

For Sandra, now and forever

The watches in this book are named after their first owner or a prominent technical feature. Names given to watches by George Daniels have been retained. Technical information regarding the watches has been taken from Daniels's own books, or from the Sotheby's Catalogue written for Daniels's retrospective edition in 2006.

ON PAGE 1

Diagram of the co-axial escapement as developed by Omega from George Daniels's original design.

PAGES 2-5

George Daniels in his London workshop in the 1970s, aged 50. He wears glasses with two additional lenses; the lens nearest the glasses is of 30 cm (5½ in.) focal length, the other is 5 cm (2 in.).

RIGHT

Under-the-dial view of Daniels's first horological exercise: his marine chronometer. He made the box from a Victorian sideboard purchased in a second-hand shop.

OPPOSITE

Daniels's marine chronometer with dial in place. Completed in 1954, the work on the marine chronometer was mostly done in Daniels's lodgings in South London. (See page 51.)

First published in the United Kingdom in 2015 by
Thames & Hudson Ltd, 181A High Holborn, London WC1V 7QX

George Daniels: A Master Watchmaker & His Art
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Text © 2015 Michael Clerino

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British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 978-0-500-51676-2

Designed by Adam Hay Studio

Printed and bound in China by Toppun Leefang

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OPPOSITE

A 2011 Omega advert for the DeVille Co-axial Chronometer. The ad emphasized the two great benefits of the co-axial: reduced friction and greater accuracy.

ABOVE

Daniels delivering a speech at his retrospective exhibition, which opened at Sotheby's, New Bond Street, London, on 18 July 2006.

OVERLEAF

A Westclox Big Ben alarm clock of the type Daniels opened in the family living room as a child. Years later he purchased this specimen and kept it in the Riverside workshop.



George Daniels
LIFE
1960-1983

'From repairer to restorer': Old masters, first books and fast cars 1960-1967

Daniels got mixed up with Breguet and the fascinating world of antique watches through the intervention of a man named Sam Clutton.

Cecil Clutton CBE, known to everyone as Sam, was born in 1909 to a wealthy family that owned a successful London estate agency. Educated at King's School, Worcester, he entered the business in 1927. During the Second World War he was an RAF pilot. After the war Sam prospered at the family firm despite devoting much time to his interests: pipe organs, vintage cars and antique horology. He wrote books on all three subjects and was an Honorary Fellow of the Royal College of Organists, President of the Vintage Sports Car Club (1954-57), a Fellow of the Society of Antiquaries, and Master of the Worshipful Company of Clockmakers (1975-74). Clutton combined a wiry build with a haughty manner and an ego-deflating wit, liberally unleashed on anyone who bored him.

Daniels and Clutton met in 1960 at a vintage car rally – the occasion described in *All In Good Time*. 'I was driving a sports tourer Bentley, which in the previous six months I had rebuilt. He admired the car and its condition, and the conversation then turned to horology... I knew I was being probed to see if I was worth continuing with, I had no practical experience of antique watches, but I was generally familiar with their history from the books I had read as a schoolboy. His comments and questions were put to me in a stiff and formally detached manner... Suddenly his voice changed dramatically, and in the friendliest tones he invited me to dine with him at his house in Blackheath.'

Unknown to Daniels, Clutton reported the meeting to Edward Hornby, an affluent stockbroker, occasional columnist for *The Observer* newspaper and a watch collector. In 1984 Hornby gathered some of his columns and other writings in a book, entitled *The Adventures of Edward Hornby as a Christmas gift for family and friends*. In the book his previously unpublished version of the first Daniels/Clutton meeting appears.

'One morning... I was rung up by a friend called Sam Clutton, "I think I have found just the man we

are looking for", he said, "I was at a car rally last weekend with my Bugatti and I came across a remarkable fellow who mends watches... he'd got the most super Vauxhall 50/98 of the 1920s which he's put into pristine condition, I asked him if he mended watches as well as he did cars and he said "Yes, better and quickly too." I told him there was an opening for someone who could repair antique watches and that I would put him in touch with patrons. I said there would be a lot to learn but that there would be really good money in it. May I bring him along to see your collection and, if you could find a watch or two that needs some attention, not of too great a value, it would be a great kindness to let him have a go at it." Of course I said yes and George was around within a week and we have been really good friends ever since.'

At the Riverside kitchen table reading that passage for the first time since 1984 Daniels explodes with mock exasperation: 'What possessed Hornby to write that? I never owned a Vauxhall 50/98 or any other Vauxhall. After I started with my Bentleys I would never knowingly be in the same garage with a Vauxhall! He's right about Sam though, he drove a Bugatti that day. Sam was a Bugatti man. I never liked his Bugattis; they handled like lorries.'

Daniels and Clutton became unlikely but steadfast friends. Clutton, 51, was from a comfortable background and never wanted for money, he was aloof in his manner and Daniels believed that from the time 'his nanny was pushing Sam in his pram his voice sounded like he had a mouth full of cut glass.' At 54 the once-poor Daniels toiled at an inhuman pace to earn money, had purposefully shed his cockney accent and met everyone in an outgoing and friendly way. These two opposites were bound together by their intense interest in vintage cars and antiquarian horology. Both loved music, but while Clutton was an authority on pipe organs, clavichords and harpsichords, Daniels opted for harmonicas and accordions. 'I preferred instruments you held in your hands, that you could take with you. That is difficult with a pipe organ.'

