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A James Harrison Turret Clock

at Brocklesby Park, Lincolnshire

By Colonel H. QUILL, CBE, DSO, MVO,
Royal Marines (Retd.)

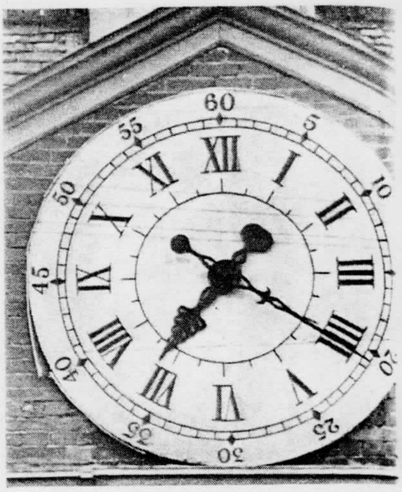


Fig. 1 (Below). The dial facing the stables yard. The hands on the dial facing the house (right) are more elaborate.

A James Harrison Turret Clock

at Brocklesby Park, Lincolnshire

TO all those who are interested in clocks, watches and problems of navigation, the name "Harrison" is immediately associated with John "Longitude" Harrison, who, some 200 years ago, constructed the first accurate marine chronometer and thereby won a splendid prize of £20,000.

What else is known of John Harrison? And why did the Government award him such an immense sum of money ?

THE HARRISON FAMILY

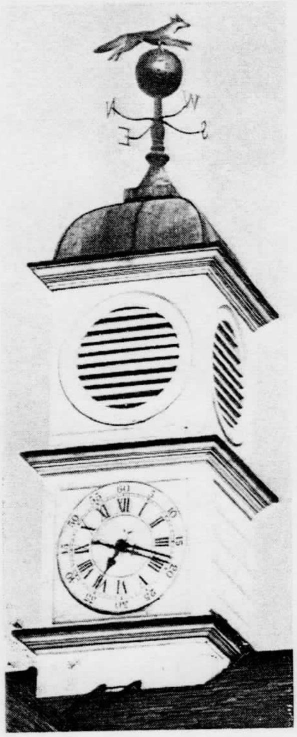
John Harrison was born in 1693 and was brought up as an estate carpenter in the small and very isolated Lincolnshire village of Barrow, where the opportunities for education or for meeting men of learning must have been extremely limited.

John had a young brother, James, and it appears that even in their early days both of the brothers were naturally attracted to clockwork, and we know that John was only 18 when he constructed the first of a series of longcase clocks, in which he used oak for all the plates, arbors and even the wheels themselves.

By 1729, John and James between them had constructed some eight or nine of these wooden timekeepers, in which the design showed progressively immense technical and inventive skill, and this in spite of the fact that the two brothers were still village carpenters who had never had any training as clockmakers.

THE DIFFICULTIES OF NAVIGATION IN 1714

In the early 18th century, England was on the threshold of great developments in sea power, but the wonderful opportunities of discovering new lands or exploiting rich overseas trade routes were gravely handicapped by the fact that even the best and most experienced navigators could never be quite sure of their position on the ocean. These navigators had no difficulty in calculating accurately their ship's position in miles north or south of the Equator (latitude), but when it came to deciding the position of their ship east or west of its starting-point (longitude), all calculations were completely upset owing to the rotation of the earth in a west to east direction. A navigator in order to find his longitude had to fall back on making an intelligent guess! In consequence, ships of all nations were frequently becoming lost on the high seas, suffering untold dangers, delays, privations and, worst of all, being subject to the constant risk of shipwreck.



THE £20,000 PRIZE

In 1714 the losses to our shipping from these causes had become so heavy that the Government decided by Act of Parliament (12 Anne Cap. 15) to offer a prize of £20,000 to anyone who could devise a practical way of "fixing" a ship's position east or west of Greenwich — in other words, to be able to determine accurately longitude at sea.

The news of this £20,000 prize did not reach remote Barrow for another twelve years—to be exact, in 1726—but when it did it so inspired John Harrison that he devoted the remainder of his life to the solution of the problem, and, after forty years of immense perseverance in the face of seemingly endless difficulties, he emerged victorious.

