

# Who invented the duplex escapement?

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*The question of who invented the duplex escapement has been a matter of speculation for well over two centuries. This article tries to put the available information into order and into context, separating facts from hearsay, and highlighting potential misunderstandings. It also discusses two possible technical developments in which the duplex escapement came to be.*

The duplex escapement has the distinction of being one of some half-dozen escapements which have found favour with the practical watchmaker. Millions of watches have been sold using one of its three main variations. However, nothing is known with certainty about its development: when it was invented, who invented it, or even why it is named duplex. Indeed, for more than a hundred years there was no agreement about its name.

Discussions about who invented it started at the beginning of the nineteenth century. At that period the French and English empires competed on everything, including supremacy in the watchmaking world. Hence English and French 'schools' developed, attributing the origin/invention/perfecting of the duplex escapement to 'national champions', mainly Pierre III Le Roy for the French and Thomas Tyrer for the English. The two schools simply dismissed or ignored each other; and sadly this 'tradition' remains strong.

Just as an example, in a pamphlet published in 1851 Edward J. Dent stated about the Duplex escapement: 'This is of English invention', with no explanation.<sup>1</sup> In 1858 the pamphlet was re-published in the USA by the

company Palmer & Bachelders, with the only difference being that now it stated 'This is of French invention'.<sup>2</sup>

## Definition of the duplex escapement

Strictly speaking, any escapement with two escape wheels, one acting as a locking wheel and the other as an impulse wheel, can be called a duplex escapement.

However, the discussions in the nineteenth and the beginning of the twentieth century focused essentially on the duplex escapement in its established form, i.e. on the escapement successfully used in pocket watches. In the following, to avoid confusion, this latter escapement will be referred to as the 'established duplex escapement'. The established duplex escapement is considered to have these properties<sup>3</sup> (Fig. 1)<sup>4</sup>:

- It splits the locking and impulse between two sets of teeth with different length; the two sets of teeth can be part of two concentric wheels of different diameters mounted on the same arbor, or of a single one; in the latter case, the axis of the two sets of teeth are aligned along two different directions.

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1. Edward J. Dent, *On the Construction and Management of Chronometers, Watches and Clocks* (London: Self-published, 1851), p. 17.

2. Palmers and Bachelders, *A Treatise on the Structure of Watches* (Cambridge: H. O. Houghton and Company, 1858), p. 22.

3. See further: George Daniels, *The Practical Watch Escapement* (London: Philip Wilson Publishers, 2016), pp. 18–20; Olivier Laesser, *Les Échappements en Horlogerie Mécanique* (Saint-Imier: Juillerat Chervet SA, 2021), pp. 205–206; David Penney, *Tyrer's DUPLEX escapement: a century of use* (Bishops Stortford: Self-published, 2022), p. 4.

4. Paul M. Chamberlain, 'The Evolution of Watch Escapements', *The Jewelers' Circular and Horological Review*, 73/14 (1 November 1916), p. 119, figure 20.

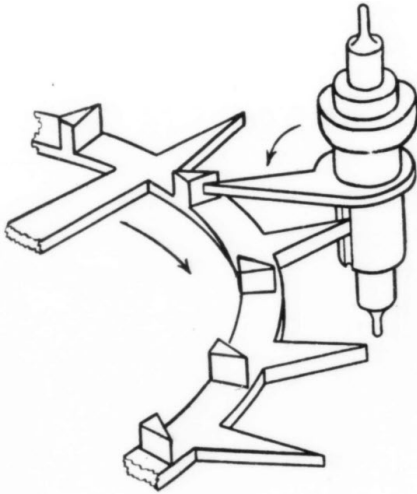


Fig. 1. *Established* duplex escapement.

- The longer teeth are used for locking and, in operation, a locking tooth 'friction-rests' on a (ruby) cylinder mounted concentrically on the balance axis.
- A notch is cut axially in the surface of the (ruby) cylinder to allow the long locking tooth to pass.
- When the locking tooth is free, a tooth of the shorter radii set gives an impulse to a pallet mounted on the balance axis; the impulse is short and with almost no sliding friction as in the chronometer escapement.
- Then the next locking tooth drops on the (ruby) cylinder.
- The impulse occurs in one vibration only; the return vibration is an idle one with the locking tooth 'friction-resting' on the (ruby) cylinder for its entirety.

The interaction between the notch and the locking teeth causes both a small impulse and a small recoil:

- On the impulse vibration, when passing, the locking tooth first drops in the notch against its departing side, and then presses against it, generating a small impulse.

- On the idle vibration, the locking tooth drops in the notch against the incoming side, being then pressed by it out of the notch. The incoming side of the notch therefore causes the locking tooth to recoil slightly.

Both the impulse and the recoil have a very slight effect on the working of the escapement; better said they are a mere disturbance to be minimized. The minimum disturbance is obtained by using a tooth as thin as possible, and a notch whose width is the minimum required to allow the tooth to free itself.

Hence, the *established* duplex escapement is a single-impulse frictional-rest escapement with no relevant recoil, i.e. a single-impulse dead-beat escapement.

However, as 'deadbeat' is so irrevocably associated with Graham's frictional pendulum and balance escapements, the French equivalent 'à repos' will be used in the following to avoid any misunderstanding.

### Brief history of the duplex escapement

Pocket watches with duplex escapements surfaced around 1780, as shown by the earliest known ones: a pocket watch signed Lepine with a double-wheel duplex escapement datable to 1778–1780;<sup>5</sup> a pocket watch signed Francis Upjohn with a single-wheel duplex escapement, and whose internal case carries the London date-letter for 1781–1782;<sup>6</sup> a movement signed William Hughes, circa 1783, with a double-wheel duplex escapement.<sup>7</sup>

The *established* duplex escapement was particularly successful in England where it was taken up for the better London work.<sup>8</sup> English watchmakers mostly used a single escape wheel with two sets of teeth, the impulse teeth extending parallel to the wheel arbor.<sup>9</sup>

On the continent this was less popular, and watchmakers used instead two escape wheels mounted on the same arbor.

A duplex escapement with a single escape wheel could be used in flat watches as shown

5. Adolphe Chapiro, *Jean-Antoine Lépine horloger (1720–1814)* (Paris: Les Éditions de l'Amateur, 1988), p. 98.

6. Giuseppe Brusa and Charles Allix, 'The Eminent Pierre Le Roy in the Art of Timekeeping', *Antiquarian Horology*, 29/5 (September 2006), 659, footnote 16.

7. Penney, *Tyrer's DUPLEX escapement*, pp. 12–13.

8. Penney, *Tyrer's DUPLEX escapement*, p. 8.

9. Penney, *Tyrer's DUPLEX escapement*, p. 6.

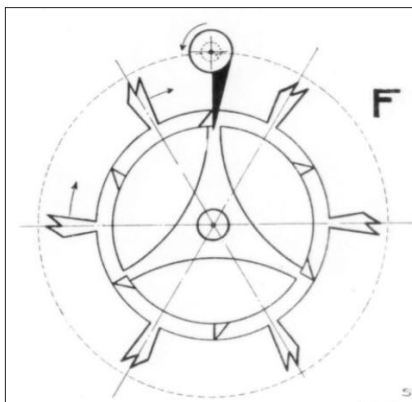


Fig. 2. Chinese duplex escapement.

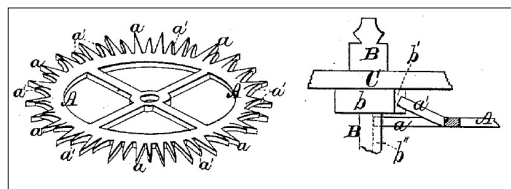


Fig. 3. The duplex escapement patented by the Waterbury Watch Company..

where the escapement has two set of teeth of different length on its periphery (patent US203999); the two sets were bent in opposite directions (Fig. 3).<sup>15</sup> This escapement was used by the Waterbury Watch Company and its successors in their dollar watches.

### Duplex or duplex's escapement?

Nowadays, it is generally accepted that the duplex escapement is called as such because of the two escape wheels, *duplex* being the Latin word meaning double.

