John Wolff's Web Museum

The Original-Odhner Pinwheel Calculator - Technical Description

Contents

Original-Odhner Model 127, c.1950

Introduction

This page gives a brief technical description of the internal mechanism and principles of operation of the Original-Odhner pinwheel calculator.

The Original-Odhner is a relatively simple machine of the traditional design, which serves as a good introduction to the principles of any type of pinwheel calculator (all of which are based, to a greater or lesser degree, on W.T.Odhner's designs from the 1870s and 80s).

Information on the early development of the pinwheel mechanism can be found on the Pinwheel Calculators page, along with a selection of pinwheel machines from manufacturers around the world. Further information about the Original-Odhner company and their product range can be found on the main Odhner page.

The text and illustrations following are based on a typical Odhner Model 127 machine from the 1950s, but are applicable (with minor adjustments) to most of the Odhner models from the 1920s to the 1970s. Although the "7" series (7, 27, 127, 227) were the base-model machines, they all included a rotor quick-clearing mechanism, and all but the Model 7 included a back-transfer mechanism. The optional setting check dial, counter tens-carry, and automatic counter reversing mechanisms from the late-model machines are described in the section on Additional features in Model 239.

Readers interested in restoring an Original-Odhner to working order will find an illustrated overview in the section on Assembling the Odhner 127, and a detailed step-by-step procedure in the notes on Rebuilding the Odhner 239.

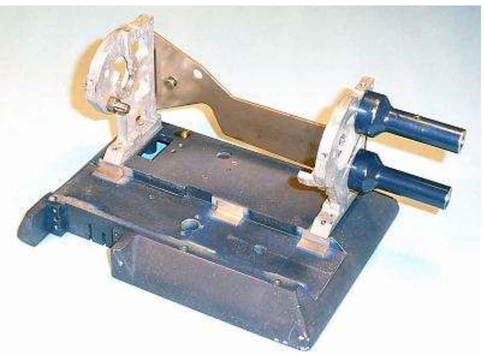
I would welcome your comments or suggestions for improvement via the Enquiry Form.

Layout and construction

General arrangement.

The Odhner 127 mechanism consists of just under 700 parts, arranged in three major assemblies:

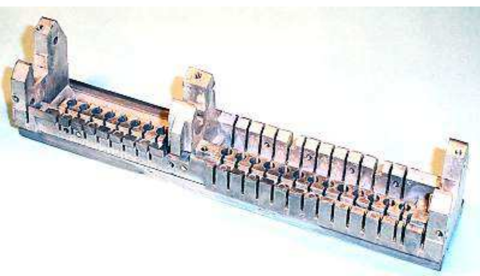
- The base and covers, including the rotor supports, winding handle, and the carriage positioning mechanism at the front left.
- The rotor, consisting of the ten pin-wheels, some interlocks, and part of the tens-carry mechanism.
- The sliding carriage, containing the counter and accumulator registers, the accumulator tens-carry mechanism, and the back-transfer mechanism.



The base and side plates.

The mechanism is built on a heavy die-cast base about 190mm wide by 140mm deep, formed into a pedestal about 25mm high. The two die-cast end plates are dowelled and screwed to the base, and are supported laterally by a heavy steel plate across the back. The extended bushings for the winding handle and the handle stop are screwed to the right-hand end plate.

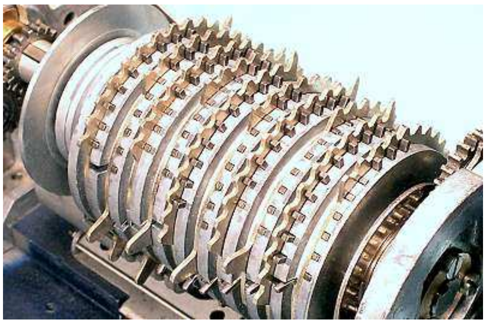
The carriage slides on the six bearing surfaces in the channel at the front of the base. Carriage travel is limited by a stop plug which fits into the 10mm hole in the centre of the channel. The smaller hole to the right is threaded for a locking screw to secure the carriage during shipment.



The carriage frame.