JOHN HARRISON'S SOLUTION TO THE PROBLEM

John Harrison's solution was to construct a timekeeper that would maintain its accuracy at sea in spite of buffeting by rough weather or being subjected to extremes of temperature. In these early days the construction of such a timekeeper was considered quite impossible because the motion of a ship eliminated any use of a pendulum, and yet the most accurate watch of the day was a simple uncompensated "verge" which even under the best conditions on shore was a very poor timekeeper. But the active and determined John Harrison persevered and in 1764, after a voyage to Barbados, his No. 4 timekeeper was officially observed to have gained only 34 seconds in seven weeks, a performance which was the equivalent to recording the longitude of Barbados to within nine miles.* This out-

* One second of time = 15 seconds of longitude = ¼ nautical mile (approximately).

standing achievement was well within the requirements of the Act of Parliament, and thereby Harrison was entitled to the great prize. But the Board of Longitude, which acted for the Government, considered that the startling and unbelievable accuracy demonstrated by Harrison's No. 4 must be the result of a freak performance, and Harrison's steadfast refusal to disclose the mechanism of the timekeeper did nothing to dispel their doubts. In consequence the Board of Longitude were unable to assess whether it would be possible or economic to construct copies of No. 4 which could then be made available for general use afloat. They decided, therefore, to award Harrison £10,000 and to withhold the remainder of the prize until further trials had been made.

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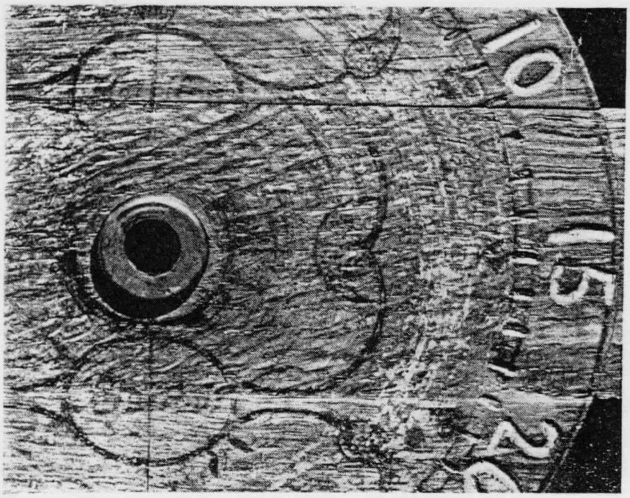


Fig. 2. The set hands dial showing the words "Harrison" and "Barrow" in the ovals above and below the centre.

