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Engine Houses in South-West Britain

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Abstract

In this paper 'Cornish Engines' are defined and their unique technical features are outlined. The purpose of the engine house as an integral element of the engine is explained and the main features of a range of typical houses are described. The existence of atypical examples is also discussed. The number of Cornish engine houses which survive in a reasonable state of completion today in Cornwall is approximately 220, compared with just 14 in south-west Devon (see Nance & Nance this volume). Additionally, the stumps or vestigial remains exist of at least 100 others, and there are undoubtedly still more awaiting discovery.

DEFINITION

What do we mean by a 'Cornish engine'? The true definition is a non-rotative beam pumping engine working on the Cornish single acting steam cycle (Fig 1). Such an engine need not necessarily have been built in Cornwall. Examples were built in France, Belgium, U.S.A. and Australia as well as by 'upcountry' firms in Britain, but in fairness the majority were built in Cornwall: probably upwards of 1,000 in the period 1815 to 1912.

However, in recent years the term 'Cornish' has been applied to rotative beam engines, mostly double acting, which were used for hoisting, crushing, or stamping, or for pumping at smaller mines where a purpose-built engine was not justified; or for a combination of these functions, (Fig 2). Such engines are loosely called 'Cornish' if they were built in Cornwall or by one of the Plymouth or Tavistock foundries, just across the Devon border. The author has estimated that upwards of 2,000 of them were built: usually double acting, that is taking steam on both sides of the piston. However, some examples built in the first half of the 19th century used the single-acting Cornish cycle with the connecting rod to the crank-pin specially weighted to perform one half stroke.

In the pumping engine, of course, the weight of the timber pump rod in the shaft, together with the pump plungers and jointing plates, etc., was usually more than enough to perform the pumping on the 'down' stroke of the rods, such that a degree of counterbalance was employed. Steam applied above the piston and vacuum in the condenser below combined to depress the piston and raise the shaft rods ready for the next stroke (Fig 1). It was always said that a well-tuned Cornish engine should be capable of working at any speed between one stroke in ten minutes and ten strokes in one minute. In practice, due to decay of vacuum in the condenser if the pause between strokes was excessive, engines were normally worked at from three to eight strokes a minute. A pause between each half stroke allowed time for the hinged non-return pump valves, or 'clacks' in the shaft, to shut gently under gravity without shock.

THE CORNISH ENGINE HOUSE AS THE ENGINE FRAME

A feature of the Cornish engine was that its house was not merely its enclosure: it was actually the engine's frame. If you take away the house the engine will fall down. The structure was also designed to assist with the engine's erection. The strength built into the engine house helps to account for the inherently long life, extending perhaps 100 years after removal or destruction of the roof. Details of the house are intimately associated with those of the engine it contained so their accurate interpretation can provide a wealth of information to the industrial archaeologist. Some of these details are discussed below, though it is impracticable here to illustrate more than a fraction of them.

Figure 2 is a simplified cross-section through a typical Cornish pumping engine house, emphasising the blocks of masonry of which it is composed. Of particular note are the extra thick wall, the 'bob wall' which supports the rocking beam, or 'bob'. From 4 to 8 feet (1.2 to 2.5 metres) thick according to the size of the engine, it has to withstand not only the weight of the bob which can exceed 50 tonnes, but also complex dynamic forces which tend to push it back and forth. The section is taken through the narrow 'plug doorway' opening through which the engine-man, standing level with the cylinder bottom, can observe the working of the condenser air pump and feed pump immediately outside, between the bob wall and the shaft.

Also noteworthy is the massive block of masonry, the 'cylinder loading' on which the cylinder stands. It is penetrated by horizontal bolt tunnels, to provide access to fit cotters, the cylinder being held down firmly using from four to eight long bolts. With steam being taken above the piston, the tendency is for the cylinder to lift at each stroke and the tonnage of masonry in the loading is in proportion to the power of the engine.

ENGINE POWER

Cornish engine power was usually expressed in inches of cylinder diameter, which also became part of the name. For example 'Goold's 80-inch engine' was a large pumping engine on Wheal Grenville mine, having a cylinder of 80 inches (2 metres) bore and pumping from Goold's Shaft. (R. W. Goold was chairman of the company when the engine was ordered in 1877.)

An 80-inch engine was generally rated at 335 horsepower, the fact that the stroke could be anything between 10 and 12 feet (3 and 3.6 metres) never seems to have been of great account. Small pumping engines could have a cylinder of 18 inches (280 mm) or less, and a stroke of only 5 feet (1.5 m). With rotative engines the cylinder could be even smaller and the normal maximum size for one of these was 40 inches by 10 ft stroke (1 by 3 m). That was for a stamps engine; a whim engine purely for hoisting seldom, had a cylinder larger than 30 inches by 8 ft stroke (0.76 by 2.4 m). The largest cylinder size ever used in Cornwall was 100 inches by 11 ft stroke (2.5 by 3.4 m) though a few larger cylinders were supplied for use elsewhere.