The first mention of a duplex escapement is found in England in a letter by S. Varley dated 31 May 1798, and published in the *Philosophical Magazine*. Discussing the effects of magnetism on time-pieces, he states: '... for though it was a duplex escapement, which is perhaps the best yet invented ...'.<sup>16</sup> The name 'duplex escapement' has been used from there onwards in all languages: 'échappement duplex' in French, 'Duplexhemmung' in German, 'scappamento duplex' in Italian and so on.

Nevertheless, in the second half of the 1820s, in France this escapement started to be referred to also as Duplex's escapement ('échappement à la Duplex')<sup>17</sup>, thereby attributing the invention to a certain Duplex. In 1834 L. Perron specified that Duplex was an English watchmaker, who invented the *established* duplex escapement in 1770.<sup>18</sup>

by an example presented by Joachim Mauss. It has a maximum height of 8 mm including the glass, the movement itself 5.8 mm; it uses a 13-tooth gilt duplex escape wheel. The origin of the watch appears to be Swiss around 1790; it is signed *Ja.<sup>s</sup> Upjohn, London 7506*.<sup>10</sup>

In 1836 the 19-year-old Charles-Edouard Jacot-Descombes invented the so-called Chinese duplex<sup>11</sup> (Fig. 2)<sup>12</sup>, a variation of the *established* duplex escapement that allowed the manufacture of watches with a single wheel-train and with a centre second hand jumping once a second; these watches were particularly popular on the Chinese market.

Meanwhile in England, the competition of the lever escapement and the poor reputation of the duplex amongst watch repairers owing to locking depth issues mostly caused by wear, almost resulted in the demise of the *established* duplex escapement by 1840.<sup>13</sup> The use of a lighter escape wheel and a less powerful mainspring extended its life up to the 1880s.<sup>14</sup>

In May 1878, D. Azro A. Buck patented in the USA an *established* duplex escapement

10. Joachim Mauss, 'Das Beispiel: eine außergewöhnlich flache Goldtaschenuhr mit Duplexhemmung von etwa 1790', *Schriften der Freunde alter Uhren*, XVI (Verlag Wilhelm Kempter KG, Ulm: 1977), 93–96.

11. *Courier des Théâtres* (14 December 1836).

12. Chamberlain, 'The Evolution of Watch Escapements', p. 115, figure 21.

13. Penney, *Tyrer's DUPLEX escapement*, p. 9.

14. Penney, *Tyrer's DUPLEX escapement*, p. 10.

15. Patent US203999, figures 1 and 4.

16. S. Varley, 'On the Irregularity in the Rate of Going of Time-Pieces, occasioned by the Influence of Magnetism', *The Philosophical Magazine*, I (June 1798), p. 20.

17. *Dieppe in 1826* (Dieppe: Marais Fils, 1826), p. 161.



Fig. 4. Details of a watch by Hudry [courtesy of Dr Claude Anfossi].

None of the sources, including Perron, ever explains why they attribute the escapement to Duplex or offers any proof. The attribution to Duplex was questioned by Pierre Dubois in 1849.<sup>19</sup> After that no other source could be found referring to a Duplex's escapement.

For completeness, a watchmaker named Pierre Duplex was active in Geneva at the end of the eighteenth century,<sup>20</sup> but no connection could be found to the *established* duplex escapement.

## Dupleix

Next to duplex and Duplex's escapement, a third name was used for at least 120 years: 'Dupleix's escapement'.

As an example, in Fig. 4 on the left, a detail of the cuvette of a watch by the French watchmaker Hudry of Paris is shown; the cuvette is inscribed '*échappement duplex*'. The watch has an *established* duplex

escapement with a single escape wheel with two sets of teeth (Fig. 4 on the right).

In 1805, in a supplement to the *Encyclopaedia Britannica* under the section *watch work*, John Robison refers to 'the scapement of Dupleix'.<sup>21</sup> He is followed in 1825 in the *Dictionnaire Technologique* ('échappement de Dupleix'),<sup>22</sup> and in 1827 by William Kitchiner ('Dupleix's escapement').<sup>23</sup>

While in England after Kitchiner no one attributes the *established* duplex escapement to Dupleix anymore, in France 'échappement de Dupleix',<sup>24</sup> 'échappement à la Dupleix'<sup>25</sup> or 'échappement Dupleix'<sup>26</sup> continue to be used until at least 1925<sup>27</sup> in watchmaking journals, dictionaries, encyclopaedias, and the reports of the world expositions, notwithstanding being objected to by Thomas Reid in 1805,<sup>28</sup> Pierre Dubois in 1849,<sup>29</sup> and Claude Saunier in 1855.<sup>30</sup>

As per Duplex, none of the sources

18. L. Perron, *Essai sur l'Histoire Abrégée de l'Horlogerie* (Bachelier, Paris; Binson, l'auteur, Besançon: 1834), pp. 73 and 175.

19. Pierre Dubois, *Histoire de l'Horlogerie* (Paris: 1849), p. 287.

20. Osvaldo Patrizzi, *Dictionnaire des Horlogers Genevois* (Genève: Antiquorum Editions, 1998), p. 174.

21. Reprinted in John Robison, *A System of Mechanical Philosophy* (London: John Murray, 1822), vol. IV, p. 604.

22. *Dictionnaire Technologique*, VII (1825), 383.

23. William Kitchiner, *The Traveller's Oracle* (London: Henry Colburn, 1827), p. 65.

24. As an example, see Seb. Le Normand et Janvier, *Nouveau Manuel Complet de l'Horloger*, (Paris: Librairie Encyclopédique de Roret, 1850), p. 73.

25. As an example, see French patent 12243 granted to Coquiard et Cressier on 6 December 1854.

26. As an example, see M. Michel Chevalier, *Rapports du Jury International, Exposition Universelle de 1867 à Paris, Tome Troisième* (Paris: Imprimerie Administrative de Paul Dupont, 1868), p. 328.

27. 'Ecole d'Horlogerie d'Anet à Dreux (Eure-et-Loir): Distribution des Prix', *L'Horloger*, 21 (Septembre 1925), p. 336.

28. Thomas Reid, 'Letter from Mr. Thomas Reid on the Construction of Timekeeping Machines', *A Journal of natural philosophy, chemistry and the arts*, XI (May 1805), p. 5.

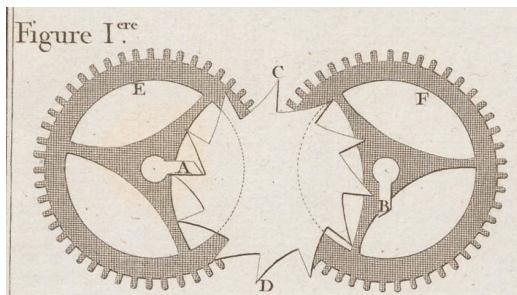


Fig. 5. Escapement with two balances.

attributing the escapement to Dupleix ever presents any basis for the claim. The only Dupleix that could be found is a ‘cadraturier’ named Jean-Pierre Dupleix [or Duplex] active in Geneva at the end of the eighteenth century,<sup>31</sup> but once again with no connection to the established duplex escapement.

### Jean-Baptiste Dutertre and Robert Hooke

The invention of the *established* duplex escapement was already attributed to Jean-Baptiste Dutertre in 1801 by Thomas Reid,<sup>32</sup> who later — first in the *Edinburgh Encyclopaedia* and then in his book *A Treatise on clock and watch making, theoretical and practical* first published in 1826 — presented the following four steps as leading to the alleged invention:<sup>33</sup>

- (a) The first step was an anonymous recoil escapement with two foliot/balances geared to each other and one escape wheel (Fig. 5)<sup>34</sup>; the escapement was found in a German clock. From the figure, the German escapement appears to be a form of Bürgi’s cross-beat escapement.
- (b) The German escapement was reinvented and improved by Dr Hooke in 1675; the

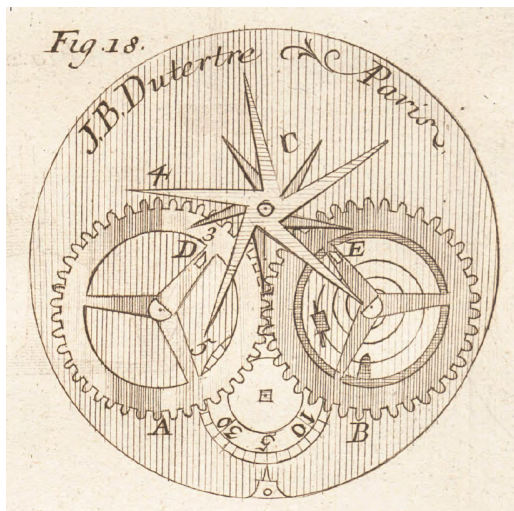


Fig. 6. Dutertre’s escapement with two balances and two escape wheels.

main difference appears to reside in the fact that the axis of the two balances and of the escape wheel are disposed on the vertexes of an equilateral triangle, and a balance spring is mounted on one of the balances. This escapement is the origin of the *established* duplex escapement.