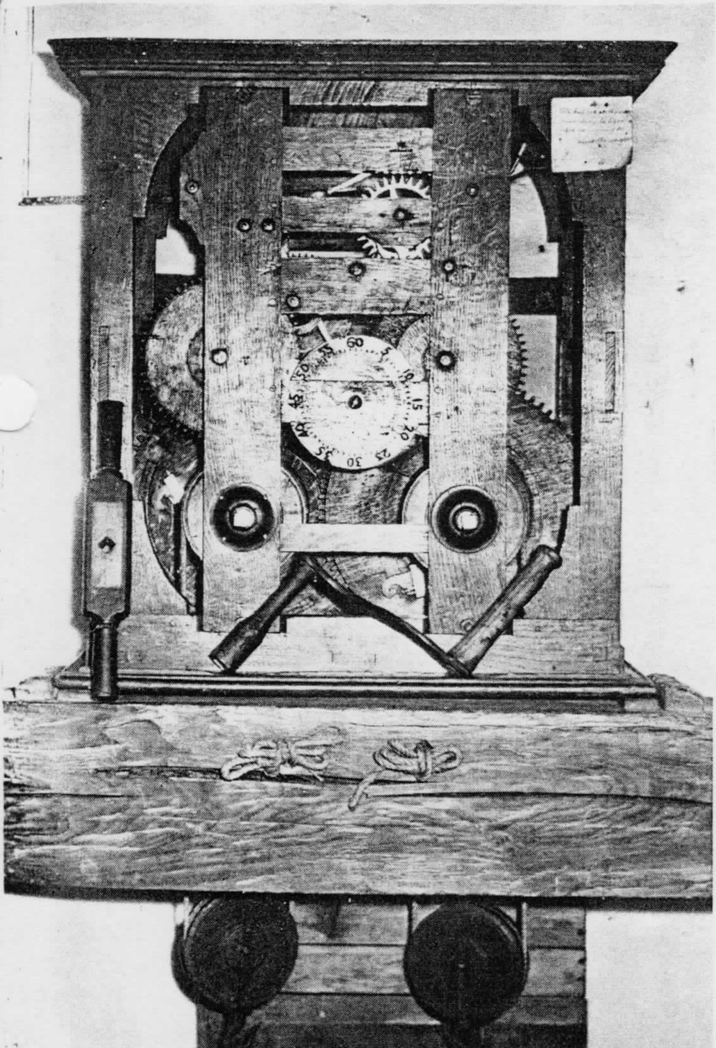


Fig. 3. The mechanism. The escape wheel and one pallet are clearly visible in the upper portion. The original winding handle is on the left.

For the next nine years, endless arguments, discussions and further trials took place, but eventually in 1773 Harrison received the full £20,000, but even then the award was only made because of the great support given to his cause by King George III in person.

CONTEMPORARY OPINION OF JAMES HARRISON

Some small mention of the younger brother, James Harrison, has already been made, but he is not well known and there is no mention of him in the extensive records of the conversations and dealings that occurred between the Board of Longitude and John "Longitude" Harrison. Nevertheless, certain contemporary opinions considered young James to have been the greater inventive genius of the two brothers, and this view is expressed by T. Hatton, who in his "Introduction to the Mechanical Side of Clock and Watchwork" (1773) says: "*I perceived that he* (James) *had a great share in the inventive part and his brother* (John "Longitude") *that of the execution to a greater degree of accuracy.*" This contemporary statement is startling and immediately focuses attention on the comparatively unknown younger brother, James Harrison.

In consequence of this it was an event of great interest when an opportunity occurred recently to make a thorough examination of a James Harrison turret clock, which although made of wood in 1727, has been maintained ever since in going order at Brocklesby Park, the seat of the Earl of Yarborough (Fig. 1).

THE BROCKLESBY CLOCK

The existence of this most interesting clock is hardly known, and even in North Lincolnshire there appears to be only a handful of local inhabitants who are aware of this Harrison clock and they, almost without exception, believe that it was made by John "Longitude" Harrison. However, it seems certain that the clock is the work of his younger brother, James (1697-1766), because in *Mechanics Magazine* for June, 1829, can be found a letter written by a James Harrison, who was a grand-nephew of "Longitude" Harrison, part of which reads as follows: "*The turret clock at Brocklesby Hall, the seat of the Rt. Hon. Lord Yarborough, made by my grandfather about* 1727 . . ." Further on, this same letter gives mechanical details which agree almost exactly with those of the existing clock at Brocklesby.

Fig. 4. The wooden screws that secure the front plate to the frame.

THE SIGNATURE ON THE CLOCK

The clock itself bears a signature, and if careful examination is made of the "set-hands dial" on the front plate (Fig. 2) the words "Harrison" and "Barrow" can be distinguished in the ovals above and below the centre respectively. These names appear to be painted on the woodwork and then to have been covered with varnish which has become scratched and opaque with age. It is quite possible that if this varnish was carefully removed an actual Christian name and date would be revealed.

The clock is housed in a tower over the stables and shows time on two dials which are at different levels; the mechanism (Fig. 3) is two-train which strikes the hours; it goes for eight days on one winding and is provided with maintaining power. The framework of the clock is of oak 32 inches high, 29 inches wide and 15 inches deep, the front plate being secured to it by four large boxwood screws (Fig. 4) which have a coarse thread that is typical of the carpenter's trade, and would in consequence have been perfectly familiar to the Harrison brothers.

WOOD CONSTRUCTION

In common with other early Harrison clocks, the frame, plates, arbors and wheels, and even the carefully pierced hands, are all made of oak (Fig. 5) and the workmanship is very fine, especially in the great wheels. These wheels, which are 16 inches in diameter, are fabricated from some eighteen separate parts, each piece utilising the direction of the grain of the wood so as to give maximum strength and freedom from warping (Fig. 6).