Clutton's collection mesmerized Daniels.

Before him were watches by Tompion, Mudge, Arnold, Le Roy, Emery, Lipine, Berthoud, Breguet and others. The watchmakers Daniels had read about as a boy, but whose works he had never held in his hands or even seen.

'Sam was very generous because he put the whole of his collection at my disposal to play with and examine ... They were beautiful machines. But I was not nervous about handling them. I thought this is what I want for myself, I wanted to work with these watches, I want to know their secrets.' And he did. Clutton and Hornby drip-fed Daniels antique watches for repair and minor restoration for a few months before introducing him to additional collectors and more extensive restoration projects. Daniels devoured the work. As Clutton had promised, the pay was good – so good that Daniels refused trade repair work from all but the most upscale retailers whose customers owned only the best Swiss wristwatches. Daniels returned to his punishing all-night watches-and-Bentley routine. His only restraints were a lack of tools, space (his workshop was still the roll-top desk in his flat) and once again his health.

By late 1961 the headaches and flashing lights had returned. A doctor advised slowing down. Daniels limited his working hours to 12 a day and increased his sleep to seven nights a week. He also decided that migraines are a complaint of children and women, not something that should afflict a fit 55-year-old male. So, to the doctor's advice he added his own cure: banishing migraines from his life. He would not think about them nor even admit they had once troubled him. He never experienced debilitating headaches again.

'It was never overwork that caused my health problems, I was very fit in those days. It was over-anxiety. Failure was not to be contemplated under any circumstances. With my cars and my watches everything had to work perfectly, one hundred per cent demonstrated superiority – very important that all those things are attended to. That much closeness, which is unavoidable in watchmaking, does bring on migraines. It's a very concentrated business working

The movement of Breguet No. 4558, a *Lipine* calibre minute repeater. A tubular gong for the repeater, one of Breguet's innovations, is clearly visible around the edge of the movement (starting at about 12 and ending over the signature). Daniels considered Breguet's repeaters to possess unsurpassed elegance.



'The foremost watchmaker of the century'

ultimately survive the quartz onslaught. He also delighted in an irony. In 1955 the award's first recipient was William Shortt inventor of the Shortt's Free Pendulum: an electromechanical device. The 1975 award went to W.A. Morrison: the builder of the first quartz clock. Ewen received the 1957 award for his atomic clock. The next Tompion laureate in 1965 was Max Hetzel: the inventor of the acoustic frequency watch, which replaced the oscillating balance wheel with a tuning fork. Seventeen years later the award rested in the large, agile hands of a mechanical watchmaker. In Daniel's opinion, 'Where it should have been from the start.'

After his year as master Daniel accepted the job of chairman of the company's Horological Industries Committee. From his new position he directed the disbursement of scholarship money to aspiring watchmakers. 'It is a delicate business interviewing young people for possible charitable

largesse and I think we did a good job of it. Many of the people we selected for scholarships went on to set up their own workshop, which I find especially pleasing because it means we facilitated their education and we encouraged their independence.'

In 1981 Daniel was recognized with two more awards: he became the first recipient since 1957 of the Gold Medal of the British Horological Institute; and his sovereign conferred the other honour. In her New Year Honours list Queen Elizabeth II bestowed on George Daniels the rank of Member of the Most Excellent Order of the British Empire – or MBE. Daniels is the only watchmaker to have received the honour.

The next year, 1982, the Daniels family sold the houses on Thornett Road and Cold Cotes and moved to Riversdale. A decade earlier Sam Chilton had moved to the Isle of Man, and Daniel's frequent visits there to consult with his friend convinced him of the islands congeniality compared to London's crowds, noise

and congestion. As he had become wealthy dealing in vintage cars and his watches now sold for fabulous sums the island's status as a tax haven also appealed. *Spice Traveller II* would be the first watch completed in his purpose-built workshop in the Riversdale garden. At 65 m² (700 ft²) the workshop occupied a larger space than most suburban swimming pools.

In the 15 years from 1968 to 1985 Daniel had established his reputation as the foremost watchmaker of the century, written five books, endured two life-threatening illnesses, restored and raced vintage cars, risen to the pinnacle of the British horological establishment and received a trophy cabinet of awards and honours. When asked how he managed to do so much he responded with his typical disarming humour: 'I procrastinate. In order to avoid doing one thing I do another. In the end everything gets done.'⁴⁷

In those same years he accomplished another, even greater, achievement.

George Daniels WATCHES 1983–2011

The Space Traveller

Movement: Of gilt brass construction; L'Epine calibre; 12-hour duration. Two going barrels with identical trains driving the two escape wheels of the Daniels independent double wheel escapement, incorporating a Y shaped central locking detent with three pallets. Monometallic, stainless steel, four armed balance with gold adjusting weights, Daniels auxiliary compensation and free spring overcoil balance spring. The two trains calculated for mean solar and sidereal time, including seconds. Annual calendar ring with kidney cam and equation of time indication. Accurate lunar dial driven from the sidereal train with indications of the age and phase of the moon. Signed on the main movement bridge: DANIELS LONDON.

