

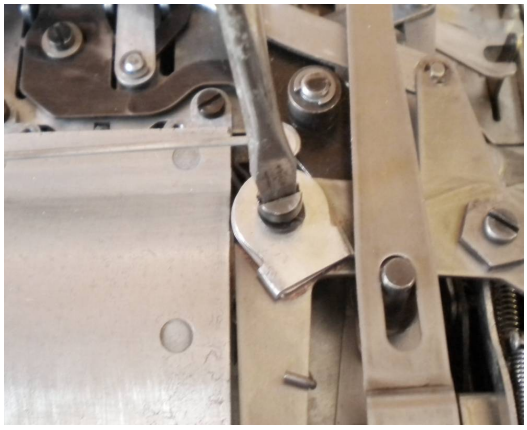


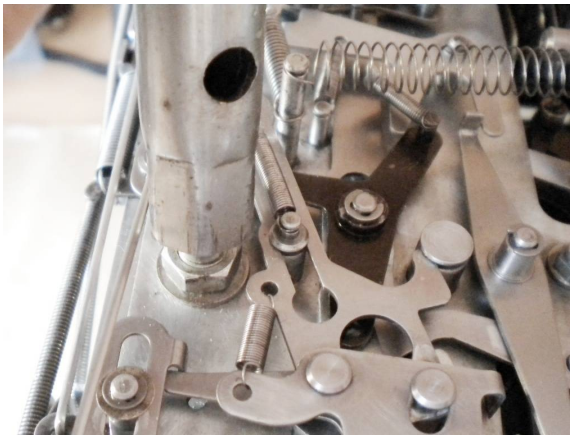
Ensure that the chassis of the bottom sub-assembly does not now rock or flex and sits down flush onto all of its anchor points. Do not force the unit down. When all the components are correctly engaged, the unit will easily sit down flush onto all of its anchor points. Before attempting to screw the unit down, go around all the check points once more to verify correct part engagement as one or more levers could have jumped out of alignment during installation.

The rotor and pinbox return lever 13423 should now sit flush with the square end of rotor return/clear shaft 12913.



Screw down the rotor and pinbox return lever 13423 with screw 906-5 and keeper 10863 (23).





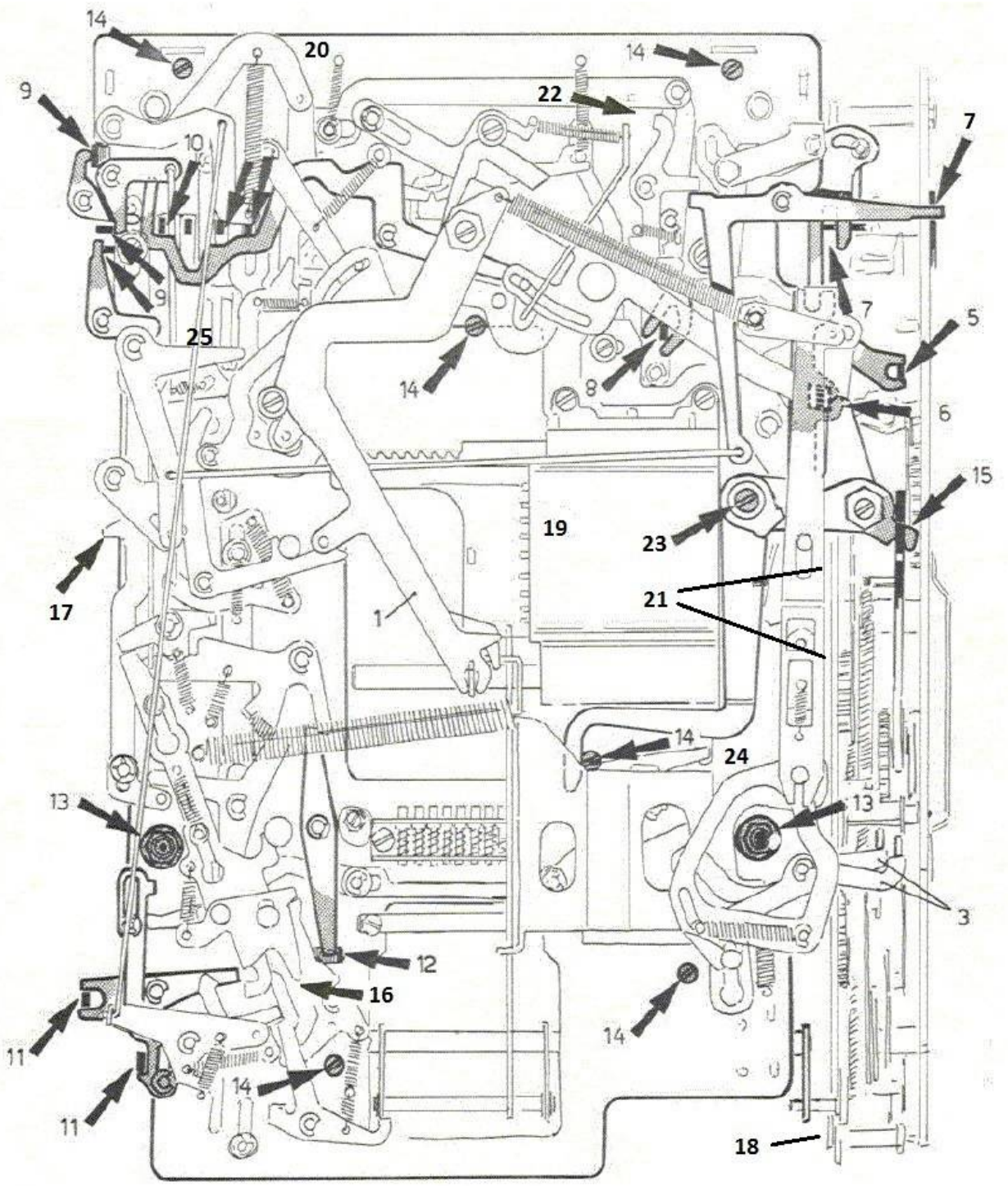
Anchor the unit with two nuts 905-8 and washers by using an 11 mm box spanner (13).

Install 2 retainers and finally screw down the bottom sub-assembly with 6 screws 904-1 (14).

Finally, place the machine right side up and hand-crank a few turns to ensure all systems are free.

A total of 30 check points in 25 places for this major installation.

Diagram of the bottom sub-assembly showing the locations of the anchor points and the positions of the numbered lever engagement points.

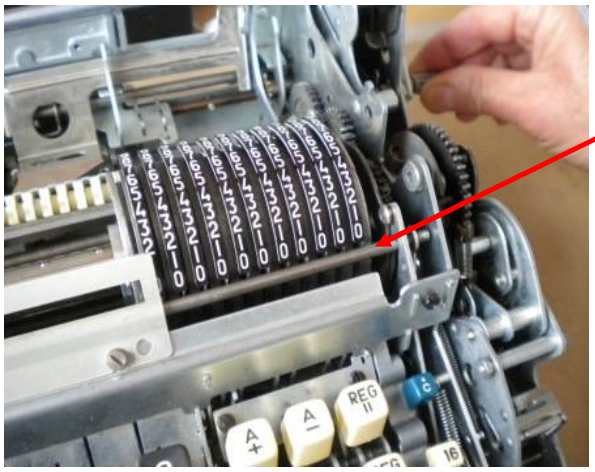


Test the Register Reset Mechanisms

Reset the setting register's rotor to the right and hand-crank a few turns to reset the systems.

Load the setting register with all 9s then press the "I" key and hand-crank to verify the correct setting register I reset functionality.

At the end of each test, each button should be reset and switch plate toggle 11306 should be automatically returned to the right.

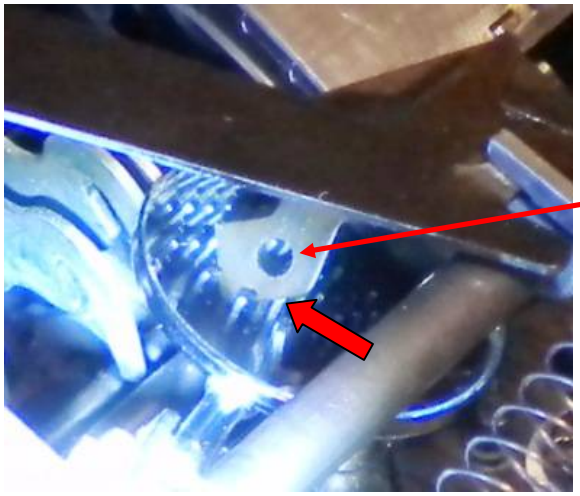


At the end of the cycle, make sure that the setting register's rotor is pulled as much as possible to the right side wall of the machine when rotor clearing bail 10769 has reached its highest point.

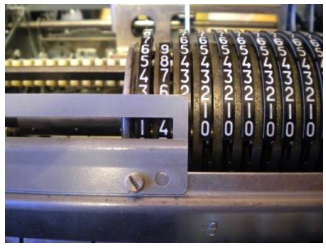
Press the "II" key and verify that the right transmission sub-assembly will perform a reset function on counter register II when the registers II & III sub-assembly is installed.

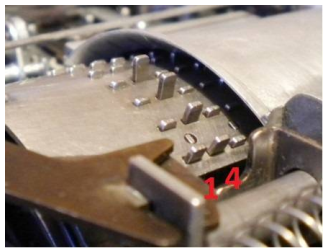
Press the "III" key and verify that the left transmission sub-assembly will perform a reset function on accumulator register III when the registers II & III sub-assembly is installed.

With the use of a powerful torch and a mirror, verify that the end effecter on rotor setting segment 11181 can easily and smoothly depress the pins into pinbox assembly 13206. The number of pins which are depressed on any column is dependent on the numerical key depressed.



11181

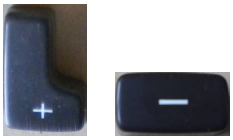




Perform a Trial Addition and Subtraction

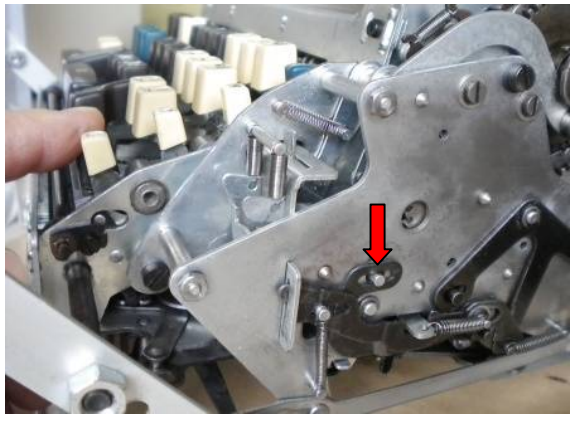
Although the numerical result of this test cannot be seen (as the tens carry rotors nor the registers II & III sub-assembly are not yet installed), it is prudent at this stage to verify this functionality.

Load the setting register I with a series of numbers and press the "+" key.



After the "+" key is pressed, check that +/- pulldown link lever 12132 has moved to the right and that sliding link 12156 and clear-after-add sliding link 12158 is actuated.

12132 12156 12158



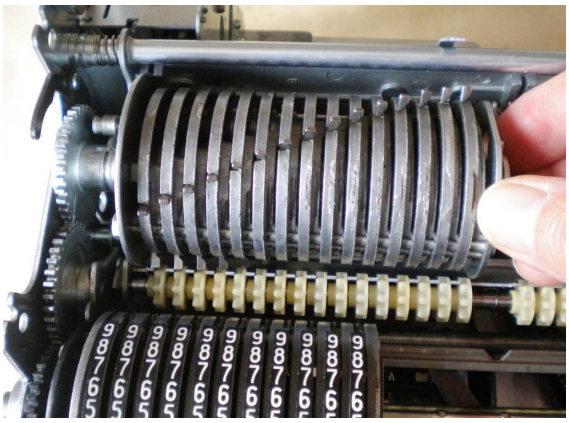
(these photographs show the "-" key being depressed)

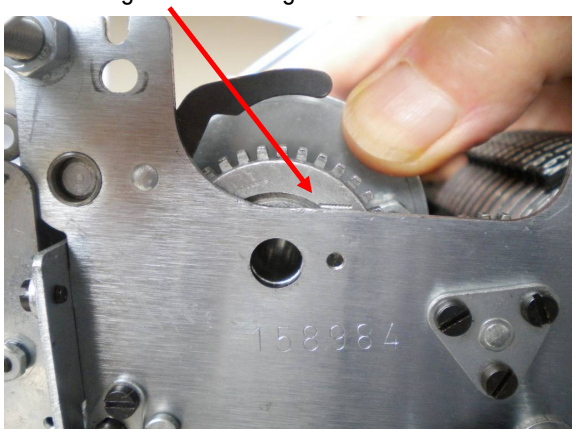
Crank and verify that the setting register's rotor turns 'down', ie. the numerals at the top of the rotor move towards the front of the machine before the rotor is reset. Repeat this check with the "-" key pressed whereupon the rotor should move in the opposite direction before reset.

Repeat this series of checks a number of times to ensure continuous and repeatable functionality.

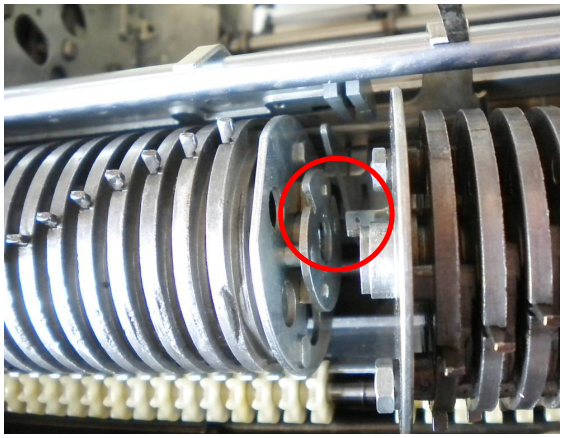
12 - INSTALLATION OF THE TENS CARRY ROTORS

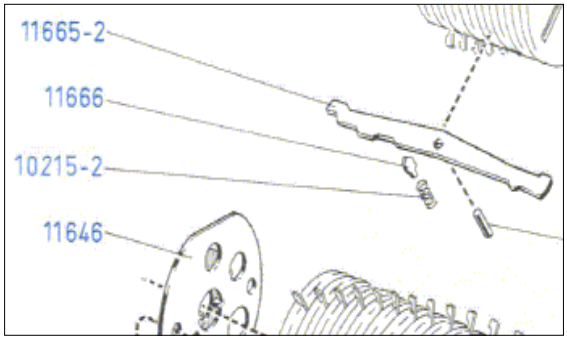
Insert the accumulator tens carry rotor so that the mark on the gear wheel aligns with the left side wall.



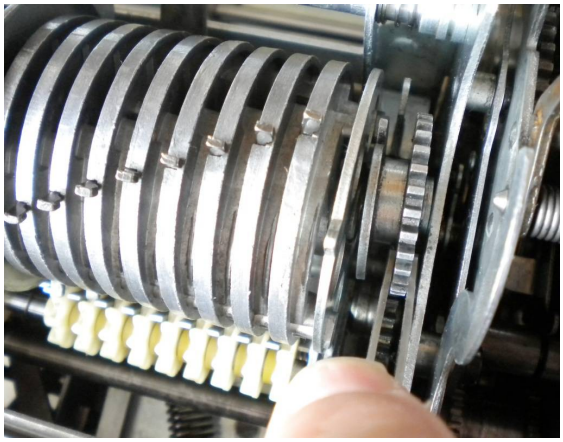


Next, make sure that rotor coupling link 11665 can detent positively into each of its positions then insert the counter tens carry rotor and connect rotor coupling link 11665 to the accumulator tens carry rotor.

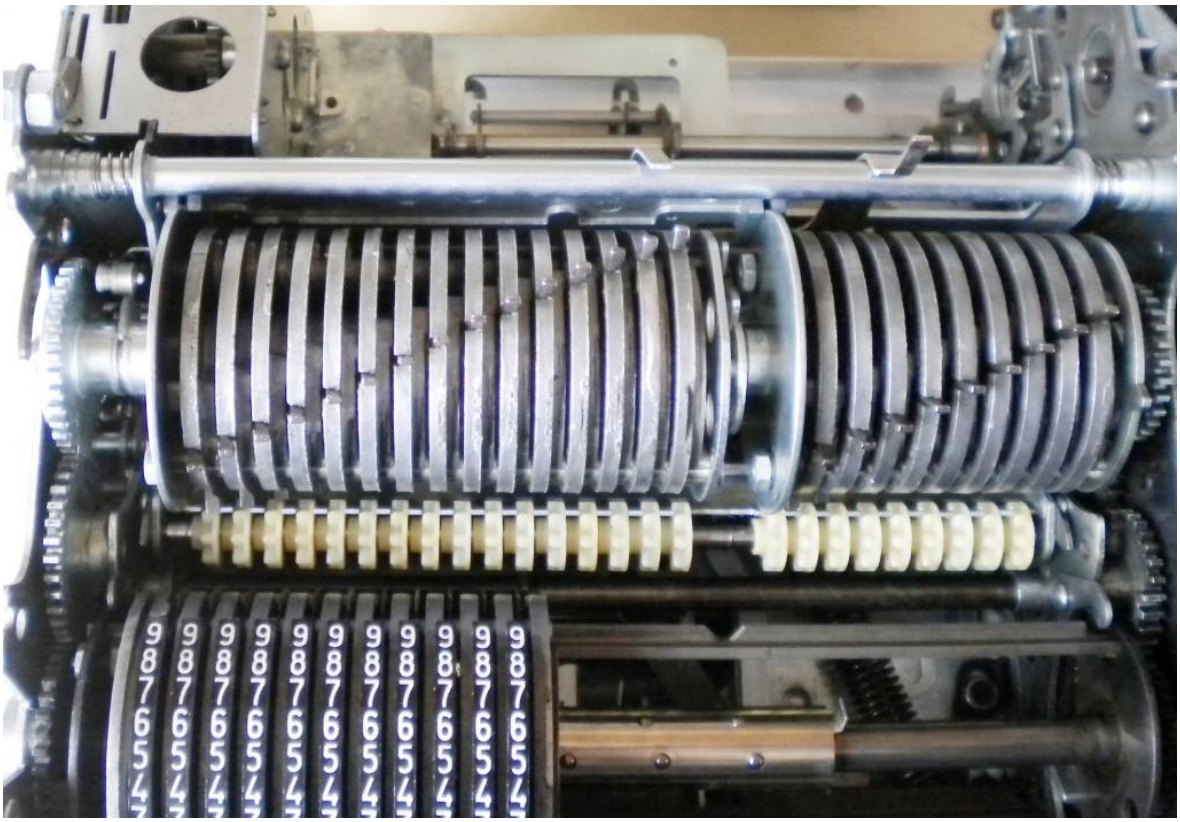




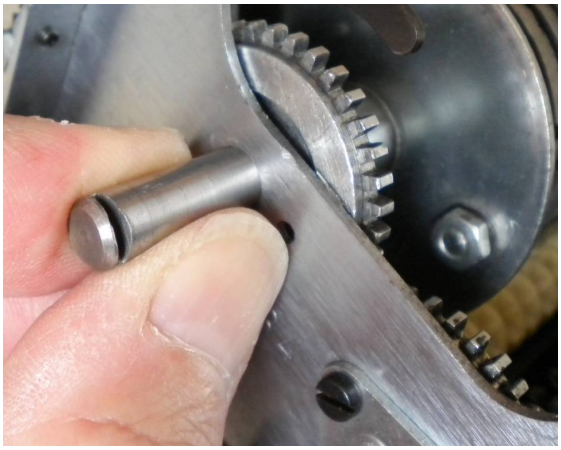
Insert gear wheel 11671 in such a way that the mark aligns with the right side wall.

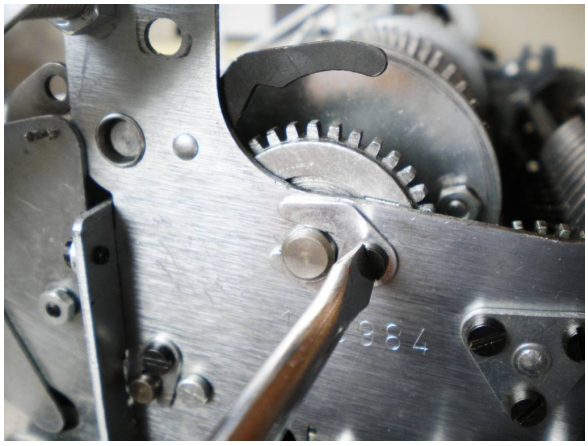


The large diameter flat disks 11620 and 11638 at the left end of each of the tens carry rotors should both engage in the chassis slots.

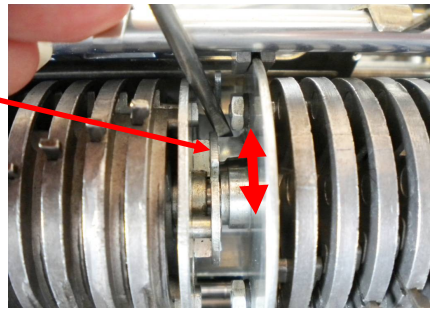


Insert shaft 10844 and secure with retainer 10845.

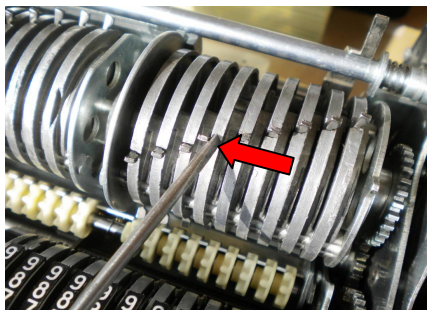




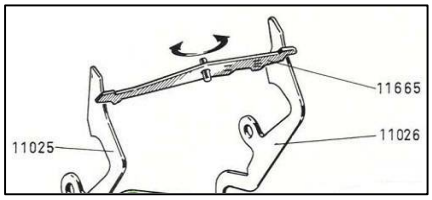
Check that tens carry rotor coupling link 11665 is free to move and can rock in and out of the slots in both of the register II and register III tens carry rotor's small end locking disks.



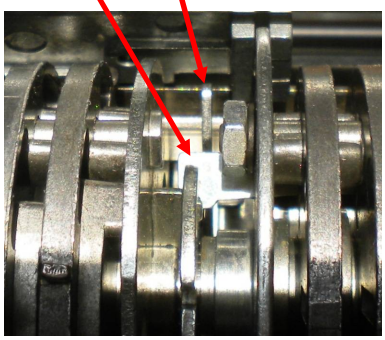
Also make sure that all of the transfer pins 11658 on both tens carry rotors are free to move sideways and spring back freely.

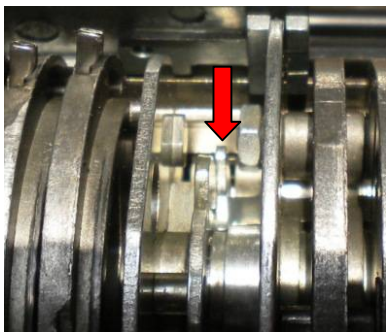


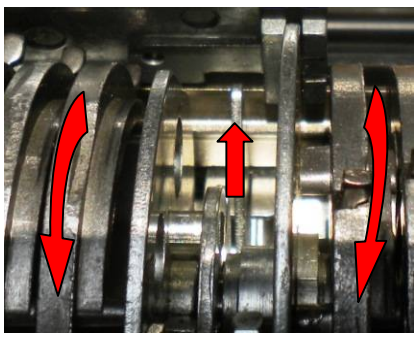
Perform an addition or subtraction and hand-crank to make sure that carry rotor coupling link 11665 is actuated by counter direction lever 11025 and that the lever springs back at the end of the cycle. Both tens carry rotors must rotate in the same direction during an addition or subtraction.