The oak arbors are all fitted with brass pivots which in turn work in bushes of lignum-vitæ (*Guaiacum officinale*) which is a naturally oily wood with a very close grain, the parent tree being found in the Caribbean. An exception to this can be found in the bushes of the great wheels, which are of boxwood and are secured in position by a cap and the employment of double tapers.

PINIONS

The pinions are of solid brass, some with seven leaves and others with eight; the escape pinion is an exception, for it is a lantern of seven lignum-vitæ rollers working on fixed brass pins (Fig. 7).

THE ESCAPE WHEEL

The only metal wheel in the clock is the escape wheel (Fig. 7), which is made of brass and has 30 teeth. These are curved and sharp-pointed (Fig. 8) and so differ materially from those in John "Longitude" Harrison's marine timekeepers which were invariably provided with straight-sided teeth, each ending in a small flat tip. In spite of 225 years' service the escape wheel teeth of the

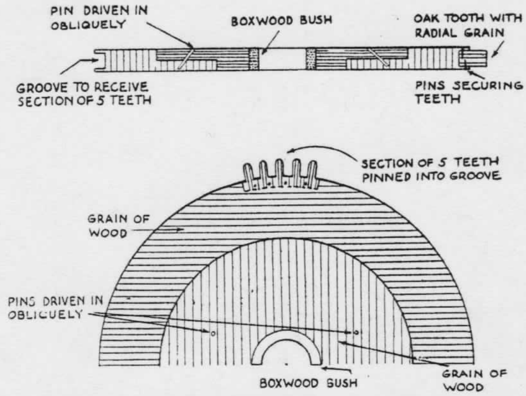


Fig. 6. The construction of the great wheels showing how the grain of the wood is utilised to give strength. The teeth are made in sections of five and are fitted and pinned into a groove in the rim of the wheel.

Brocklesby clock show no signs of wear, which is a wonderful tribute to the frictionless qualities of the "grasshopper" escapement with which the clock is provided.

ANTI-FRICTION WHEELS

The brass pivots at either end of the escape wheel arbor are each supported by a plain brass wheel (2 in.) having a fixed lignum-vitæ centre which turns very sweetly on a brass pin fixed in the framework. The end of one of these fixed pins can be seen protruding through the frame and below the bush which takes the escape wheel arbor. (Fig. 9.)

This combination of a normal pivot and bush placed vertically above a single anti-friction wheel is peculiar because if the pivot is a good fit the wheel cannot be operative and vice-versa. On the clock the actual bush is worn and hence it is the anti-friction wheel that takes the weight of the escape wheel arbor.

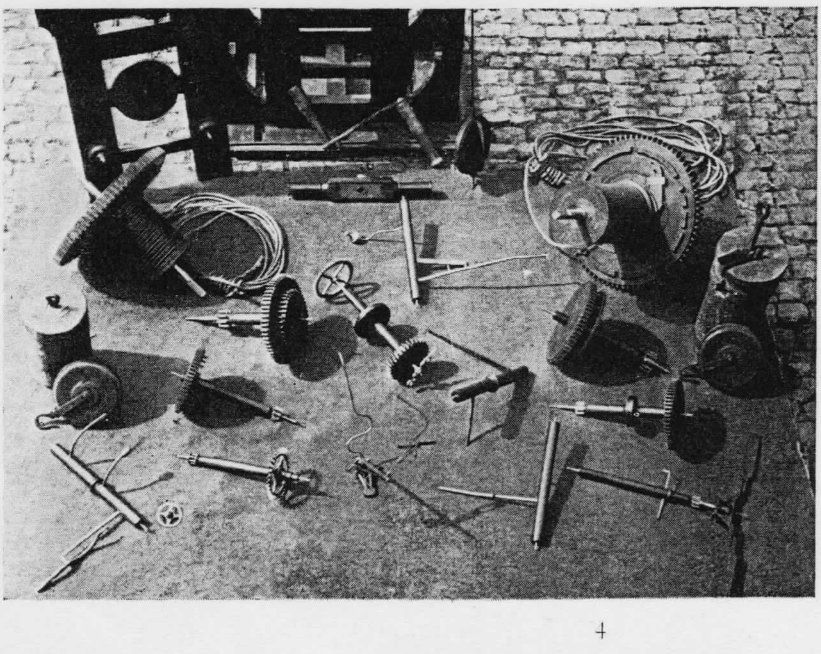


Fig. 5. The mechanism dismantled. The going train is on the left and the striking train on the right.