Dial and hands: Silver engine-turned dial with a 24-hour chapter ring to the left for sidereal time and a 12-hour chapter ring to the right for mean solar time, each with seconds below. A silver star above the sidereal time chapter ring and a gold sun above the mean solar chapter ring. Aperture in the mean solar chapter ring for the annual calendar and apertures in the sidereal dial for the age and phases of the moon. Quadrant above for the equation of time. Signed DANIELS LONDON in a cartouche below the seconds rings. Gold Daniels hands to the mean solar dials and blued steel Daniels hands to the sidereal dials.

Case: 18ct gold, open face case with Daniels pendant and bow. Case maker's mark GD. Short, gold, graduated double link chain with gold and blued steel double-ended key.

Diameter: 65 mm (2 1/2 in.)

Band: Blue leather; velvet lined; fitted.

Completed: 1982

History:
Sold to Bobinet Limited, 1982
Jay Lennon Esq.
Private collection (Germany)



ABOVE

The movement of the *Space Traveller*. Unlike other watches with his independent double wheel escapement, here Daniels decided to expose the winding wheels, barrel wheels, click spring and pawl, contrasting their silvery grey with the honey tones of the gilt brass.

LEFT

The dial design is a superb example of Daniels's doctrine: simplicity, homogeneity and elegance.

OPPOSITE

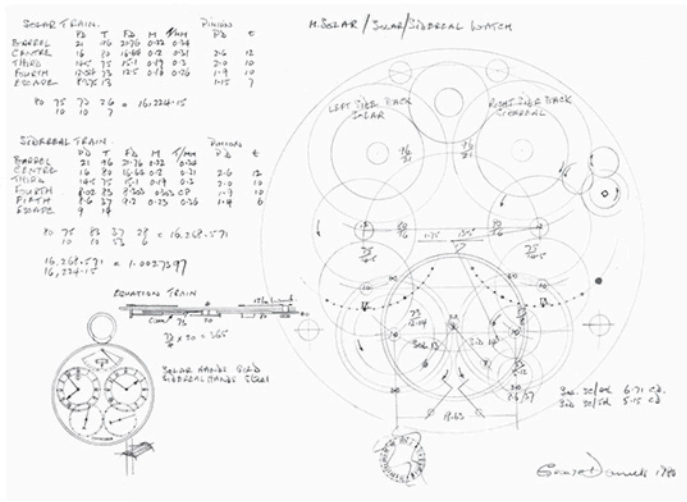
Daniel's own photograph giving an under-dial view of the *Space Traveller*. He has placed the moon disc and the annual calendar in the lower portion of the dial to show the equation of time cam and train.





ABOVE
Another under-the-dial view with the two
dials inverted.

RIGHT
Movement of the Space Traveller.



On the right is Daniel's drawing of the wheel train for his solar/sidereal watches. In most fractions the upper figures refer to wheel teeth and the lower figure refers to pinion leaves. Daniel has indicated the number of teeth on each escape wheel

in the lower portion of the drawing by writing "Sol 15, Sid 14". On the left are the wheel train calculations for the solar/sidereal watches. The figure 16,224.15 is the number of vibrations per hour for the solar train, 16,268.571 is the number of

vibrations per hour for the sidereal train. The figure at the bottom is the ratio of a solar day to a sidereal day. (See page 154.) Below the ratio is a drawing showing the elevations of the equations train and another of the dial.

The Grand Complication

Movement: Of gilt brass construction with single going barrel; 36-hour duration. Daniels' slim co-axial escapement mounted in a polished steel, two-armed, one-minute tourbillon carriage under a polished steel balance rock. Monometallic, stainless steel, three-armed balance with gold adjusting weights. Differential screw mechanism for power reserve indication. Instantaneous perpetual calendar mechanism designed by Daniels, with retrograde date and leap-year cycle indication. Annual calendar ring with kidney cam and equation of time indication. Minute repeater mechanism striking on two gongs. Bimetallic thermometer under the dial. Signed on the plate: DANIELS.

Dial and hands: Silver engine-turned dial with polished gold chapter rings for hours, minutes and seconds. Polished silver quadrants for the concentric date indicator and within the seconds ring for the thermometer. Subsidiary silver dials for the day of the week and the month (with concentric leap-year cycle indication). Aperture at 12 for the phase of the moon disc. Gold Daniels hands for the hours, minutes and seconds, blued steel hands for the calendar. Signed DANIELS LONDON within the seconds ring.

Case: 18ct gold, open faced case with Daniels keyless pendant and bow. Sliding repeat and calendar setting in the band of the case. Glazed aperture in the back revealing quadrants for the equation of time, year calendar and power reserve.

Diameter: 61 mm (2½ in.)

Completed: 1987

History

Retained by the maker

The piece was entered into the George Daniels Horological Collection sale, held at Sotheby's, London, November 2012

Daniels's astounding *Grand Complication*. The dial design maintains legibility while containing an abundance of information: the temperature gauge is located within the seconds ring; the date ring is situated within the main chapter ring; and the date hand ends in an unusual open square. The leap year and month rings are concentric and matched with the day subdial while the moon phases disc seems to float in between.



One reason why the dial of the *Grand Complication* is so legible is that Daniels chose to put some information on the back of the watch – three quadrants for the equation of time and the power reserve are displayed. Notice that the clamp that secures both quadrants has an arrow pointing to the date on the equation of time calendar ring. Also visible is the equation of time cam at 11 and the gongs and chimes of the minute repeater mechanism.