- (c) In 1724,<sup>35</sup> Dr Hooke’s escapement was transformed by Jean-Baptiste Dutertre into an escapement *à repos* by the addition of a second escape wheel: one escape wheel acts as the locking wheel and the other as the impulse wheel (Fig. 6).<sup>36</sup>
- (d) In 1727, Dutertre and Pierre II Le Roy invented the escapement shown as Fig. 7.<sup>37</sup> According to Reid ‘This is, then, the duplex escapement, or the nearest possible approach to it.’

Reid took these steps from the *Traité d’Horlogerie* of J. A. Lepaute published in

29. Dubois, *Histoire de l’Horlogerie*, p. 287.

30. Claudius Saunier, *Traité des Échappements et des Engrenages* (Paris: Dufour, Mulat et Boulanger, 1855), p. 187.

31. Patrizzi, *Dictionnaire des Horlogers Genevois*, p. 174.

32. Thomas Reid, ‘On the Escapements of Time Pieces’, *A Journal of natural philosophy, chemistry and the arts*, V/51 (May 1801), 57.

33. Thomas Reid, *A Treatise on Clock and Watchmaking Theoretical and Practical*, Third Edition (Edinburgh: Blackie & Son, 1847), pp. 225, 226, 237–239.

34. J. A. Lepaute, *Traité d’Horlogerie* (Paris: Samson, 1767), Table XIII, Figure 1.

35. According to Lepaute the date of the invention of this escapement is 1726.

36. Thiout l’aîné, *Traité d’Horlogerie Mécanique et Pratique* (Paris: 1741), Table 42, Figure 18.

37. Thiout, *Traité*, Table 41, Figure 16.

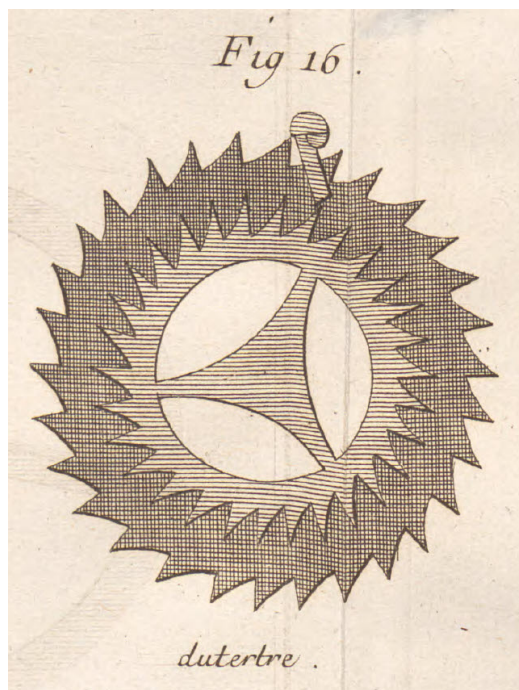


Fig. 7. Dutertré's escapement with one balance and two escape wheels.

1767 in the part dedicated to the *examen des différens échapemens de Montres* (Examination of the different escapements of watches);<sup>38</sup> however, since it had still not been invented, or at least not named as such, the duplex escapement is not mentioned in Lepaute's book. Consequently, while the four escapements are already presented as a continuous development by Lepaute, it was

Reid who connected them to the *established* duplex escapement.

Lepaute and Reid took the description of Hooke's escapement from Henry Sully's *Règle artificielle du Temps*,<sup>39</sup> and Dutertre's escapements from Thiout's *Traité de l'Horlogerie mécanique et pratique*.<sup>40</sup>

Reid also added a fifth step indicating that the *established* duplex escapement was perfected and introduced in England by Thomas Tyrer (see below).

Reid's history was then repeated with more or less details by later writers up until the 1890s; for example, Rev. Nelthropp (1873)<sup>41</sup> re-proposes all five steps, while Adam Thomson (1842),<sup>42</sup> Henry F. Piaget (1860)<sup>43</sup>, and James W. Benson (1875)<sup>44</sup> just state that the *established* duplex escapement was invented originally by Dr Hooke and perfected by Tyrer, ignoring Dutertre's escapements.

From 1894 onwards, the English school started focusing only on Thomas Tyrer (see below), and the 1727 escapement by Dutertre was forgotten; examples of this are Shenton<sup>45</sup> and Penney,<sup>46</sup> who discuss only Hooke's escapement and the 1724 Dutertre-one.

In the French school, Saunier (1855)<sup>47</sup> and Gros (1913)<sup>48</sup> saw Dutertre's escapements as the springboards from which Pierre III Le Roy developed the *established* duplex escapement. Instead, Conrad Dietzschold (1905),<sup>49</sup> G. F. Berner (1912)<sup>50</sup>, and Willis I. Milham (1923)<sup>51</sup> attributed the invention of the *established* duplex escapement to Dutertre, with Pierre III Le Roy only

38. Lepaute, *Traité*, pp. 164–169.

39. Henry Sully, *Règle Artificielle du Temps* (Paris: Imprimerie de Moreau, 1731), pp. 243–245.

40. Thiout, *Traité*, pp. 101–103.

41. Rev. H. L. Nelthropp, *A treatise on Watch-Work Past and Present* (London: E. & F. N. Spon, 1873), pp. 159–164.

42. Adam Thomson, *Time and Timekeepers* (London: T. & W. Boone, 1842), pp. 86, 87, 112, 113.

43. Henry F. Piaget, *The Watch: its Construction, its Merits and Defects* (New York: Self-publ., 1860), p. 2.

44. James W. Benson, *Time and Time-tellers* (London: Robert Hardwicke, 1875), p. 80.

45. Alan Shenton, *Pocket Watches 19th & 20th Century* (Woodbridge: Antique Collectors' Club, 1996), p. 215.

46. Penney, *Tyrer's DUPLEX escapement*, pp. 3–4.

47. Saunier, *Traité des échappements et des engrenages*, p. 187.

48. Charles Gros, *Échappements d'Horloges et de Montres*, Deuxième Edition (Paris: Bureau de l'Almanach de l'Horlogerie-Bijouterie, 1913), p. 110.

49. C. Dietzschold, *Die Hemmungen der Uhren* (Krems a. Donau: C. Dietzscholds Verlag, 1905), p. 157.

50. G. F. Berner, *L'Echappement Duplex* (Genève: Administration du Journal Suisse d'Horlogerie, 1912), p. 7.

perfecting it. Finally Droz & Flores (1979) attribute the invention of the *established* duplex escapement with two escape wheels to Dutertre, and the one with one escape wheel with two sets of teeth to Pierre III Le Roy.<sup>52</sup>

While Reid's claims about Hooke's and Dutertre's escapements are documented, neither passes a more detailed analysis.

Dr Hooke's escapement is a recoil escapement and, to use the words of Chamberlain, 'it is difficult to see wherein it was in any way the germ of the duplex escapement'.<sup>53</sup>

Dutertre's escapement of 1724 is effectively an escapement *à repos*.<sup>54</sup>

- In Fig. 6, a tooth of the repose wheel is seen escaping through the notch on the arbor of balance B, and tooth 3 of the impulse wheel is ready to hit the pallet D mounted on balance A.
- Then the locking tooth 4 drops on the cylinder mounted on the balance A
- On the opposite vibration, the locking tooth 4 escapes through the notch on the arbor of balance A, an impulse tooth hits the pallet E on balance B, and locking tooth 5 drops on the arbor of balance B.