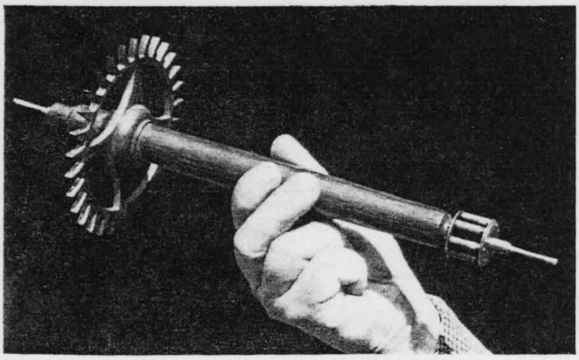


Fig. 7. The escape wheel showing the curved teeth and also the lantern pinion with lignum vitæ rollers.

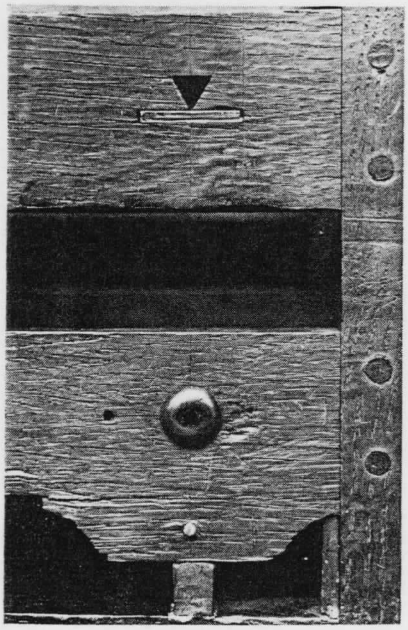


Fig. 9. A portion of the front plate showing the lignum vitæ bush for the escape wheel arbor. Below it is the end of the fixed pin on which the anti-friction wheel moves. At the top is the triangular shaped aperture to receive one of the grasshopper knife edges and below it is the horizontal glass plate on which the knife edge rocks.

John "Longitude" Harrison used these anti-friction wheels or "rolls," as he termed them, extensively and far more effectively on his large marine timekeepers.

THE "GRASSHOPPER" ESCAPEMENT

It is generally supposed that the "grasshopper" escapement (Fig. 10) was the invention of John "Longitude" Harrison; he certainly used it from 1735 to 1755 in his three large marine timekeepers with which he competed for the £20,000 prize offered by the British Government for a solution to the problem of finding longitude at sea. But the Brocklesby clock gives definite evidence that James Harrison used the "grasshopper" at least eight years before John "Longitude's" first example appeared, and moreover the Brocklesby grasshopper must have been in service some two years before John described the principle of this escapement in his MS. of 1730*. Consequently it would seem that it is James Harrison and not John "Longitude" who must be regarded as the inventor of this celebrated escapement.

The action of the "grasshopper" differs from all other escapements because, with it, the pallet and its escape wheel tooth come together very slowly and lock in silence and with complete absence of drop or slide. Similarly, very slight recoil of the escape wheel causes the locked surfaces to disengage instantaneously and again with no slide. This absence of friction or slide is a great advantage because it eliminates the need for any oil on the pallets, the presence of which is such a disturbing factor in any escapement.

The Brocklesby "grasshopper" itself is full of interesting and unusual features, some of which are:—

(a) The pallets are carried on the only metal arbor in the clock. In this case it is of brass and its ends are provided with pivots in the form of knife edges, which are also of brass.

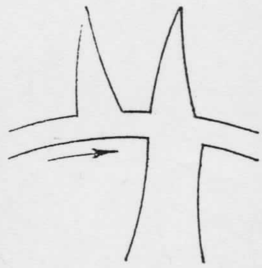
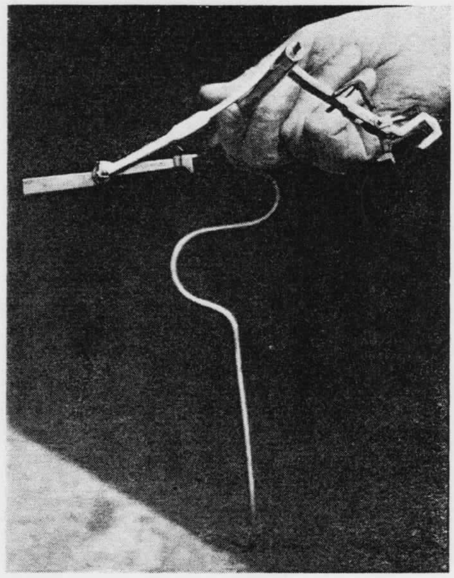


Fig. 8. The escape wheel teeth. Full size.