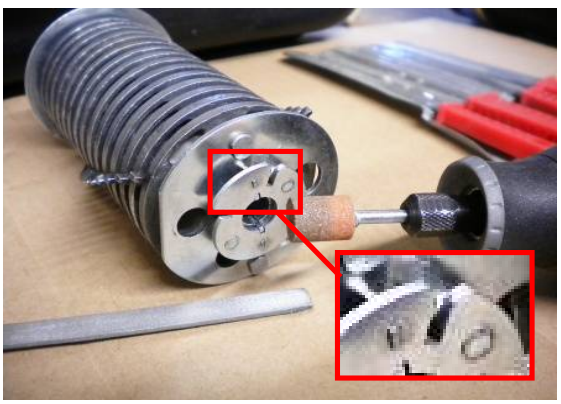


11665 11025







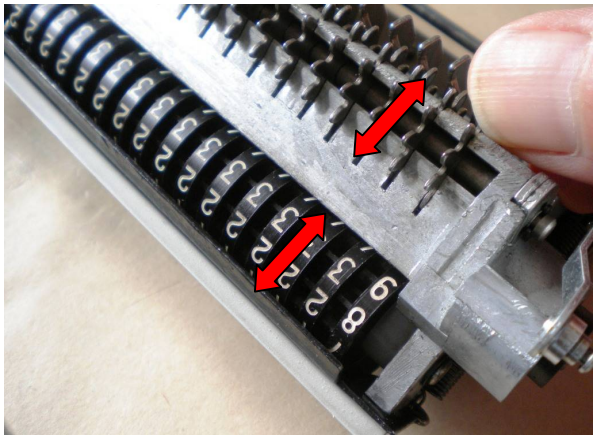


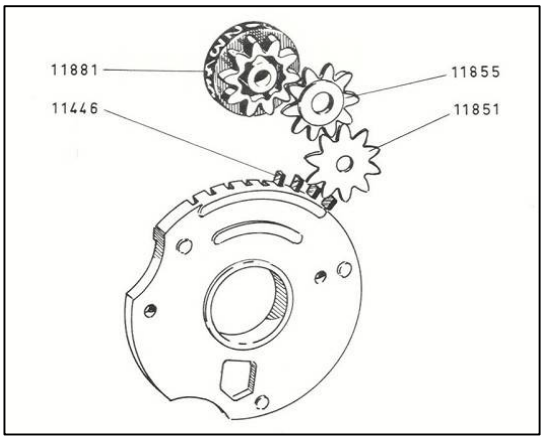
Due to past wear of the counter register II's tens carry rotor's gear train and replacement of some new parts, it was found necessary to increase the lead-in of the interlock slot on the accumulator register III tens carry rotor's end locking disk. This enabled carry rotor coupling link 11665 to slide more easily into this slot without fouling on the edge of the end locking disk.

13 - INSTALLATION OF THE REGISTERS II & III SUB-ASSEMBLY.

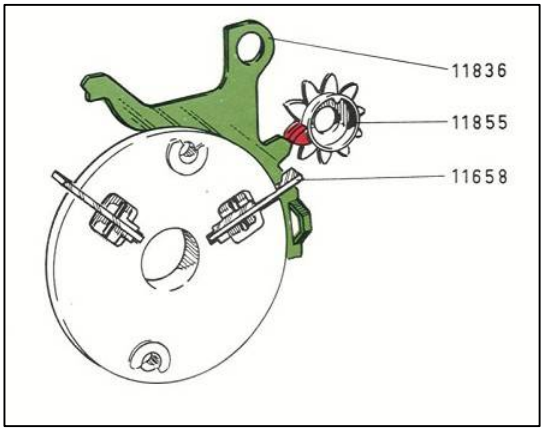
Prior to installation, the following checks should be carried out:

i. On each decade, check that star wheel 11851 can turn number cylinder 11881 via computation wheel 11855.

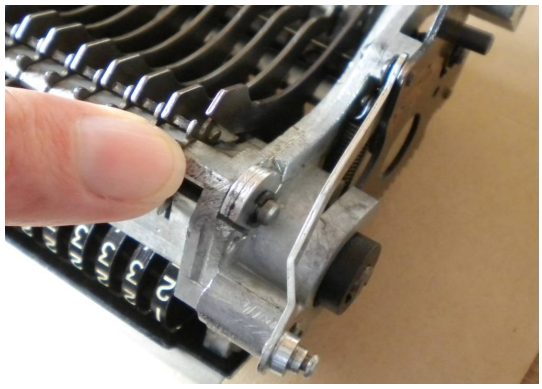




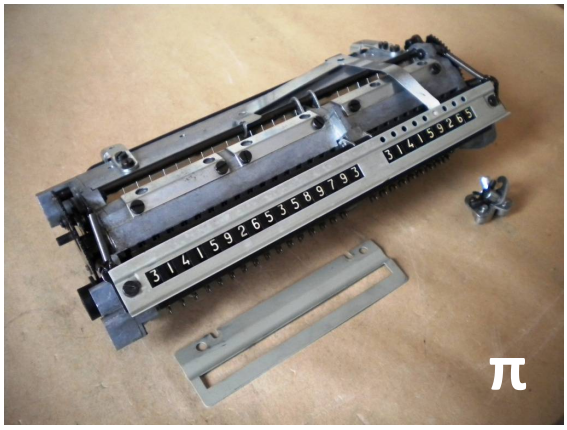
ii. On each decade, check the free rocking movement of transfer hook 11836.

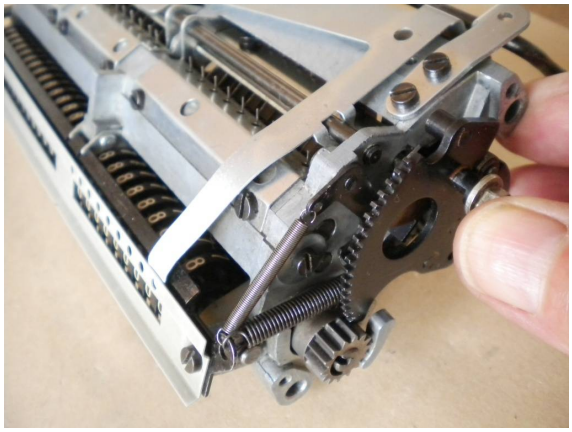


iii. Also check that, when each star wheel 11851 is rotated such that number cylinder 11881 advances from the 9th to the 10th position, the transfer hook 11836 is lifted by means of the transfer cog (seen in red in the diagram above) on computation wheel 11855.

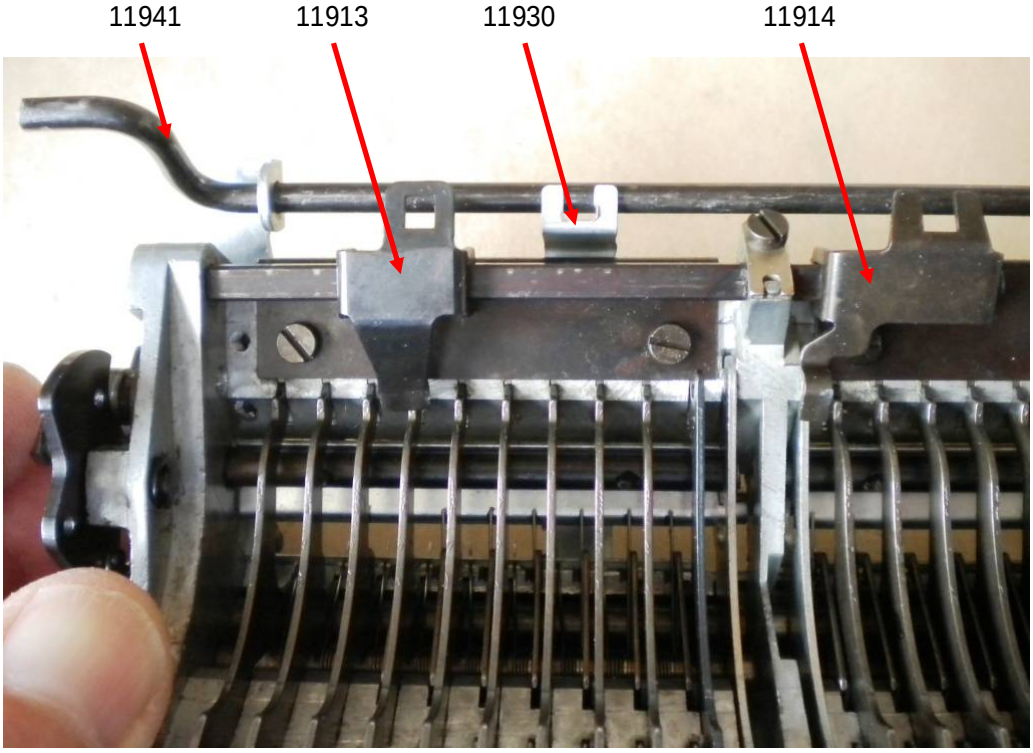


iv. Rotate the star wheels to input some numbers, then check the operation of both the accumulator register III clearing sector 11906 and counter register II clearing sector 11910. When manually operated, these should reset the number cylinders 11881 back to zero on each decade.



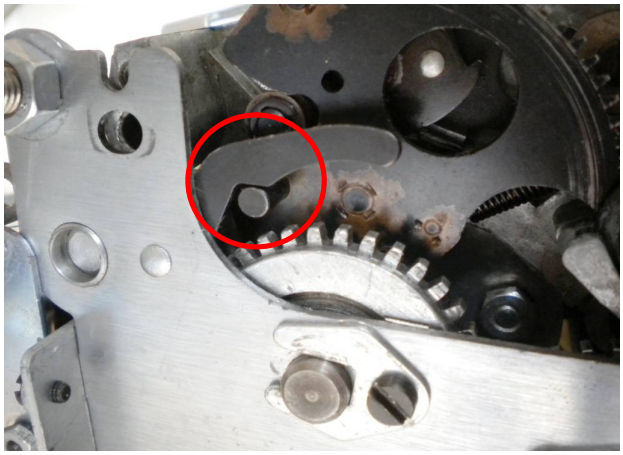


v. Check the free movement of lever 11930, counter register II drive pawls 11913 & 11914 and division trip cross shaft 11941.

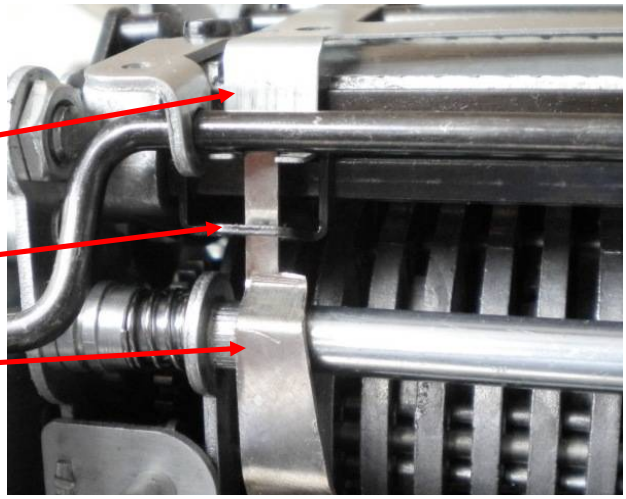


Installation of the Registers II & III Sub-Assembly

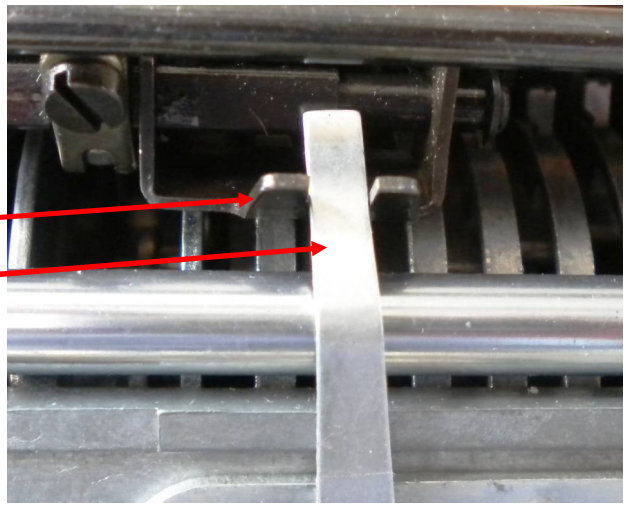
Insert the mechanism diagonally, so that the pin on accumulator register III clearing sector 11906 is positioned under lever 11098.



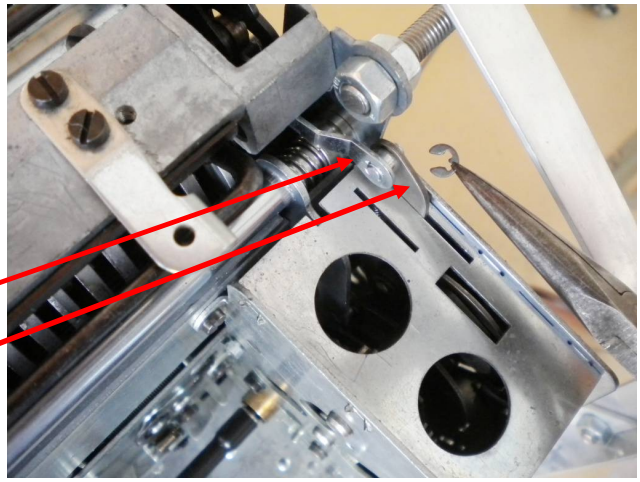
Ensure that quotient coupling indicator 10795 engages counter register II drive pawl 11913 and lever 11930.



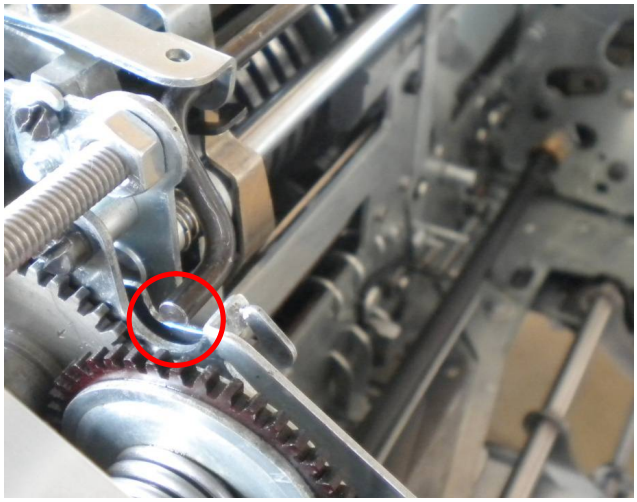
Ensure that counter disable lever 11030 engages counter register II drive pawl 11914.



Connect accumulator register III clearing link 12583 with register III clearing cam follower lever 12579 and secure with a circlip.

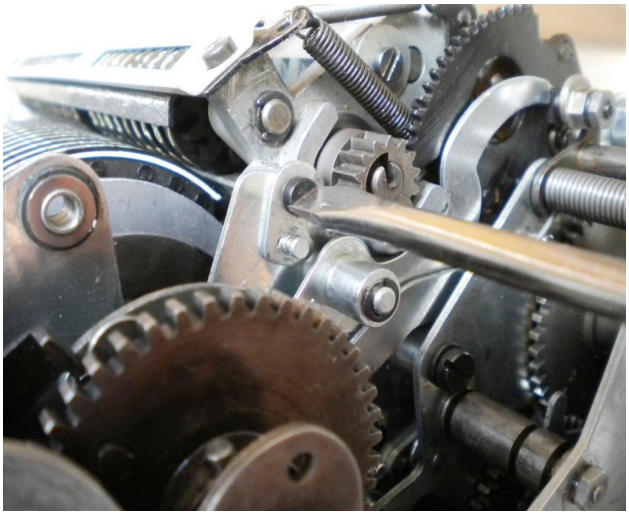


Division trip cross shaft 11941 should lie in the recess in stop lever 10983.



Affix four retainers 11934 and screws 904-4.

Finally secure the setting rotor mask window 10170 in place.



The machine as a whole is now more than twice as heavy and very much more complicated!

14 - MODULE ADJUSTMENTS - 3

NB: All further hand-cranking operations in this manual are carried out with the machine in an upright orientation. Between cranking operations, functionality checks and adjustments are carried out with the machine in various orientations where appropriate, but the machine is again turned upright prior to further cranking being continued.

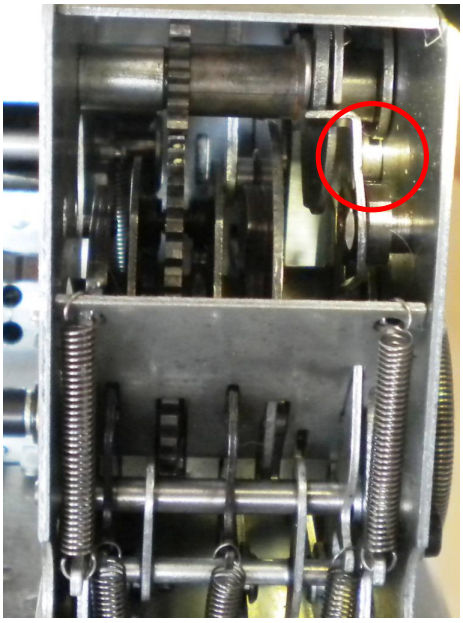
Number Cylinders Movement

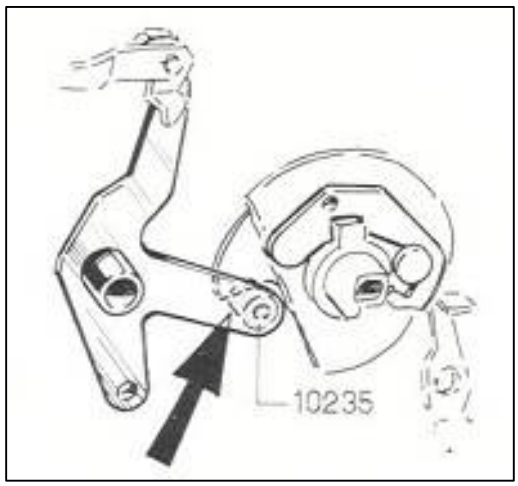
During the reset operation of the accumulator register III clearing mechanism, check whether the number cylinders 11881 perform an excessive movement after the calculation wheels have been turned to their reset position.

Carry out this check by manually spinning the star wheels to rotate the accumulator away from zero on each decade.

Press key "III" and hand-crank approximately 7 turns (after clearing sector 11906 starts to move) to clear the accumulator.

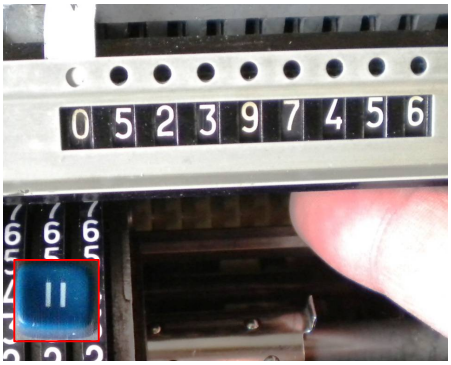
Adjustment is carried out by changing roller 10235 in the left transmission sub-assembly.





During the reset operation of the counter register II clearing mechanism, check whether the number cylinders 11881 perform an excessive movement after the calculation wheels have been turned to their reset position.

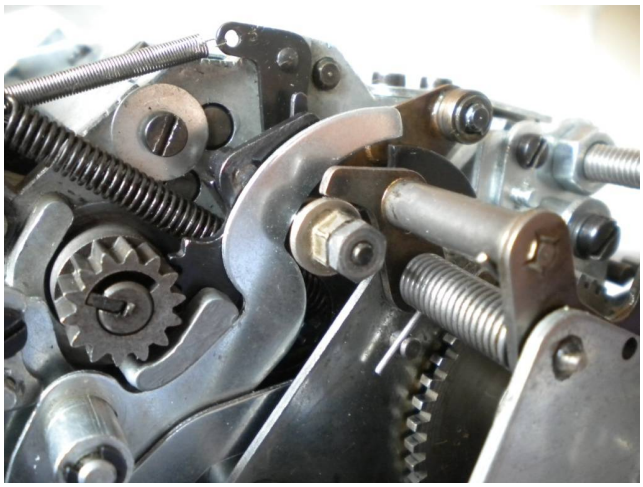
Carry out this check by first placing the setting rotor into its leftmost position by repeatedly pressing the "←" key whilst hand-cranking (note that after the setting rotor has stepped left once, carry on cranking for a further 8 turns to reset the mechanism).

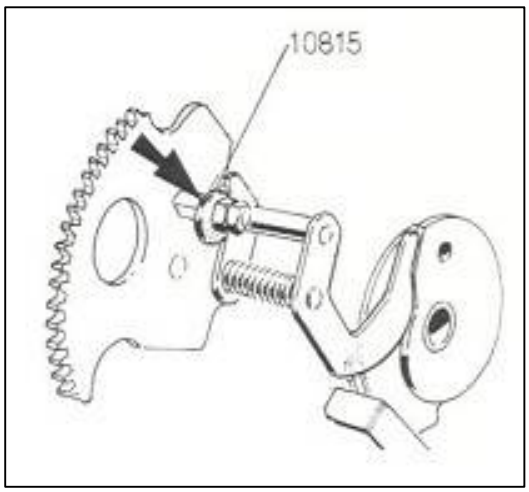


Manually spin the star wheels to rotate the counter register II away from zero on each decade.

Press key "II" and hand-crank approximately 7 turns (after clearing sector 11910 starts to move) to clear the counter register II then a further 11 turns to reset the mechanism.

Adjustment is carried out by turning eccentric 10815.



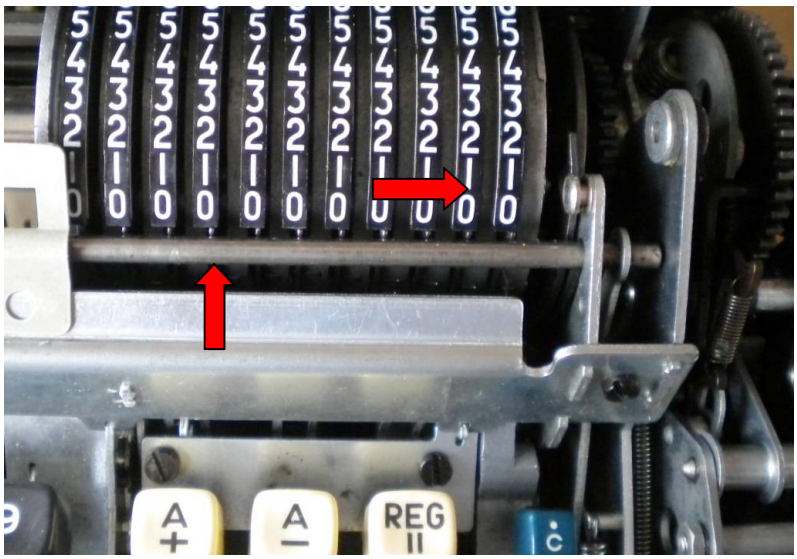


Setting Rotor Positioning

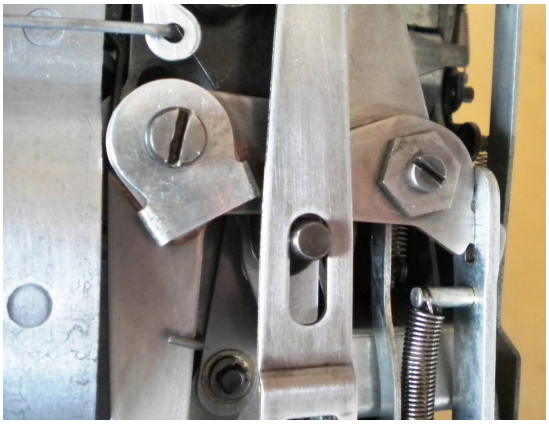
When resetting the setting register's rotor, make sure that the rotor is pulled as much as possible to the right side wall of the machine when rotor clearing bail 10769 has reached its highest point.

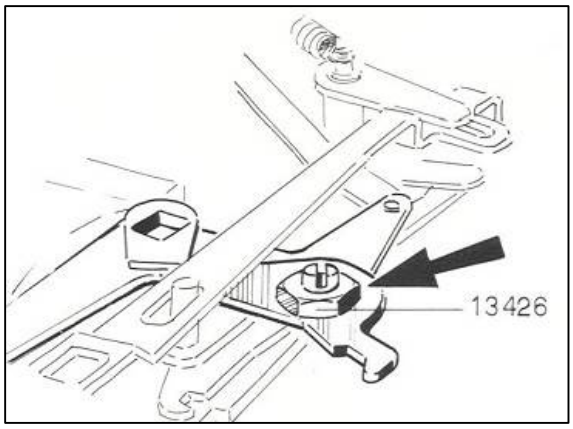
Carry out this check by pressing key "I" and slowly hand-cranking the setting rotor from its leftmost position.

When the rotor clearing bail 10769 is at the top of its travel, observe the setting rotor's rightmost position. Crank a further 5 turns after the clearing bail has dropped to reset the mechanism.



Adjustment is carried out by turning eccentric 13426 on the pinbox return lever 13423.