In Figure 2, note that the chimney stack is built integral with one corner of the house. This is one of several alternative arrangements. It was also common to have a free-standing stack close to the end of the boiler-house to keep the flue short. Another arrangement was to stand the stack further away, for example on a hillside where it could sometimes be made shorter or to find a firmer foundation. No clear rule has emerged.

EXTERNAL FEATURES

Figure 3 is an isometric view of a pumping engine house based on a sketch prepared by the Cornwall Archaeological Unit. It is largely self-explanatory but note the position of a 'balance bob' close to the shaft. This was an auxiliary beam linked to the pump rod at one end and carrying a weight box at the other, to counteract the excess weight of the pump rod (Plate 2). In a deep shaft there would be several of these, correct balance of the engine being vital to efficiency. Note also the ledge along the inside top of the side walls, which was used to enable erection of the engine under cover, and the hole for the massive timber 'main girder', which spanned the house and took any shocks from the engine trying to make too long a stroke: a not infrequent occurrence.

Note too the circular cast iron wall plates which mark the ends of wrought iron tie rods running horizontally through the walls of the house. Their purpose was to tie the walls together to help resist the racking action imposed on the bob wall. Sometimes they were applied retrospectively to solve a problem, in which case they can be seen inside the house. The practice may be said to have anticipated the pre-stressing of concrete which, like masonry, is weak in tension though strong in compression.

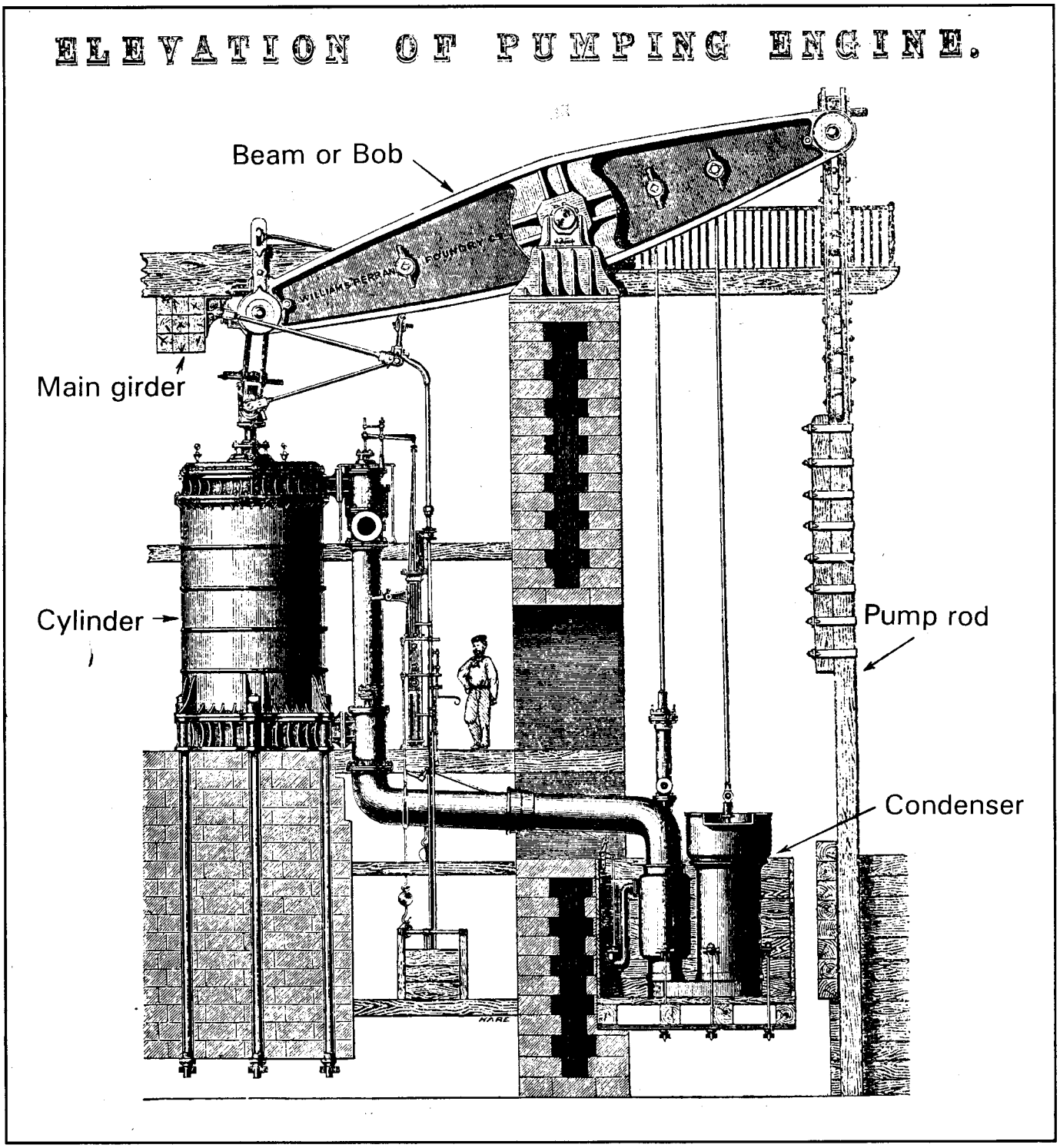

Fig. 1. A typical, large Cornish pumping engine. From the Perran Foundry catalogue (Copyright Trevithick Society).