(Right) Fig. 10. The "grasshopper," showing the wooden pallets and also one of the knife edges at the end of the brass arbor. The pallet on the left is not original. Note the bends in the crutch.

(b) These knife edges rock on plates of glass let into the framework (Fig. 9), an arrangement that is of particular interest because this "*means of rendering friction insensible*" is described by Harrison in his MS. of 1730.

(c) The centre of gravity of both pallets has to be very carefully adjusted in order to insure that at the beginning of a vibration each pallet in turn falls by gravity to the precise position for engaging a tooth of the escape wheel.

(d) Each pallet when engaged with the escape wheel is in compression; this is different from the action in "Longitude" Harrison's No. 1 timekeeper, in which each pallet is under tension.

(e) The U-shaped end to the brass arm carrying the shorter pallet is a mystery, and it has no apparent use except the very minor one of providing a stop for the club-shaped balance weight.

(f) The crutch is a long, thin brass wire provided with a double curve so as to avoid touching adjacent arbors.

CYCLOIDAL CHEEKS

The clock is provided with a 5 ft. long pendulum which owing to the large escaping arc, of the "grasshopper," swings through a very wide angle (12-15 degrees). This was considered by John Harrison to be an advantage, and in his MS. of 1730 he wrote: "A clock cannot be made to go so true with a little vibration as with a large." But it is a remarkable thing that the Harrison brothers, in spite of their humble and isolated upbringing in the country, some-

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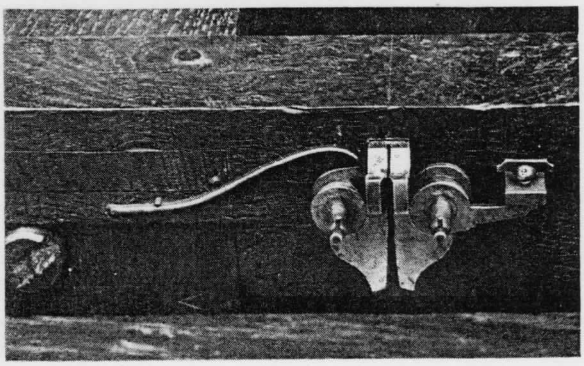
how discovered, or learnt, the mathematical fact that the correct path for a pendulum swinging widely must be a "cycloidal" and not a "circular" curve if uniformity in the time of its vibration is to be secured. But in 1727 when James built the Brocklesby clock he appears to have been fully aware of the properties of the cycloid, and consequently he provided his clock with brass adjustable "cycloidal cheeks" (Fig. 11)



(Left) Fig. 11. The cycloidal cheeks which are adjustable by means of the thumb screw on the right of the picture.

which, acting on the top portion of the suspension spring, give the pendulum an isochronous vibration.

Adjustment of the gap between the two cheeks is made by turning the thumbscrew on the right, which, owing to a cam and S-shaped return spring, causes the two cheeks to move in unison closer together or further apart and so vary their effect on the suspension spring.

These cycloidal cheeks also protect the suspension spring itself from breakage by ensuring that it always bends in an easy curve, which is an important matter, as the spring is 9 in. long and made of hammered brass (Fig. 12).

THE PENDULUM

As James Harrison had gone to the trouble of providing the complication of cycloidal cheeks one would have expected him to have included a device to deal with the vital problem of temperature compensation in the pendulum. But this is not so, for the pendulum is a plain brass rod. This fact is very surprising because there seems to be little doubt that the Harrison brothers developed their form of cycloidal cheeks and their "grid-iron" pendulum in the same year which, according to that intelligent and reliable observer, James Short, FRS, was in 1726.