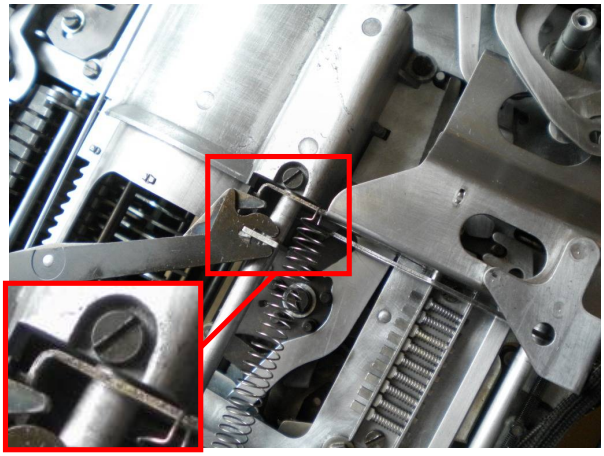
When eccentric 13426 is adjusted, the reset positions of the feeler mechanism and the feeler carriage must also be checked.

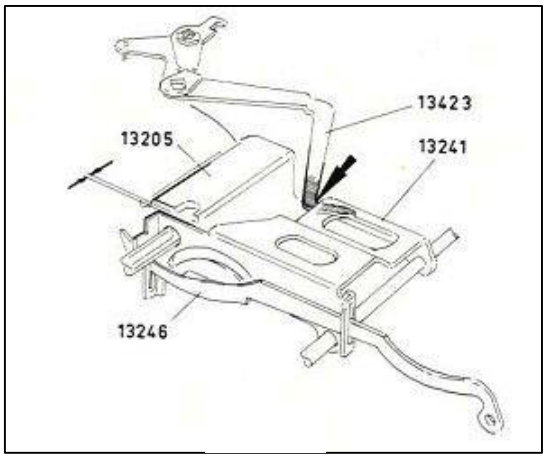
Feeler Carriage Positioning

Repeat the above operation and temporarily stop cranking when rotor clearing bail 10769 has reached its highest position.

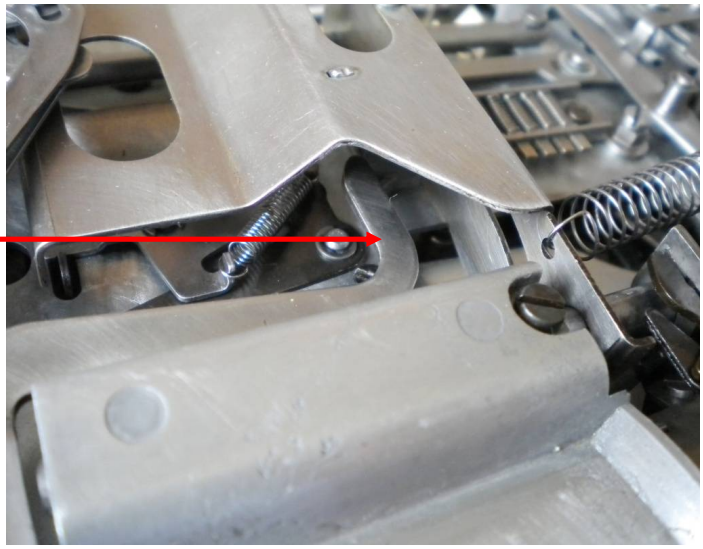
Invert the machine.

Check that feeler carriage 13241 definitely gets reset. However, the movement can only be so big that there is still some clearance between the carriage and pinbox housing 13205 when the rotor clearing bail 10769 has reached its highest point.



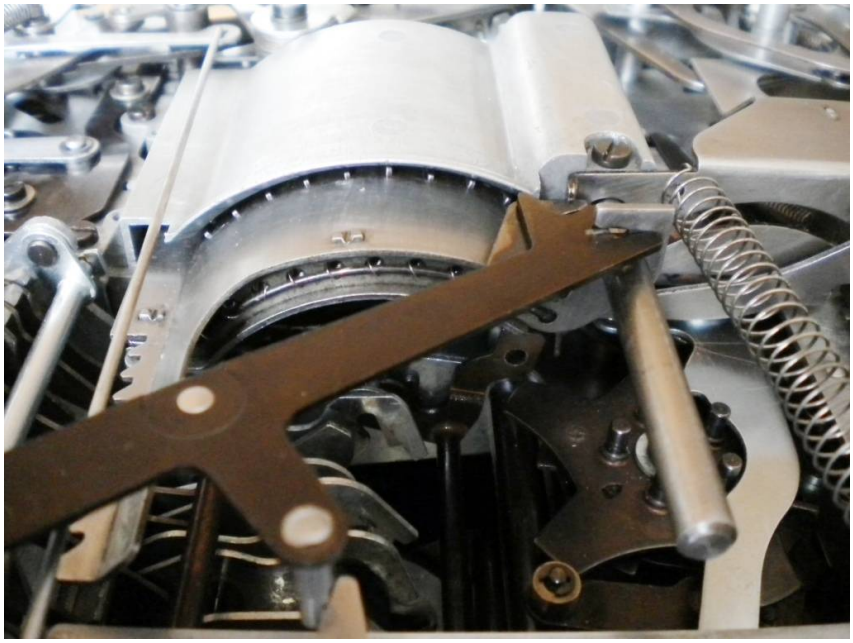


Adjustment is carried out bending rotor and pinbox return lever 13423.

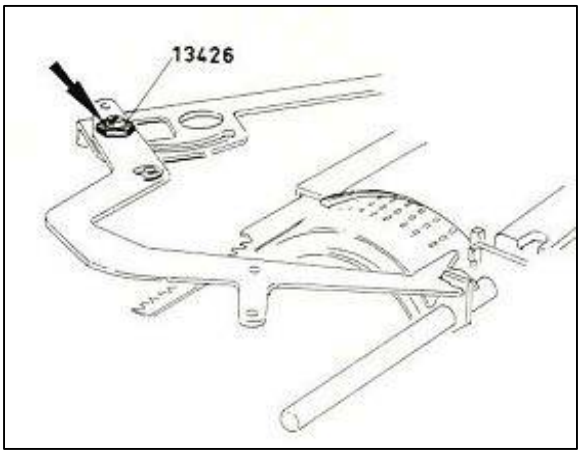


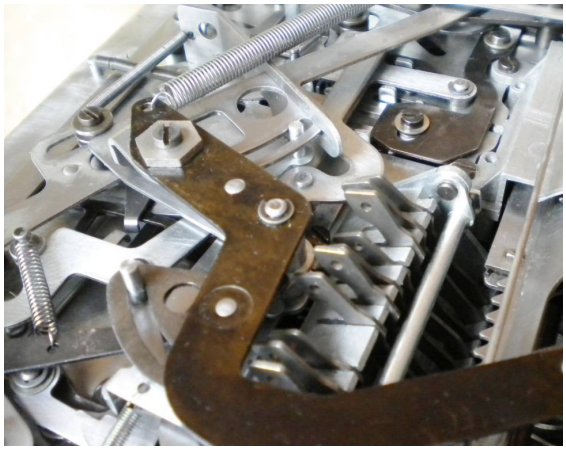
Pinbox Pins Reset Movement

Check that the pins in the pinbox mechanism get reset without causing tensions when the rotor clearing bail 10769 has reached its highest point.



Adjustment is carried out by turning eccentric 13426 on the pinbox return lever assembly 13431.



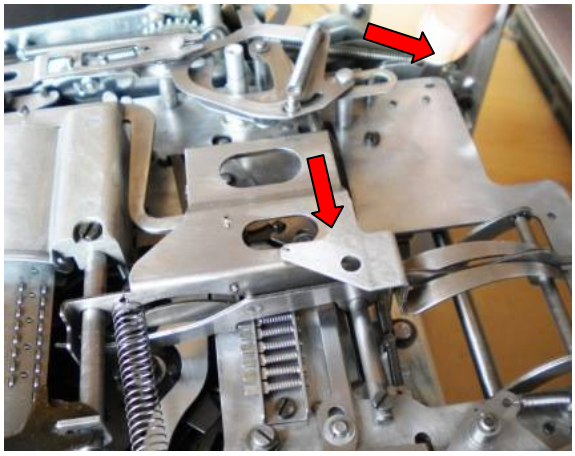


Pinbox Feeler Lever Positioning

Check that pinbox feeler lever 13246 strikes exactly in the middle of the pins in the feeler escapement holder 13250. This check has to be carried out on pins 0 and 8.

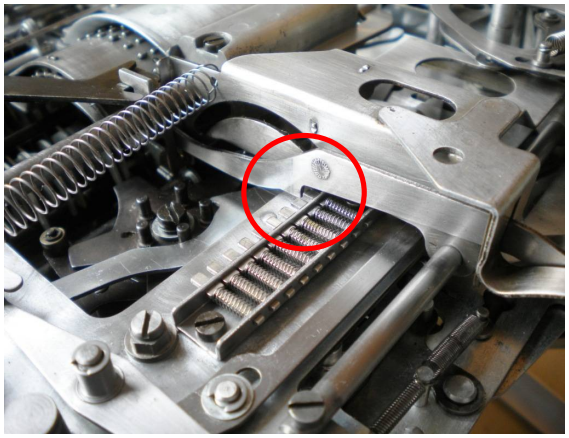
Carry out this check by first keying in 8 zeros.

Invert the machine and check the position of the feeler lever at position 0. Next manually and repeatedly depress feeler shaft assembly 13254 to position the pinbox feeler lever 13246 over to position 8. On each depression, the feeler carriage 13241 should slide smoothly from one pin to the next when pulled by spring 10216-26 and must come to rest exactly in the middle of each of the pins in the feeler escapement holder 13250.

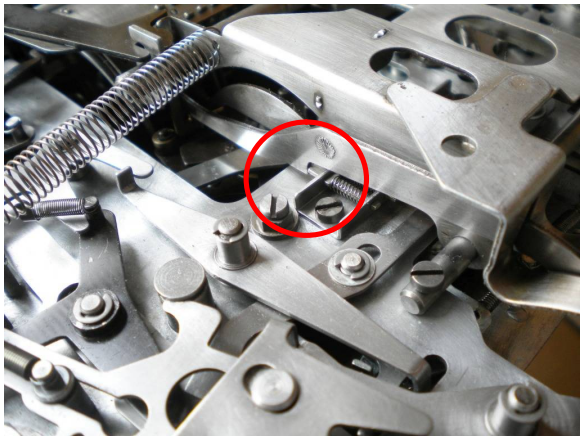


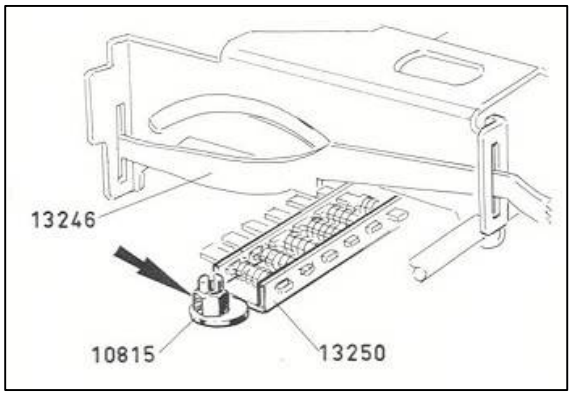
When these checks have been carried out, manually push back the pinbox feeler carriage back to position 0 and reset the setting register's rotor by pressing key "I" and hand-cranking.

Position 0



Position 8

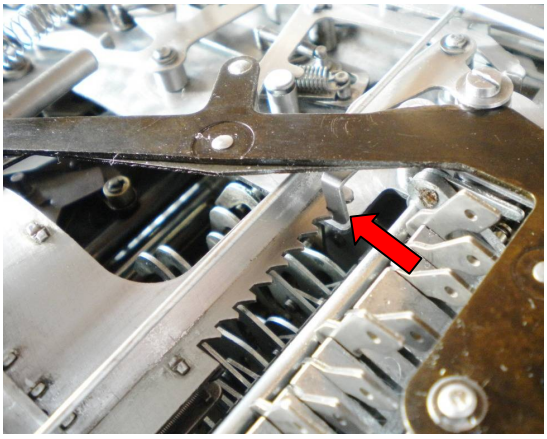


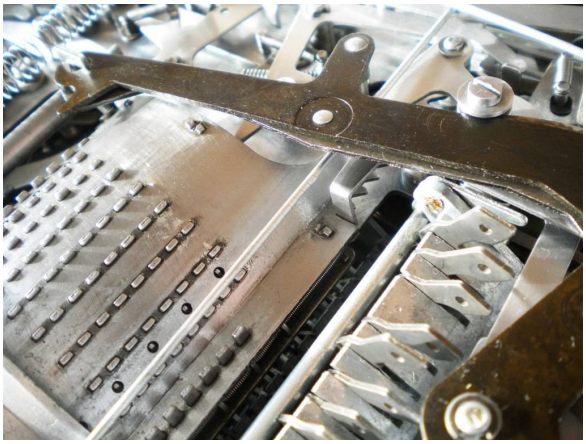


Adjustment is carried out by loosening the screws for feeler escapement holder 13250 and relocating the latter by using eccentric 10815.

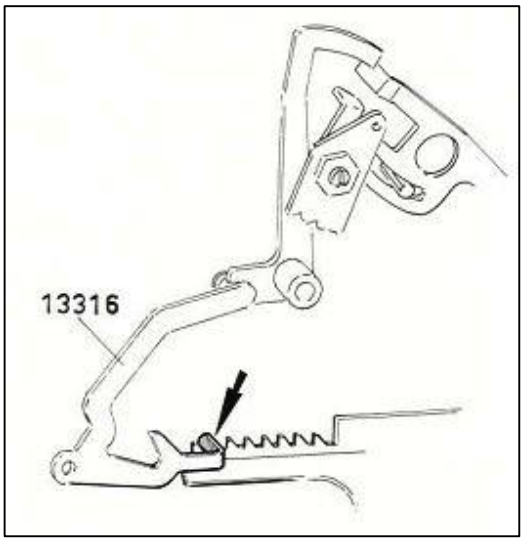
Pinbox Lock Lever Engagement

Key in a zero, press 2-arm pinbox lock lever 13316 against the ratchet on the pinbox assembly whilst checking that the pinbox assembly doesn't change its position when the lock falls in. Repeat the same control with 8 keyed in zeros.





Adjustment is carried out by bending pinbox lock lever 13316.



Pull the lever away from engagement with the ratchet then reset the setting register's rotor by depressing reset key "I" and manually cranking.

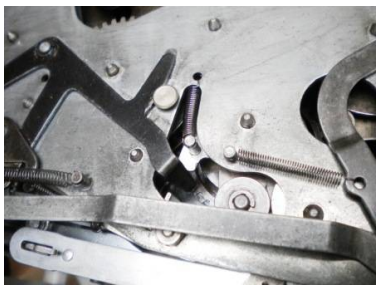
Rotor Clearing Clutch Lever Operation

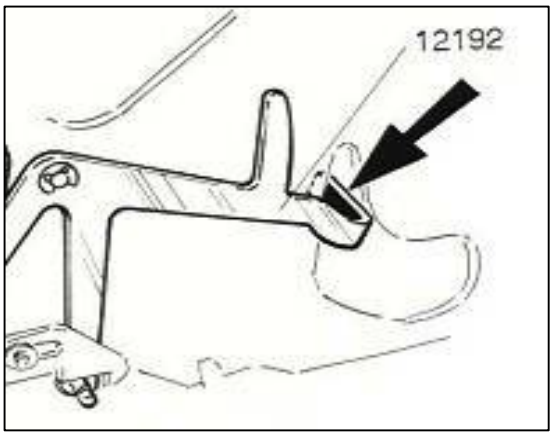
Depress reset key "I" and check the position of rotor clearing clutch lever 12192 as the machine is hand-cranked.

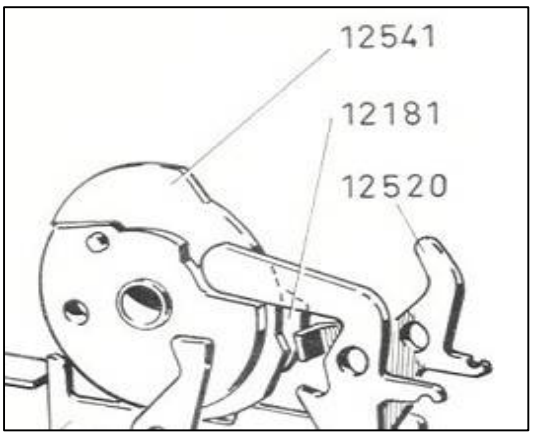
Before key "I" pressed

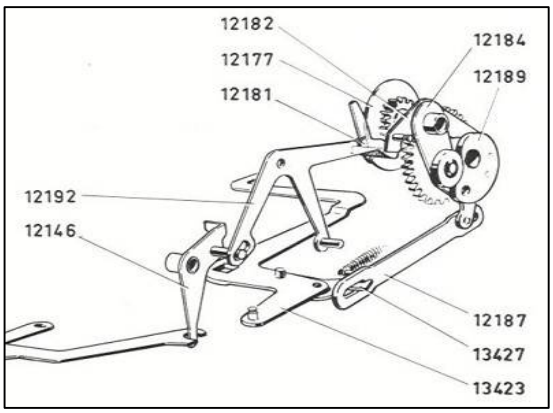
After key "I" pressed

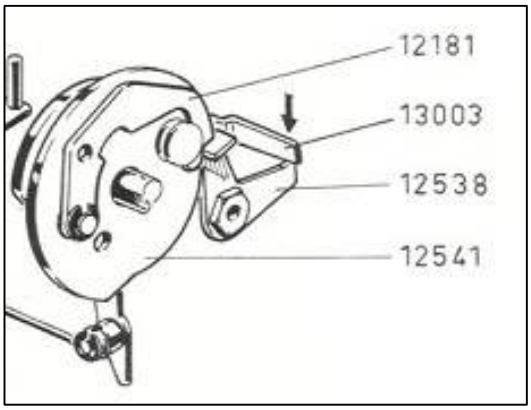
As the setting rotor is clearing











Lever 12182 prevents rotor clearing clutch lever 12192 from intervening straight after the first revolution and disengaging register I/register II clutch pawl 12181.

Adjustment is carried out by bending the angle on the rotor clearing clutch lever 12192 which rests on register I/register II clutch pawl 12181 as shown by the arrow in the diagram above.

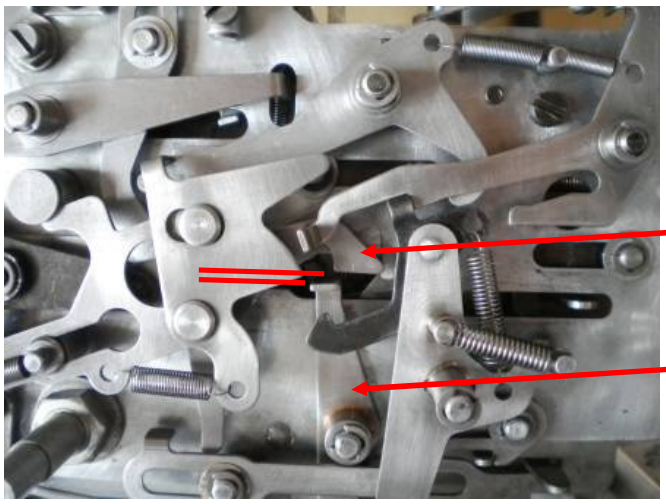
Pull Hook Functionality Checks

Depress a function key as listed on the next pages to the extent that it locks into its lowest position.

Check that the clearance between pull hook 13336 and forked lever 13327 (marked with "A" in the diagram below) should be at least 1 mm. Then crank until the pull hook 13336 engages in the angled end of forked lever 13327. Check in this position that the engagement is satisfactory.

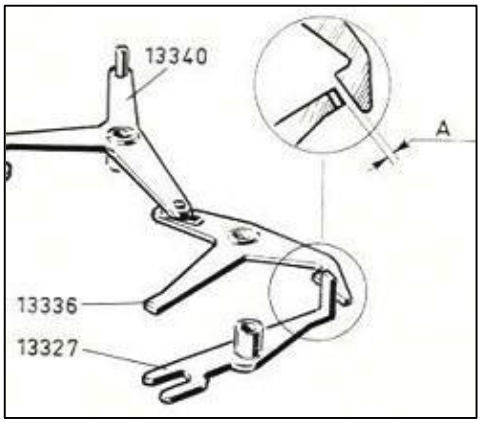
Afterwards, continue hand-cranking until all mechanisms are reset.

(In all the following photographs in this section, the machine is inverted with its left side nearmost.)



After the function key has been depressed (except for accumulator register III reset).

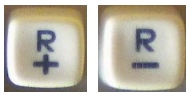
After 13336 is engaged with 13327.

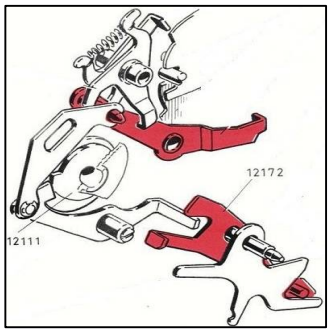


After each adjustment is carried out as detailed below, recheck the functionality of pull hook 13336 and forked lever 13327 as shown on the previous page.

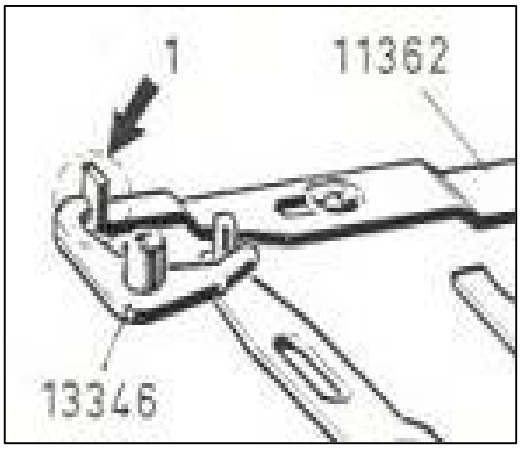
Adjustments are carried out in different places for the different functions as follows:

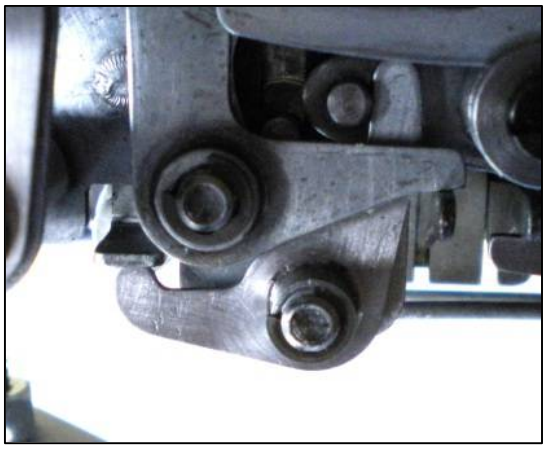
i. Repetition Function for Register I Addition & Subtraction
(the start cam set 12111 has just triggered)





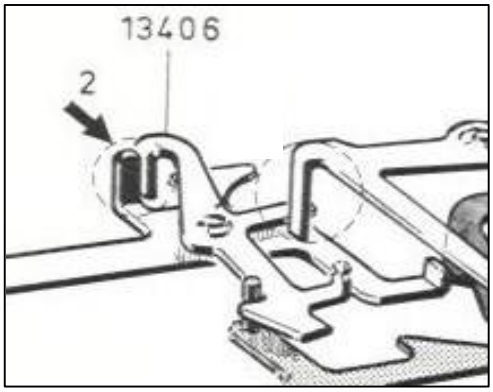
Adjustment is carried out by bending the tongue marked with "1" on sliding link 11362.





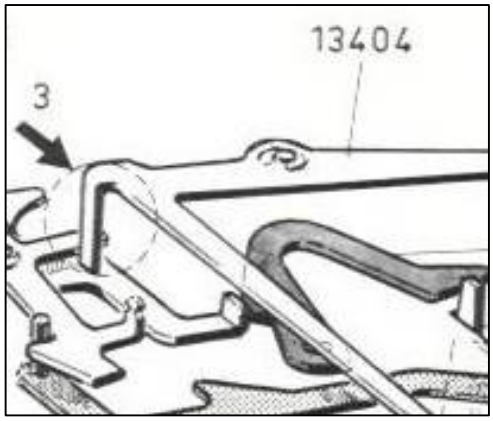
ii. Setting Register I Reset

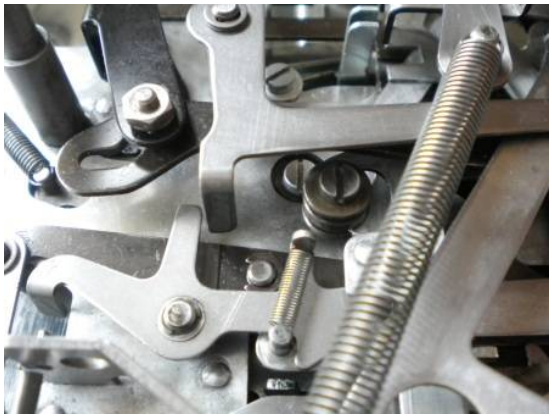
Adjustment is carried out by bending the tongue marked with "2" on sliding link 11362 or the neighbouring tongue on lever 13406.