The sliding carriage is built on a one-piece die-cast frame about 210mm wide. The counter and accumulator registers are supported between the three vertical pillars. The slots and holes accommodate the carry and detent levers and their various shafts and springs. The carriage is positioned by a toothed rack which attaches to the lower front face.

The pinwheels and rotor

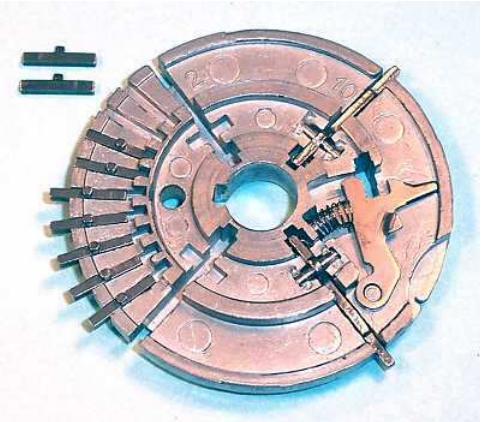


The rotor assembly.

The rotor consists primarily of ten die-cast pinwheels assembled side-by-side on a central shaft. The pressed-metal setting rings rotate in grooves between each pair of discs to extend or retract the pins. Three additional rotor discs to the left of the pinwheels extend the tens-carry across the full width of the accumulator register. A pair of threaded collars at the left-hand end clamp the discs tightly together to form a rigid assembly.

The rotor shaft is supported in plain brass bearings in the two end plates, and is driven 1:1 from the winding handle by a pair of plain steel gears. A non-return gear and pawl (next to the drive gear) ensures that a turn must be completed once the addition phase has commenced, so as to prevent errors due to incomplete carries. The pawl can be lifted manually to allow "backing out" if the machine jams during maintenance.

The gear at the left-hand end of the rotor drives a pawl or finger which advances the counter register by one place per turn.



The pin-wheel.

The die-cast pin-wheels are 53mm in diameter and 7mm thick at the centre. The thickness of the wheel determines the horizontal spacing of the digits on the setting board and in the carriage. The setting ring is inset 1.5mm into the top (or left-hand) face of the pin-wheel. A groove and cam are cast into the bottom face for the carry reset, leaving a rim only 3mm wide around the outside to hold the pins. The discs are mounted side-by-side on a 10mm keyed shaft, with a separate locating rod through the round hole to maintain alignment.

The nine retractable pins measure 1.5 x 1.7 x 10mm, and slide in the channels cast into the disc. Two pins are shown in side view. Note that the pins on each disc are *not* aligned horizontally across the rotor (see the previous view), but are staggered to operate at slightly different times, giving a smoother and less "clunky" feel.

The spring-loaded pawl (centre right) provides a constant detent for the setting ring. The detent (and hence the ring) can be locked by a toothed bar which passes through the small rectangular slot above the pawl.

The cut-out in the outside of the disc (near the detent pawl) provides clearance for the back-transfer gears to engage with the setting ring.

The two extended pins on either side of the detent pawl are the carry operating fingers, which move vertically (in this view) on their pivots, or right-to-left when assembled. Two small compression springs are set into the disc under the short ends of these fingers. The pivot pins are staked into the die-cast disc and are not removable.

The carry fingers are arranged in sequence from discs 2 to 13 so that a ripple carry can propagate across the whole machine. There are two sets of carry fingers, arranged symmetrically on either side of the retractable pins, to provide for carries on both addition and subtraction.

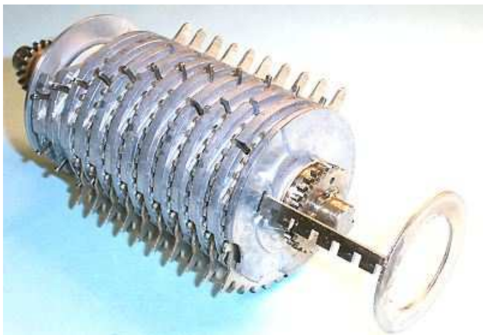
Note that in order to reduce the number of different castings, the rotor discs have been made with two alternative locations for the carry fingers. This disc could be used for either position 2 or 10 (labelled near the top), but has been assembled at the factory for position 10.