Wristwatch II (The Spring Case)

Movement: Of gilt brass construction with two going barrels engaging a common offset centre pinion; 48-hour duration. Daniels' slim co-axial escapement mounted in a polished steel, one-minute, four-armed tourbillon carriage under a polished steel bridge, beryllium copper, four-armed balance with gold adjusting weights. Free spring overcoil balance spring. Differential screw mechanism for power reserve indication.

Dial and hands: Front dial – engine turned silver with eccentric gold chapter ring and large interlaced gold seconds ring. Small gold chapter ring below 12 for power reserve indicator. Rear dial – engine turned silver with two gold subdials for the day and the date, and a glazed aperture revealing the tourbillon carriage. Gold Daniels hands. Signed DANIELS and LONDON in cartouches either side of the chapter ring.

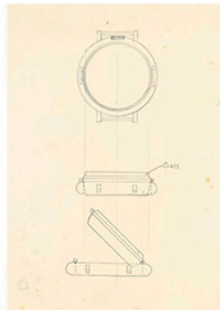
Case: Of gold case comprised of an outer band with a sprung, hinged inner case containing the movement. When released by a pusher in the band the inner case opens to display the calendar dials and the tourbillon.

Diameter: 42 mm (1.6 in.)

Completed: 1992

History:
Private collection (UK)

The rear dial of Daniels' second wristwatch showing the day and date subdials and the tourbillon. On the subdials Daniels used a smaller version of his hour hand.



LEFT

A drawing by Daniels showing three views of the case of his second wristwatch: (from top) front view of case, profile of case and with the inner case in the open position.



ABOVE

A view of the front of Wristwatch II with the inner case in an open position.

Outwitting the quartz watch: Inventing the co-axial escapement

1975–1993

A moment is an uncertain period of time. Seconds, minutes and hours, are precise, definite, but the measurement of a moment is not possible. George Daniels created machines that flawlessly measured time, but a single moment in his life was to matter more than all the certainties of his perfect timepieces.

In one moment countless mechanisms converged: the Roskopf watch and Westclox alarm clock on the mantelpiece in Watling Avenue; Sybil's wristwatch; stolen gramophones; the movements of clocks spirited from homes with unlocked doors or bought at jumble sales; the watches of schoolmates and teachers; the Kasee projectors converted in Soper's garage; the watches repaired in the Egyptian desert; and the Hetchins bicycles admired on the streets of North London. Time collapsed during that moment: the days at a workbench with Jimmy Battle, the nights as a trade repairer when he did not sleep, the weekends when grease blackened his hands as he forced antique engines to roar again; the years dedicated to untangling the mysteries of the masters; and the thousands of hours spent making his own watches. In that moment his soaring ambition was realized and his rock-solid self-confidence justified. In that moment George Daniels invented the co-axial escapement.

Back at Riverside in 2011, Daniels sits in a small room he calls the office.⁶⁸ The green wallpaper is covered with pictures and photographs of his awards, his cars and his heroes. Many of the same faces (Arnold, Breguet, Mudge, Harrison and Bentley) hung on the wall of his London workshop. A clock that once belonged to Sam Clifton adorns the black mantelpiece. Daniels enjoys the office, finding comfort in the heat of the fireplace where yellow flames flicker even on a summer afternoon. He provides in a red armchair next to a small table covered with an open copy of *Witchamming*, a cup of milky tea and Bakewell tarts. After a few meditative sips he begins the story of the co-axial escapement.

At about three o'clock one morning in the summer of 1975 Daniels recalls waking. 'I'm certain about the

time because I remember thinking that in about two hours there would be enough daylight for me to start in the workshop. At that time of year the sun comes up early. I woke up and I had an image of what I wanted to do. I could visualize the co-axial escapement. So I made a quick sketch.'

Several experimental escapements of dubious utility whirled in metal boxes in his workshop. Daniels sensed this escapement was different. Enveloped by the euphoria he experienced whenever he knew an idea was sure to work he fell back to sleep. At five o'clock he was up and in the workshop. Wanting to explore his invention and using the sketch as a guide, Daniels prepared a drawing 20 times the size of the actual escapement. His hands were impatient to start cutting metal to construct the mechanism but first he considered the new invention. Instinctively Daniels knew the co-axial escapement would improve the performance of the mechanical watch.

At the time, the mechanical watch seemed destined for quaint obsolescence, reduced by the all-conquering quartz watch to a curiosity like the magic lantern or the zoetrope – something kept in attics, sold in antique shops and exhibited in museums. In Switzerland the watch industry reeled as sales of mechanical watches plummeted and tens of thousands of watchmakers lost their jobs.⁶⁹ Daniels wanted the co-axial to contribute to the revival of the mechanical watch, something he foresaw as inevitable in defiance of all the marketplace indicators.

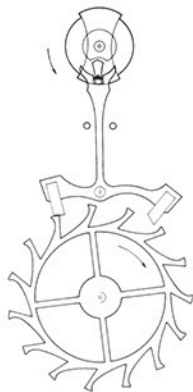
Daniels explains that the escapement is 'the crucial component' of a watch. 'The movement of a watch is like the engine of a car; it needs energy to run. The energy for a car engine comes from petrol. When you wind a watch you are tightening the mainspring and putting energy into the watch. When the mainspring unwinds it supplies the energy to run the watch. The escapement controls the energy.' In a mechanical watch the energy from the mainspring rotates the toothed mainspring barrel, which powers an interlocking gear train of wheels starting with the centre wheel.