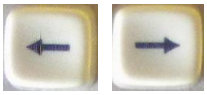
iii. Counter Register II Reset

Adjustment is carried out by bending the tongue marked with "3" on register II clear lever 13404.

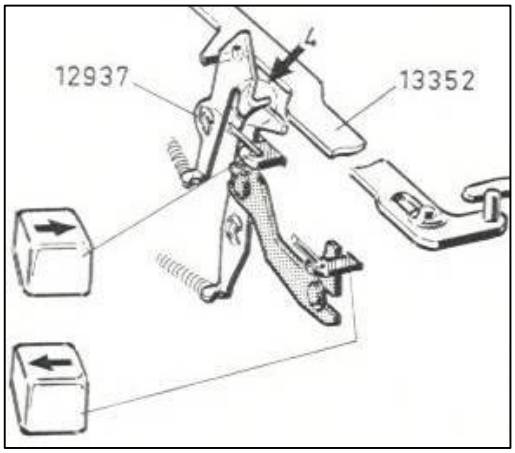




iv. Setting Register I Left and Right Shift

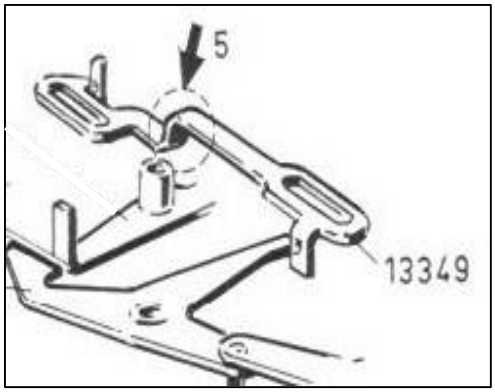


Adjustment is carried out by bending the tongue marked with "4" on lever 12937.

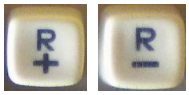


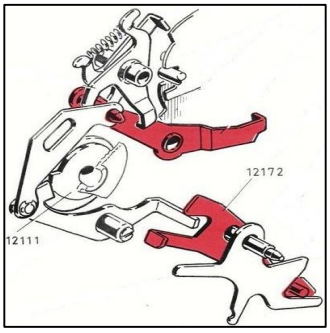
v. Accumulator Register III Reset

Adjustment is carried out by shortening or extending sliding link 13349 marked with "5".

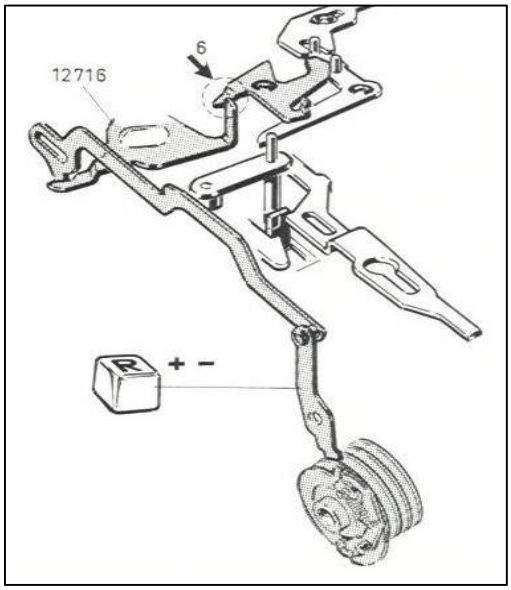


vi. Repetition Function for Register I Addition & Subtraction
(start cam set 12111 has been caught by hook 12172)

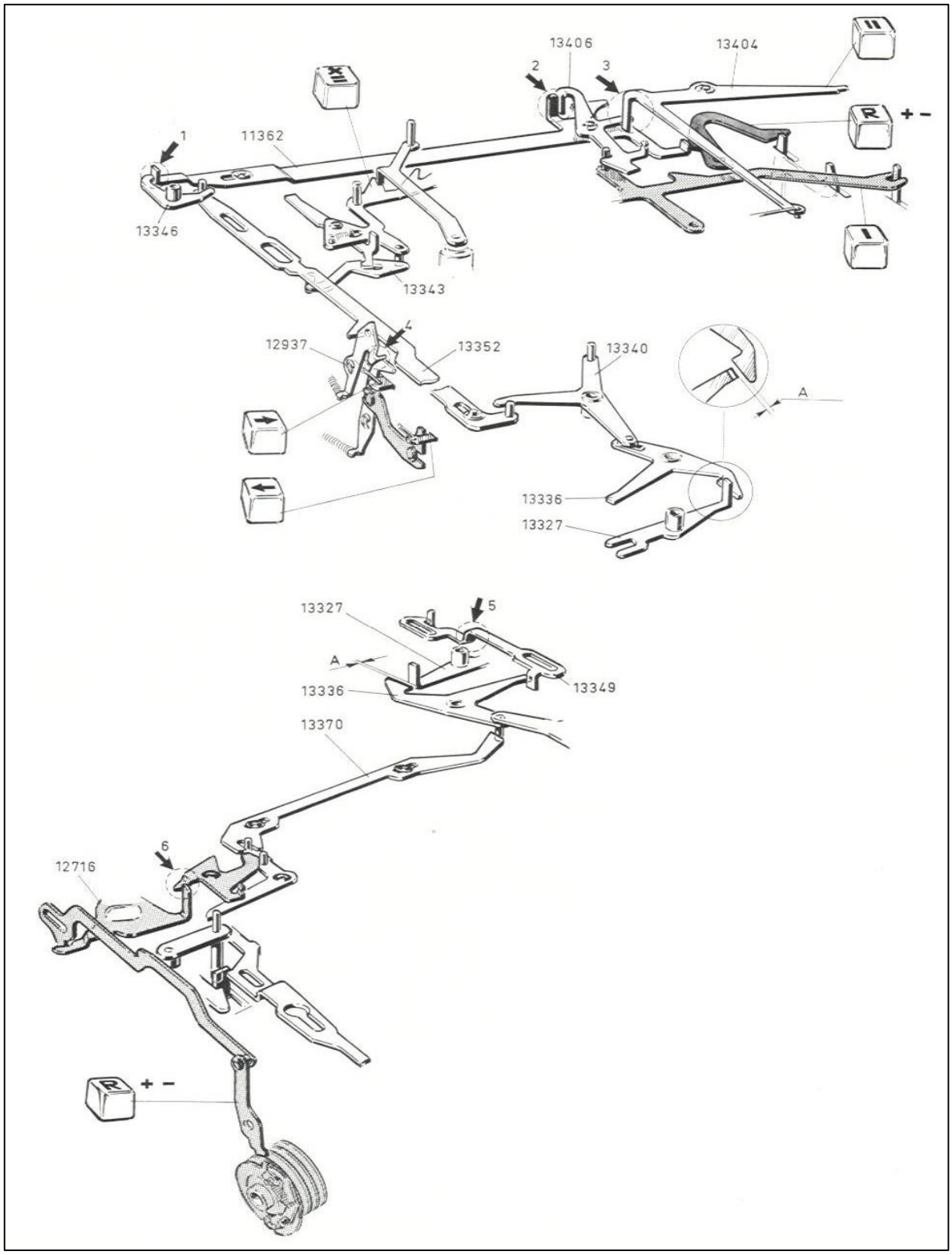




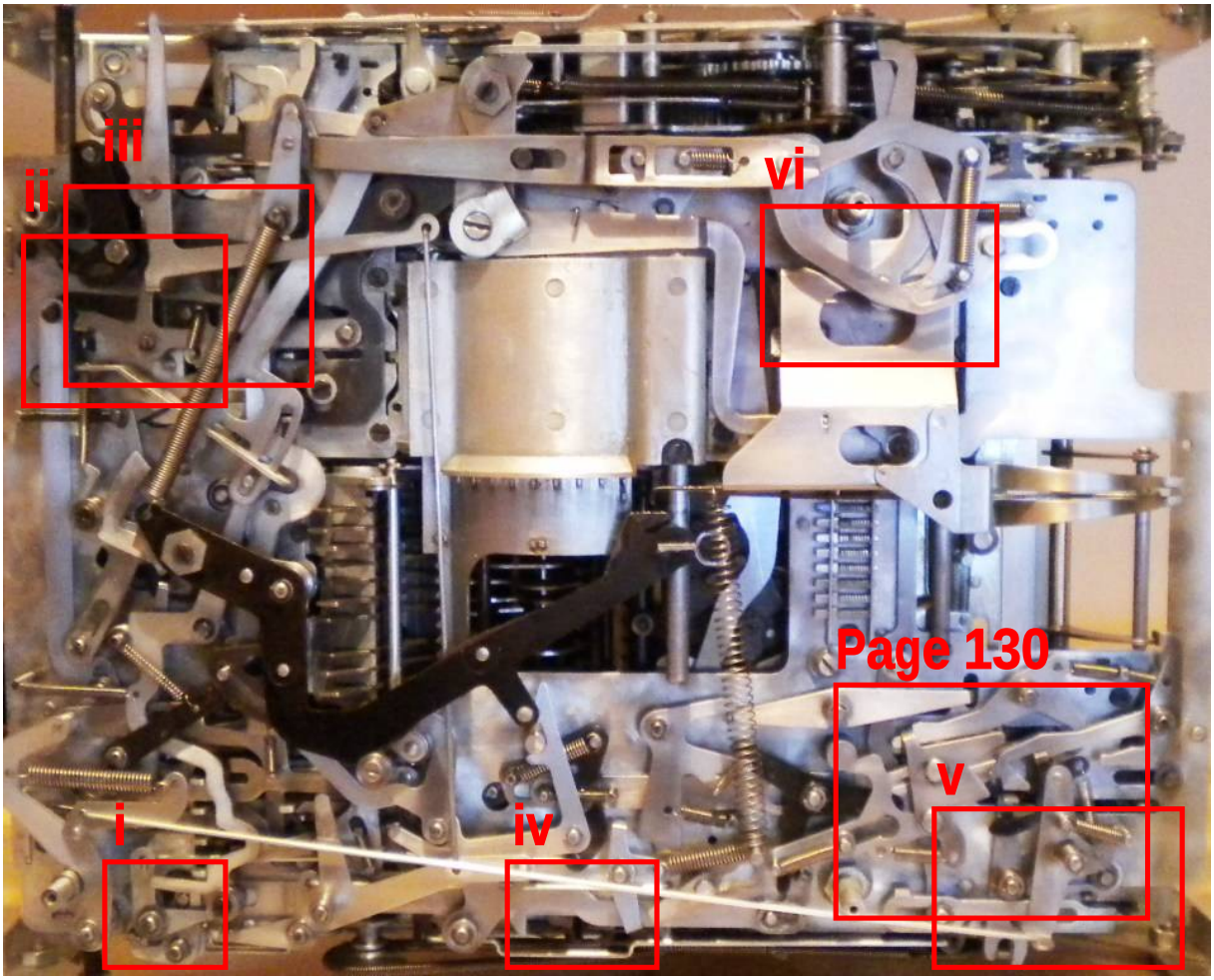
Adjustment is carried out by bending the tongue marked with "6" on lever 12716.



Overview diagram of adjustment locations as detailed on previous pages above.

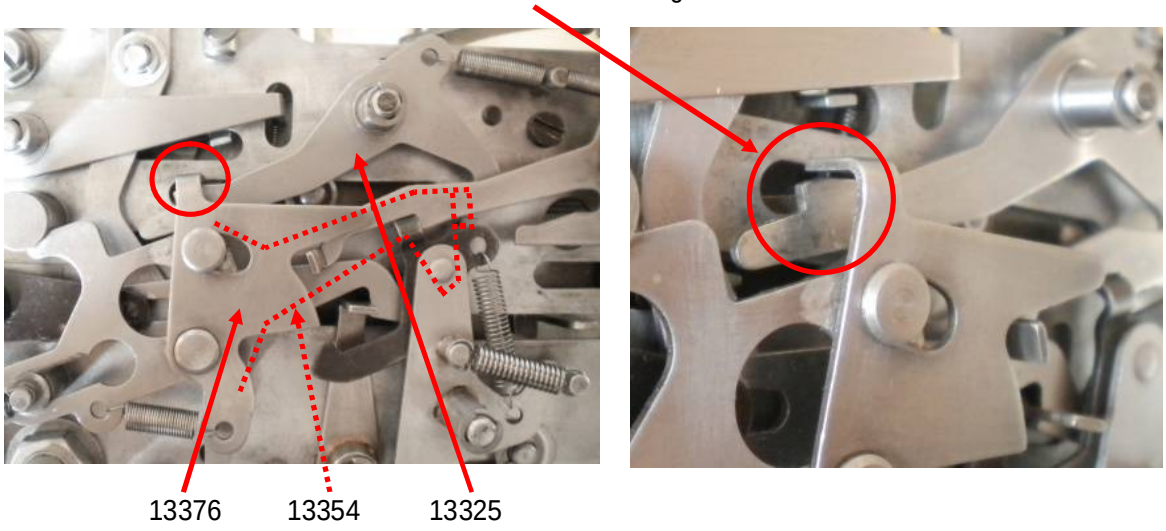


Overview showing locations of photographs as detailed on previous pages above.

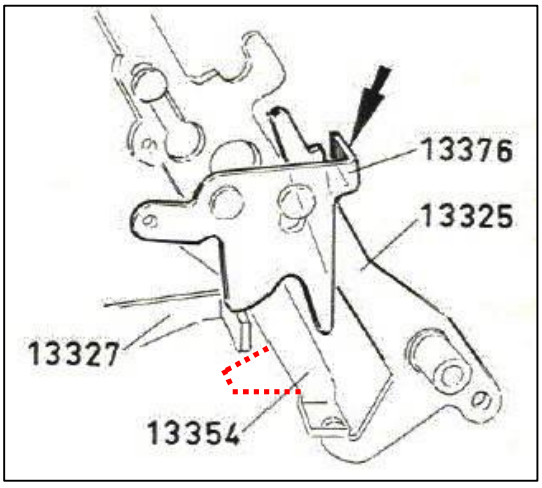


Hook And Lock Clearance

Depress key "R+" and crank until switch-off slider assembly 13354 has reached its rearmost position (to the right in the photograph). This should release hook 13376 from lock 13325. Lock 13325 should have a small excess clearance from the angle on hook 13376.



Adjustment is carried out by bending the angle on hook 13376 as indicated by the arrow at right.

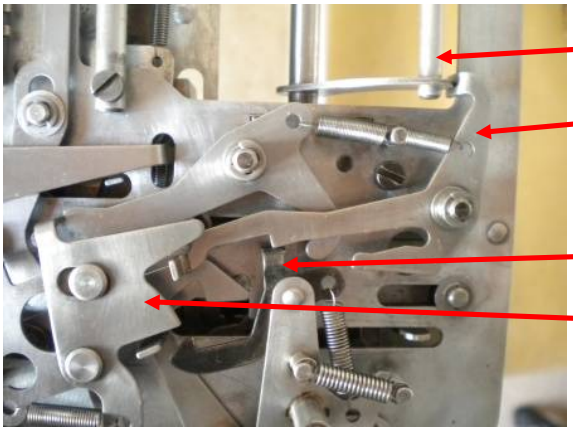


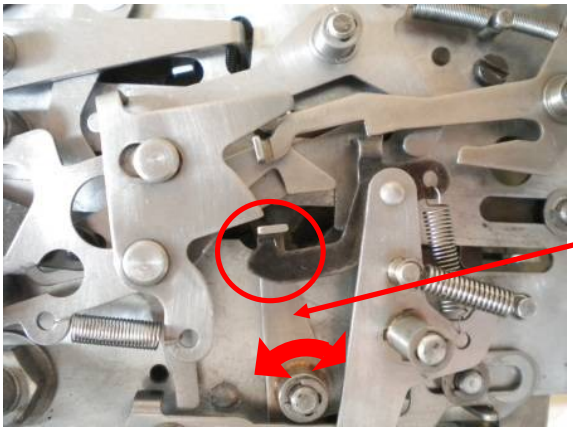
(Note the different shape at the end of switch-off slider assembly 13354 in the machine under test to that of the diagram taken from the German Service Manual)

Continue hand-cranking until all mechanisms are reset

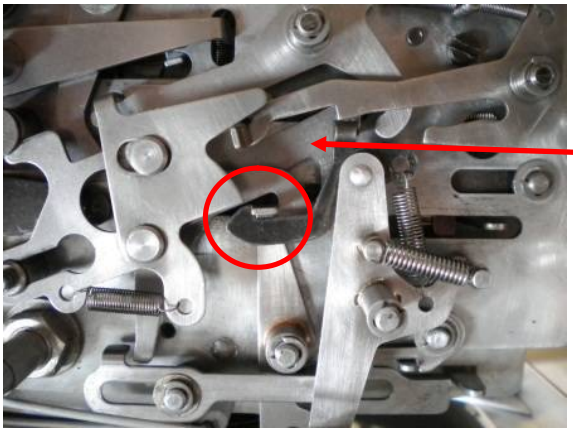
Start Hook Disengagement

Key in a zero and depress key "X=". Then manually crank until feeler shaft assembly 13254 impacts and pushes on indent lever 13329. This releases start hook 13323 and hook 13376 is kept away by the angled end of indent lever 13329.

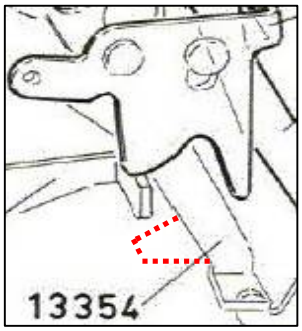




Now check that start hook 13323 doesn't engage in forked drive lever 13327 as it swings back and forth as cranking is continued.



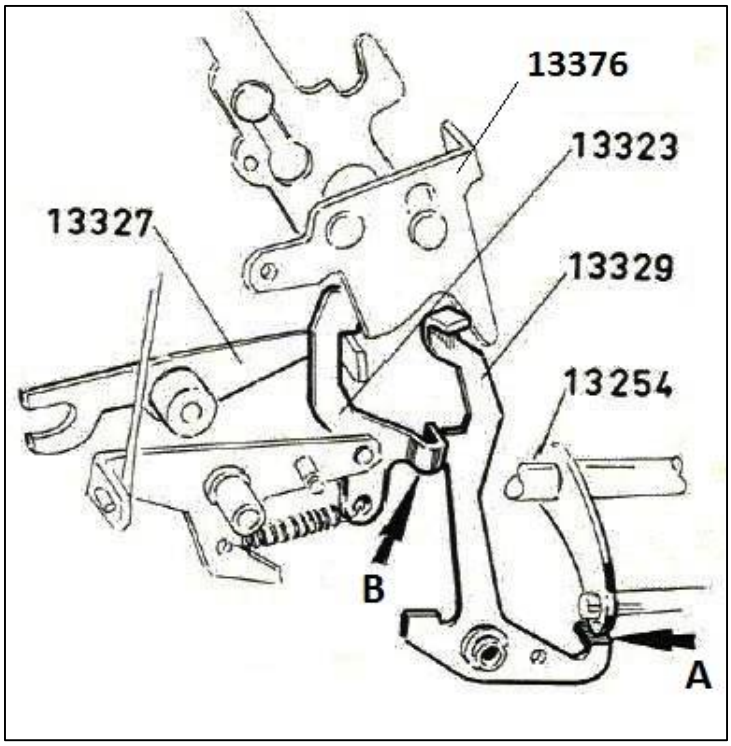
The engagement must only happen when switch-off slider assembly 13354 has reached its rearmost position.



After switch-off slider assembly 13354 has reached its rearmost position, continue cranking for a further approximately 20 turns to reset the mechanisms and place the setting register's rotor into its rightmost position.

If the movement of feeler shaft assembly 13254 isn't sufficient to release start hook 13323, this is corrected by bending the angle on indent lever 13329 where it touches feeler shaft assembly 13254 as indicated by arrow "A" at right.

The position of the start hook 13323 in relation to forked drive lever 13327 is adjusted by bending the angle on start hook 13323 as indicated by arrow "B" at right.

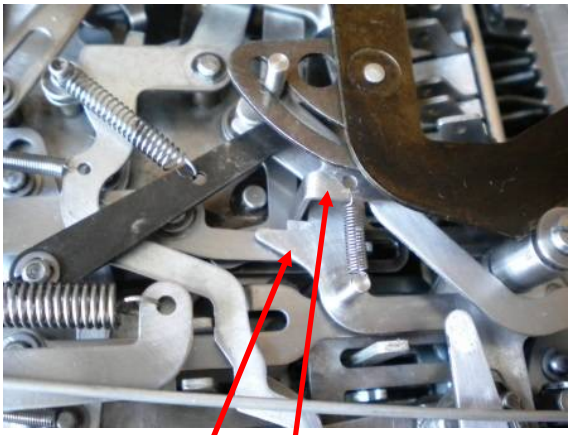


Multiply Linkage Lock Lever Positioning

Key in a zero and then press key "X=".

Check the positions of multiply linkage lever assembly 13439 and multiply linkage lock lever 13395.

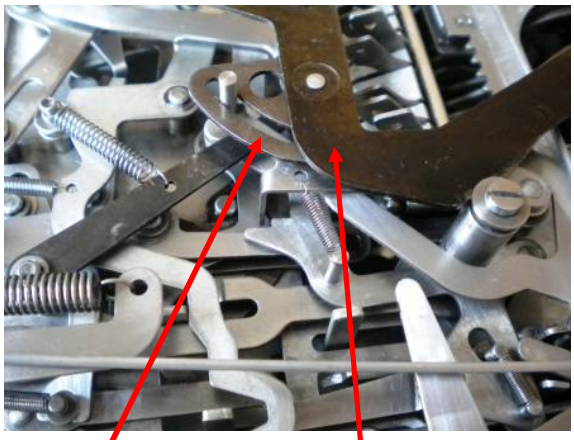
Positions of levers prior to key "X=" pressed



13439 13395

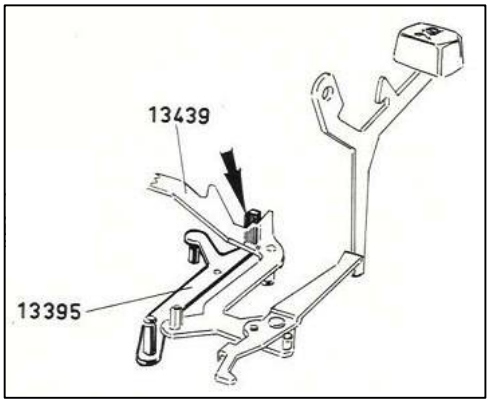
Positions of levers after key "X=" pressed

Crank and check that the movement emanating from cam & countback clutch 12201 via pinbox return lever 13431 and pinbox push link 13429 is sufficient to get multiply linkage lock lever 13395 to engage and lock multiply linkage lever assembly 13439.



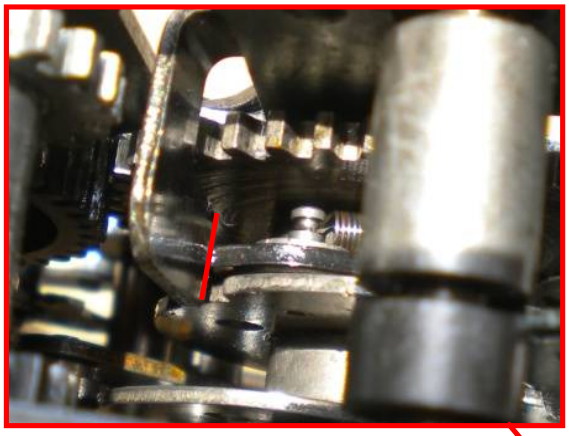
13429 13431

Adjustment is carried out on the angle of lock 13395.