The setting ring.

The setting ring performs six different functions:

- The handle at the top rotates the ring to set the pins manually.
- The ramped slot at the left raises or lowers the pins and holds them in position as the ring is rotated.
- The teeth on the inside of the ring engage with the spring-loaded detent pawl to provide a positive setting.
- The teeth on the outer right-hand side engage with the back-transfer gears in the carriage to rotate the setting ring during a back-transfer operation.
- The teeth on the outer left are used (on more elaborate models) to drive a check dial, which gives a straight-line display of the rotor setting.
- The long tooth at the bottom of the ring is part of the rotor "quick clearing" mechanism.

There are five different setting rings, with the ramped slots in slightly different locations to suit the staggered arrangement of the pins. Each ring is stamped with the numbers of the two matching pinwheels.



The rotor locking bar.

This view shows the notched locking bar partially withdrawn from the rotor.

The detent pawls align with the notches when the bar is fully inserted, allowing the setting rings to rotate. Withdrawing the bar by about 2mm blocks the movement of the detent pawls and locks the setting rings in position.

The locking bar is operated automatically from the winding handle interlock, via a forked pin which engages with the disc at the right-hand end.

The handle locking pin.

The rotor lock is operated by a shaft through the extended bushing below the winding handle. The tip of the shaft is visible in the centre of the vertical slot at the end of the bushing. The shaft is spring-loaded outwards, into the locked position.

The pin on the inside of the winding handle sits in the vertical slot when the machine is at rest. This pin is pushed to the left by a much stronger spring inside the handle.

When the machine is at rest, the handle spring pushes the locking shaft inwards, releasing the lock and allowing the setting rings to be rotated manually. When the handle is pulled outwards to commence a turn, the shaft follows and locks the rotor setting.

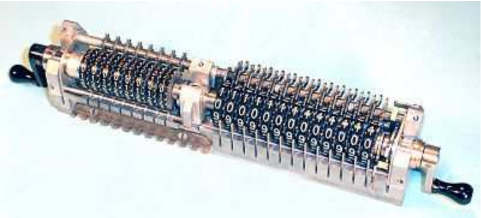
The rotor components.

This view shows the component parts of the rotor assembly (minus the locking bar), arranged in order.

At the top left are the counter drive gear and the rotor clamping components. Next comes an interlock disc, followed by the three extended-carry discs and the ten pinwheels. At the lower right are the quick-clear interlock disc, the drive gear, and the non-return gear.

The slotted and keyed mainshaft and the small aligning rod are at the bottom. The two zip-lock plastic bags contain the 90 pins and the 10 detent pawls and springs.

The carriage and registers



The carriage with covers removed.

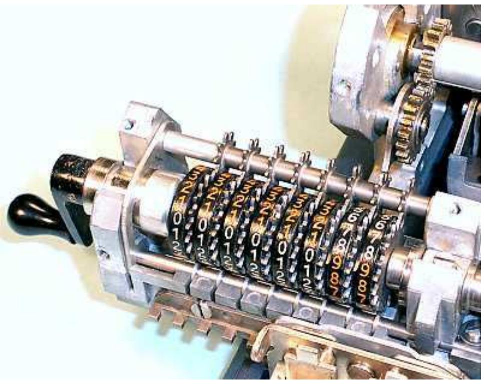
The 8-digit counter register is at the left of the carriage, with the 13-digit accumulator at the right. The registers are driven from the rotor by two sets of intermediate star wheels on the shaft at the top rear.

The carriage is positioned by the toothed rack at its lower left-hand end, which engages with a push-button shift mechanism at the front of the machine. The carriage moves 7 steps of 7mm (49mm total) in the channel at the front of the base.

The registers.

The accumulator and counter registers and their clearing handles can be removed from the carriage as complete assemblies.

The cam discs on the inner ends of the register shafts connect (via an intermediate linkage) to the interlock disc at the left-hand end of the rotor. The interlock prevents a clearing operation unless the rotor is in its home position, and prevents the rotor moving while a clearing operation is in progress.



The counter, quotient, or proof register.