The centre wheel rotates once per hour. It controls the minute hand and drives the third wheel. The third wheel drives the fourth wheel, which rotates once per minute and controls the seconds hand. A gear attached to the minute hand controls the hour hand. Into this configuration comes the escapement, which interacts with the fourth wheel.

As Daniels said to Seth Atwood, the challenge is to create an escapement that, like the lever escapement, delivers impulses in two directions but that, like the chronometer escapement, does not require oil. Most mechanical watches in 1975 had lever escapements, the central element of which is a steel lever shaped like a fork at both ends. Each fork has two times. At the larger end, set into each of the two times flash with the surface of the lever, are rectangular rubies (called pallets) with one short side cut at an angle. The fork at the other end of the lever is smaller and fashioned without pallets. The other two components of the lever escapement are the escape wheel (usually with 15 foot-shaped teeth) and the oscillating balance.

In a lever escapement the energy generated by the mainspring travels along the gear train until it reaches and rotates the escape wheel. The escape wheel's rotation alternately starts and stops, in the process starting and stopping all the wheels in the gear train. The action of the escape wheel is what prevents all the energy in the mainspring escaping in an instant, and enables the watch to perform its time-telling functions.

The escape wheel's rotation is stopped and then released by the pallets in the larger fork of the lever as they intersect with the path of the escape wheel's teeth. First one pallet tilts towards a tooth, eventually stopping the wheel. An instant later, the lever and pallet begin to tilt back, releasing the escape wheel. The rotation of the now released escape wheel forces the foot-shaped tooth to slide along the pallet jewel, imparting some energy to the lever in the process. The escape wheel is quickly arrested again as the other pallet moves into the path of another tooth.



The lever escapement. This diagram clearly shows the nature of sliding friction. The pallet on the left is sliding against the surface of the escape wheel tooth.

This alternate tilting of the lever is governed by the third element of the escapement, the oscillating balance. The balance and the smaller fork at the far end of the lever carry on a symbiotic relationship. As the name implies, the oscillating balance swings in two directions, clockwise and counter-clockwise, under the influence of the balance spring. The balance has a tiny ruby pin (called the impulse jewel) protruding downwards into the path of the smaller fork of the lever. The action at this end of the lever is synchronized in a see-saw fashion with the action at the other (escape wheel) end. As one of the pallets is lifted away from an escape wheel tooth, the motion of the lever forces the small fork to strike the impulse jewel, impelling the balance on its clockwise journey; simultaneously, the lever lowers its other pallet into the path of an escape wheel tooth, stopping the wheel again. The balance travels without interference but is designed to run out of energy before being able to complete a full 360-degree rotation. The lifting of the lever positions the small fork to strike the impulse jewel again and reverse the direction of the balance to counter-clockwise. It is the oscillation of the balance that rocks the lever back and forth, alternately tilting the pallets that interact with the escape wheel. Meanwhile it is the action of the escape wheel against the pallets, called sliding friction, that impales the balance first in one direction and then the other.

The lever escapement is a formidable invention. Ease of manufacture and reliability ensured its domination over watchmaking for more than two centuries. The weakness of the lever escapement is the sliding friction. In one day, a pallet meets an escape wheel tooth 694,000 times.⁷⁰ Smooth functioning requires a smear of oil on the surfaces of teeth and impulse pallets. The oil deteriorates, drying and flaking or evaporating, causing the watch to lose time and eventually stop. The only successful preventive medicine is regular servicing.

The other escapement with more than two centuries of pedigree, the chronometer escapement, has a completely

different design. The escape wheel teeth and the pallets meet in a quick skimming action called tangential friction, eliminating (as Daniels pointed out to Atwood) the need for oil. More accurate than the lever escapement, the chronometer escapement is also a more delicate mechanism, impales the balance in only one direction, is not self-starting, and is impossible to mass-produce.

The difference between the two venerable escapements and the co-axial startled Daniels. 'I talk to myself frequently when I work. I have heard the point of view expressed that talking to oneself qualifies one for a certain type of hospital. But I think that anyone who spends days at the drawing board or at the bench like I do would start chattering away. You talk about what you're doing, and why you're doing it. And then you make notes, little notes about something or other. When I was first drawing the co-axial I would explain to myself how it worked.'

The escapement Daniels had sketched on the graph paper had two escape wheels on the same axis, a larger wheel above a smaller wheel. Both wheels had 12 pointed teeth. A vaguely fork-shaped lever held three pallets. Two were set in the lines of the fork as on the lever escapement, but unlike the pallets on the lever escapement these pallets were triangles with one curved side. Both pallets rose a fraction of a millimetre above the surface of the lever. The third pallet, an angled rectangular ruby, was set in between the other two and on a slightly lower plane. At the far end of the lever (the location of the smaller fork on the lever escapement) the co-axial tapered to a point. The small fork was there but in an odd place, next to one of the pallets on the lever and adjacent to the oscillating balance.

As the first co-axial was bound for a pocket watch movement, the balance in Daniels's drawing differed significantly from a lever escapement balance. The oscillating balance Daniels envisioned resembled those of traditional English pocket watches: two rotating circular plates, called rollers, were stacked on the balance staff, a smaller one on top of a larger one.