The slot in the pendulum rod in which the crutch-pin works is remarkable because it is provided with lignum-vitæ dovetailed inserts (Fig. 12) to reduce wear on the crutch-pin to a minimum.

The bob is a disc of lead but is peculiar because, riveted to each side, is a "fin" of soft copper (Fig. 13) and one can only imagine that Harrison intended these "fins" to act as air brakes which could be bent as necessary to check excessive swing or to eliminate any tendency of the bob to roll.

THE WINDING HANDLE

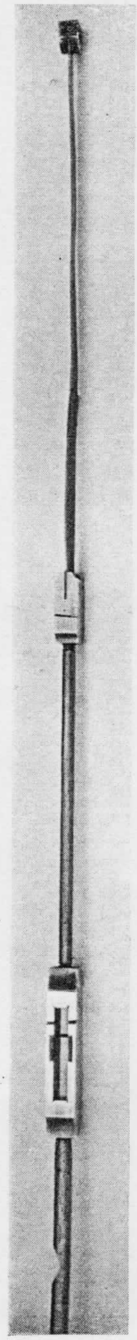
The original winding handle is a straight piece of oak 14 in. long and provided with two hand grips; it can be seen in Fig. 3 leaning against the left of the frame. This handle proved most inefficient in use, and so at some time in the past a cranked winder was provided and is now used invariably.

OIL ELIMINATED

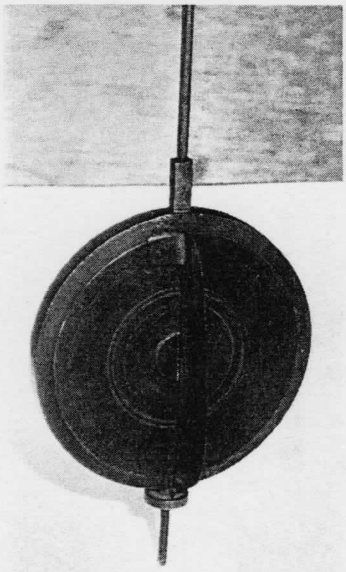
Because of the lavish provision of self-oiling lignum-vitæ bushes and other anti-friction devices, no portion whatever of the Brocklesby clock requires any oil, and, as the mechanism is covered by an oak hood, dust is excluded and wear as a whole reduced to a minimum.

TRANSMISSION TO DIALS

Harrison's care in eliminating friction did not extend to the transmission from the clock to the two dials, for this drive is extremely primitive and inefficient, the initial shaft being a seven-foot length of hardwood some 1½ in. square which terminates in a toothed wheel of oak (Fig. 14). This wheel is in itself inoperative, but bolted to it is a larger one of metal which in turn drives a vertical shaft via a metal contrate-wheel. Presumably this initial wooden shaft and oak wheel are the remains of the original transmission, but it seems likely, although it is by no means certain, that the metal wheels and shafting, although of considerable age, are nevertheless replacements.



(Right) Fig. 12. The top portion of the pendulum rod, showing the 8 inch brass suspension spring and also the lignum vitæ inserts in the pendulum block which prevent wear on the crutch pin.



(Above) Fig. 13. The lead bob, showing one of the soft copper fins.

REPLACEMENTS AND REPAIRS

It is not easy to be exact in deciding which portions of the clock have been renewed since it was originally made in 1727, but it is probable that the renovations are :—

(a) Grasshopper.—The replacement of the long left-hand pallet and the shortening and re-weighting of the pallet on the right.

(b) Fan.—The back pivot of the 20 in. fan has been broken and repaired by sweating on brass collars.

(c) Glass-plates—Renewed.

(d) Suspension spring.—Has been broken and repaired by riveting.

(e) Hemp-rope.—Replaced.

(f) Bushes.—Although all bushes appear to be original, nevertheless on the wooden casing surrounding the pendulum there is a pencilled notation to the effect "1884 RE-BOSSED." It is known that the Brocklesby clock was maintained for many years by an old Ulceby clockmaker, A. Fryer, who died in 1947 at the advanced age of 92, and it may be that in 1884 he replaced some of the bushes and at the same time repaired the grasshopper.

(g) Transmission.—It cannot be said definitely if this is in its original state.