ENGINE ERECTION

The normal method of lifting a bob, the first large item of an engine to be erected in the house, is shown in Figure 4. It is taken from a paper read by the late Jack Trounson to the Royal Institution of Cornwall in 1967. Both the bob and the cylinder were dragged in through the rear doorway, made specially large for the purpose, and lifted into place using movable timber beams and tackle supported on the ledge along the side walls previously mentioned. Nance has instanced engine houses at some Devon mines having no rear doorway, in which special tackle would have been needed to lift the bob in from the front (Nance & Nance this volume). In a rotative engine with a relatively light bob, where external lifting tackle is needed anyway to assemble the flywheel and crankshaft, the method is understandable. However with a pumping engine the bob would have needed special tackle to lift it in over the shaft: the weight for a 50-inch engine being approximately 10 tons. Moreover the plug doorway needed special enlargement to take the cylinder through, which seems to be highly undesirable structurally.

In the Devon engine houses referred to, and in a few instances in Cornwall, the chimney stack occupied the centre of the rear wall. But with some stamps engines, the boiler-house was placed across the rear of the house instead of at one side to leave the area around both ends of the crankshaft free for ore feeding arrangements. In such cases the cylinder doorway was sometimes located in one of the side walls. One exceptional pumping engine house survives at West Chiverton mine, near Truro, where a side opening was dictated by architectural rather than structural considerations.

External features close to an engine house are often germane to any interpretation of the site. They include a balance bob mounting or pit; the boiler-house, a long, more lightly constructed building usually abutting one side of the engine house; a circular level 'plat' for a horse gin or manual capstan; and mounting blocks for tall shearlegs over the shaft,