Besides the presence of a second balance engrained with the first, this escapement differs from the *established* duplex escapement by having a double impulse. For example, balance A received an impulse through pallet D in the first vibration, and through balance B in the opposite vibration.

It is also to be noted that by eliminating one of the balances and modifying the escape wheels accordingly, Dutertre's 1727 escapement is obtained.

The 1727 escapement has two wheels mounted concentrically; the bigger one is the locking wheel while the smaller one is the impulse wheel; a pallet is mounted on

the balance arbor, which is notched into the centre under it. Its operation, when applied to a watch, is as follows:<sup>55</sup>

- In Fig. 7, the balance is oscillating towards the right with a locking tooth friction-resting on the arbor.
- On the return oscillation, when the pallet is about to meet an impulse tooth, the locking tooth escapes through the notch on the arbor.
- The impulse tooth then drops on the pallet, and it is pushed back by it until the momentum of the balance is exhausted, i.e. until the oscillation comes to an end.
- Once the balance starts again oscillating in the first direction, the impulse tooth pushes the pallet until the next locking tooth hits the balance arbor.

Hence Dutertre's second escapement is a half-recoil half-*à-repos* escapement: it acts during an oscillation as an escapement *à repos*, and during the opposite oscillation as a recoil escapement.

And the recoil is not a mere accident, but a fundamental part of the operation of the escapement: it is needed to avoid the escape wheels 'running away' during one of the vibrations. The amount of recoil is determined by the amplitude of the vibration, and hence, short of reducing the latter, it cannot be minimised.

Also, the locking tooth escapes during opposite vibrations in the two escapements: when the notch is moving *towards* the tooth in Dutertre's escapement, and when the notch is moving *away from* the locking tooth in the duplex escapement.

Finally, even if both have a single impulse, a further difference between the two escapements lies in the impulse type: 'push' for Dutertre's escapement, short and without sliding friction for the *established* duplex escapement.

51. Willis I. Milham, *Time & Timekeepers* (New York: The Macmillan Company, 1923), p. 545.

52. Y. Droz et J. Flores, 'Échappements de Montres', *Horlogerie Ancienne*, n. 4 (1978), pp. 98–101.

53. Paul M. Chamberlain, *It's About Time* (London: The Holland Press, 1978), p. 129.

54. See also Laesser, *Les Échappements*, pp. 107–109.

55. See also Laesser, *Les Échappements*, pp. 101–102.

## Thomas Tyrer

Reid's history of the *established* duplex escapement contains a fifth step: Thomas Tyrer, an obscure English watchmaker, introduced in England and perfected the duplex escapement into its established form, which was originally known as *Tyrer's escapement*.<sup>56</sup>

This step is repeated as such until 1894 when Britten published the information that Tyrer patented the duplex escapement.<sup>57</sup> From then onwards, the English school focuses on the fact that the duplex escapement was patented/invented by Thomas Tyrer; to cite a few authors: Clutton,<sup>58</sup> Cutmore,<sup>59</sup> Daniels,<sup>60</sup> Weiss,<sup>61</sup> Shenton,<sup>62</sup> and Penney.<sup>63</sup> It is also often underlined that 'little is known' about Tyrer.<sup>64</sup>

As an example, in their book *Watches*, Clutton & Daniels first state in the main text that the principles of the duplex escapement had been devised by Dutertre in the second quarter of the eighteenth century, and that Tyrer patented in 1782 the established version with two concentric wheels.<sup>65</sup> Then, in the bibliographical notes about Tyrer, they write that Tyrer 'did not invent the duplex escapement, but he brought it more or less to its established form',<sup>66</sup> in line with Reid's position. Finally in the *glossary of technical terms* they write about the duplex escapement that 'the escapement in its widely-used form

was invented by Thomas Tyrer in 1782'.<sup>67</sup>

An exception is Camerer Cuss, who attributes the invention of the duplex escapement to Dutertre, and its perfecting to Pierre Le Roy (see below), and attributes to Tyrer only having patented it in England.<sup>68</sup>

The French school never mentions Thomas Tyrer; the only exceptions being *l'Art de l'Horlogerie, enseigné en trente Leçons* where in 1827 it is mentioned that the duplex escapement was named *tyrer* in England;<sup>69</sup> and Brusa & Allix in 2006, who mention the patent.<sup>70</sup>

However, the position of the English school is not followed here because Tyrer did not obtain a patent and it is unknown what the escapement to be patented looked like; also Reid's statement is at least questionable.

In 1782 Thomas Tyrer only filed the *letters patent*, the equivalent of today's request for a patent. Fig. 8 shows the letters patent in question, which constitutes the entire alleged patent obtained by Tyrer; at the bottom it is stated 'no specification enrolled', which renders the patent void. As noted by Penney,<sup>71</sup> this statement is repeated also in Bennett Woodcroft's *Patent Abridgements* of 1858, but why let facts ruin a nice story?

In England in 1782 the grant of a patent for inventions was still regulated by the *Statute of Monopolies*, an act passed on 29 May 1624 (new style) during the reign of James I. Even if

56. Reid, *A Treatise on Clock and Watchmaking*, pp. 239–240.

57. F. J. Britten, *Former Clock & Watchmakers and their Work* (London: E. & F. N. Spon, 1894), p. 261.

58. Cecile Clutton, 'The Collection of the Worshipful Company of Clockmakers displayed at the City of London Guildhall', *Antiquarian Horology*, 10/2 (Spring 1977), p. 200.

59. M. Cutmore, *Watches* (Devon: David & Charles, 2002), p. 69.

60. George Daniels, *English & American Watches* (London: Abelard Schuman, 1967), p. 39.

61. Leonard Weiss, *Watch-Making in England* (London: Robert Hale, 1982), pp. 126–127.

62. Shenton, *Pocket Watches*, p. 215.

63. Penney, *Tyrer's DUPLEX escapement*, p. 4.

64. Cecil Clutton and George Daniels, *Watches* (London: Philip Wilson Publishers Ltd, 1979), p. 286; Penney, *Tyrer's DUPLEX escapement*, p. 5.

65. Clutton & Daniels, *Watches*, p. 67.

66. Clutton & Daniels, *Watches*, p. 286.

67. Clutton & Daniels, *Watches*, p. 293.

68. T. P. Camerer Cuss, *Antique Watches* (Antique Collectors' Club, Woodbridge: 1976), p. 309.

69. *L'Art de l'Horlogerie, enseigné en trente Leçons* (Paris: Chez Audin, 1827), p. 440.

70. Brusa & Allix, 'The Eminent Pierre Le Roy', p. 659, footnote 16.

71. Penney, *Tyrer's DUPLEX escapement*, p. 5.

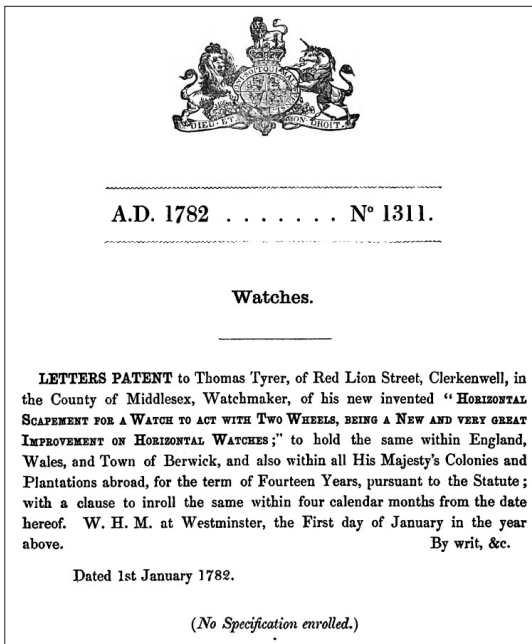


Fig. 8. Tyrer's Letters Patent.

there is nothing in the *Statute* itself requiring a specification,<sup>72</sup> in 1782 any letters patent contained a clause requiring the patentee to

particularly describe and ascertain the nature of his invention and in what manner the same is to be performed, by an instrument in writing under his hand and seal, and cause the same to be inrolled in His said Majesty's High Court of Chancery within four calendar months next and immediately after the date of the said Letters Patent, that then the said Letters Patent, and all liberties and advantages whatsoever thereby granted should utterly cease, determine and become void ...'[from the patent granted to Arnold in the same year].