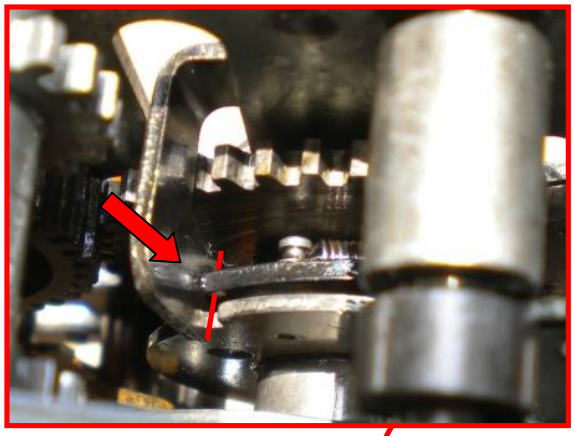


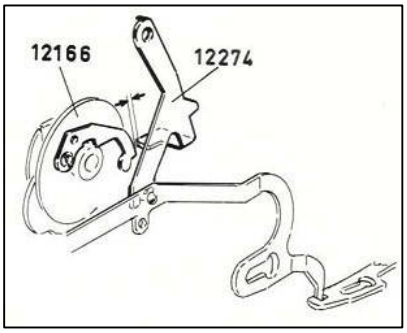
During this cycle, check that the 2nd trip lever 12274 doesn't catch start pawl 12166 until the cam set 12201 has rotated though 2+ turns.

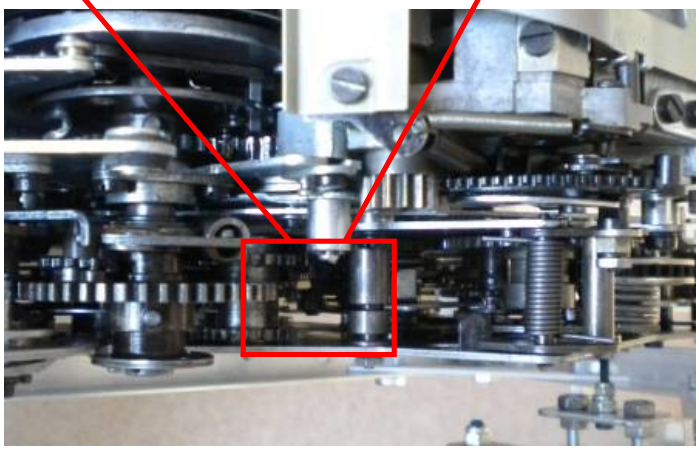
Trip lever disengaged from clutch after "X=" key pressed



Trip lever re-engaged with clutch after the cam set has turned through 2+ turns

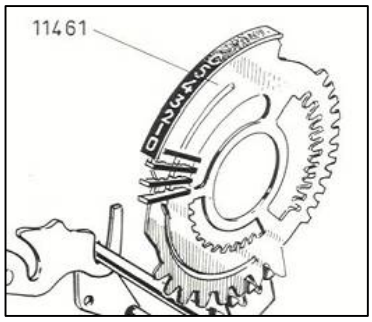






Setting Rotor Lateral Movement

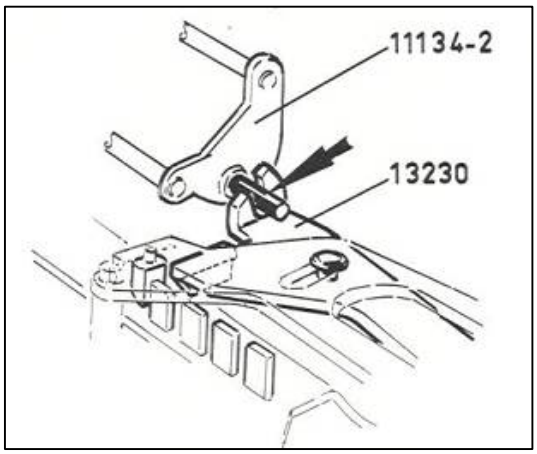
When a single digit is entered, the lateral step movement of the setting rotor must not take place until setting disc 11461 has reached the position which matches the keyed in number.



Number key pressed

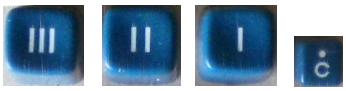
Key released, setting rotor steps left

Adjustment is carried out by bending the pin on trigger bridge 11134-2.



Exercise the Tens Carry Facility

Clear the machine by pressing, in turn, keys "III", "II", "I" and "ċ".



As noted previously, after pressing each key, hand-crank the requisite number of turns to allow the machine to perform the reset function.

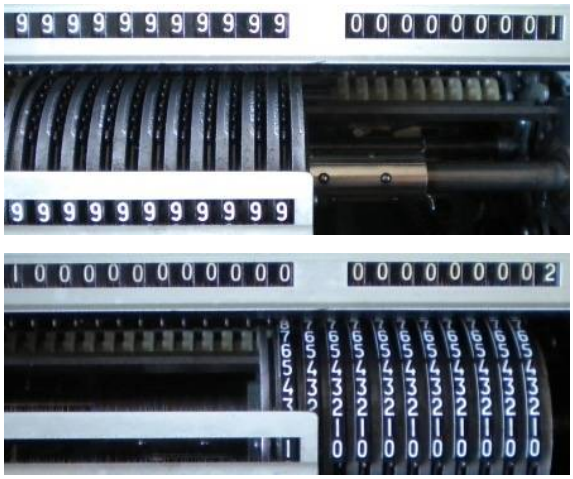
Press the "REG II" key. This will enable the counter register II to tally the additions.

a) Enter 99999999999 then press the "+" key. Hand-crank to enter the number into the accumulator register III.

   The counter register II will tally the additions and further cranking will clear setting register I.

b) Enter 1 then press the "+" key. Hand-crank to add this number to the accumulator register III and verify that tens carry operations have been rippled through.

   Check that the counter register II has incremented. Further cranking will clear the setting register I



c) Subtract 1 and verify that the accumulator register III has returned to displaying all 9s and that the counter register II has decremented back to 1.

d) Subtract 99999999999 and verify that the accumulator register III has returned to displaying all 0s and that the counter register II has decremented back to 0.

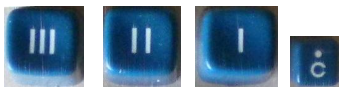
e) After subtracting 1 the accumulator register III and the counter register II should displaying all 9s.

f) Add 1 to verify that the accumulator register III and the counter register II will display all 0s.

Reset the "REG II" key by pressing the "ċ" key.

Enter step (a) again then repeat steps (b) and (c) repeatedly as fast as is feasible (when the motor is installed these operations will take less than 1 second to complete).

Perform a Trial Multiply Calculation

Clear the machine by pressing, in turn, keys "III", "II", "I" and "c". 

As noted previously, after pressing each key, hand-crank the requisite number of turns to allow the machine to perform the reset function.

From the calculator's Instruction Manual, perform the following calculation:

Key in 189 then press the "X" key. 

Key in 53678 then press the "X=" key. 

The result of 10145142 should appear in the accumulator register III.

(photograph taken just prior to the setting register I being reset)

Continue hand-cranking to reset the register.

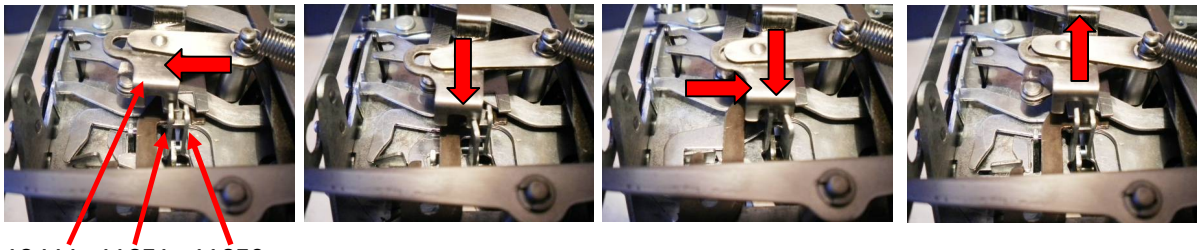
Perform a Trial Square Calculation

Key in 19 then press key "X=" (giving $19^2 = 361$ after approx. 70 turns).

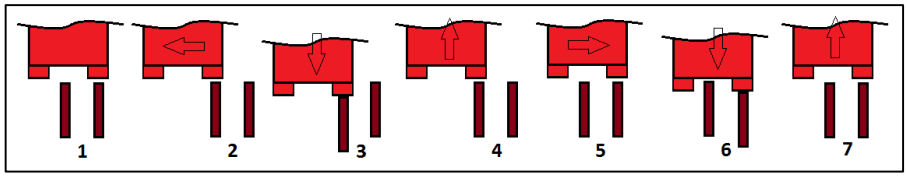
a) Crank and check whether multiply +/- selector lever 13444 has taken up the best position in relation to plus and minus levers 11350 and 11351.

b) Repeat the same check but firstly press the "NEG" key before keying in 19 and pressing key "X=".

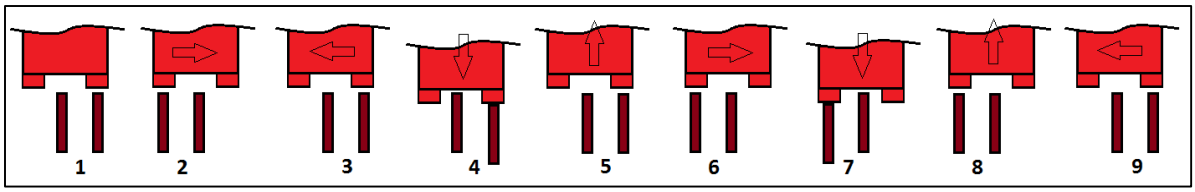
Example photographs taken during the test sequence. Machine is inverted with the front nearmost.



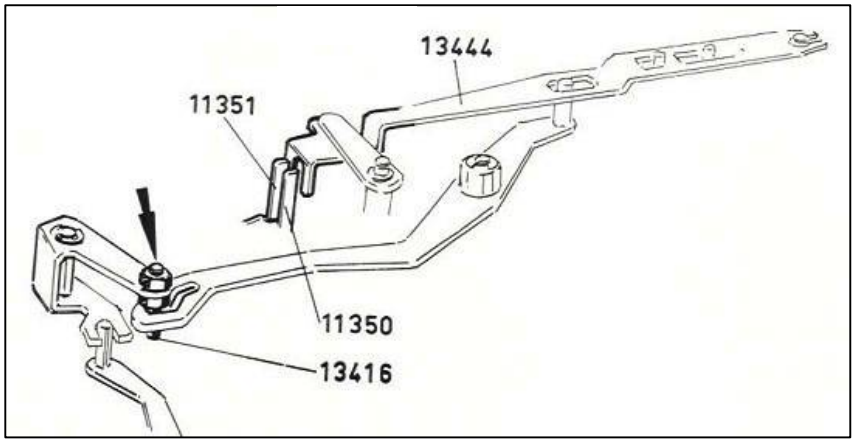
Sequence (a) mechanism movements. 1 is the initial position.



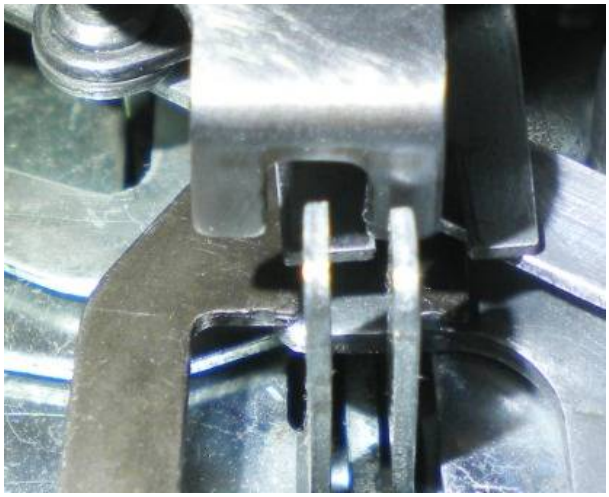
Sequence (b) mechanism movements. 2 is after the "NEG" key has been depressed.



Adjustment is carried out using eccentric pin 13416.



The angles on multiply +/- selector lever 13444 should be positioned directly and centrally in line with plus and minus levers 11350 and 11351.



Sequence (a) result of 361 (19^2) in accumulator register III.

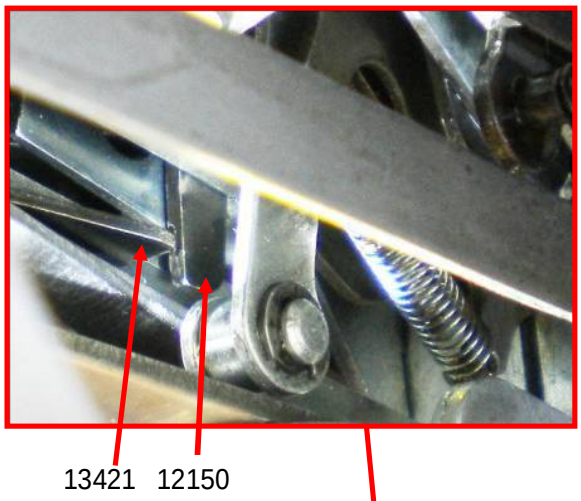
Photographs taken just prior to clearing setting register I.

Sequence (b) result of ...999639 (10^{16}-19^2) in register III.

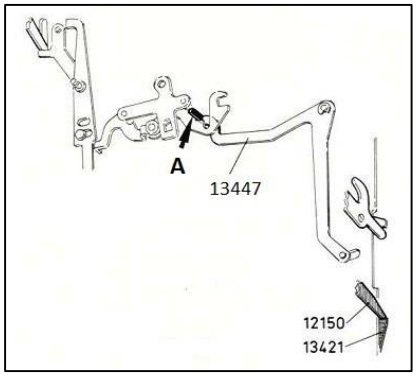
3-Arm Start Lever Engagement

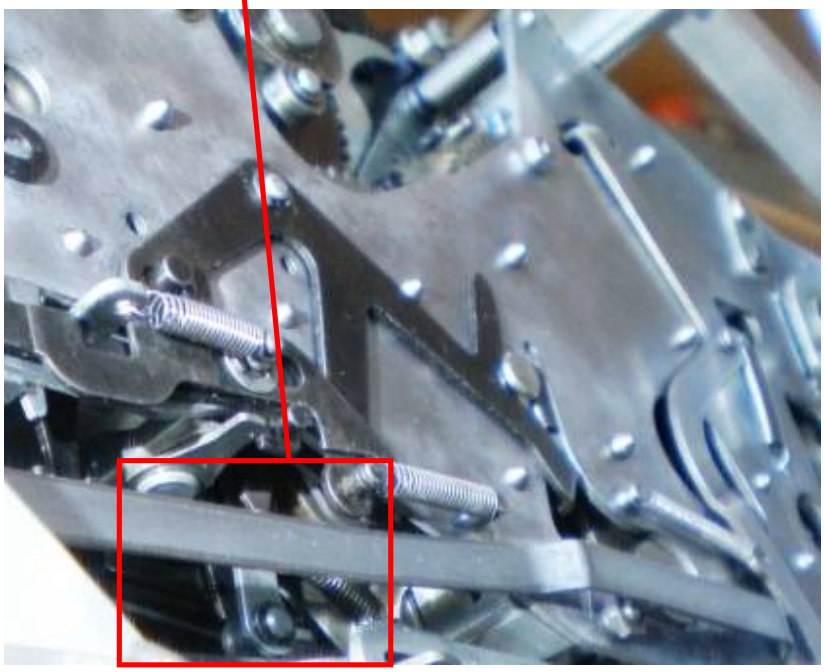
Press key "÷" and manually crank. 

Check that 3-arm start lever 12150 sufficiently engages in division start lever 13421. The outer edge on division start lever 13421 should protrude approximately 4 mm out from the side chassis of the bottom sub-assembly .



If the engagement is too bad this can be corrected by bending the angle on division lever 13447 as shown by arrow "A".

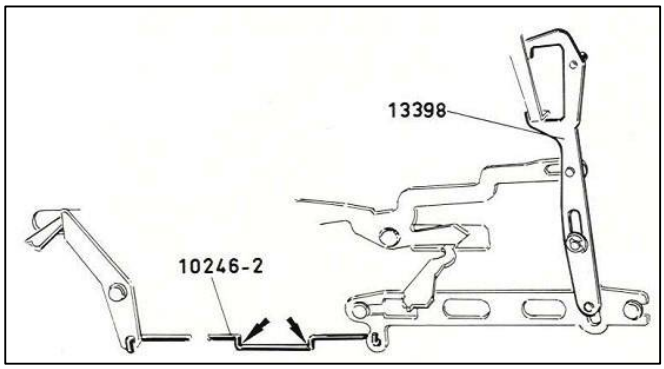




Division Start Selector Lever Movement

If the first start of start cam set 12111 during division doesn't take place, it may be due to the movement of division start +/- selector lever 13398 being too small.

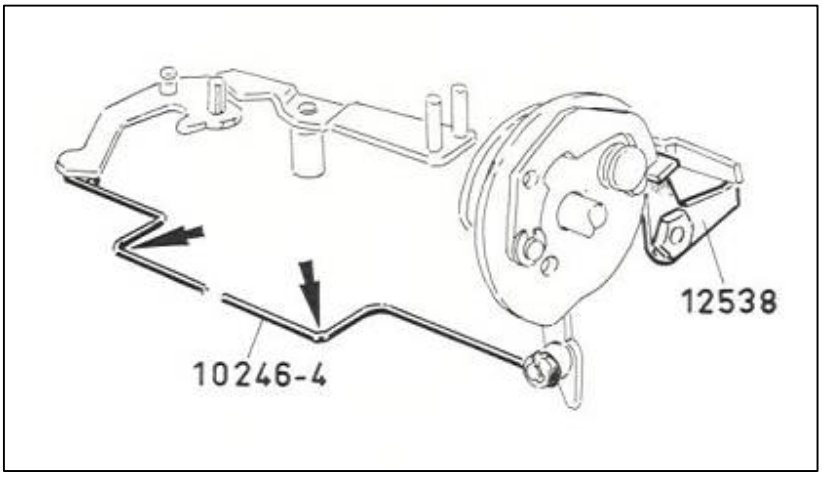
This movement can be increased by carefully shortening wire link 10246-2 by bending it where shown by the arrows.



Division Cam Pawl Triggering

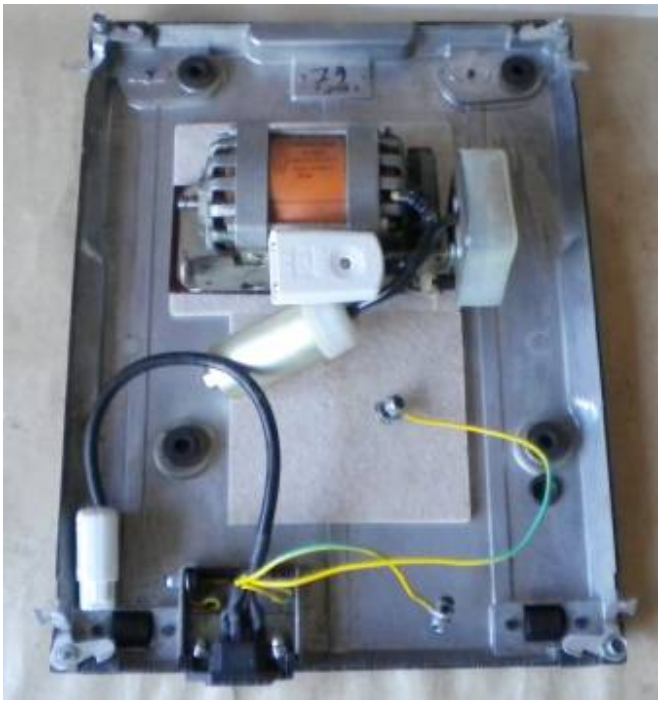
If, after keying in the dividend (and pressing key ":"), division cam pawl 12538 is not triggered, it may be due to wire link 10246-4 being too long.

Adjustment is carried out by carefully bending wire link 10246-4. After forming it by bending where shown, it must then be checked that the link doesn't splay on its bearing pins.



15 - MOTOR INSTALLATION

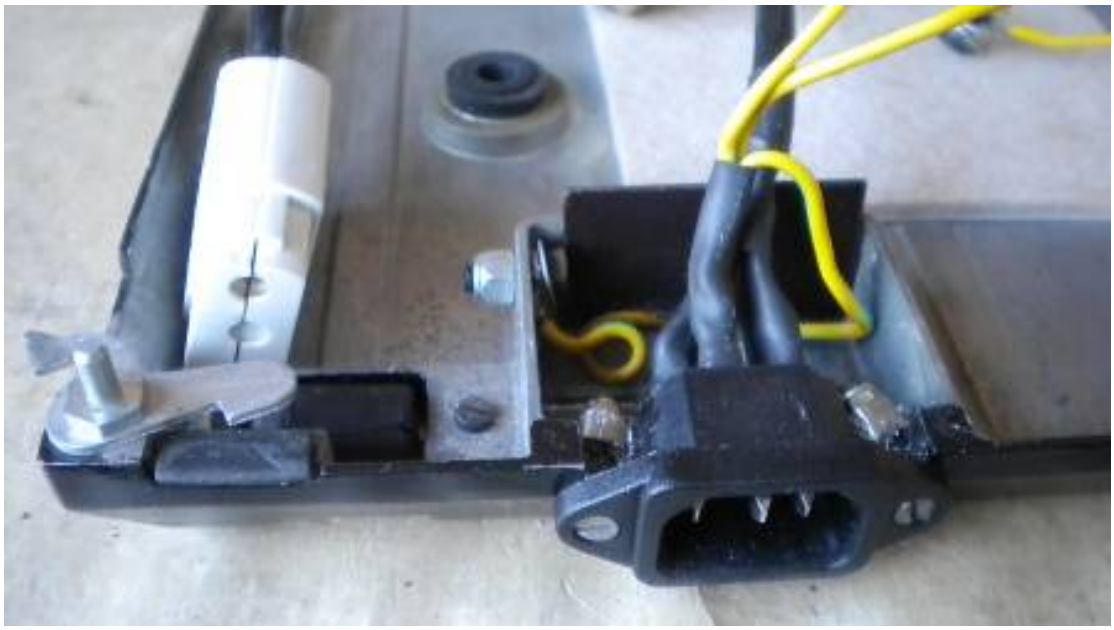
Note: Before the drive motor is installed, it was deemed necessary to replace the original mains connector in the cast base plate with a modern 3-pin 240 V AC mains captive plug connector and add earth bonding wiring from the new connector to the motor's base plate, the calculator's framework and the cast base plate prior to installing the motor. Additionally, ensure that the spark suppression capacitor is not leaking and remove the cover from the switch box to clean the electrical contacts.



The earth pin on the captive plug has had three flying leads soldered. These separately earth bond the base plate, the calculator's framework and the drive motor which itself is electrically insulated from the calculator's framework.

The opportunity was also taken to insert a two pin insulated in-line plug-socket into the motor's supply line (with the plug on the load side). This will supply the electrical power from the mains supply via the base plate's connector to the motor when the motor itself is mounted onto the calculator's framework during final testing prior to the latter being installed onto the base plate.

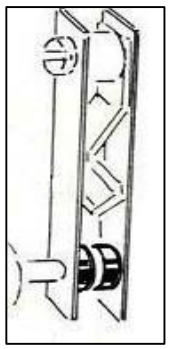
Note also the addition of new felt sound-proofing insulation.

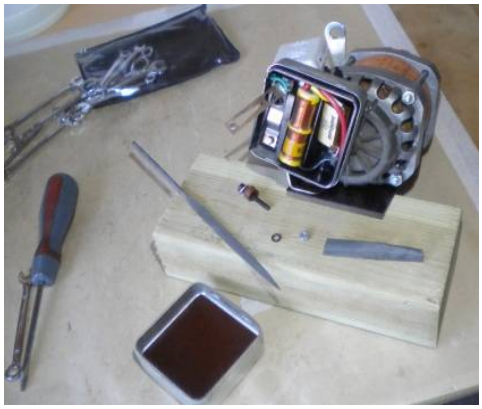


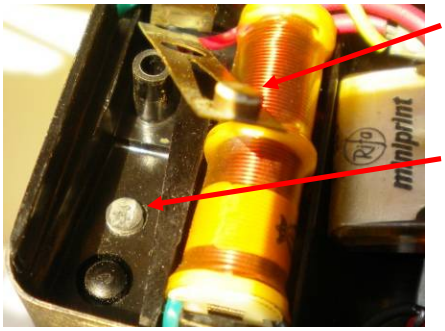
Open the drive motor's switch box cover to inspect the electrical switch contacts.

In addition, the capacitor's end cap should also be removed to check for any signs of leakage.

When the contacts 1257-4 are separated for cleaning, be sure to replace leaf spring 1395 into the correct orientation.