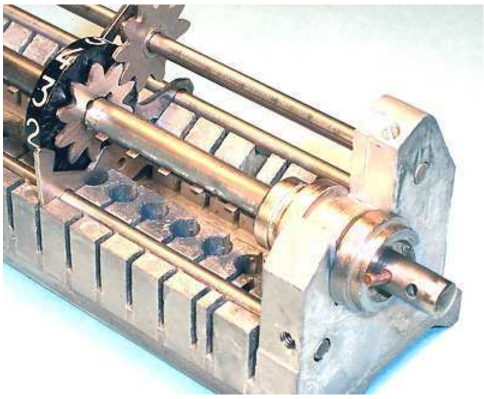
The left-hand register is variously known as the "counter" register (because it counts turns of the rotor), the "quotient" register (because that is where the quotient appears in division), or the "proof" register (which "proves" the number of turns in multiplication).

This view shows the counter register with the carriage installed in the machine. The register is secured at the outer end by a link between the detent shaft at the front and the star wheel shaft at the top rear, and by a screwed retainer on the centre pillar.

A single operating finger geared to the mainshaft engages with the intermediate star wheels and advances the selected digit by one position for each turn of the rotor. Note that the top of the mainshaft is cut away to allow the finger to pass.

The counter wheels are numbered in both directions to avoid a complement display when the rotor is turned backwards for subtraction. Numbers 0 to 8 in one direction are in white for addition, and 1 to 9 in the other direction are in red for subtraction. Zero and 9 only appear once, so 9 is red regardless of direction. There are 18 numbers on the wheel, not 20, and 9 teeth on the star wheel to give the 2:1 reduction.

There is no carry mechanism on the counter register, as it is never necessary to make more than 9 turns in any digit position. However, a tens transmission was available on the more complex (and expensive) machines to allow various short-cut methods to be used in multiplication and division.



The register clearing mechanism.

This view shows the register clearing mechanism on the accumulator side. Each numeral wheel has a single projection formed on the *inside* of its drive gear (between digits 3 and 4), which engages with the toothed key strip on the register shaft to perform the clearing operation. (The notch adjacent to digit 6 on the gear is a clearance slot to allow the wheels to be assembled over the keyway).

The register shaft can move a short distance horizontally. It is pre-loaded to the left by a strong spring inside the shaft bushing, and restrained by the pin which runs on the outer face of the bushing. The pin normally sits in the notch at the rear of the bushing (in the 3 o'clock position), with the shaft pressed fully to the left. The teeth on the keyway are positioned to the left inside the numeral wheels, clear of the internal projections on the right, so the wheels are free to rotate.

The clearing handle is pinned to the end of the register shaft. As the handle is turned forward (clockwise), the ramp at the rear of the bushing will pull the register shaft outwards by about 2mm. The teeth on the keyway move to the right inside the numeral wheels, bringing them into line with the internal projections. As the handle is turned further, the keyway teeth engage with the projections and turn the wheels backwards towards zero. The mechanism disengages when the pin drops back into the slot at the end of the turn.

The clearing mechanism for the counter register is similar, except that the pin is on the inner end of the bushing and the shaft moves inwards.

The add and carry mechanism

The addition mechanism.

The basic addition mechanism is very simple. As the rotor is turned, the extended pins on the pin-wheel act as gear teeth to advance the intermediate star wheel, which advances the numeral wheel by one place per pin.

The numeral wheels are held in position by detent levers, operated by coil springs and steel balls in the cylindrical wells. The vertical arm on the detent lever acts as an escapement to prevent over-run on the final step.

The carry sense levers.

This view from the left-hand rear of the carriage shows the arrangement of the carry sense levers. The essential features are the V-shaped section at the top front of the lever, the offset ramps and tongue at the top rear, and the forward tail and detent pin at the bottom.