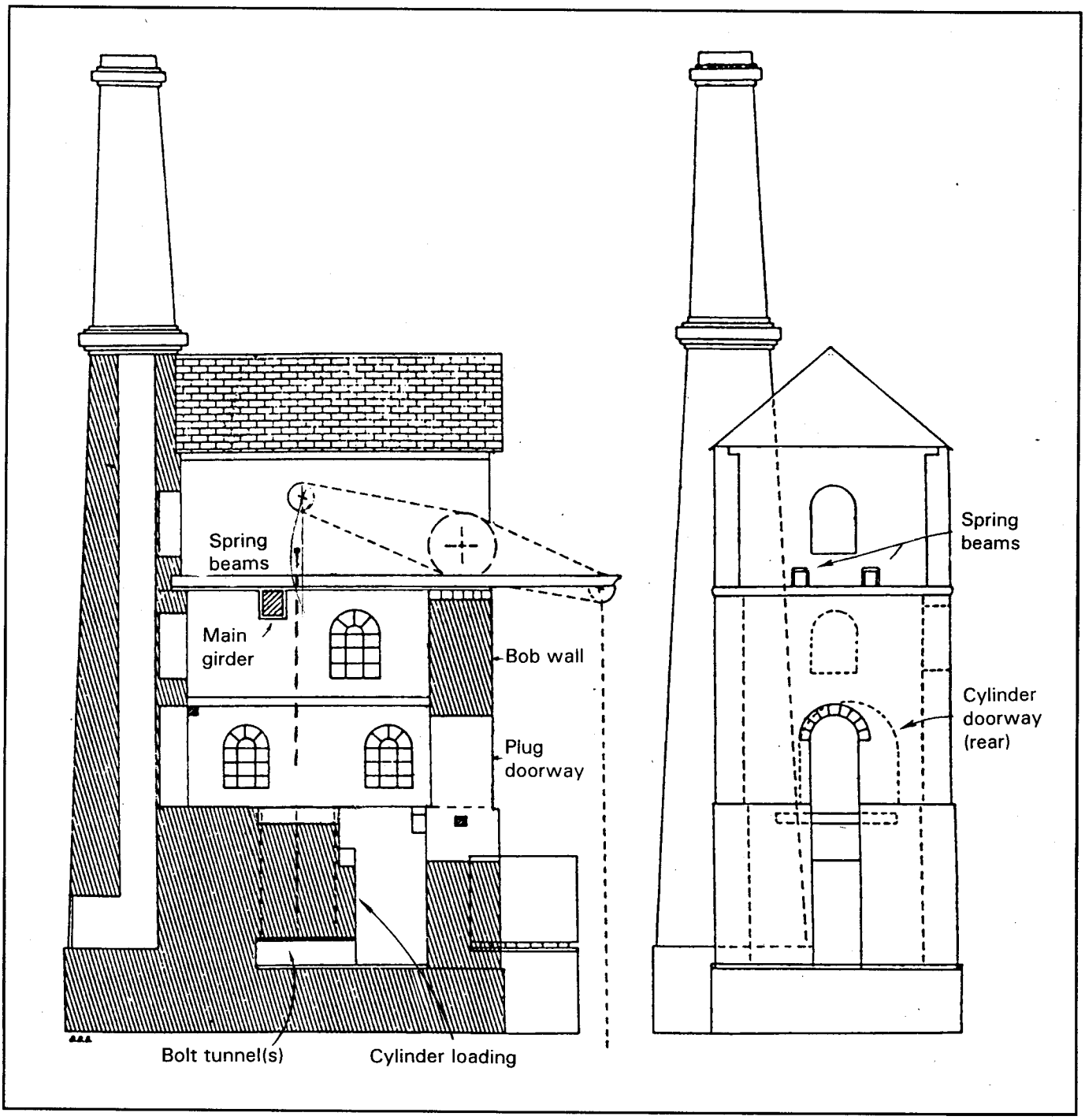

Fig. 2. Section through a typical pumping engine house and shaft elevation.

tall enough to handle a length of pump rod (commonly 60 ft or 18.3 m). Many boiler-houses have been badly robbed for their stone, sometimes to the point of total disappearance. A manual 'capstan plat' can be distinguished by a masonry pit in the centre with a rope trench aligned with the base of the shears. Not many are obvious today. As a point of interest, the massive masonry foundations of an engine-house were frequently left *in situ*, even where the house itself was demolished. If the need to recover the stone was great enough to remove the foundation masonry too, the result was a huge pit, one particularly good example of which survives at the site of Williams' 80-inch engine at Wheal Unity Wood mine. (Here too, the capstan plat is remarkably intact - see *Exploring Cornish Mines*, Vol. 2 pp 68 - 70.) Many engine foundations lie buried where this was not done: sometimes they come to light during shaft-plugging operations.

Building an engine house was generally entrusted to a builder who specialised in that class of work. Drawings supplied by the mine's consulting engineer or the engine builder showed the main dimensions, wall thicknesses, etc., but left the architectural details to the company. Depending on the mine's opulence there could be many or few windows, and the wall openings could have brick arches, or timber or stone lintels. Windows in the rear wall were important because when 'heaving in' the bob, ropes from winches outside to the tackle inside passed through them. When an engine was sold for re-use elsewhere, as frequently happened, dismantling was carried out in a similar manner. In a few engine houses damage to rear window arches where wire ropes have scored the brickwork can still be seen.

The late Mr. W. Tregoning Hooper, one of the founders of the Cornish Engines Preservation Society, had a grandfather who ran a building firm. He built a house for a 70-inch pumping engine in the 1860s for which he was never paid because the mine company ran out of cash before the engine was put in. The unused engine house still stands today, while the engine was eventually sold to the Van mine in mid-Wales where it gave many years of faithful service.

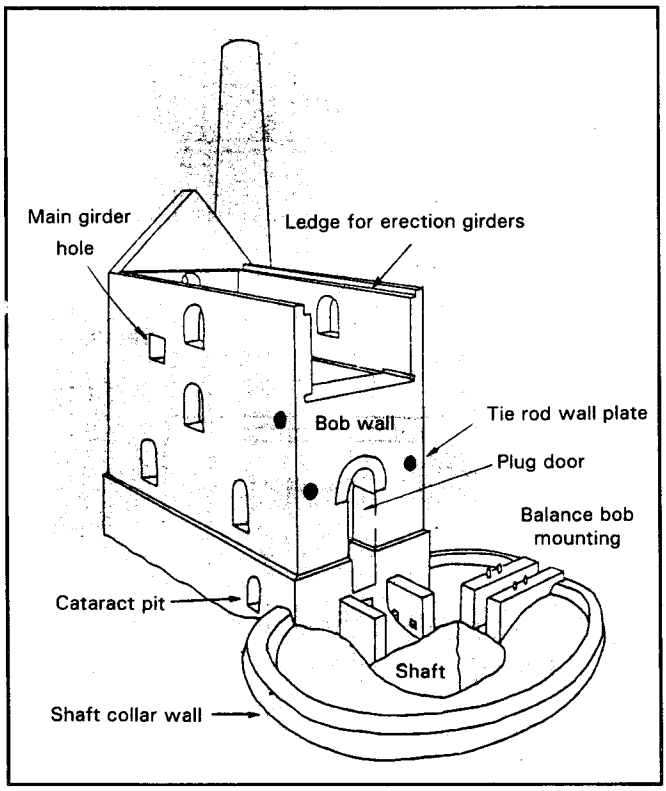

Fig. 3. Isometric view of a pumping engine house, showing external features.