Tyrer's letters patent only specified that the patentee had to 'inroll the same within four

calendar months from the date thereof', amounting to the same.

Besides being void, Tyrer's letters patent contains only the technical features: 'a horizontal scapement for a watch to act with two wheels, being a new and very great improvement on horizontal watches'.

The expression 'to act with two wheels' has been taken to indicate the presence of two separate escape wheels; strictly speaking, however, this is not true *per se*. For example, Thomas Reid writes that the duplex escapement has two escape wheels, one of repose and one of impulse, 'both being formed out of the same piece of brass'.<sup>73</sup> Hence 'to act with two wheels' could indicate the presence either of two escape wheels or of a single one with two sets of teeth. In any case what was their action is a pure matter of speculation.

Furthermore, while technically the *established* duplex escapement is a horizontal escapement, the terms 'horizontal escapement' and 'horizontal watch' were at least until the middle of the nineteenth century used respectively as a synonym for the cylinder escapement and a watch with a cylinder escapement. For example, in *Rees's Cyclopaedia*, published in 1820, the cylinder escapement and the *established* duplex escapement are described under the headings 'cylinder or horizontal escapement of Graham' and 'duplex escapement' respectively.<sup>74</sup>

Hence Tyrer wanted to patent 'a cylinder escapement for watches with two escape wheels (or a single one with two sets of teeth)'. As already indicated by Penney,<sup>75</sup> this is completely unclear; furthermore, it is impossible to ascertain how this cylinder escapement looked in practice, and if it had anything to do with the duplex escapement.

Only one watch movement with a duplex escapement and signed Tyrer is known; the watch movement is dated around 1790.<sup>76</sup>

In the *Edinburgh Encyclopedia* and then again in his book Reid states:

72. Joseph Chitty, *A Treatise on the Law of the Prerogatives of the Crown* (London: Joseph Butterworth and son, 1820), p. 182.

73. Reid, *Treatise*, p. 240.

74. Republished in *Rees's Clocks Watches and Chronometers* (Devon: David & Charles (Publishers) Limited, 1970), pp. 197 and 209.

75. Penney, *Tyrer's DUPLEX escapement*, p. 6.

76. Penney, *Tyrer's DUPLEX escapement*, p. 6.

The duplex escapement, as it is now called, was introduced into its native country [i.e. England] about thirty years ago or more, under the name of Tyrer's escapement, *the name it is supposed of him who put the last hand to improve that ...*<sup>77</sup>

However, there are some questions about Reid's statement:

- The book was published about forty-five years after the appearance of the first pocket watches with duplex escapement, and therefore it is off by about fifteen years in its estimation.
- As seen earlier, 'duplex escapement' was already in use in England before 1798. Hence the name 'Tyrer's escapement' must have been used, if at all, for a relatively short period of time, more than thirty years before Reid's book was written. And this was not commonly known as Rees in 1819 does not cite Tyrer at all and about the duplex escapement states '... we are not informed who was the original contriver ...; neither we are aware of its date; ...'.<sup>78</sup>
- Reid learned about Tyrer only after 1805, at the earliest: in 1801 in a letter published in the *Journal of natural philosophy, chemistry and the arts*, he wrote: 'Pray who first applied the duplex escapement, in London, to watches? It is the invention of a Dutertre early in the eighteenth century.'<sup>79</sup> Again in 1805, in a second letter to the same journal, he described shortly the first four steps to be found later in his book but made no reference to Tyrer.<sup>80</sup>

Since Reid does not cite any source for his

statement about Tyrer, it begs the question: from where did he learn about Tyrer? And, if the source was reliable, why did it not mention Tyrer's letters patent?

Finally, more than a little is known about Thomas Tyrer. In 1842 Adam Thomson noted<sup>81</sup> that Thomas Tyrer was the father of Sarah Liston, the wife of Robert William Liston, quite a famous comedian at the time. Coincidentally, according to some sources,<sup>82</sup> Robert William was the son of the watchmaker Robert Liston. This has made Thomas Tyrer of interest also outside the horology world.

While a detailed biography of Tyler is outside the scope of this article, the following is easily found:

- Thomas Tyrer was born on 14 December 1739 in London;<sup>83</sup> he married Barbara Howe before 1771 and they had at least seven children.<sup>84</sup> Thomas was a rigid presbyterian.<sup>85</sup>
- Thomas took three watchmaker apprentices: Richard Everleigh in 1770, George Rutt in 1780 and Henry Marder in 1785.<sup>86</sup>
- In 1770 Thomas' shop was in the parish of St. John, Clerkenwell.<sup>(see note 83)</sup> The London directories of 1778 show Thomas Tyrer as a 'musical clock and watchmaker' active at 1 Prescott Street, Goodmansfields, St. Mary's Whitechapel.<sup>(see note 81)</sup>
- In 1781 he lived with his family in a house with garden at Seward Street, Goswell Street, St. Luke's,<sup>(see note 82)</sup> while the letters patent of 1782 shows Thomas as watchmaker active at Red Lion Street, Clerkenwell.
- By 1787 he had moved shop and dwelling to Millmann Street, Bedford Row, St. Pancras,<sup>87</sup> where he died on 13 October 1794.<sup>(see note 80)</sup>

77. Reid, *Treatise*, p. 239.

78. Rees's *Clocks Watches and Chronometers*, p. 209.

79. Reid, 'On the Escapements', p. 57.

80. Reid, 'Letter on the Construction', pp. 4–5.

81. Thomson, *Time and Timekeepers*, p. 113.

82. George Raymond, *The Life and Enterprises of Robert William Elliston, Comedian* (London: G. Routledge & Co, 1857), p. 1.

83. Geneanet.org

84. Ann Spiro, 'Clock & Watchmakers', *The Blacksmiths Index*, available at <https://blacksmiths.mygenwebs.com/clockmakers-1.php#T>

85. 'Mrs. Liston', *The Lady's Monthly Museum*, XI (October 1811), p. 183

86. Dennis Moore, *British Clockmakers & Watchmakers Apprentice Records* (Ashbourne: Mayfield, 2003), p. 332.

87. *Sun Life Insurance*, Volume 347 (9 October 1787).

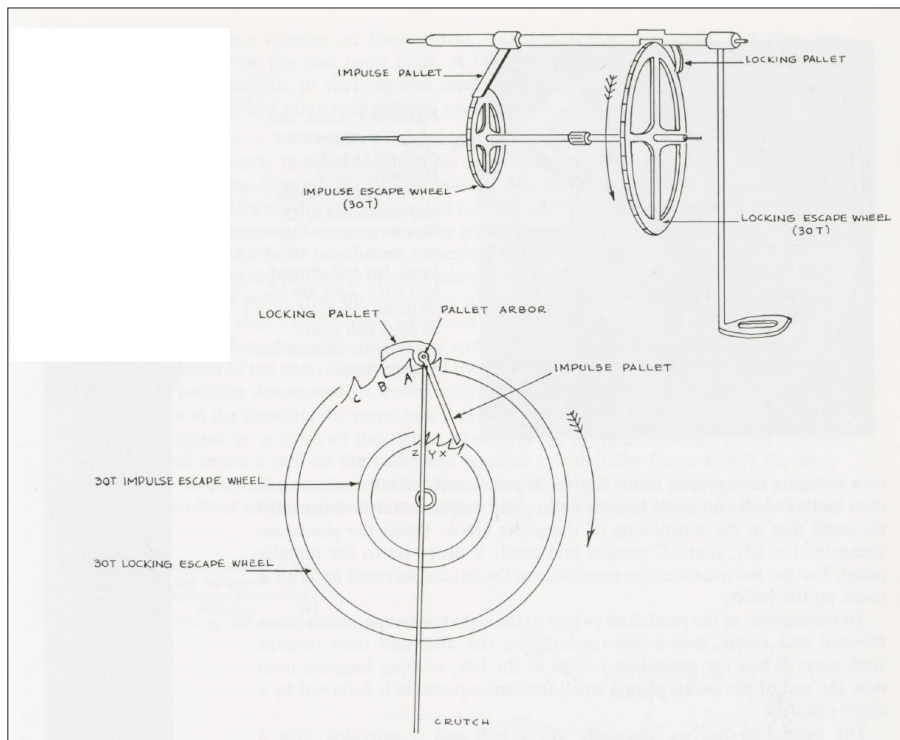


Fig. 9. Delander's escapement.