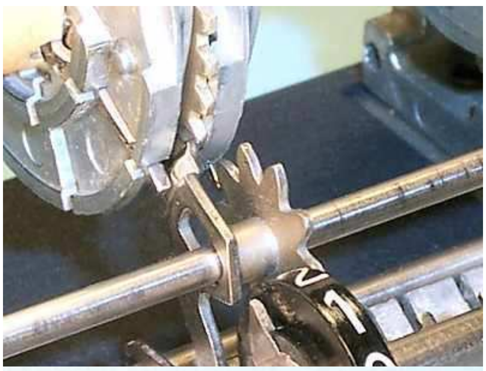
The lever is pivoted on a rod at the rear of the carriage, but its movement is restrained by the intermediate star wheel shaft which passes through the slot at the top. The forward-facing tail on the bottom of the lever acts against a spring-loaded detent pin in the base of the carriage, and holds the head of the lever securely in either the forward or rearward position.

A machine cycle starts with the carry sense levers reset in the forward position (as shown). If the numeral wheel passes between 0 and 9 in either direction, the pointed finger between digits 2 and 3 will push the sense lever over the detent and into the rearward position.

The carry operating pins.

After the addition pins have passed the star wheels, the carry fingers sweep past in sequence from right to left as the rotor turns clockwise (or reverse for subtraction).

If the addition has not resulted in a carry, the sense lever will remain in the forward position. The carry fingers on the rotor disc will pass clear of the carry lever, and nothing will happen.



Carry operation.

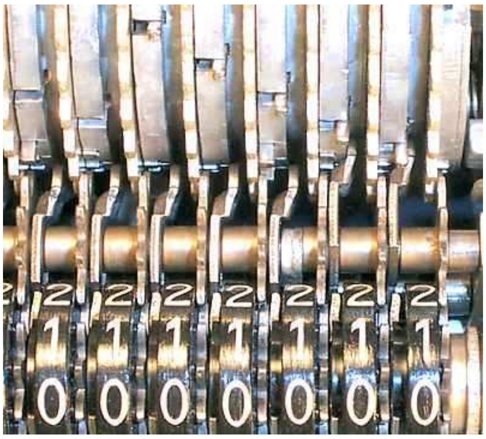
If a carry is required, the sensing lever will have been pushed (and latched) rearwards.

As the rotor turns, the spring-loaded carry finger on the *next* rotor disc will meet the ramped surface formed on the back of the carry sense lever. The finger will be pushed sideways, moving it to the left and into the path of the next star wheel (not shown). The finger will advance the star wheel by one position as it passes.

The sense lever remains in the rearward position, with the offset tongue behind the ramps extending into the groove between the two rotor discs.

Carry reset.

This view of the under or right-hand side of a pin-wheel shows the outer groove in which the carry sense lever rests. The groove is shaped into a cam, which resets the sense lever by pushing it forwards near the end of the cycle.



Carry sequencing.

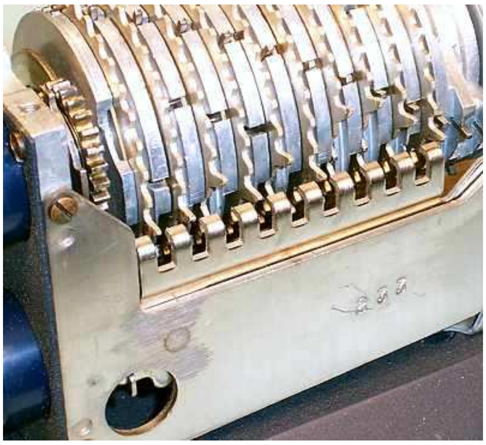
This detail view from the front of the machine shows the alignment and sequencing of the add-and-carry mechanism when fully assembled.

Note the arrangement of the carry fingers in sequence from right to left across the rotor. This view shows the carry phase of the cycle about to commence on digit 2 (from the right), although digits 4 and 8 have not yet completed their additions. (Naturally, there is no incoming carry mechanism on digit 1).

On digits 2 and 3 the carry sense levers are shown rearwards, with their reset tongues in the grooves between the rotor discs. Digit 2 clearly shows how the carry finger will be pushed sideways to advance the next star wheel.

A second set of carry fingers is arranged symmetrically on the opposite side of the rotor for use in subtraction cycles.

The rotor clearing mechanism



The rotor "quick-clearing" mechanism.

This view from the back of the machine shows the slotted comb and the extended rotor teeth that form the quick-clearing mechanism.