EVOLUTIONARY PROCESS

The seeds of the mighty Cornish pumping engines were sown early in the 18th century with Thomas Newcomen's creaking and extravagant atmospheric engines. In these engines the wooden bob was supported on a masonry pillar, gracefully tapered, one of which was excavated a few years ago at Wanlockhead lead mine in the Scottish lowlands. It is thought to have belonged to Symington's improved atmospheric engine erected there in the 1760s. As time went on, it became desirable to protect the driver so walls and a roof were added. In Boulton and Watt's time, around the turn of the century, not only had the engine received a cylinder cover beneath which low pressure was applied but timber gave way to cast iron for the bob. This meant making the bob wall more substantial, but no plug doorway was needed because Watt's condenser was in the house. This condenser position may be seen today in two of the re-built Watt-type engines, now working on the Cornish cycle, preserved at the Kew Bridge Steam Museum in West London. It also shows in the house of a 48-inch pumping engine at Wheal Ann, in Wendron parish. This engine had a wooden bob and hence a relatively narrow bob wall, with a reduction of thickness at about half height.

This house also exhibits another early feature, not a lot of room between the back of the cylinder and the rear wall of the house. Cornish engineers recognised the need to make overhauls a bit easier: after all, an engine stopped meant the

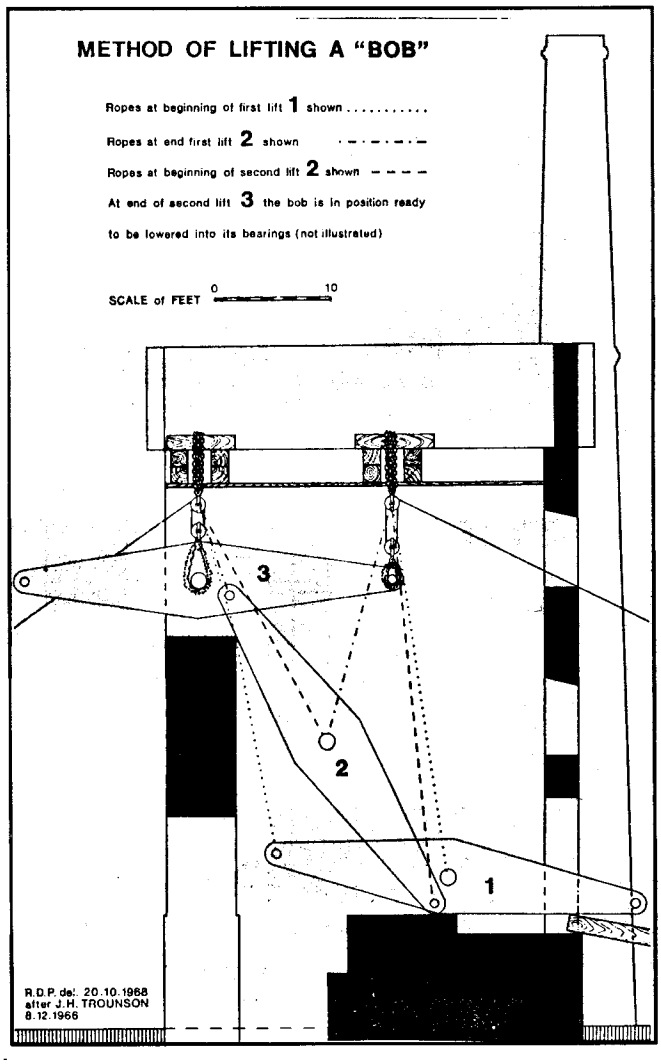

Fig. 4. When erecting an engine the bob was lifted first using tackle suspended from temporary wooden lifting girders, carried on the side walls of the house. The cylinder came in by the same method.