When the clock was dismantled for examination it was found that, in the past, the lignum-vitæ bushes had been oiled and that black-lead had been applied to the teeth of the wooden wheels. As this lubrication was unnecessary, and indeed incorrect, the question of cleaning arose. It was considered that it would be unsafe to employ benzine or other normal cleaning agents because their use might have dissolved the natural oil out of the lignum-vitæ. This would have resulted in the fibres of the wood breaking up and thus ruining the original bushes made by Harrison, which would have been a calamity. Consequently all bushes were "pegged" with lengths of thick, soft string which was pulled to and fro through each bearing. More than 35 yards of string were used in the process! The black lead was wiped off the oak wheel teeth with rags moistened with methylated spirit, and finally the whole movement was assembled in a completely dry state.

JAMES HARRISON

Clocks by James Harrison are extremely rare, and the only other known specimen of his work is a longcase clock made in 1728, and which is now exhibited in the Clockmakers Company Museum in the Guildhall.

This clock bears a very striking resemblance in miniature to the Brocklesby clock, but differs by having a form of "grasshopper" in which the escape wheel puts one pallet in compression and the other in tension. The Guildhall example also has the only known specimen of an original "gridiron" pendulum.

The great originality of thought shown by James Harrison is revealed in a truer light if some of the original features contained in the Brocklesby and the Guildhall clocks are tabulated, thus :—

(a) The employment of "lignum-vitæ" for bearing surfaces.

(b) The employment of glass-plates for bearing surfaces.

(c) The employment of anti-friction wheels.

(d) The elimination of the need for oil.

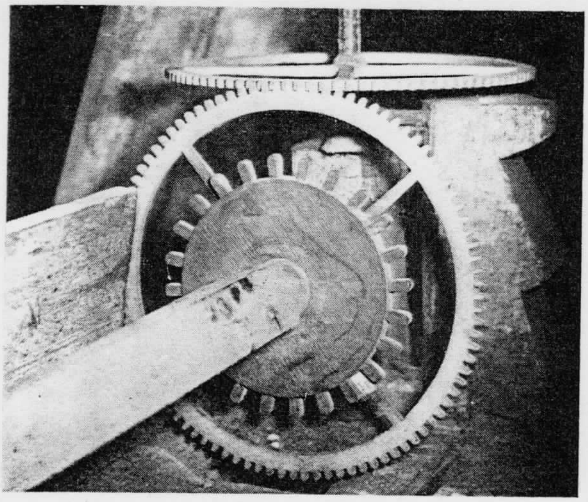


Fig. 14. The wooden shaft of the transmission and also the inoperative wooden wheel to which is secured the multi-toothed metal wheel. Note the primitive construction, the depthing and the crude wooden supporting frame.

(e) The development of adjustable "cycloidal cheeks" (it is believed that Huygens' work on the cycloid in 1659 was quite unknown to the Harrison brothers).

(f) The invention of the "gridiron" pendulum.

(g) The invention of the "grasshopper" escapement.

Not one of these features appears in any clock made before 1735 by John "Longitude" Harrison; on the other hand, he wrote about them in his MS. of 1730 and, of course, he adopted and adapted them for use in his marine timekeepers.

But the many ingenious and original features that James employed successfully in his two clocks must add very considerable weight to the view already mentioned that it was James Harrison who was the inventor, while John "Longitude" Harrison was the craftsman, but who, in addition, displayed ambition, determination and business-like qualities in his character.

But it is an extraordinary thing that John "Longitude" Harrison in all his writings does not give one work of acknowledgment to the genius of his young brother James.

A turret clock by one of the Harrison brothers is not in fact unique, for it is recorded that John "Longitude" Harrison, when a young man, also constructed a turret clock for Trinity College, Cambridge, but about fifty years ago it was replaced by a modern timekeeper and, sad to relate, no information has so far been found which throws any light on the ultimate disposal of this great rarity.

Therefore, the James Harrison clock at Brocklesby can claim to be the only Harrison turret clock still existing, and further, it joins the John "Longitude" Harrison regulator (*c.* 1750) belonging to the Royal Astronomical Society, as being one of the two remaining Harrison clocks still giving public service as timekeepers.

The writer would like to express his thanks to Professor D. S. Torrens, Mr. H. Alan Lloyd, and Mr. D. S. Evans for their assistance in describing the Brocklesby clock.

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