'SOMETHING DEEPLY HIDDEN' (pp. 20–25)

- 1 George Daniels, *All in Good Time: Reflections of a Watchmaker* (Ed. of Marc George Daniels, 2000) p. 5
- 2 *All in Good Time*, p. 9
- 3 Albert Einstein, *Autobiographical Notes* (Chicago: Open Court Publishing, 1979) p. 9
- 4 Albert Einstein, *Autobiographical Notes*, p. 9
- 5 Albert Einstein, *Autobiographical Notes*, p. 9
- 6 Albert Einstein, *Autobiographical Notes*, p. 9
- 7 *All in Good Time*, p. 10
- 8 Albert Einstein, *Autobiographical Notes*, p. 5
- 9 *All in Good Time*, p. 55
- 10 Online interview at Web of Stories www.webstories.com/people/george-daniels
- 11 Online interview at Web of Stories
- 12 Online interview at Web of Stories
- 13 Pierre-Augustin Caron de Beaumarchais (1732–1799) is best remembered today for writing the plays that became *Mozart's Marriage of Figaro* and *Barber of Seville*. His own musical talents secured an appointment as harp instructor to the daughters of King Louis XV – he was already the King's watchmaker. In 1755 he invented the double virgile escapement.
- 14 Frederick James Britten (1895–1974) was a watchmaker, optician and for many years secretary of the British Horological Institute. His book is still in print.
- 15 E.J. Britten, *Watch and Clockmakers' Handbook, Dictionary and Guide*, 16th edn (Woodbridge, Suffolk, England: Antique Collectors' Club, 1978) p. 12
- 16 *All in Good Time*, p. 16
- 17 *Aparatus*, ITV documentary, broadcast in 1976.
- 18 *All in Good Time*, p. 25
- 19 *All in Good Time*, p. 25
- 20 John Forster, *The Life of Charles Dickens* (London: Cecil Palmer, 1872–73) pp. 50–51
- 21 *All in Good Time*, p. 2
- 22 *All in Good Time*, p. 22
- 23 *All in Good Time*, p. 25
- 24 *All in Good Time*, p. 52
- 25 *All in Good Time*, p. 52
- 26 *All in Good Time*, p. 55

'SIXTEEN HOURS A DAY ... SEVEN DAYS A WEEK' (pp. 44–51)

- 1 *IsCine* (June, 2006) p. 96
- 2 A hand powered box lathe is a turning tool that has been used for centuries by watchmakers, particularly in England. It resembles an arcylar box – a curved piece of wood or metal with a wire attached at either end. The wire is wrapped around a pulley and the operator of the lathe moves the box up and down with one hand to rotate the pulley, which in turn rotates an object, such as a piece of metal. To shape the object the operator uses a chisel held in his other hand.
- 3 An escapement is the part of a mechanical watch that dissipates stored power in a controlled way. A detent is a stop or catch that prevents motion in the escapement until it is released by the balance at precise and regular intervals. A detent escapement is more delicate than the lever escapement that is in most wristwatches, and more difficult to make.
- 4 Timing machines acoustically test the accuracy of a watch. A microphone amplifies the tick of the watch and the

sound is compared to that of an accurate clock, which is part of the machine. When the watch and the clock are in perfect synchronization for 24 hours the repairer knows the watch is accurate.

FROM REPAIRER TO RESTORER: OLD MASTERS, FIRST BOOKS AND FAST CARS (pp. 98–115)

- 1 *All in Good Time*, p. 46
- 2 Edward Horley, *The Adventures of Edward Horley* (Edward Horley: London, 1984) p. 55
- 3 Cecil Clutton and George Daniels, *Watches* (B.T. Batsford Ltd: London, 1956) pp. 55–59
- 4 *Watches*, p. 45
- 5 *Watches*, p. 55
- 6 *Watches*, p. 55
- 7 *Watches*, p. 60
- 8 *Watches*, p. 65
- 9 George Daniels, *English & American Watches* (Abelard Schuman: London, 1972) p. 51
- 10 *English & American Watches*, p. 55
- 11 *English & American Watches*, pp. 46–49
- 12 *English & American Watches*, pp. 54–55
- 13 *English & American Watches*, p. 55
- 14 *The Adventures of Edward Horley*, p. 51
- 15 Daniels refers to one of the great mysteries of horology, Harrison's H₂, now in the Greenwich Observatory, has a verge escapement with diamond pallets. How Harrison made these pallets defied explanation for over two hundred years.
- 16 A combination of hands (beetle for the hour and pecker for the minutes) common in the 18th and early 19th century. The hour hand is so called because of its resemblance to the stag beetle.
- 17 Daniels in fact wrote two articles about Mudge for *Antiquarian Horology*, the journal of the Antiquarian Horological Society. The first appeared in June 1961 and second, which he refers to here, in June 1968.
- 18 A balance spring with its terminals curved inward to as nearly as possible the centre of oscillation.
- 19 The inner cover of a watch case, usually featuring an aperture for winding and regulating.
- 20 A high-grade single watch with one hand. Its name was derived from the fact that part point of sale was made by the purchaser on ordering and the balance was paid on completion of the watch.