The comb is able to slide a short distance along the back plate. It is coupled to the handle interlock shaft (via the pin visible in the opening at the bottom left), and moves in tandem with the rotor locking bar.

During a normal cycle, the handle interlock shaft is in its outer position (to the left in this view). The setting rings are locked, and the long teeth pass freely through the slots in the comb.

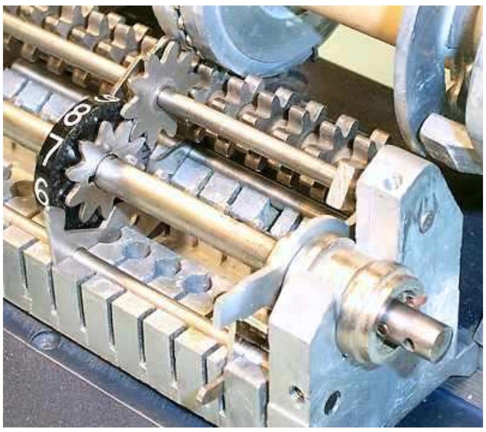
Operating the quick-clearing control over-rides the automatic rotor lock, and allows the machine to commence a forward turn with the setting rings free to move. (An interlock at the right-hand end of the rotor prevents the handle being turned backwards).

With the rotor lock disabled, the sliding comb remains positioned to the right, so that its teeth align with the setting rings. As the rotor is turned forwards (anti-clockwise in this view) from the home position, the long teeth are caught under the comb. The setting rings are (in effect) pulled backwards towards zero as the rotor continues to turn under them. The handle stops after about a quarter of a turn, when all the rings are back to zero. The rotor non-return mechanism has not yet engaged, so the handle can safely be turned backwards to its home position.

The description takes much longer than the operation - in practice, clearing is just a matter of pushing the button, cranking the handle forward until it stops, then back to home.

On the Model 127, the over-ride control is a small metal tab next to the carriage shift buttons. On the Model 227, it is a sleeve over the rotor locking shaft, allowing the clearing operation to be performed with only one hand. On early models the comb is at the front of the machine rather than at the rear, and is operated by a button on the right-hand side plate.

The back-transfer mechanism



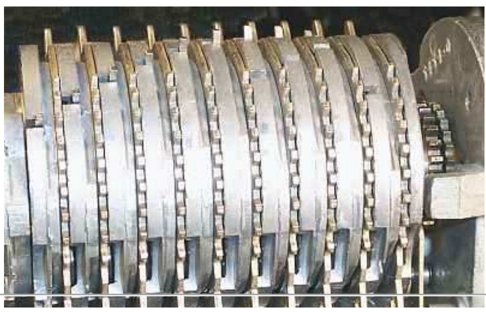
The carriage back-transfer gears.

The back-transfer mechanism is used to transfer an intermediate result from the accumulator back to the rotor, for use in further calculations.

The mechanism uses a set of idler gears suspended from the intermediate star wheel shaft. The idlers are permanently meshed with the star wheels, but usually hang vertically at the rear of the carriage and take no part in normal operations.

Performing a back-transfer involves first clearing the rotor, then raising the idler gears to mesh with the outer gear teeth on the rotor setting rings. The setting rings are offset to the left of the star wheels, so the idler teeth are made wider to mesh with both. The idlers are raised by the lever at the right-hand end of the accumulator, which is held in position by the small latching lever below.

The clearing handle is then turned, collecting the numeral wheels and driving them back to zero. The motion is transferred through the star wheels and the idler gears to advance the setting rings by the same number of positions. A cam on the accumulator shaft releases the latch at the end of the clearing cycle, dropping the idler gears back to their rest position.



The rotor back-transfer gears.

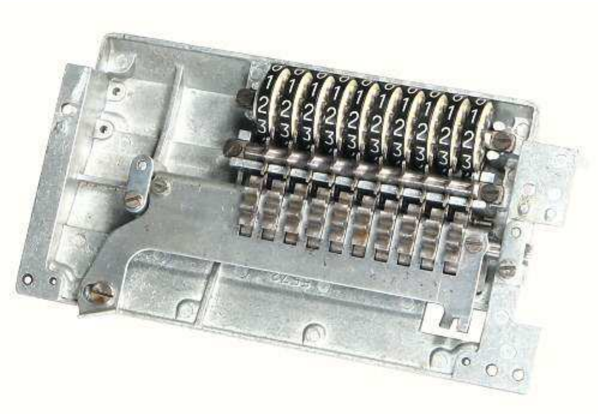
This view is taken from the front of the machine, looking up under the rotor. The rotor is in its home position, with the setting rings at zero. The setting handles are visible at the top of the picture.