The house and garden at Seward Street were sold to pay the debts he left behind.<sup>88</sup>

### Daniel Delander

At the beginning of the eighteenth century, Daniel Delander used in a series of longcase clocks an escapement with two escape wheels, one for locking and one for impulse<sup>89</sup> (Fig. 9)<sup>90</sup>. Consequently, as this is earlier than any of the escapements previously discussed, some authors have attributed to him the invention of the duplex escapement.<sup>91</sup>

However, similarly to Dutertre's escapement of 1727, Delander's one is also a half-recoil, half-à-repos escapement and has a 'push' impulse, and is hence fundamentally different from the *established* duplex escapement.

Delander's escapement has two escape wheels mounted on the same arbor: a small impulse one between the plates and a big repose one outside them. The two escape

wheels interact with two pallets mounted on the arbor of the pendulum. Looking at the wheels so that the small wheel is on top of the big wheel, when the pendulum swings to the right, an impulse tooth pushes the impulse pallet until it finally escapes; then a locking tooth drops on the locking pallet, where it stays until the pendulum swings back. With the pendulum swinging to the left, once the locking tooth escapes the locking pallet, an impulse tooth drops on the impulse pallet and any further movement of the pendulum towards left causes a recoil as the impulse tooth slides up the pallet.

As in Dutertre's escapement, in Delander's one the recoil is not a mere accident, but a fundamental part of the operation of the escapement.

88. Thomas Tyrer's last will and testament, TNA PROB 11/1252/36.

89. Tom Robinson, *The Longcase Clock* (Woodbridge: Antique Collectors' Club, 1981), pp. 161–163.

90. Brusa & Allix, 'The Eminent Pierre Le Roy', p. 659, figures 15 and 16; with permission.

91. Robinson, *The Longcase Clock*, p. 161; Jeremy Evans and Anna McBroom, 'The Chandos Delander', *Antiquarian Horology*, 41/4 (December 2020), p. 526.

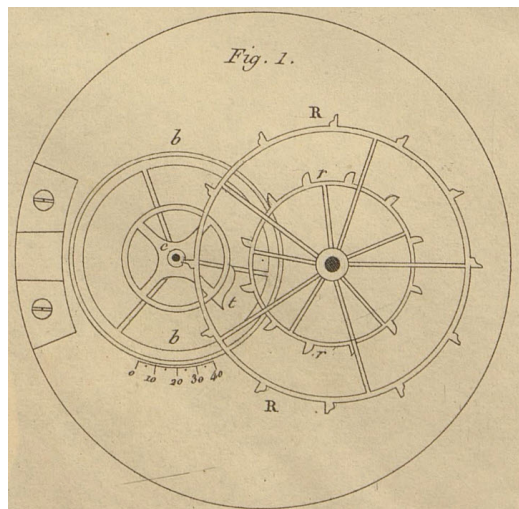


Fig. 10. Tavan's model of a duplex escapement.

## Henry Sully

In none of his writings has Henry Sully presented anything resembling a duplex escapement, nor is any watch with the said escapement and signed by him known. As reported in the *Horological Journal*, this did not prevent John James Hall in 1902,<sup>92</sup> and Inkerman Rogers in 1922,<sup>93</sup> from crediting Henry Sully with the invention of the duplex escapement.

## Pierre Le Roy

According to Lepaute, Pierre Le Roy published Dutertre's escapement as his invention in 1727.<sup>94</sup> Lepaute can only be referring to Pierre II Le Roy, as the nephew Pierre III Le Roy would have been only ten years old. As indicated by Reid, this escapement

was considered as the *established* duplex escapement.<sup>95</sup>

In 1806 a collection of escapements made by Antoine Tavan was presented to the French Academy of Science.<sup>96</sup> For the first time the *established* duplex escapement is explicitly presented as an invention of Pierre Le Roy. However, it is not clear which of the two Pierres is intended. The escapement model made by Tavan (Fig. 10)<sup>97</sup> has two escape wheels mounted on the same arbor. Even though it was made more than twenty-five years after the duplex escapement came into use, in successive publications it is presented as its original form.

As indicated by Brusa & Allix, during the nineteenth century the achievements of the two Pierres were confused, and in general attributed to the more famous of the two, i.e. Pierre III Le Roy.<sup>98</sup> Probably for this reason, by 1850 Pierre Dubois writes that Pierre III Le Roy invented the *established* duplex escapement around the middle of the eighteenth century.<sup>99</sup> Dubois's position is followed by many authors of the French school like Saunier (1854),<sup>100</sup> Brusa & Allix (2006),<sup>101</sup> and Oliver Laesser (2021).<sup>102</sup> Charles Gros (1913)<sup>103</sup> instead attributes to Le Roy only the perfecting of the *established* duplex escapement, like Adolphe Chapiro (1995),<sup>104</sup> who attributes the invention to Dutertre, with Le Roy heavily improving it.

Only Chapiro and Brusa & Allix provide any basis for this claim:

- Chapiro focuses on a pocket watch made by Pierre III Le Roy in 1759 and signed Julien Le Roy with an escapement with two escape

92. John James Hall, 'Time and Timekeepers', *Horological Journal*, XLIV/11 (July 1902), p. 140.

93. Inkerman Rogers, 'The Progress of Horology', *Horological Journal*, LXIV/761 (January 1922), p. 79.

94. Lepaute, *Traité*, p. 169.

95. Reid, *Treatise*, p. 239.

96. 'Séance du 28 Juillet 1806', *Procès-Verbaux des Séances de l'Académie*, III (1804-1807), 401; the escapement models are part of the collection of the Musée d'Art et d'Histoire in Geneva.

97. Dubois, *Histoire*, p. 287, figure 1.

98. Brusa & Allix, 'The Eminent Pierre Le Roy', p. 656.

99. Dubois, *Histoire*, p. 287.

100. Saunier, *Traité des Échappements et des Engrenages*, p. 187.

101. Brusa & Allix, 'The Eminent Pierre Le Roy', p. 656.

102. Laesser, *Les Échappements*, p. 205.

103. Gros, *Échappements*, p. 112.

104. Adolphe Chapiro, *Taschenuhren aus vier Jahrhunderten* (Munich: Callwey Verlag, 1995), p. 323.



Fig. 11. Pierre Le Roy's escapement with two escape wheels.

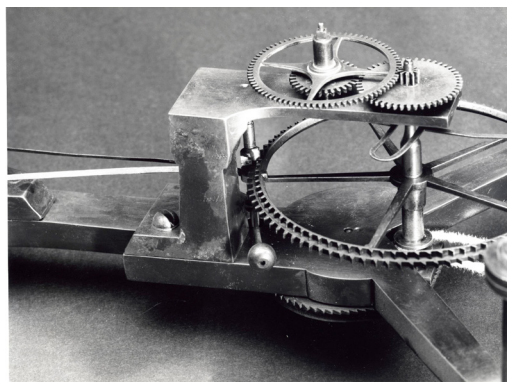


Fig. 12. One-wheel escapement by Pierre Le Roy.

wheels:<sup>105</sup> one shaped like the escape wheel of a cylinder escapement and acting as the locking wheel, and one with vertical teeth acting as the impulse wheel by pushing on an impulse pallet mounted on the balance axis (Fig. 11).<sup>106</sup>

- Brusa & Allix focus on the 'one-wheel clock' built in 1752 by Pierre III Le Roy — a clock that uses an escapement with two escape wheels, one acting as a locking wheel and the other as an impulse wheel — and on the one-wheel watch described in the *Etrennes*.<sup>107</sup>

Only three authors of the English school discuss any role of Pierre III Le Roy in the development of the *established* duplex escapement. Camerer Cuss<sup>108</sup> attributes to Le Roy its perfecting; Shenton<sup>109</sup> writes that Le Roy 'addressed' it; and Penney discusses only the pocket watch of 1759 pointing out that it does not have a 'hammer-and-nail' impulse.<sup>110</sup>

A closer analysis shows that both of Pierre III Le Roy's escapements are half-recoil half-à-repos escapements.