'THE FOREMOST WATCHMAKER OF THE CENTURY' (pp. 116–56)

- 1 For a discussion of the division of labour in the watch industry in the 17th and 18th centuries see Adam Smith, *The Wealth of Nations* (London: Everyman, 1993) p. 225
- 2 Michael Clestin, *Masters of Contemporary Watchmaking* (London: Thames & Hudson, 2009) p. 16
- 3 *Masters of Contemporary Watchmaking*, p. 16
- 4 *Masters of Contemporary Watchmaking*, p. 17
- 5 *Masters of Contemporary Watchmaking*, p. 17
- 6 *Masters of Contemporary Watchmaking*, p. 17
- 7 *Masters of Contemporary Watchmaking*, p. 17
- 8 Online interview at Web of Stories www.webstories.com/people/george-daniels
- 9 Cecil Clutton, *Collector's Collection* (London: The Antiquarian Horological Society, 1973) p. 77
- 10 Online interview at Web of Stories
- 11 Online interview at Web of Stories

- 61 *Collector's Collection*, p. 77
- 62 *Collector's Collection*, p. 79
- 63 Andrew Croft, *George Daniels' Retrospective Exhibition Catalogue* (London: Sotheby's, 2006)
- 64 *All in Good Time: Reflections of a Watchmaker*, p. 85
- 65 *Masters of Contemporary Watchmaking*, p. 46
- 66 George Daniels, *The Art of Breguet* (London: Sotheby Parke Bernet, 1973) p. 5
- 67 *The Art of Breguet*, p. 13
- 68 *The Art of Breguet*, p. 13
- 69 *The Art of Breguet*, p. 13
- 70 *The Art of Breguet*, p. 13
- 71 *The Art of Breguet*, p. 13
- 72 *The Art of Breguet*, p. 13
- 73 *The Art of Breguet*, p. 13
- 74 *The Art of Breguet*, p. 13
- 75 *The Art of Breguet*, p. 13
- 76 *The Art of Breguet*, p. 13
- 77 *The Art of Breguet*, p. 13
- 78 *The Art of Breguet*, p. 13
- 79 George Daniels, *Watchmaking* (London: Sotheby Parke Bernet Publications, 1981) p. 6
- 80 *Watchmaking*, p. 6
- 81 *Watchmaking*, p. 6
- 82 *Watchmaking*, p. 6
- 83 *Watchmaking*, p. 6
- 84 *Watchmaking*, p. 6
- 85 *Masters of Contemporary Watchmaking*, p. 51
- 86 Derek Pratt, 'The Art of George Daniels', *Horological Journal* (August, 1991) pp. 50–51
- 87 Timothy Trellis, 'Omega: Daniels' Ambition Achieved', *Horological Journal* (May 1999) pp. 152–54

ON TWITTING THE QUARTZ WATCH: THE INVENTION OF THE CO-AXIAL ESCAPEMENT (pp. 186–99)

- 88 The room was known as the office because Daniels's secretary, Carolyn Grogan, spent much of her time there at a desk with a permanently open laptop.
- 89 For details of the rapid decline of the Swiss watch industry see David S. Landes, *Revolution in Time* (Cambridge, Mass: Harvard University Press, 1983) p. 555. Landes puts the Swiss watch industry workforce at 55,000 in 1965 and 25,000 in 1980.
- 90 'Wall Odds', 'The Anchor Escapement', <http://www.timezone.com/2002/09/06/the-anchor-escapement/>
- 91 Daniels believed the large wheel on the first co-axial measured 6 mm in diameter and the small wheel only 4 mm.
- 92 *The Art of George Daniels*, pp. 50–56
- 93 *Revolution in Time*, p. 551
- 94 These movements were produced with the help of English watchmaker Derek Pratt, whom Daniels had known since 1974. Daniels requested Pratt's aid because he owned the spark erosion machines needed to produce the small components of the slim co-axial. Derek Pratt recounts their meeting in his August 1991 article 'The Art of George Daniels'.

FINDING A HOME: OMEGA ADOPT THE CO-AXIAL (pp. 200–10)

- 95 Exceeded only by the pile of documents concerning the patent application for the co-axial, which rises to 22 cm.
- 96 Daniels had used the lower rates of 270° and 25,200 vibrations per hour. Omega would revert to his lower rate for many of their watches in 2005, though they continue to use the 28,800 for chronographs with the co-axial escapement.
- 97 Dana Sobel, *Longitude: How the Mystery Was Cracked*, *Harvard Magazine* (March–April 1991) pp. 41–52

Glossary

- amplitude** Maximum displacement of a balance from the stationary position.
- automatic watch** An automatic watch uses the motion of a semi-circular disc called an oscillating weight or rotor to engage a train of gears to wind the watch.
- arbor** The axle of a watch wheel. The arbor of the balance is usually called the balance shaft.
- balance cock** The bar or bracket in which the bearing for the upper part of the balance wheel is fitted.
- balance spring** A thin wire spring used to control the period of oscillation of the balance wheel.
- balance wheel** The means of controlling the speed at which the mainspring of a watch unwinds. More properly called circular counterforce than a wheel, this component oscillates and forth deriving power from the balance spring and is maintained in its motion by the escapement.
- band** The middle ring or side of a watchcase, especially a pocket watch, into which the movement fits. The back or front bands are hinged or snapped onto it.
- barrel** The circular-shaped box containing the mainspring.
- beat or vibration** The movement of an oscillating body, limited by two consecutive extreme positions. If a watch balance makes for beats per second (8,000 per hour) the watch is said to have a beat per hour rate of 8,000. Two vibrations make up one oscillation.
- beveling or chamfering** Cutting an angle on the edge of a flat surface. On watch movements beveling is used on levers, bridges, plates and other components, including screws. Beveling practices differ from watchmaker to watchmaker and country to country. Some prefer straight edges while others opt for slanted or rounded bevels. Bevels are one of the key elements of finish.
- bezel** A piece of metal – in the shape of a circle, a square, a rectangle or any number of other shapes – that covers the watch dial and secures the crystal to the case.
- bi-metallic** Composed of two metals or alloys. A bi-metallic balance uses two metals to compensate for changes in temperature.
- black polish** Also known as mirror polish, flat polish and, in French, *spéculaire*. The process of black polishing produces a finish on the surfaces of steel watch components that is as shiny and reflective as a new mirror when looked at from small angles. However, hold the component directly parallel to your eyes and the surface is completely black without any reflective qualities.
- blued steel** Steel that has been treated with heat until its surface oxidizes, turning the colour of the steel to a rich, dark blue. Steel screws are the components most frequently blued.
- Doa Sobel**, *Longitude: How the Mystery Was Cracked*, *Harvard Magazine* (March–April 1991) pp. 41–52