The wide back-transfer gears on the carriage move upwards into the semi-circular cut-outs in the rotor discs. The gears are guided into engagement by a slightly elongated slot below the first tooth in the cut-out. The gears will not align with the cut-outs unless the rotor is in the home position, and the teeth will not mesh unless all the setting rings are at zero. (Later models have a separate interlock mechanism to ensure that the rotor has been cleared before the back-transfer can be engaged).

As the accumulator numerals move back to zero, the idler gears pull the setting rings downwards by the same number of positions. The idler gears are released and drop away at the end of the clearing cycle.

Additional features in Model 239

The most obvious difference in the Odhner 200-series from the mid-1950s is the new die-cast external casing. Internally, the Model 239 is essentially the same as the Model 127 described above, but with the addition of a setting check dial behind the rotor and a tens-carry mechanism with automatic reversing behind the counter register. Other minor differences include a relocated quick-clearing control, an additional gear on the left-hand end of the rotor to drive the new counter mechanisms, an improved back-transfer release, and an additional interlock between the rotor and the back-transfer mechanism.



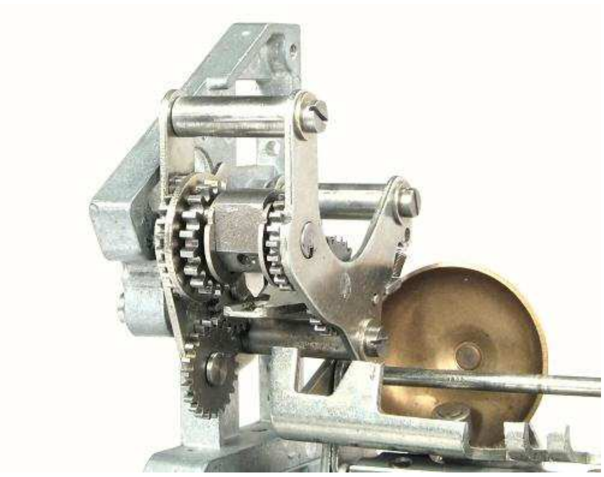
The setting check dial.

The check dial mechanism is assembled on a die-cast rear panel which replaces the plain back panel and the rotor clearing comb.

The numeral wheels on the top shaft mesh with a set of narrow star wheels on the centre shaft. The star wheels have a set of light detents underneath, and mesh with a set of wide star wheels on the lower sliding plate. The sliding plate is coupled to the winding handle interlock via the forked tab at the lower right, in the same manner as the previous rotor clearing comb.

With the handle in its stop, the wide star wheels are engaged with the teeth on the rear of the rotor setting rings and the dials follow the settings on the rings. When the handle is pulled outwards, the sliding plate follows to the right. The star wheels disengage from the setting rings and move onto a set of fixed pins cast into the rear panel, thus holding the dials stationary while the rotor turns. The wide star wheels re-engage with the setting rings when the handle returns to its stop.

The clearing comb of the Model 127 is replaced with a set of fingers on the check dial numeral wheels and a set of fixed stops on the panel behind. The fingers (between positions 6 and 7) stop the rotation of the rings in the same manner as the comb plate. The check dials advance to all-nines as the handle is turned forward, then back to zero on the return stroke.



The counter reversing mechanism.

The counter reversing mechanism is attached to the left-hand side plate, in place of the simple gear and pawl drive mechanism.