In the one-wheel clock built in 1752 Le Roy uses two escapements interacting with each other; one of the two escapements used appears at first sight as an escapement à repos

using a single wheel having two adjacent sets of ninety ratchet-shaped teeth, the longer for locking and the shorter for giving impulse (Fig. 12)<sup>111</sup>; the arbor of this escapement is part of the other one and carries among others an incomplete roller for locking and releasing the longer set of teeth of the first escapement and a pallet for receiving impulse from the shorter set. It works as follows:<sup>112</sup>

- At the beginning of the impulse action, an impulse tooth drops on the pallet and pushes it for 30 seconds.
- When the impulse tooth frees itself from the pallet, the locking tooth drops on the roller, where it will friction-rest for a 30-second return swing.
- At the end of the return swing, the locking tooth frees itself from the roller and the following impulse tooth drops on the pallet.

No recoil is present, and therefore this escapement, apart from the push-type impulse, appears to work as the *established* duplex escapement. However, this is due to the fact that the swings of the escapement in the one-wheel clock are only half of the

105. Chapiro, *Taschemuhren*, pp. 126–127, figures 289 – 290b.

106. Brusa & Allix, 'The Eminent Pierre Le Roy', p. 657, figure 12; with permission.

107. Brusa & Allix, 'The Eminent Pierre Le Roy', pp. 650–657.

108. Camerer Cuss, *Antique Watches*, p. 309.

109. Shenton, *Pocket Watches*, p. 215.

110. Penney, *Tyrer's DUPLEX escapement*, p. 3.

111. Brusa & Allix, 'The Eminent Pierre Le Roy', p. 655, figure 10, detail; with permission.

112. Brusa & Allix, 'The Eminent Pierre Le Roy', pp. 652–654; see also Laesser, *Les Échappements*, pp. 210–214.

normal length. The impulse swing starts with the pallet pointing basically towards the centre of the escape wheel, and the return (repose) swing finishes also with the pallet in the same position.

If we imagine the escape arbor connected to a pendulum, the pendulum would start from straight down, swing up in a first direction, swing back until the initial position and then swing up again in the first direction; i.e. the pendulum would only carry out half swings. With the pendulum carrying out full swings, after the locking tooth frees itself from the roller and the impulse tooth falls on the pallet, the latter would start pushing against the impulse tooth causing a recoil until the end of the return swing.

Hence the escapement used by Pierre III Le Roy in the one-wheel clock is nothing else than the Dutertre's half-recoil half-à-repos escapement, including the escape wheels with ratchet-shaped teeth (see Fig. 7).

In part eight, article V of the *Etrennes*, Pierre III Le Roy described quite obscurely a one-wheel watch of which twelve examples were fabricated by 1757; none of the watches survived.<sup>113</sup> The position of Brusa & Allix that Le Roy used the established duplex escapement in these watches cannot be followed: all the limitations derived from the text of the *Etrennes* by these authors in their articles, apply equally to the established duplex escapement or to the half-recoil half-à-repos Dutertre's escapement; and the same authors indicate that Pierre III Le Roy would have used in these watches a similar escapement as in the one-wheel clock, i.e. the Dutertre's half-recoil half-à-repos escapement.

The escapement with two escape wheels in the Pierre III Le Roy's watch of 1759 is also a half-recoil half-à-repos escapement, since the escapement works exactly in the same way as the Dutertre's half-recoil half-à-repos escapement.<sup>114</sup> Indeed, the only difference between the two escapements is in the locking 'part': in Le Roy's watch, the locking is carried out by a cylinder escapement where

the cylinder has no impulse lips, i.e. it retains only the locking function.

## The most promising springboard – part 1

Unless the inventor of an escapement described their thought process, trying to determine the origin of one is always an exercise verging on the sin of teleology. Nevertheless, the most promising springboards for the development of the established duplex escapement can be pointed out, without any pretence of knowing what really went on.

Considering Dutertre's half-recoil half-à-repos escapement has been confused more than once with the duplex one, the former is obviously a very promising springboard for the latter and indicated as such for example by Charles Gros.<sup>115</sup>

However, the modification to be carried out to move from one escapement to the other is not minor. The entire locking system needs to be modified: in particular the half cylinder mounted on the balance arbor is to be substituted with a full cylinder with a notch; the rest of the adjustments to be carried out are straightforward once the locking system has been modified.

As pointed out by Laesser, another escapement never taken into consideration during the first 220 years of discussion is actually a better springboard:<sup>116</sup> Tompion's half-recoil half-à-repos cylinder escapement.

## Tompion's half-recoil half-à-repos escapement(s)

All sources agree that in 1695 Tompion developed a new escapement for watches. They also agree that

any inequalities in the motive force made no deviation in its time keeping; but the friction of the balance wheel teeth on the cylinder and its edges, was so great and destructive, that it was given up in consequence.<sup>117</sup>

113. Brusa & Allix, 'The Eminent Pierre Le Roy', pp. 656–657.

114. See also Laesser, *Les Échappements*, pp. 214–215.

115. Gros, *Échappements*, p. 110.

116. Laesser, *Les Échappements*, pp. 205–210.

117. Reid, *Treatise*, p. 226.

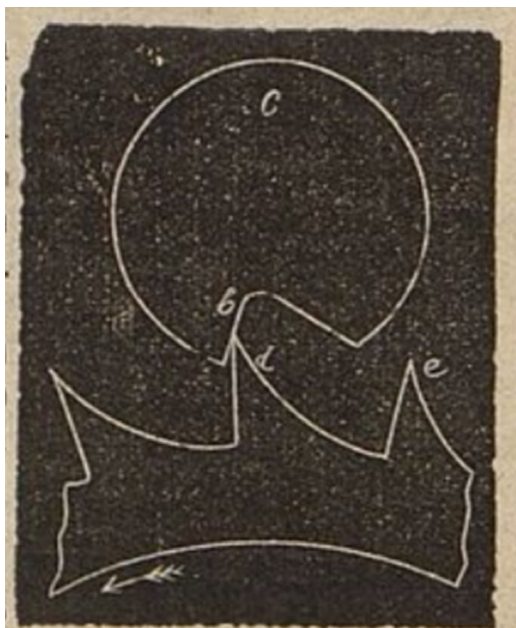


Fig. 13. Tompion's cylinder escapement.

However two different descriptions are given of this escapement.

Sully gave the oldest known description,<sup>118</sup> which was repeated almost verbatim by Reid:

The verge, or axis of the balance, was a small solid steel cylinder, cut across at the middle, and nearly half way down; in the longitudinal direction of the cylinder, a deep angular notch was made, forming a sort of pallet on the left hand side; the balance wheel was flat, and much like Dr Hooke's, the spaces between the teeth sufficiently wide to allow the cylinder to turn freely between them. When a tooth of the wheel had impelled the pallet, on escaping from it, the following tooth dropped on the outside

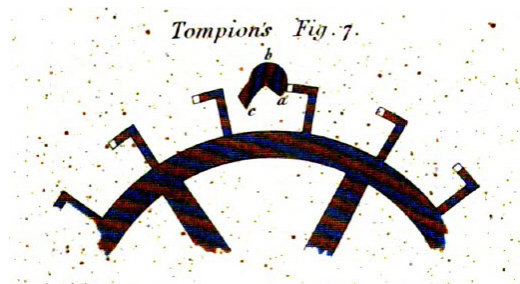


Fig. 14. Tompion's tenterhook escapement.

of the cylinder near the right edge, resting on the cylinder during this vibration of the balance; after passing the right edge, and meeting a little recoil, it got again on the pallet and gave a new impulse, which took place only at every second vibration.<sup>119</sup>

Fig. 13<sup>120</sup> is a graphical representation of the above escapement. Reid went on to claim that from this escapement Graham developed the cylinder escapement.