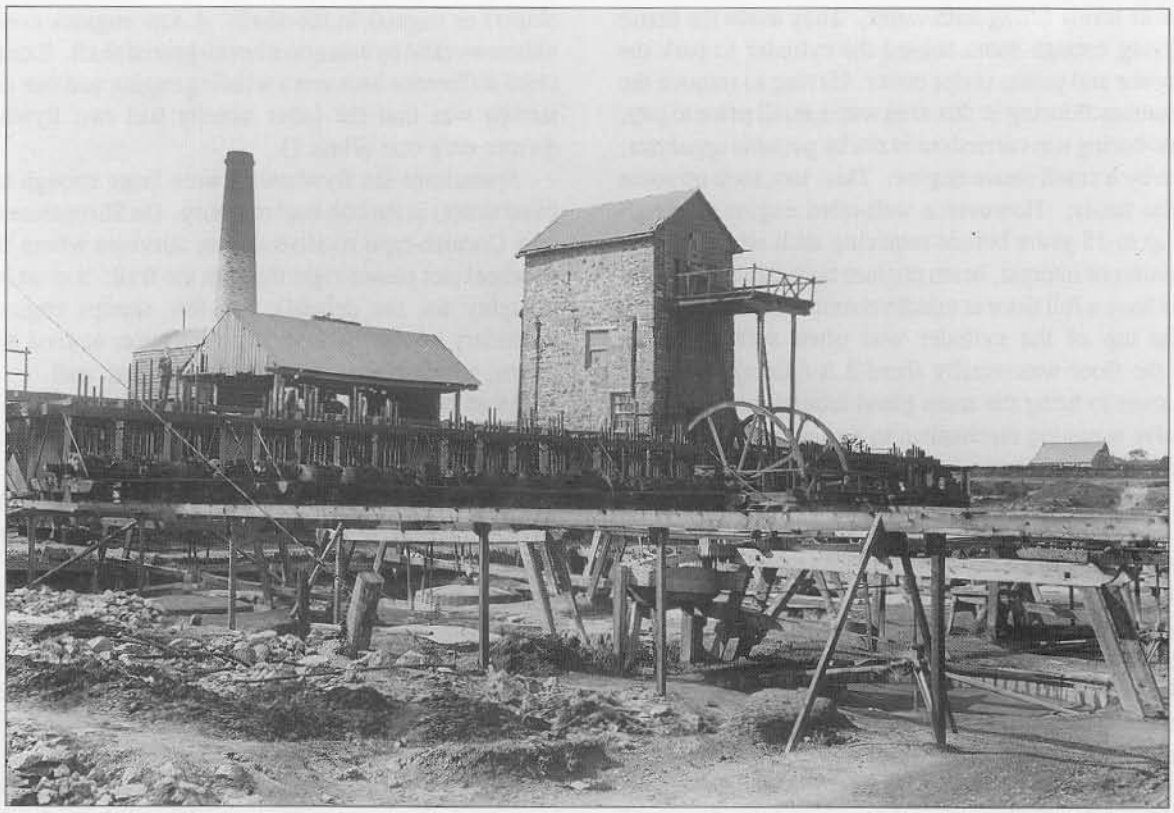

Plate 1. A typical stamps engine at Wheal Grenville, near Camborne(c1904) showing the twin flywheels, separated chimney stack and the long row of tin stamps each side. Tie rods and glands have been added to strengthen the bob wall.