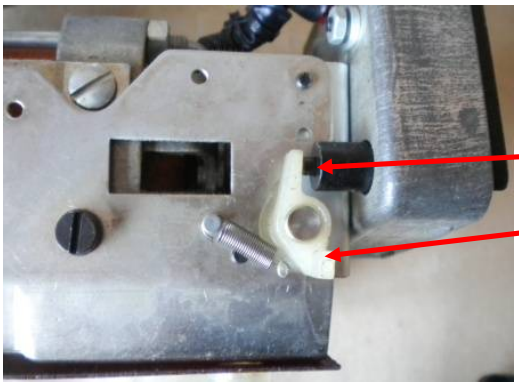






The contacts themselves should be inspected for any signs of excessive spark erosion on the contact tips and heat tempering of the phosphor bronze leaf-springs.

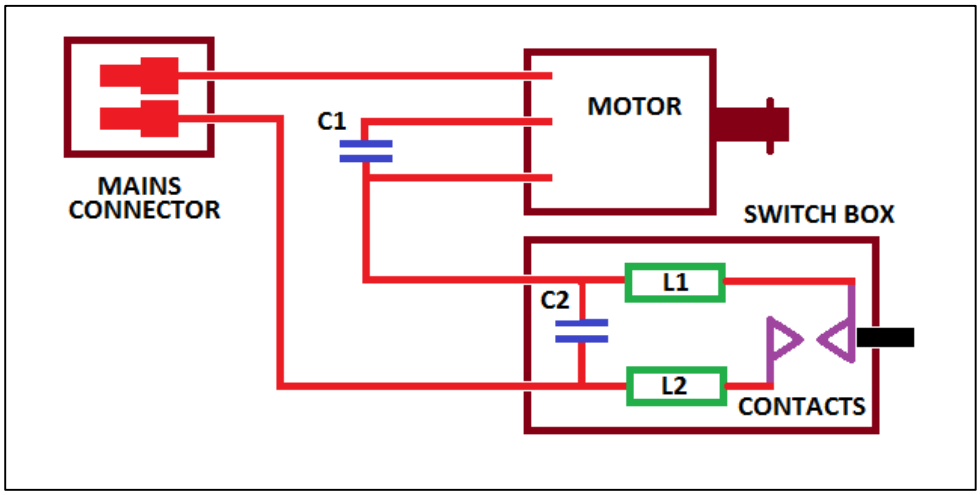
Check also for any deterioration on the neoprene buffer beneath the switch contacts



Also ensure that the white nylon contact lever 13640 is free to pivot and spring back and that plunger 2535-3 slides easily in the switch housing's boss.

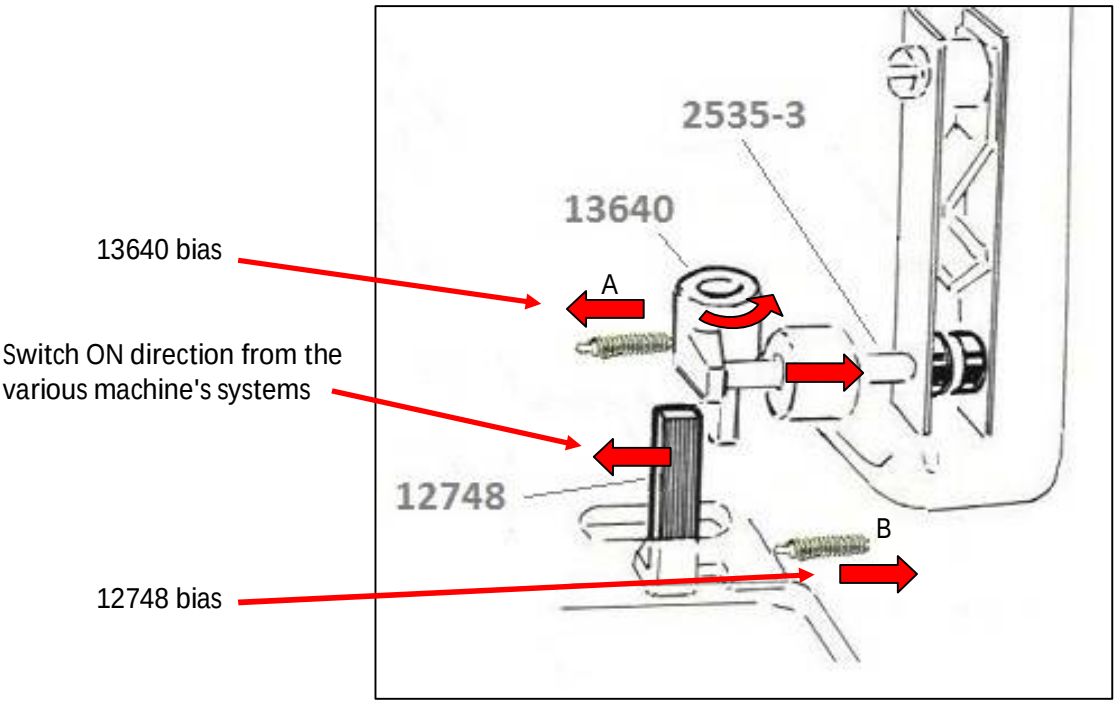
During testing it was found that the old paper 0.22 µF capacitor (C2) had become internally shorted and was continuously keeping the motor energised. This was replaced by a modern polypropylene capacitor of equivalent rating.

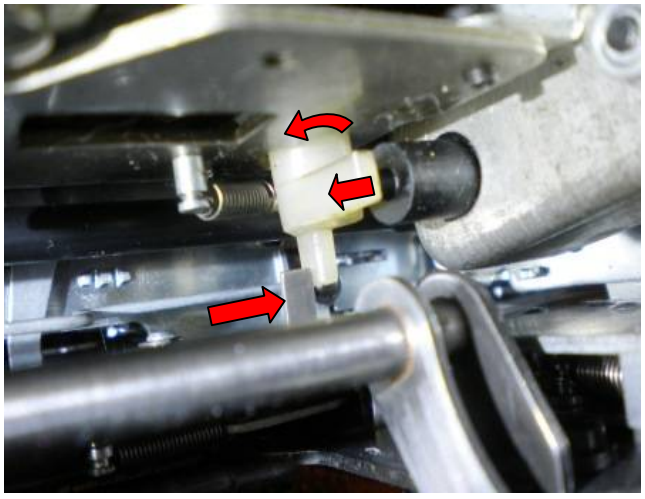
Electrical diagram of the drive motor and switch box wiring.



Component	Value
Mains Connector	240 V In-Line Plug
Motor	240 V AC Induction 50 Hz 60 W 1,500 RPM
Capacitor C1	3.5 µF 220 V AC
Capacitor C2 (old)	0.22 µF 400 V DC Paper
Capacitor C2 (new)	220 nF 500 V AC Polypropylene
Choke L1	220 V AC 2A
Choke L2	220 V AC 2A
Contacts	Phosphor Bronze Leaf Spring

This model has an unusual motor switching action in that contact lever 12748, when operated by the various systems of the machine to energise the drive motor, is moved away (to the left in the diagram below) from the switch mechanism. This allows the tension spring (A) to rotate nylon contact lever 13640 thus pushing plunger 2535-3 into the switch housing and closing the switch contacts.





Contact lever 12748 has its own spring (B) which biases the lever to touch with nylon contact lever 13640 (pulling the parts to the right in the photograph and the diagram above thereby keeping the electrical contacts open).

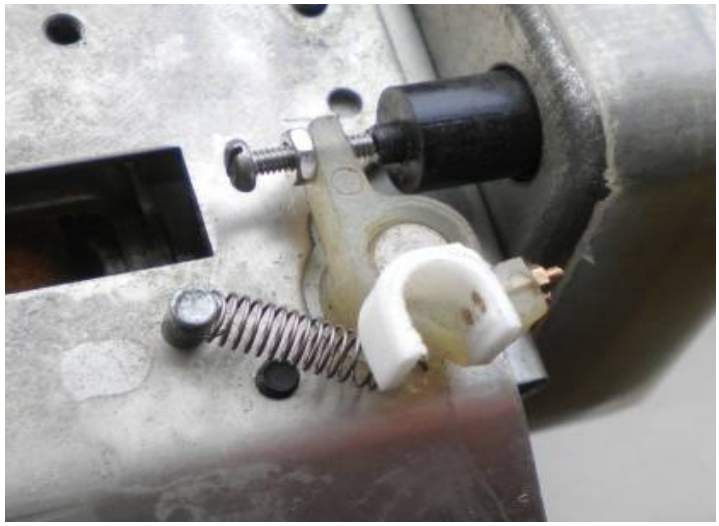
Thus, there is a fine balance between these two spring forces which have to be just right to ensure correct operation of the mechanism's switching action.

The spring pulling contact lever 12748 to the right (B) was measured at 40 grams and that of nylon contact lever 13640 (A) measured 45 grams.

The difference in these two biasing forces was deemed to be too fine to ensure consistent and reliable switching so a modern design modification was put in place.

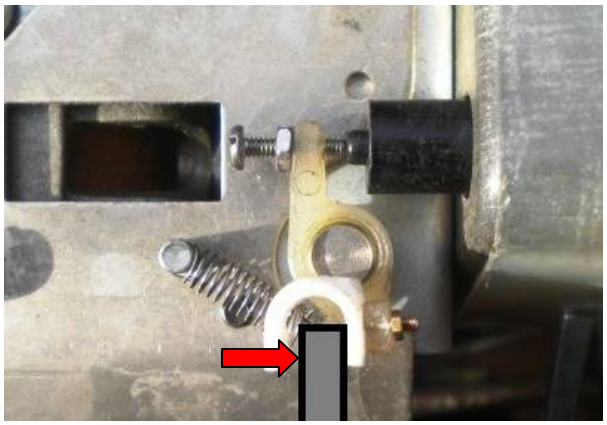
It was decided to modify the switching arrangement of nylon contact lever 13640 in order to make a more positive action when called upon to move by contact lever 12748.

As shown in the photograph below, a small nylon hook arrangement was bolted onto 13640's lower spigot to capture the movement of contact lever 12748 and an adjustable screw was incorporated into the upper spigot to finely tune the degree of travel of plunger 2535-3.

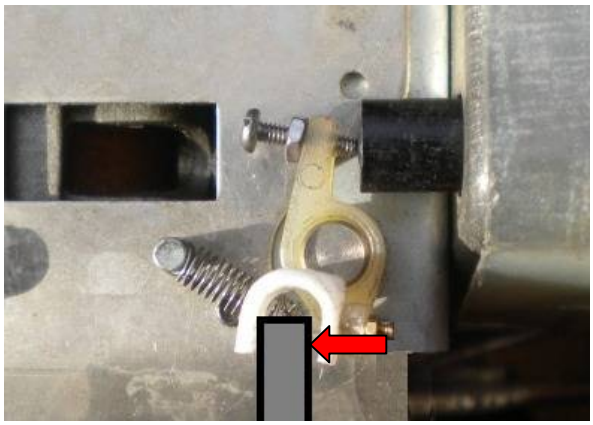


These two improvements brought about a more positive switching action and, additionally, allowed an increase in the electrical contact gap from 0.5 mm (as given in the German Service Manual) to 1.0 mm when the motor was commanded to switch off. Increasing the gap to 1.0 mm was deemed much more desirable considering the 240 V electrical potential across the switch contacts.

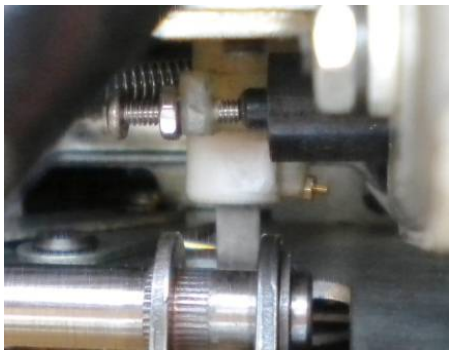
Contacts Open - Motor Off



Contacts Closed - Motor On

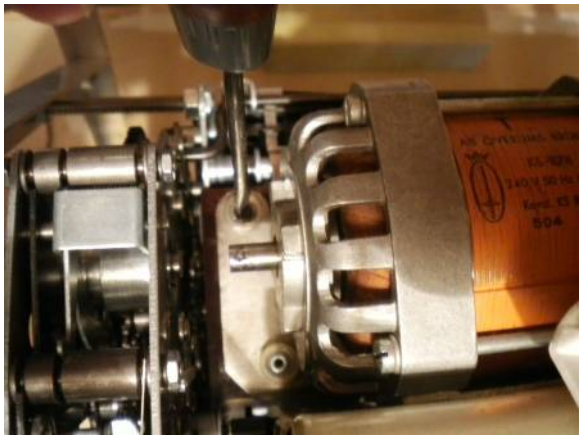


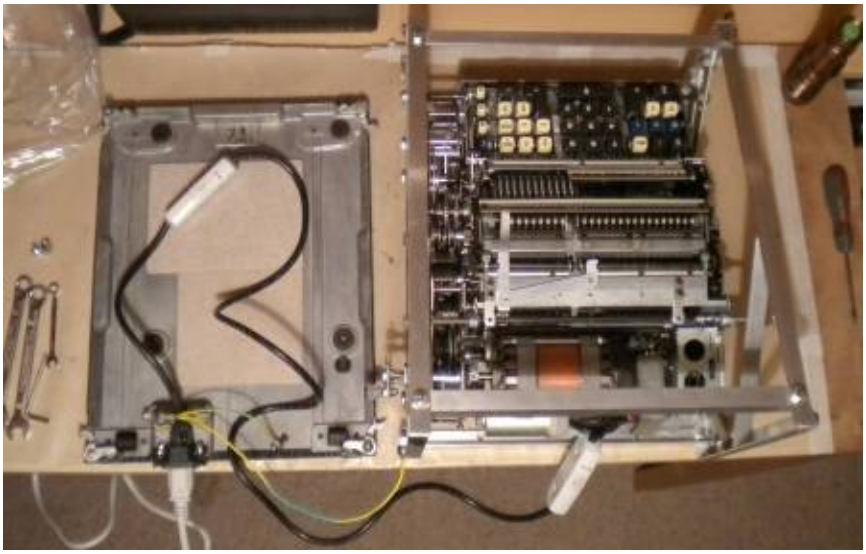
The above two photographs show how the new nylon hook will capture the movement of contact lever 12748 and rotate lever 13640 to switch the motor more positively.



Configuration after motor installation

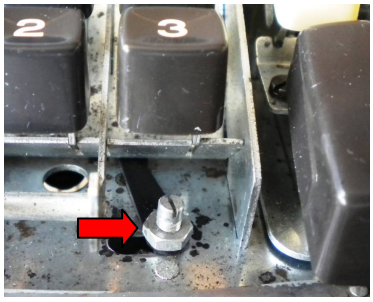
Perform a live trial motor switching test by first installing the motor without the nylon coupling.





Connect up the electrical supply (and the earth bonding for safety).

Depress each of the register clearing keys in turn "III", "II", "I" and, whilst slowly hand-cranking, check that the motor is energised as soon as a key is pressed and is de-energised when switch plate toggle 11306 has reset.



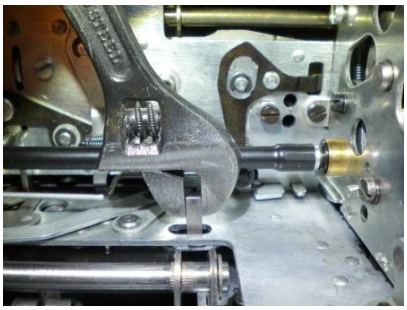
Carry out this test a number of times to ensure positive switching functionality without having the motor driving the mechanisms at speed.

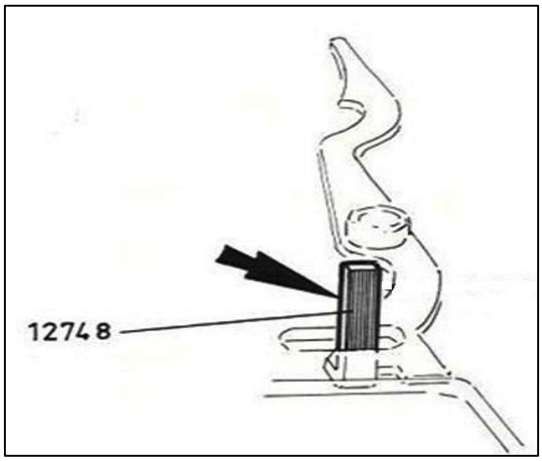
16 - MODULE ADJUSTMENTS - 4

Motor Startup

The motor contact must be set in such a way that the motor starts up on depressing three number keys, e.g. [7, 8, 9] or [4, 5, 6] or [1, 2, 3], at the same time. In order to check that the motor doesn't start up too early, 11 numbers must be set. Then three number keys must be depressed as just described. In this case, the motor should not start up.

Adjustment is carried out by removing the motor then bending the angle on contact lever 12748 - marked with an arrow.

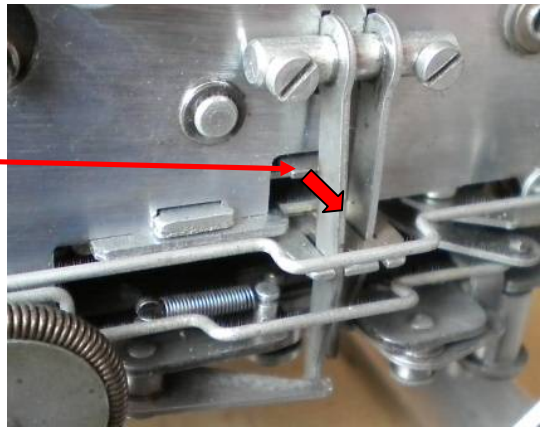


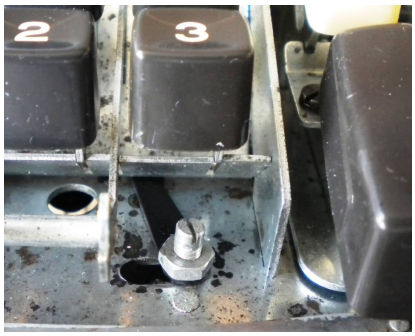


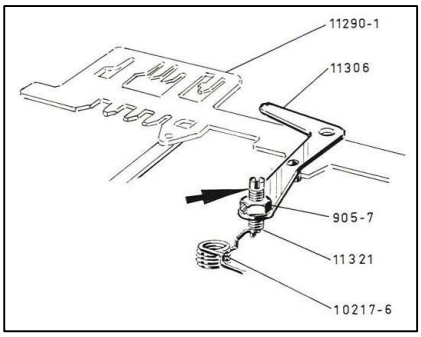
Function Key Activation

Motor start program plate 11290-1 should tip on the lightest depression of any of the function keys.

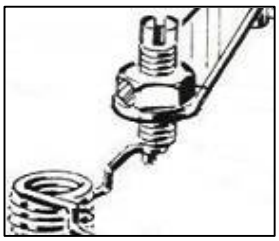
11290-1





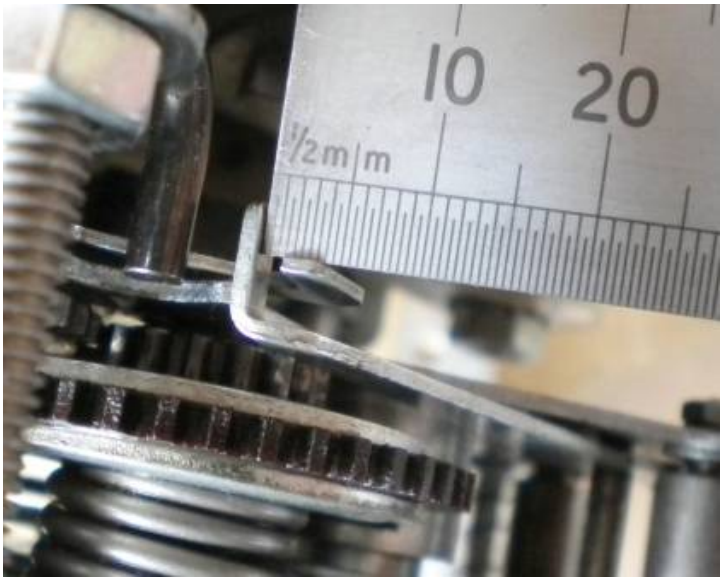


Adjustment is carried out using eccentric screw 11321.

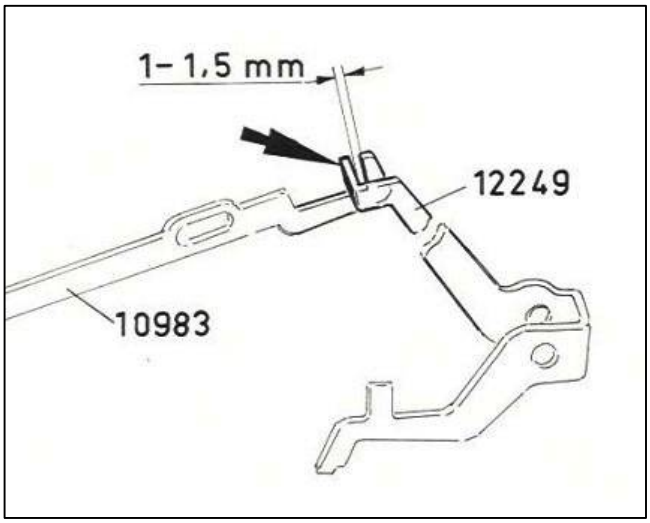


Switch-Off Clearance

Reset the machine by depressing each of the register clearing keys in turn "III", "II", "I" and hand-cranking. When the machine has been reset, check that the clearance between switch-off bracket 12249 and stop lever 10983 is 1 – 1.5 mm.



Adjustment is carried out by bending the angle on switch-off bracket 12249.

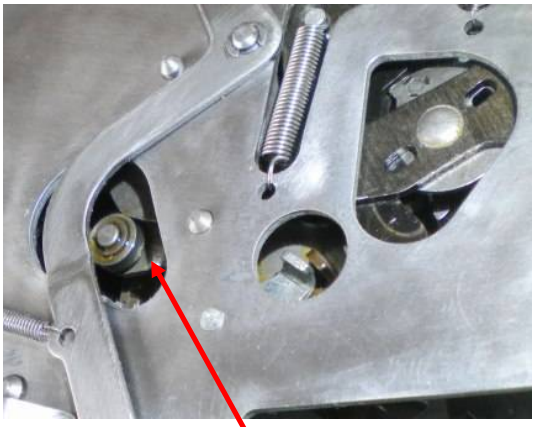


Feeler Carriage Stepping

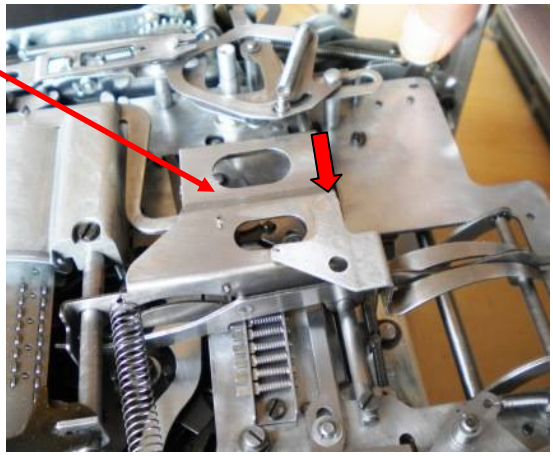
Test the step switching of feeler carriage 13241 by performing a trial multiply calculation. Clear the machine by pressing, in turn, keys "III", "II", "I" and "c". As noted previously, after pressing each key, hand-crank the requisite number of turns to allow the machine to perform the reset function.

Perform the following calculation: Key in eight nines (99999999) then press the "X=" key and crank.

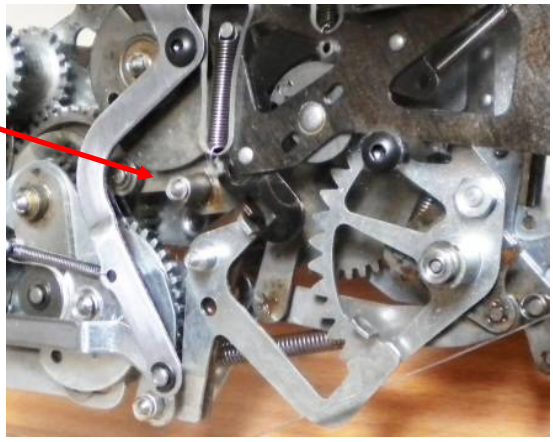
Observe the step switching of feeler carriage 13241 and, if it fails, it may be due to the movement emanating from feeler cam follower lever 12267 being too small.