In *Rees's Cyclopaedia*, two technical features are added to the above description: the cylinder terminated with a pallet, and the teeth of the balance wheel were bent at the end;<sup>121</sup> Fig. 14 is the graphical representation that accompanied this description.<sup>122</sup> This escapement has been indicated as a prototype of the virgule escapement.<sup>123</sup>

Because of the two different descriptions, on the Continent two escapements were attributed to Tompion,<sup>124</sup> the one in Fig. 13 being called Tompion's cylinder escapement, the one in Fig. 14 Tompion's tenterhook escapement.

In the English literature instead, only one escapement is attributed to Tompion: Clutton & Daniels<sup>125</sup> and Evans, Carter & Wright<sup>126</sup> describe only the tenterhook escapement,

118. Sully, *Règle Artificielle du Temps*, p. 245–247.

119. Reid, *Treatise*, p. 226.

120. 'Gli Scappamenti', *Giornale d'Orologeria*, 1/2 (15–31 October 1892), p. 32, figure 7.

121. *Rees's Clocks Watches and Chronometers*, p. 196.

122. *Rees's Clocks Watches and Chronometers*, p. 217.

123. Clutton & Daniels, *Watches*, p. 39; Jeremy Evans, Jonathan Carter and Ben Wright, *Thomas Tompion 300 years* (Stroud: Water Lane Publishing, 2013), p. 86.

124. Gros, *Échappements*, p. 46–48; Laesser, *Les Échappements*, pp. 65–66.

125. Clutton & Daniels, *Watches*, p. 39.

126. Evans, Carter & Wright, *Thomas Tompion 300 years*, p. 279.

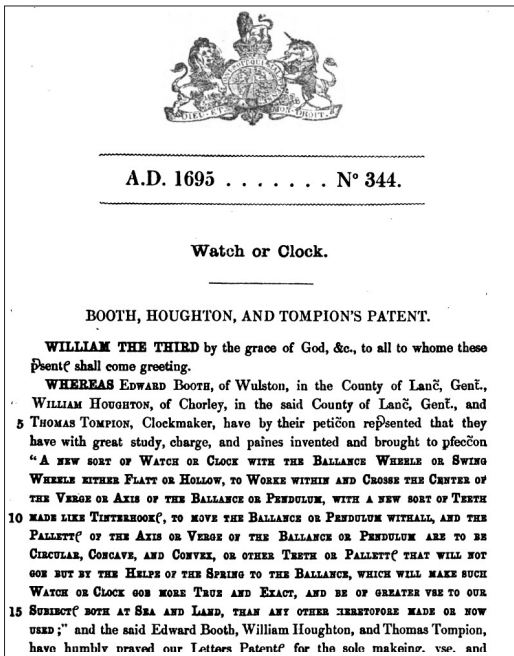


Fig. 15. English patent 344 (part).

while Symonds<sup>127</sup> describes only the cylinder one.

For completeness, Tompion appears to have patented the tenterhook escapement: together with Booth and Houghton, he filed on 23 September 1695 English patent number 344. Even if in 1695 it was still not mandatory to file a complete description of the invention, quite a few technical details are given, see Fig. 15. Among others, it is mentioned that the teeth of the balance wheel were ‘made like tenterhook’.<sup>128</sup>

Finally, according to Evans, a watch movement signed Tompion and using the tenterhook escapement is present in the collection of the Science Museum (catalogue number 1975-334);<sup>129</sup> however, according to the Science Museum website, the watch escapement was converted by Graham to a cylinder escapement.

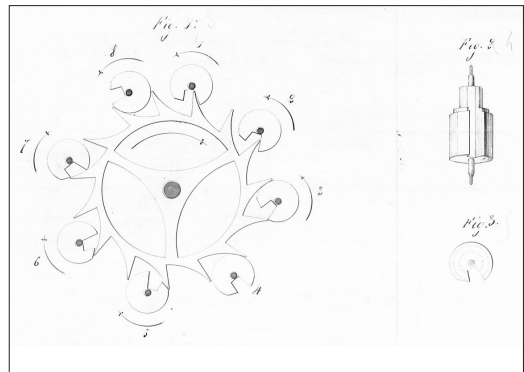


Fig. 16. Japy Frères' cylinder escapement.

## The most promising springboard – part 2

Tompion's half-recoil half-à-repos cylinder escapement (Fig. 13) is identical to the locking system of the established duplex escapement and works in the same way. The only difference lies in the dimension of the notch: the impulse of Tompion's escapement is owing only to the escape-wheel tooth pressing against the departing side of the notch and hence the dimension of the notch must be chosen so as to have a sufficiently big impulse. As discussed previously, the bigger the notch, the bigger also the recoil.

Tompion's escapement was reinvented as a simplification of Graham's cylinder escapement by Adolphe Lançon fils and patented both in France (1858) and in England (1859),<sup>130</sup> and again by Japy Frères in France in 1867.<sup>131</sup>

According to Japy Frères, the escape wheel could deliver only a small impulse to the balance owing to the small dimension of the cut in the roller; as a consequence the balance had a small oscillation. To increase the impulse, Japy Frères modified the shape of the roller on the balance axis, so that it was possible to have a bigger cut in the roller (Fig. 16).<sup>132</sup>

127. R. W. Symonds, *Thomas Tompion: his life and work* (London: B. T. Batsford, 1951), p. 242.

128. Both Gros and Symonds indicated the Tompion's cylinder escapement as being the subject matter of patent 344.

129. Jeremy Evans, 'Thomas Tompion at the Dial and Three Crowns Part II', *Antiquarian Horology*, 28/4 (December 2004), p. 439, footnote 49; Evans, Carter & Wright, *Thomas Tompion 300 years*, p. 667.

130. English patent 504, A.D. 1859, filed on 24 February 1859; French patent 37293 filed on 05 July 1858.

131. French patent 76957 filed on 20 June 1867; and Certificat d'addition filed on 05 December 1867.

132. Certificat d'addition filed on 05 December 1867, figures 1-3.

Another way to increase the impulse of Tompion's cylinder escapement is to add a pallet to the cylinder as in Tompion's tenterhook escapement. This increases both the duration of the push impulse and the arm acting on the axis of the balance.

Finally, the impulse of Tompion's escapement can also be increased by adding an additional impulse source independent from the dimension of the notch, i.e. to add an impulse escape wheel, thereby arriving at the *established* duplex escapement.

Interestingly, if the duplex escapement developed from Tompion's cylinder escapement, then the former can also be defined as a *cylinder escapement with two escape wheels*, i.e. the definition given by Thomas Tyrer in his letters patent.

## Conclusions

The question of who invented the *established* duplex escapement has been discussed in the literature for over two hundred and twenty-three years. English and French literature have attributed the *established* duplex escapement in turn to Daniel Delander, Duplex, Dupleix,

Jean-Baptiste Dutertre, Robert Hooke, Pierre II Le Roy, Pierre III Le Roy, Henry Sully and Thomas Tyrer.

None of the above attributions stands up to scrutiny, because either no documentation and/or timekeeper is available to support the attribution (Duplex, Dupleix, Sully and Tyrer), or the escapement on which the attribution is based is not an *established* duplex escapement (Delander, Dutertre, Hooke and the two Le Roys), and most often not even an escapement *à repos*.

Furthermore, for almost two hundred years the Dutertre's half-recoil half-*à-repos* escapement of 1727 (Fig. 7) has been considered the most promising springboard towards the *established* duplex escapement. However, this distinction appears instead to belong to Tompion's half-recoil half-*à-repos* cylinder escapement of 1695 (Fig. 13).

## Acknowledgements

I would like to thank Graham Morse FBHI for his support, patience and help, as well as the two reviewers whose comments helped greatly to improve this article.