The new counter drive pawl is attached to the leftmost gear on the front shaft, and is visible to the rear at the 1 o'clock position. The gear and pawl are keyed to the central block of the reversing body. The gears on either side of the central body are driven from the two gears on the rotor shaft via one and two intermediate gears, so that they rotate in opposite directions. The pointed lever below the reversing body is in the shape of a T, which locks the body onto one or other of the contra-rotating gears when tilted to either side. The T-lever is tilted into engagement as soon as the rotor starts to turn by camming surfaces inside the adjacent gears (next illustration). Once it has been set on the initial turn, the reversing mechanism remains in the same state until the counter register is cleared for a new calculation.

Clearing the counter normally raises the interlock plate (lower front) to lock the rotor. On Model 239, an extra vertical projection has been added at the left of the interlock plate, and the interlock cam on the counter side has been modified to provide increased travel. The plate lifts a slotted arm under the reversing body, which cams the T-bar back to the central position as the counter is cleared.

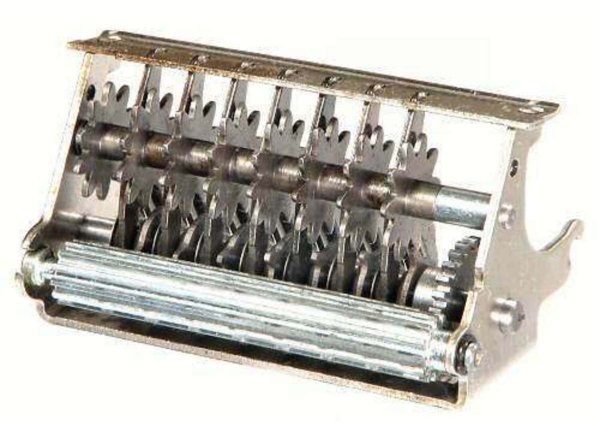
The gear at the lower left drives the counter tens-carry mechanism in the carriage.

The counter reversing gears.

This view shows the opposing snail cams inside the two contra-rotating gears.

With the T-bar centred, the horizontal arm of the T will be partly engaged with both cams. As the gears begin to turn, one or other of the cams will tilt the bar sideways, fully engaging one gear (via the notch at the 12 o'clock position) and fully disengaging the other.

There is a tiny (3/32") detent ball and spring inside the right-hand shaft to keep the central body in position after the T-bar is reset, and a small spring-loaded pin behind the T-bar to ensure that the reset arm moves away after clearing.



The counter carry mechanism.

The counter tens-carry mechanism is a self-contained unit which mounts in the previously-empty space behind the counter register. This view shows the mechanism from the rear.

The star wheels on the upper shaft engage with the register dials and the counter operating pawl in the normal manner. If a dial passes from 9 to 0 the vertical carry lever on the next decade will be pushed rearward and held by a detent underneath.

The lower end of the carry lever has two offset arms which engage with a V-groove in a sliding collar on the rotating shaft below. The collar has two carry actuating fingers which are normally held just clear of the adjacent star wheel. When the carry lever is pushed rearward the fingers move into line with the star wheel. The timing is such that one finger will have already passed the star wheel, and the second finger will advance the wheel by one position as it passes. A cam strip on the shaft resets the carry levers and returns the collars to their home positions at the end of the cycle.

The mechanism is driven via the long gear from the reversing mechanism in the main body. Timing marks are provided on the drive gear and the frame to ensure that the carry mechanism is properly synchronised.

The back-transfer interlock.

The 200-series (and subsequent) machines have an additional interlock lever to ensure that the back-transfer mechanism can not be engaged until the rotor has been cleared.

The lever is mounted on the sliding interlock plate under the right-hand end of the rotor, and travels about 10mm vertically at its forward end. It is cammed into the raised position (as shown) on every turn of the crank, and is held more or less permanently in this position by friction from the compression spring and washer on the locating pin. In this normal position the forward end of the lever blocks any attempt to lift the back-transfer gears, and prevents them entering the half-round notches in the rotor discs and engaging with the setting rings.

The interlock must be cleared by operation of the rotor quick-clearing mechanism before a back-transfer can take place. With the interlock plate held inwards during clearing, a cam on the rotor shaft pushes the lever down into its lower position as the crank is turned forwards, thus allowing the back-transfer gearset to rise fully and latch into position. Note that it is not sufficient to clear the rotor manually via the setting levers, as the interlock can only be removed by the operation of the quick-clearing mechanism.

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