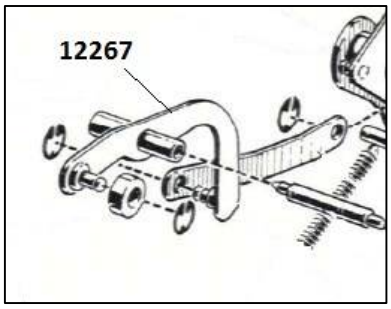


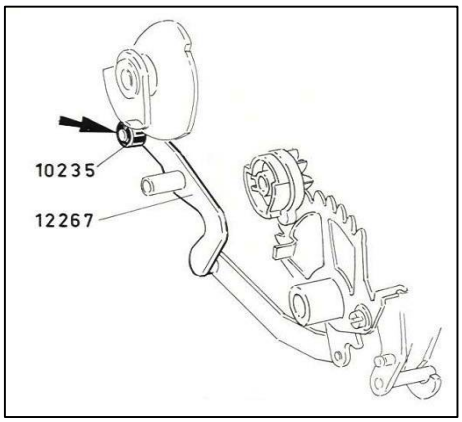
13241



12267





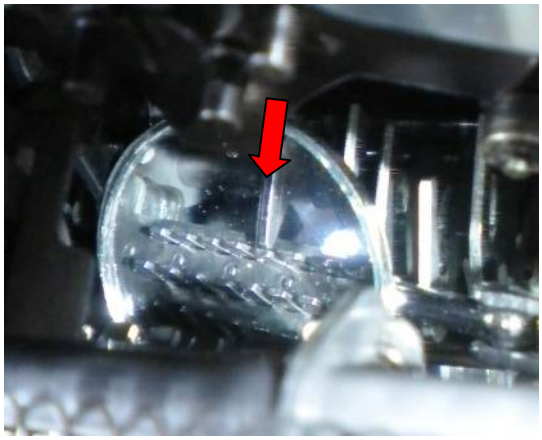


Adjustment is carried out by changing roller 10235.

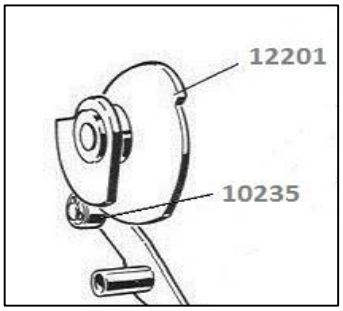
Clear the machine after the calculation.

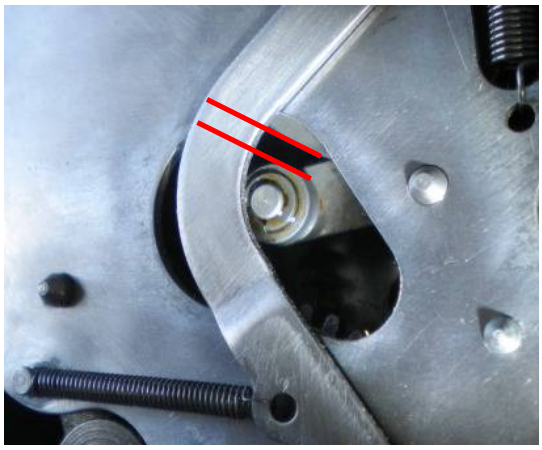
Countback Transfer Gear Clearance Adjustment

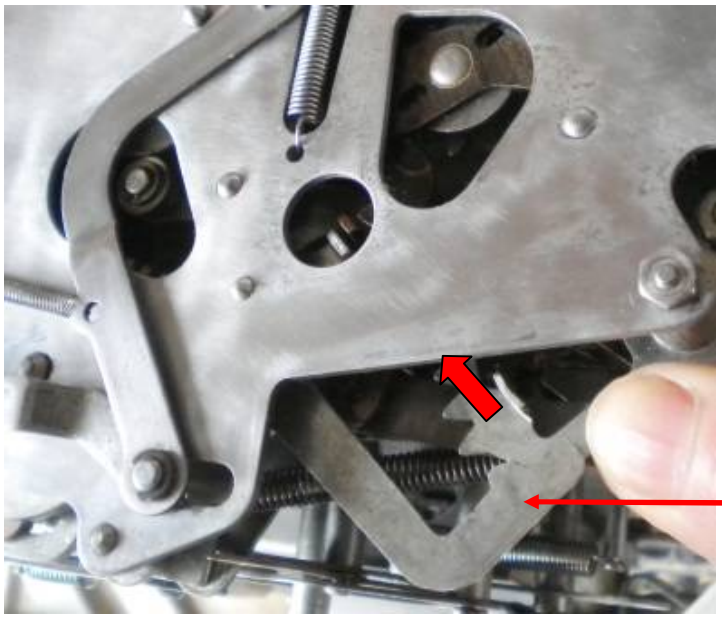
Key in four zeroes and depress key "X=". Then manually crank approximately 2 turns until pinbox feeler lever 13246 rests on the pin in the pinbox.



Continue to crank a little more (¼ turn) so that countback cam and clutch 12201 leaves roller 10235 and there's approximately 3 mm clearance between these parts.

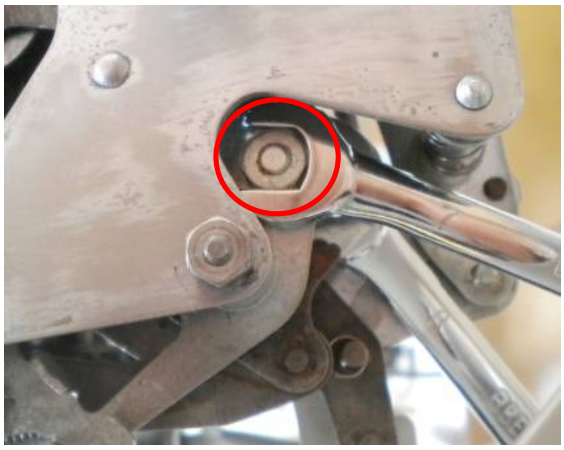


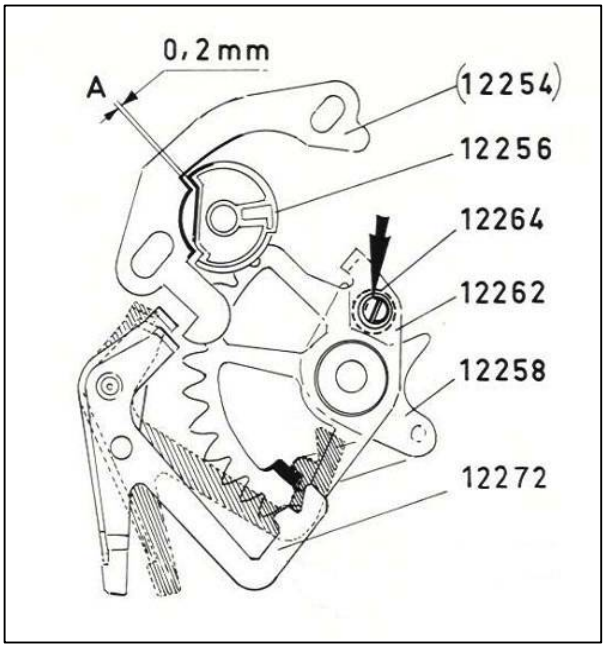




Lift quadrant gear 12262 to such an extent that shortcut select lever 12272 is released.

In this position eccentric 12264 must be set in such a way that the profile of countback transfer gear 12256 has a clearance of approximately 0.2 mm on shortcut selector 12254. This applies to point A in the diagram.





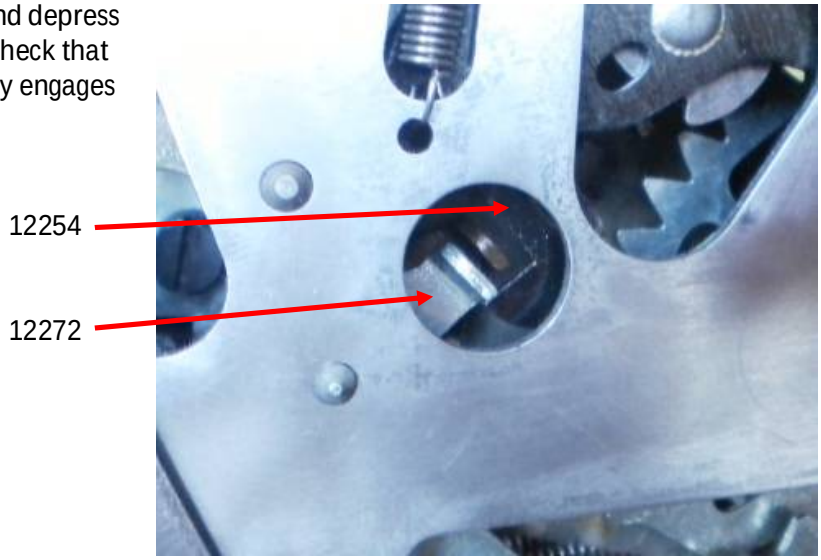
Lift shortcut select lever 12272 in such a way that it again engages in quadrant gear 12262. Now check that the clearance just mentioned hasn't changed. If the clearance has changed, it can be corrected by bending shortcut select lever 12272.

Also check that there is no clearance between shortcut select lever 12272 and quadrant gear 12262.

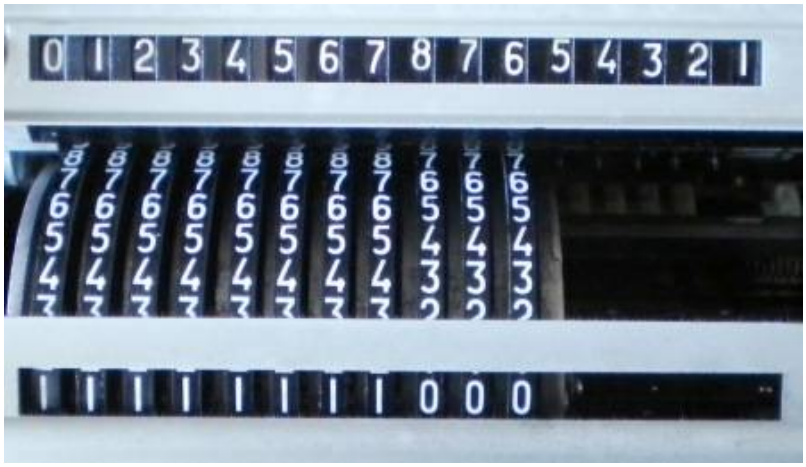
Shortcut Selector Engagement

After the above mentioned adjustment has been made, a calculation check must be carried out according the following instructions. Should an error occur, the clearance between the countback transfer gear 12256 and shortcut selector 12254 must be slightly increased or decreased.

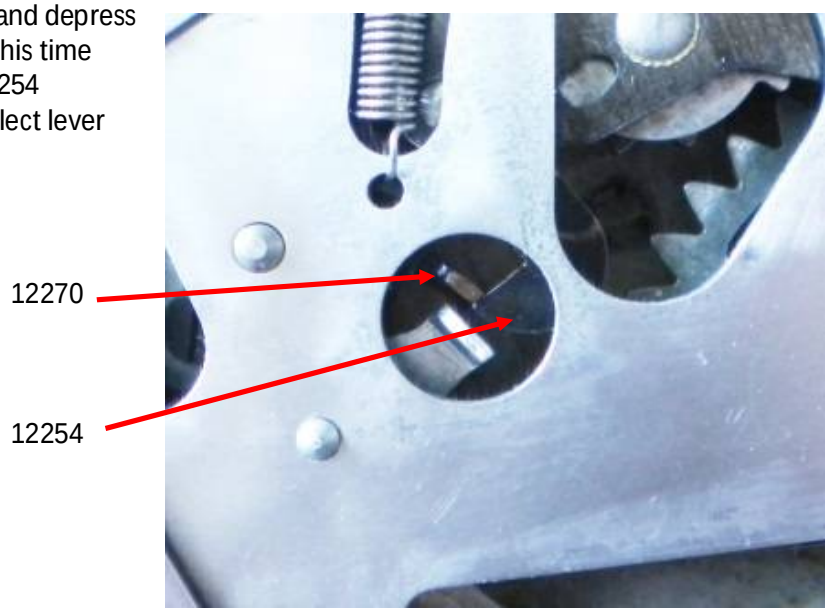
Key in eight ones (11111111) and depress key "X=". Manually crank and check that shortcut selector 12254 securely engages in shortcut select lever 12272.



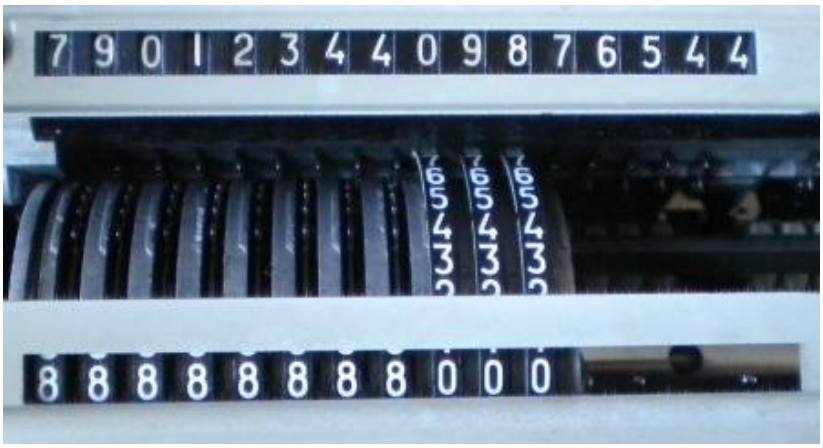
Result of 11111111^2 = 123456787654321 in the accumulator register III, just prior to automatically clearing setting register I.



Key in eight eights (88888888) and depress key "X=". Manually crank and this time check that shortcut selector 12254 securely engages in shortcut select lever 12270 only.



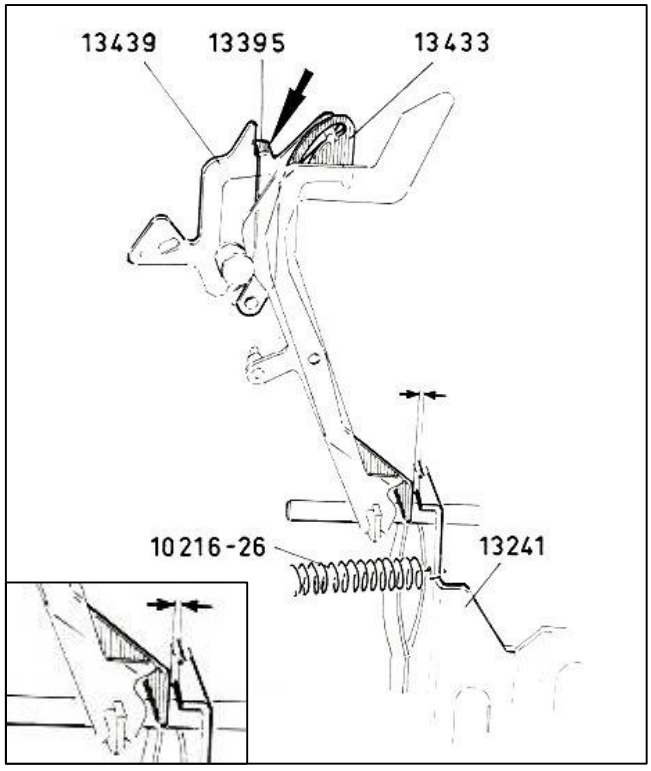
Result of 88888888^2 = 7901234409876544 in the accumulator register III, just prior to automatically clearing setting register I.



Carry out this check again with negative multiplication eg. -88888888^2 = 7901234409876544.

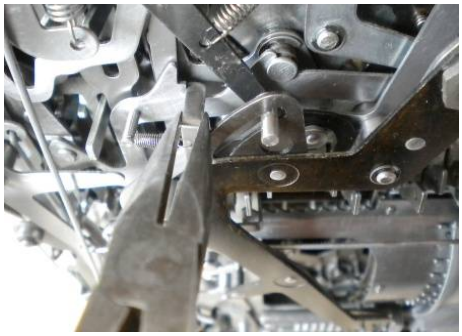
Carry out these test calculations several times with the motor activated.

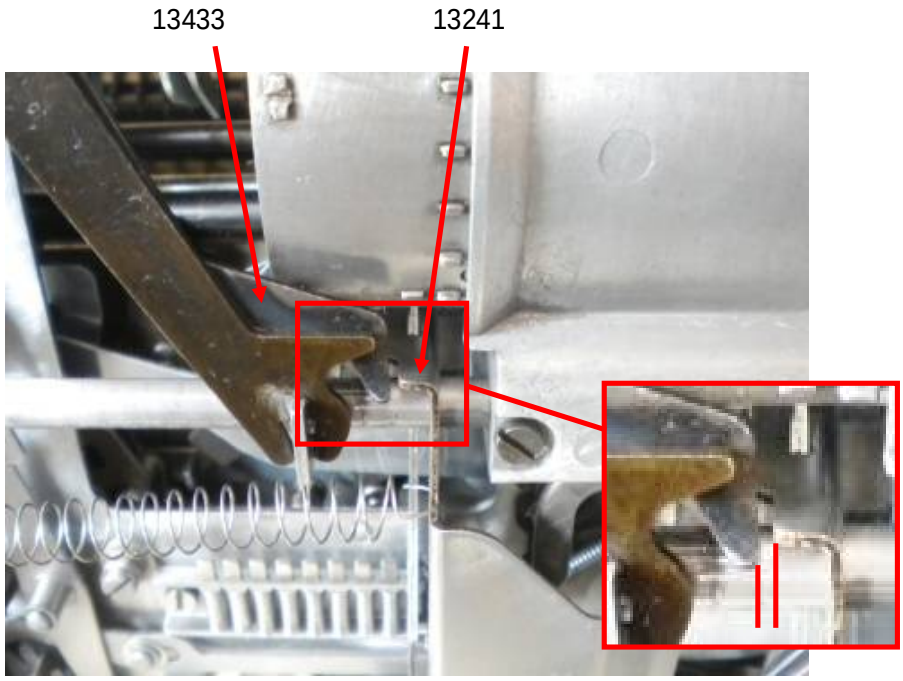
Stop Lever Positioning



Stop lever 13433 must be positioned in such a way that it is not impacted by feeler carriage 13241 before the latter has reached its last reset position.

At the same time check that stop lever 13433 doesn't stick out from the feeler carriage to such an extent that it causes the switch-off to take place one turn too late. The position of the stop lever is corrected by bending the angle on multiply linkage lock lever 13395 sideways.

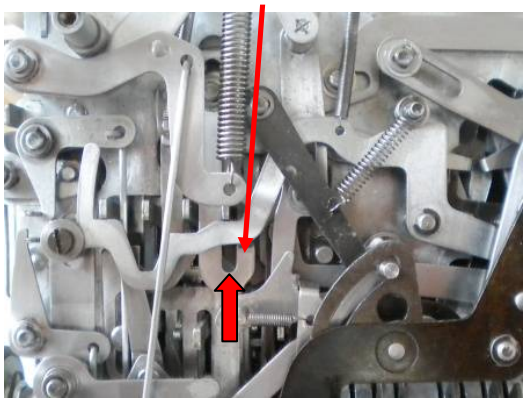


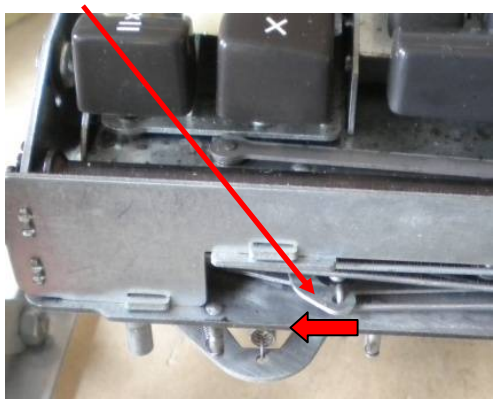


Sliding Link Actuation

Depress key "A+" and hand-crank 

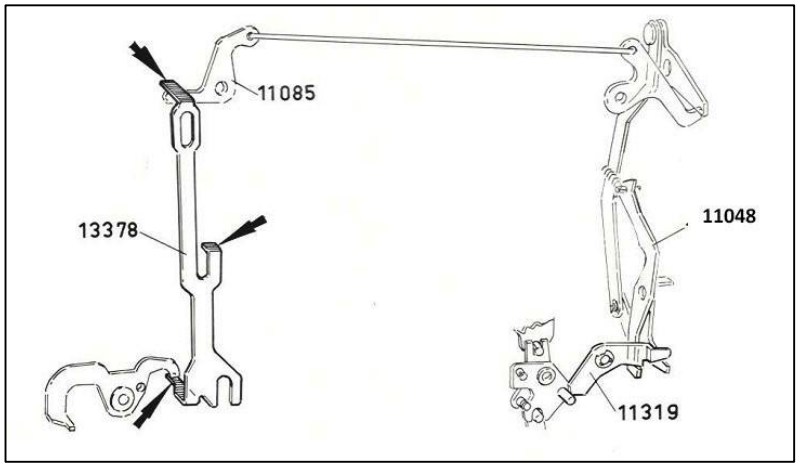
Continue until sliding link 13378 starts to turn swing link 11085.





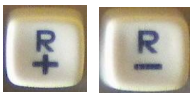
When continuing to crank, check that the lift is large enough so that arrester hook 11048 can block disengaging lever 11319.

Adjustment is carried out by bending the angles on sliding link 13378 where shown.

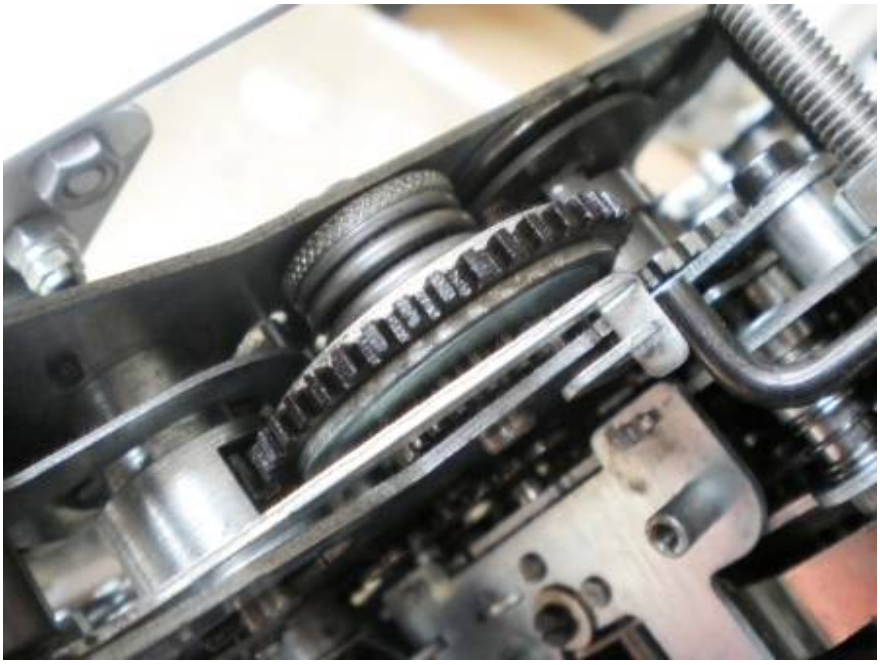


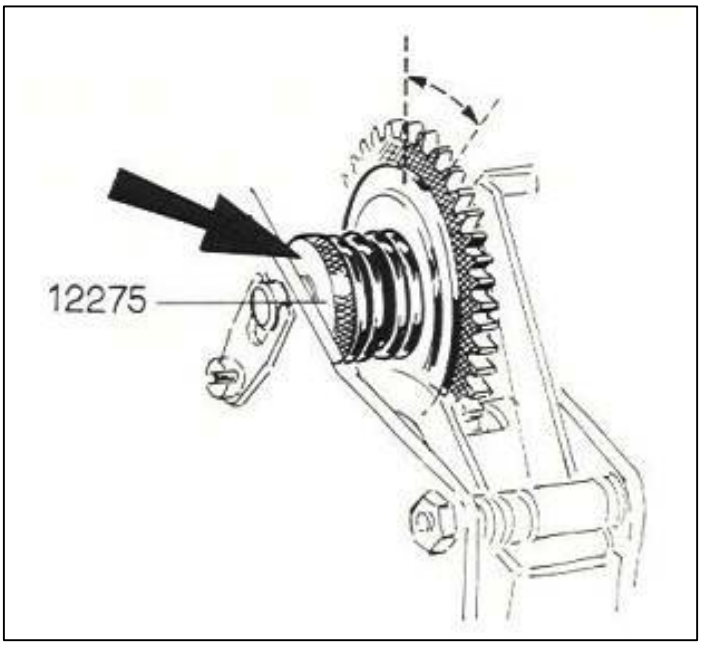
Fibre Drive Gear

Without keying in a number, either depress key "R+" or key "R-".