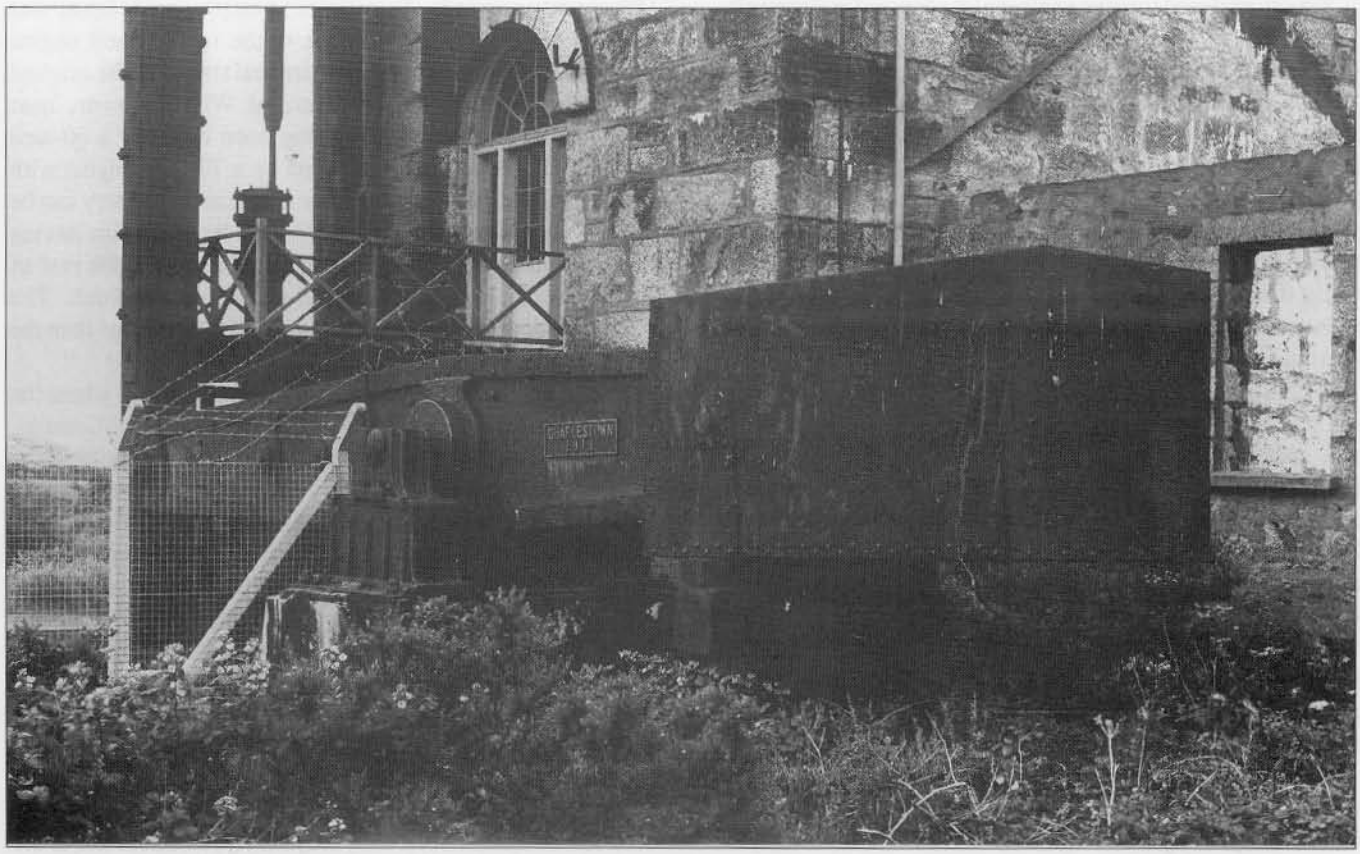

Plate 2. A 'balance bob', showing the weight box. This example utilises an old engine bob.

mine's lower levels filling with water. They made the house longer, giving enough room behind the cylinder to park the cylinder cover and piston under cover. Having to remove the middle chamber flooring in this area was a small price to pay. Cylinder re-boring was carried out *in situ* by portable apparatus, belt driven by a small steam engine. This, too, took up some room in the house. However a well-oiled engine might go anything up to 15 years before requiring such attention.

As a matter of interest, beam engines built 'upcountry' did not always have a full floor at middle chamber level: a gallery around the top of the cylinder was often sufficient. In Cornwall the floor was usually about 3 ft (90cm) below the cylinder cover to bring the main gland around the piston rod and the valve actuating mechanism to a convenient height for oiling and adjustment.

NON-STANDARD AND ROTATIVE ENGINE HOUSES

Every rule has exceptions and some Cornish engine houses did not take the exact form so far described. Some in the East of the county had a nearly flat roof with a surrounding balustrade so that it looked so. The house at Hingston Down mine, near Gunnislake, is a case in point. It was erected early this century for a rotative engine built by the Bedford Foundry, Tavistock, which had earlier worked at Devon Great Consols. The flat roof may well have been a hallmark of this foundry because precisely the same feature may be seen in the house of Richman's crushing engine at Moonta Mine, South Australia. This too was a rotative engine built by the Bedford Foundry, but differs in that the engine was totally enclosed: in other words, the house was twice its normal length and covered the crankshaft and flywheel as well as the cylinder end. The bob wall was internal.

Totally enclosed rotative engines also occurred in Cornwall. The 1840 Harvey-built rotative winding engine preserved by the National Trust at Levant Mine in the extreme west of Cornwall is a case in point. This engine is relatively small, having a 24-inch cylinder when built and 4 ft stroke (600 mm and 1.2 m) and the bob is supported on a timber girder spanning the house. (This was later reinforced with a central pillar composed of a length of cast-iron pipe.) There were a number of relatively small winding engines in the St. Just mining district which were similarly enclosed, possibly due to the Atlantic storms to which the region is exposed, but they were not unknown in other parts of Cornwall and West Devon.

With a pumping engine, the load on the bob and the bob wall is always downward so the main trunnion bearings rested on a cast soleplate which was simply dowelled into the masonry, or into a timber grillage on top of it. In a double acting rotative engine, however, steps had to be taken to resist the up-thrust from the piston. Normal practice was to secure the soleplate with four (occasionally only two) long bolts built into the bob wall and extending down to anchorages below the plug door. Sometimes these bolts were external to the wall as in the 30-inch winding engine at East Pool Mine, also preserved by the National Trust. Either way, the whole weight of the bob wall was utilised to resist uplift.

Below the plug doorway, and sometimes common with it, was a large, square opening for the engine's 'eduction pipe' which conveyed expanded steam from the exhaust valve(s) to the condenser. A double acting rotative engine required another, smaller, opening to one side to take the rods from eccentrics on the crankshaft to work the valve gear. Sometimes a bevel geared shaft ran through as well to give a winding engine driver indication of crank angle, and the position of skip(s) or cage(s) in the shaft. A few engines even had the valves worked by cams on a bevel-geared shaft. Externally the chief difference between a winding engine and one driving tin stamps was that the latter usually had two flywheels, the former only one (Plate 1).