- bow** On a pocket watch, the bow is a metal loop attached to the pendant. The watch chain is attached to the bow.
- bridge** A bridge-shaped support, attached to the movement at both ends, containing the bearing for a pivot.
- calendar** Calendars on watches take several forms. Some watches show only the date of the month, others show the date and the day of the month. Still others show the date, the day and the month. A full calendar displays the day, date, month and year. The most important distinction for calendars on watches concerns how the calendar mechanism keeps track of the information it displays. A simple calendar mechanism requires correction on the first of March, May, July, October and December. A perpetual calendar is mechanically programmed to correct the date automatically and insert 29 February every leap year.
- caliber** Originally the caliber of a watch referred to its size and the layout of its components. Today the term is used to refer to the movements in general.
- carriage** The rotating frame carrying the escapement of a ball-and-rod or harness watch.
- case** A raised ornament on a dial.
- case** A small box, made usually of metal, holding the movement of a mechanical watch. The dial and crystal are mounted to the top of the case.
- centre pinion** The first driven pinion of a watch. It is usually at the centre of the movement but it is still so called even when not central.
- centre seconds** A seconds hand pivoted concentrically with the hour and minute hands. Also termed *snappy seconds*.
- chapter ring** A ring on the watch dial bearing numerals or markings for hours, minutes and seconds.
- chronograph** A watch that is also a stop watch. A chronograph shows the time of day and has an additional mechanism that measures elapsed periods of time. Chronographs measure elapsed seconds, minutes and sometimes hours.
- chronometer** Historically the term chronometer was applied to watches with the detent escapement. Today it is applied to a watch that has undergone and passed a series of accuracy tests, including being subjected to harsh temperature and vibration movements. A watch that passes the tests is deemed to be more precise than other watches and is awarded a certificate. In Switzerland the certificate comes from Contrôle Officiel Suisse des Chronomètres.
- co-axial escapement** An escapement with two escapement wheels mounted on a common axis. Invented by George Daniels.
- cock** A bracket attached to the movement, which contains the bearing for a pivot.
- compensation balance** A compensation balance is one designed to counteract alterations in the elasticity of the balance spring under changes of temperature. The effect

- of such alteration is to make the watch go slow in high temperatures and fast in low temperatures. Compensation of the balance is achieved by enlarging the effective radius in low temperatures and reducing the radius in high temperatures. This is achieved by making the rim of the balance of two metals – usually of brass on the outer edge and steel on the inner edge.
- complication** Any watch function other than telling the time of day is a complication. Examples include: calendars, equation of time mechanisms, universal time mechanisms, chronographs, grande sonneries and petites sonneries, repeaters, power reserve indicators, day/night indicators, thermometers and barometers.
- côtes de Genève** A series of parallel rows of small curved lines applied as a decorative finish to the movements of many (though not exclusively) Swiss watches.
- crown** A knob or button on the outside of a case used for winding the watch and sometimes for setting and correcting calendars.
- crystal** This plate of glass or transparent synthetic material that covers and protects the dial of a watch.
- curvette** A second cover inside a watch's case back. Curvettes are common on pocket watches and are sometimes made from glass or synthetic plastic.
- detached escapement** An escapement in which the balance is detached during the supplementary arc. (Such as in the lever and detent escapement.)
- detent** Any piece used to lock a wheel by catching its teeth, in particular the spring or pivot mounted detent in the chronometer or detent escapement.
- detent escapement** A detent-based escapement used in watches and marine chronometers (often called a chronometer escapement in the latter). Impulse is given to the balance on only alternate oscillations. During the supplementary arc the escapement is locked by a detent. It is the watch escapement possessing the highest degree of detentment.
- dérouche** A watch movement, complete with its wheels, excluding the escapement, complications, case, dial, hands, etc.
- rudstone** A jewel placed at the end of a bridge to reduce the friction of a pivot.
- engraving turning or guilloché** A form of machined engraving used principally on the case and dial surfaces of a watch.
- equation of time** The difference between true solar time and mean time. True solar time, given by sundials, varies from day to day both because of the Earth's elliptical orbit, and due to the location of the sundial. Mean time, given by watches, ignores these variations and divides time into equal hours regardless of the time of year or the location of the wearer of the watch.
- escapement** The part of a watch interposed between the balance wheel and the train of wheels. At each oscillation of the balance the escapement is moved, permitting the mainspring to give impulse to the balance via the train of wheels.