Check that after a start whether the fibre sacrificial gear wheel 12294 has moved on by at least 4 teeth.

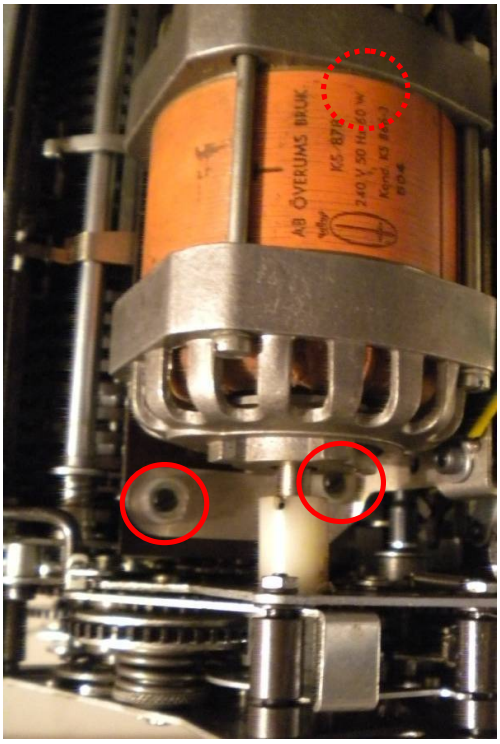




Adjustment is carried out with nut 12275 to increase or decrease the compression on spring 10215-36.

ASSEMBLY COMPLETION

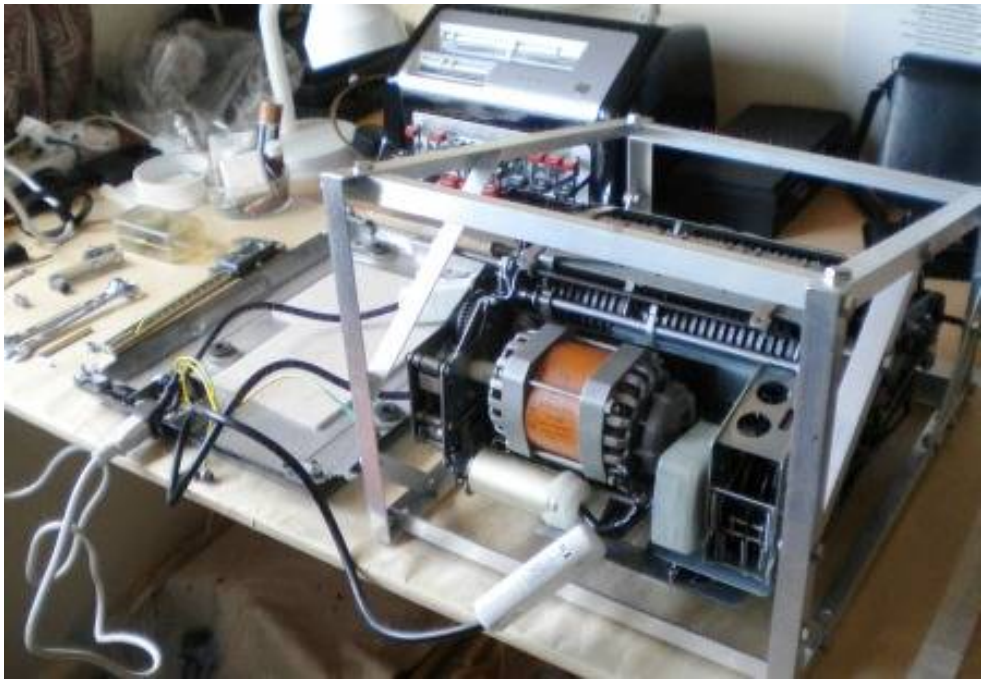
Reinstall the drive motor with its spring-loaded coupling.



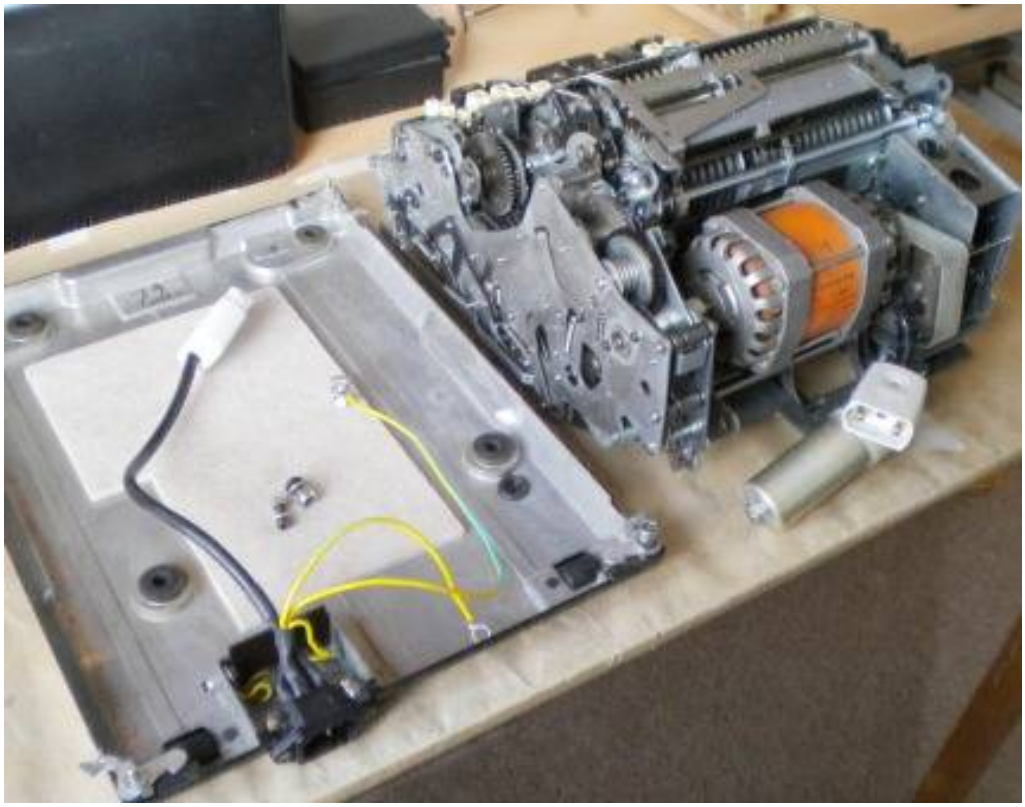
Place the machine onto its side so that the compression spring inside the motor's coupling doesn't drop into the machine.

Compress the motor coupling's spring and install the motor with 3 screws 904-2 and washers.

Remove the hand-crank, connect the electrical supply and carry out a few register reset operations to verify the motor's switching capability.



Remove the machine from the service frame. The machine will stand on its four fixing studs without the frame although it must not be placed in any other orientation for fear of bending or otherwise damaging any of the system's levers due to its weight. Note that, in this view, the capacitor has not yet been fixed to the motor's chassis as the earth bonding cable is to be bolted to a convenient hole in the motor's base plate.



When placing the machine onto the base plate, firstly insert the four large flat washers 10242 over the rubber shock-absorbers. Tighten the machine onto its base with four screws and dished washers 10115.

With the machine now firmly anchored onto its base, the final electrical connections can be made.

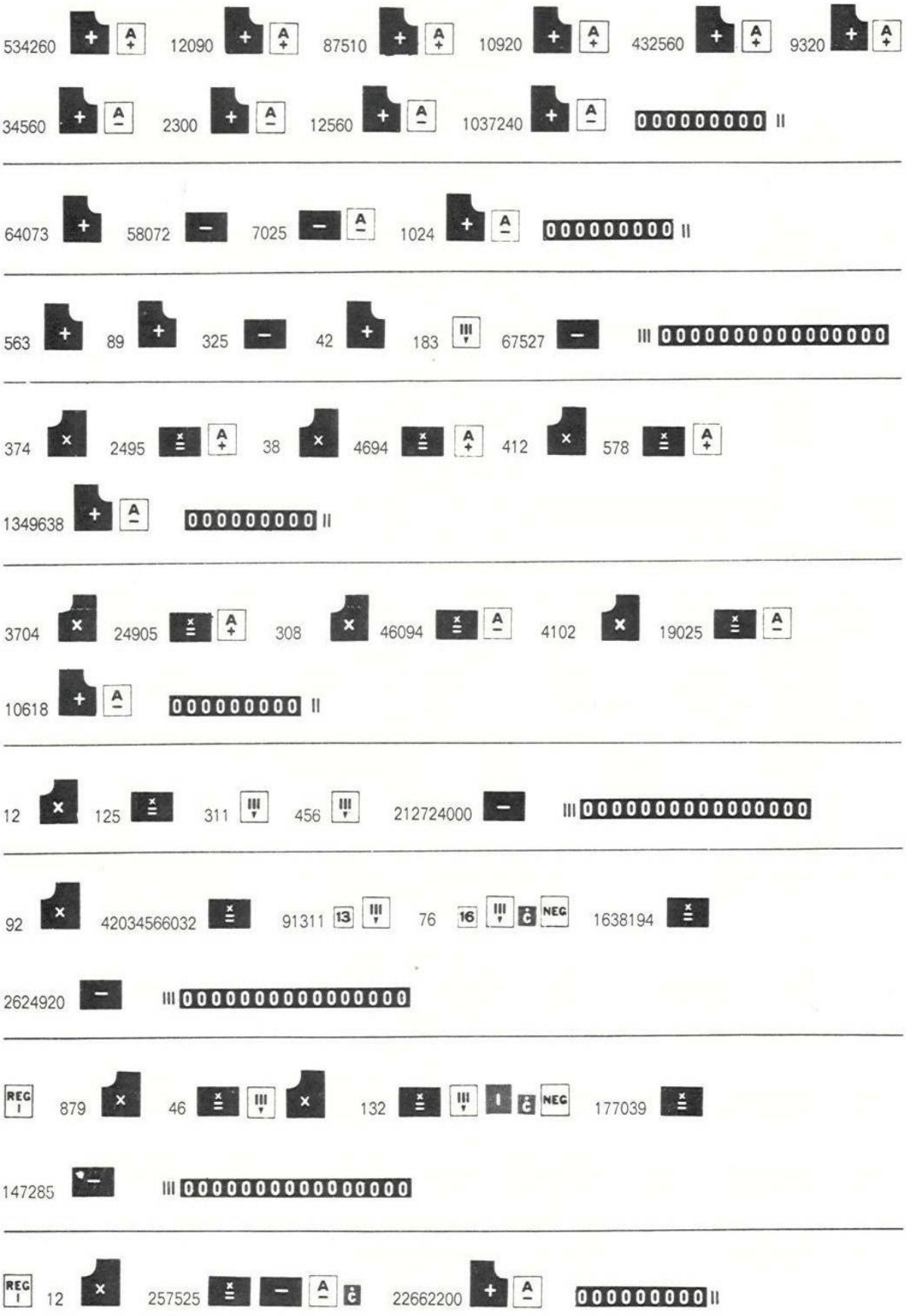
With the machine unpowered, replace the dust ingress cover and replace any keytops. Be sure not to press the key levers down when doing this as many concurrent key presses with the machine not running will surely result in a future malfunction or a mechanism lockup when the power is restored.

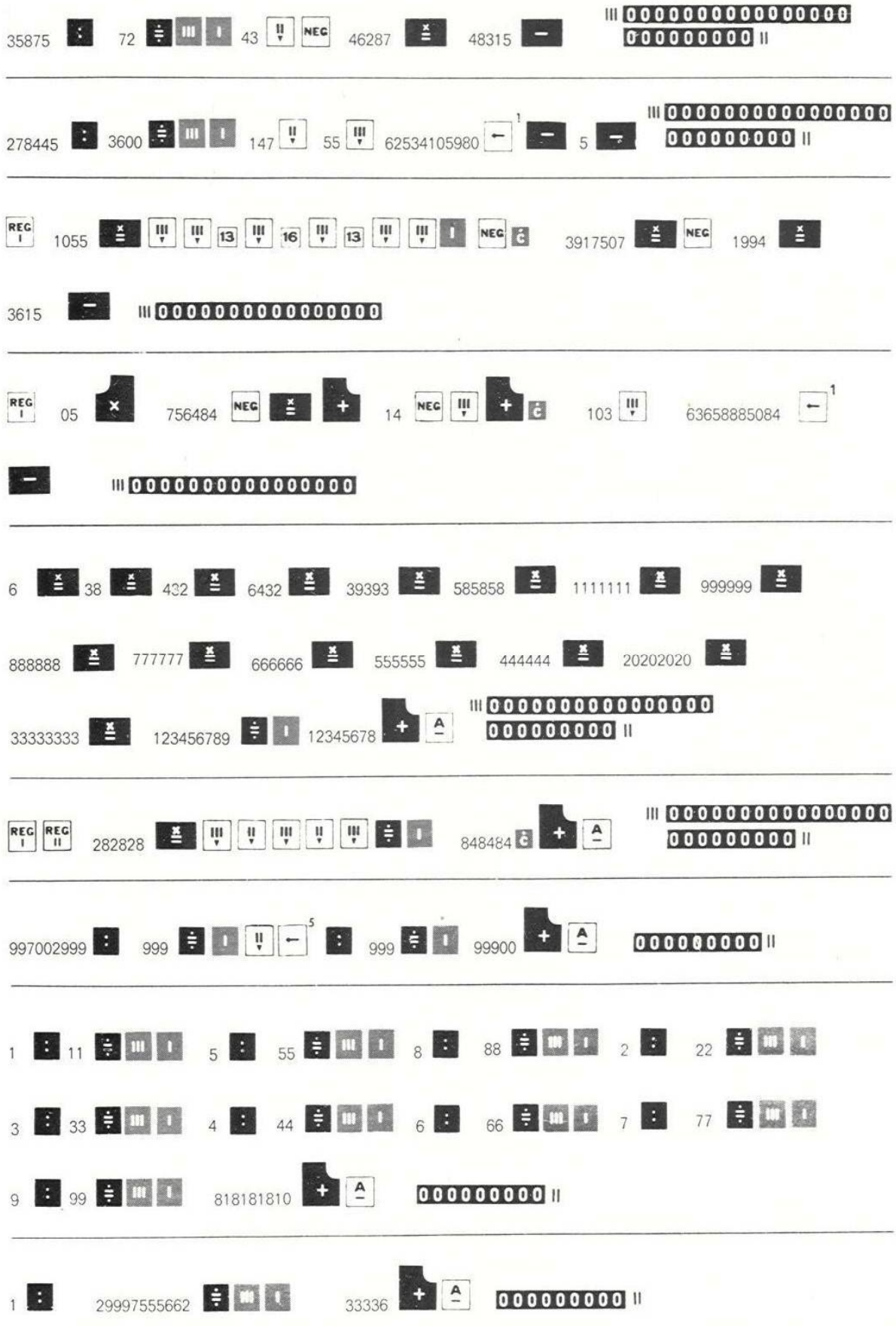
Affix the keyboard escutcheon plate with four screws. Use a magnetic screwdriver, especially for the two screws on the right side to prevent these dropping into the right transmission sub-assembly.

The completed Facit CA2-16

The CA2-16 alongside its predecessor, the Facit CA1-13

Test the calculator according to the following schema:

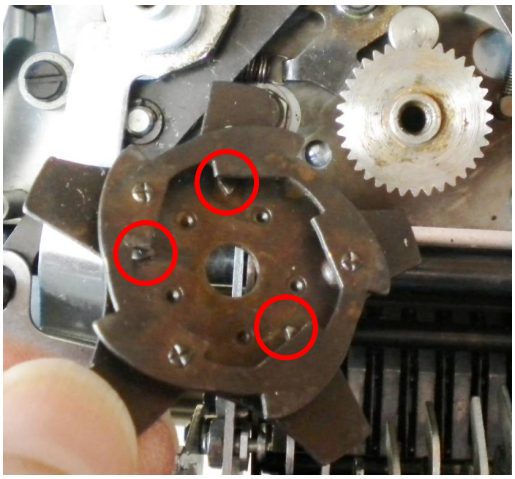

534260 12090 87510 10920 432560 9320
34560 2300 12560 1037240 000000000
64073 58072 7025 1024 000000000
563 89 325 42 183 67527 000000000000000
374 2495 38 4694 412 578
1349638 000000000
3704 24905 308 46094 4102 19025
10618 000000000
12 125 311 456 212724000 000000000000000
92 42034566032 91311 13 76 16 NEG 1638194
2624920 000000000000000
REG 879 46 132 NEG 177039
147285 000000000000000
REG 12 257525 22662200 000000000


35875 72 43 NEG 46287 48315
278445 3600 147 55 62534105980 5
REG I 1055 13 16 13 NEG 3917507 NEG 1994
3615
REG I 05 756484 NEG 14 NEG 103 63658885084
6 38 432 6432 39393 585858 1111111 999999
888888 777777 666666 555555 444444 20202020
33333333 123456789 12345678
REG I REG II 282828 848484
997002999 999 999 99900

Appendix A

ESCAPEMENT WHEEL 10955 FINE ADJUSTMENT PROCEDURE

In order to find the correct position most easily, escapement wheel 10955 must be loosened. The wheel must then be turned and all five positions of outer escapement lever 10964 must be checked. Following this, return to the best position and secure the wheel by firmly fastening screw 906-7.

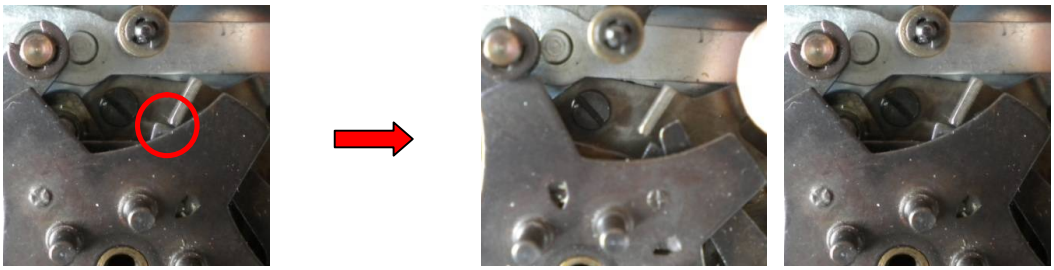


There are 36 teeth on spline wheel 10885 and 3 locators and 5 lobes on escapement wheel 10955.

Coarse adjustment is obtained by positioning the three locators on different teeth of the spline wheel.

Fine adjustment is obtained by rotating the escapement wheel to position another of its 5 lobes into the 12 o'clock position, so positioning the different locators (circled) on the same teeth of the spline wheel relative to the previous position.

Coarse adjustment sequence showing the position of the escapement wheel relative to the outer escapement lever.



Fine adjustment sequence. Note the small movement of the escapement wheel's ratchet teeth relative to the outer escapement lever as the 5 different lobes are brought to the 12 o'clock position.

Appendix B

CLEANING THE FACIT CA2-16

Cleaning in a washing apparatus

The following parts have to be removed before washing commences:

- Housing
- Keyboard Cover Plate
- Counter & Accumulator Registers Sub-Assembly
- Motor
- Tens Carry Rotors
- Bottom Sub-Assembly
- Right-Hand Transmission Assembly
- Setting Rotor

The body of the machine is fastened into the service frame and washed with an appropriate liquid, e.g. washing petroleum with added 15% oil.

The remaining parts of the machine are washed separately in the washing apparatus without further disassembly. Exceptions are the setting rotor and the right-hand transmission assembly, which must be disassembled before washing.

The plastic parts of the machine may get damaged if the washing liquid is warmer than +40°C. However, the self-lubricating bearings of the machine do not need special treatment.

After washing the parts must be dried using pressured air.

Washing by hand

If the machine is to be washed by hand, the following parts need to be removed in addition to the above-mentioned ones:

- Rear Corner Panel
- Left Transmission Sub-Assembly
- Back Transfer Sub-Assembly
- Front Corner Panel & Function Keyboards

After washing, the machine can be dried by using pressured air, the individual parts need only be disassembled as mentioned above. It is particularly important that the front corner panel is thoroughly cleaned.

Appendix C

LUBRICATING THE FACIT CA2-16

After washing, the parts must immediately be sprayed with a thin oil in order to prevent rust. In addition to spraying oil, lubricants are to be used according to the following instructions:

Recommended are the following oils and greases:

Thin oil:	Shell Risella Oil No. 17	
	Vaccum Oil 309 s/v	
	Caltex 734 Home Lubricant	
	Esso Mayoline 250 T	
Grease:	Facit Standard R-120	for normal wear
	Gulflex Moly	for exceptional wear
	Molycote	for exceptional wear

Group	Thin oil	Grease: Facit Standard	Grease: Gulflex Moly or Moly-cote
Bottom sub-Assembly	All bearing areas between metal parts and pins or ground shafts.	Selector pins 13225. Curve on over-centre toggle 13319. Neg. Changer 13408. A+ A- Selector 13413. Div. Starter 13421. Curve Nut in Feeler Carriage 13241. Positioning Pins 13251. Metal parts with dulled work surfaces resting against each other.	Division Right Shift Changer 13313. Pinbox Escapement Lever Assembly - 13230. Curve on Multiply Changer 13418. Curve on Rocker 13373. Hole in Multiply +/- Selector Lever Assembly 13444. The sliding Link area for the Pin on 13410.
Machine Body	All bearing areas between metal parts and pins or ground shafts. Roller bearings of the Step Mechanism and Rotor Pull Lever.	Rollers 10235 and 10958. Guide curve on Forked L Lever 12935. Detent Lever 12906. Sliding Link, L/R Shift 12941 and 12943. All gear wheels, tooth rail, tooth row of the Rotor Bracket. Guide of Right Step Link 10948-2. Metal parts with dulled work surfaces resting against each other. Orientation lever 12908. Quotient Switching Lever 11016.	Right-Shift Lever 12958 (curve for pushing back the Total Lever). Right-Step Lever 12953 (curve for quotient switching). The Blocker Hook curve on Escapement Release Lever 12904. The lever on 10755-2 and 10754-2. Right Shift Linkage Lever 12970 (on right-step hook).

Group	Thin oil	Grease: Facit Standard	Grease: Gulflex Moly or Moly-cote
Rear Corner Panel	All bearing areas between metal parts and pins or ground shafts.	The curves on Quotient Switch Carriage 12741. Calculation Direction member 12716. Disengagement Lever 12734. Quotient Coupling Detent Lever 12731. Quotient Coupling Linkage 12963 (the surface engaging during a step movement to the left). Metal parts with dulled work surfaces resting against each other.	Contact Lever 12748.
Front Corner Panel and Keyboard	All bearing areas between metal parts and pins or ground shafts. Working surfaces of the Programme Rails and Locking Plungers.	Toothed members 11187-11193. Keyboard Drive Roller 11186. The curves of the Number Keys. Disengagement Lever 11319. Metal parts with dulled work surfaces resting against each other.	The curves on Sliding Links 11282 and 11285. The tongue on Back Transfer Program Plate 11293 (on Sliding Link 11285).
Back Transfer Sub-Assembly	All bearing areas between metal parts and pins or ground shafts. The gear wheel shaft.	Roller 10235.	Lock Release Lever 10742.
Right-hand Transmission Sub-Assembly	All bearing areas between metal parts and pins or ground shafts.	Gear wheels, curves and rollers. Slipper Clutch. Metal parts with dulled work surfaces resting against each other.	+/- Clutch Detent Lever 12165. +/- Clutch Pawl 12167 in +/- Clutch Drive Gear 12160.

Group	Thin oil	Grease: Facit Standard	Grease: Gulflex Moly or Moly-cote
Left Transmission Sub-Assembly	All bearing areas between metal parts and pins or ground shafts.	All gear wheels and curves. Roller 10235. Metal parts with dulled work surfaces resting against each other.	
Transfer Rotor	Carry Rotors Shaft 10844. Bearing areas of Carry Rotor Coupling Link 11665-2 and the Transfer Pins.	Transfer Pins. Carry Rotor Coupling Link 11665-2 on the outer ends, the impact curves and Switch Curve 11671.	
Setting Rotor	The hubs of the calculation discs. Lock Hook 11447. Ball Holder. Lever for Ruler 11483.	Guide groove for Ruler 11483.	
Calculation mechanism	Shafts, hooks, wheels, switch wheels and Deletion Tappets 11861 and 11862.	Tooth segment and Deletion Curve, the parts for lifting the springs, Rollers 10235-1.	The tongues on 11901 and 11902.