Sometimes the flywheel(s) were large enough to require blind slot(s) in the bob wall masonry. (In Shropshire the house of a Cornish-type rotative engine survives where the single flywheel slot passes right through the wall: it must have been draughty for the driver!). A few stamps engines had a secondary bob at the rear, drawing water to feed the stamps grates, which meant having a thicker rear wall.

Most pumping engines pumped from a shaft which was vertical down to a certain level before going off on an 'underlie' to follow the angle of the lode. The pump rods and rising main of course had to follow. Many ingenious devices were employed to turn the line of rods through an angle. Occasionally the shaft underlay right to the surface. The only physical evidence of which the author is aware, which reveals how an engine was arranged to pump from an underlie shaft, is the ruin of Pearce's 50-inch engine at South Caradon. Here the bob was cranked upward outdoors and since this would have imposed a line of thrust which was not vertical, the bob wall was provided with two massive buttresses against the outer face. The condenser occupied the usual position, that is between the buttresses. The rest of Pearce's engine house has largely collapsed and the need for stabilisation of what is left of this unique structure is very urgent.

RE-USE OF ENGINE HOUSES

Moving engines from one site to another as the fortunes of mining rose and fell was a common-place procedure from the 18th century onwards. Sometimes an empty engine house was re-used, but problems arose due to the replacement engine rarely having the same cylinder size and stroke of the original one. The pumping engine house at Wheal Peevor, near Redruth, bears evidence of having been built for a 60-inch engine in 1872, and later occupied by a 70-inch engine with a longer stroke. Two openings for the steam pipe entry can be seen on the boiler-house side due to the larger engine having been of Sam Grose design with the steam valve at the rear of the cylinder instead of the normal position at the front. The later brick opening in the wall is more of a 'botch up' than the original with its quoins and lintel.

A more extreme example exists in East Cornwall where the 50-inch pumping engine at Wheal Martha, or New Consols, mine at Luckett was later replaced by an 80-inch engine in the same house. Not only was the house raised and the bob wall thickened on the outside, but a strengthening buttress was added at each end of it, giving the house a singular appearance from the front. As a point or interest, the 80-inch engine and two other engines on the mine remained derelict in their houses for more than 60 years after closure, not being scrapped until 1938. What a missed opportunity to create a 19th century mining museum! Even today, the main girder and parallel motion anchorages of the 80 remain in the house, and the roof survives thanks to a thick mantle of tree ivy.

Re-use of a house on a different site by moving it stone by stone seems to have been done only rarely, no doubt due to the ready availability of building stone in many parts of Cornwall. Opening a small quarry to provide stone for the buildings was one of the first tasks facing a new mine. Granite features for the quoins and some or all of the bob wall did, however, often come from a distance, and in some cases they were re-used.

It was quite normal for the engine house joinery - flooring, doors, windows and the roof - to accompany a second-hand engine when moved and built into the new house. Exceptionally, the stonework of Ivey's 85-inch engine house at Wheal Metal, near Sithney, is reputed to have been moved with the engine (built by Harvey and Co. in 1846) from Trelawney's Shaft at Wheal Vor, a short distance away, and rebuilt. The author once saw the house of a 30-inch engine in the Victoria Goldfields in Australia where every stone in the bob wall had a number etched on it: Roman numerals were used below driver's floor level. This seemed to indicate that the house had been moved from elsewhere.

BOILER EVIDENCE

Whereas a pumping engine, working continuously, often required more than one Cornish boiler - anything up to eight in the very largest engine - a winding engine normally had just one. Having a spare for repair or maintenance was important in a pumping engine, also in a stamps engine which normally had two. A Cornish boiler often left a horizontal depression in the ground marking the underneath flue, and cases exist where these are faintly visible even where the boiler-house itself has gone. Occasionally the stump of a wall in between boiler positions shows that at some time the boiler-house was extended to provide extra steaming capacity. Though usually at one side of the house and at a lower level, a boiler-house could be arranged across the back as we saw earlier.

Contemporary accounts of building engine houses are few and far between. Occasionally the subject received attention in the press when a disaster occurred, such as a mason being killed or a house collapsing due to undue haste in its construction. It might be thought that pumping engine houses perched close to a shaft would be especially vulnerable. However, Cornish rock is generally very competent and the only cases of engines collapsing with the bob wall into a shaft known to the author were in South Australia and Cumbria.

ACKNOWLEDGEMENTS

Much of what we know of engine houses comes from the examination of surviving structures and the author wishes to acknowledge the work of the Cornwall Archaeological Unit who share his interest in the subject. Thanks are also due to the staff of the Cornwall Local Studies Library in Redruth and the Cornwall Record Office in Truro for their ready ability to produce documents for historical research purposes.

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