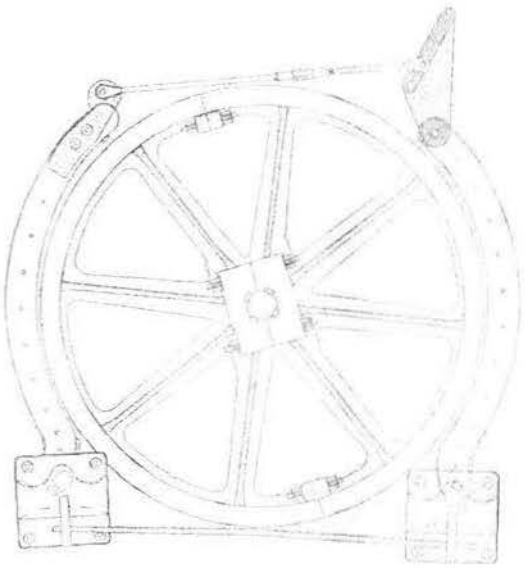
EXCAVATION AND SURVEY

OF THE V2 INCLINE

VIVIAN QUARRY, LLANBERIS



Report No: 259

Ymddiriedolaeth Archaeolegol Gwynedd

Gwynedd Archaeological Trust

EXCAVATION AND SURVEY OF THE V2 INCLINE

VIVIAN QUARRY, LLANBERIS
(G1460)

prepared for Posford Duvivier Consulting Engineers

June 1997

Gwynedd Archaeological Trust Report no. 259

The Vivian incline system in 1896, photographed by Grrifith Jones;
courtesy of the Rev. Michael Outram, great-nephew of the photographer.

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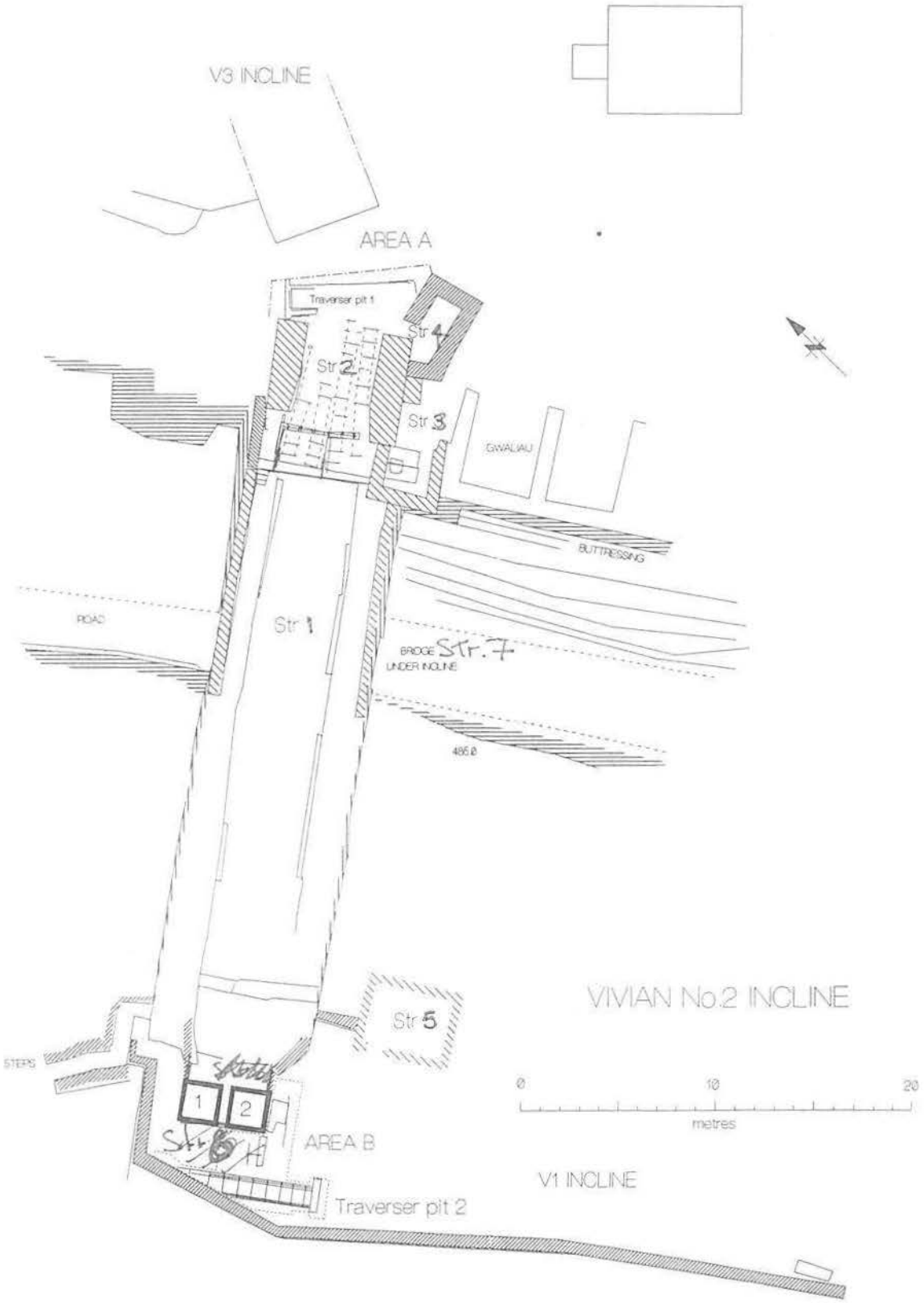

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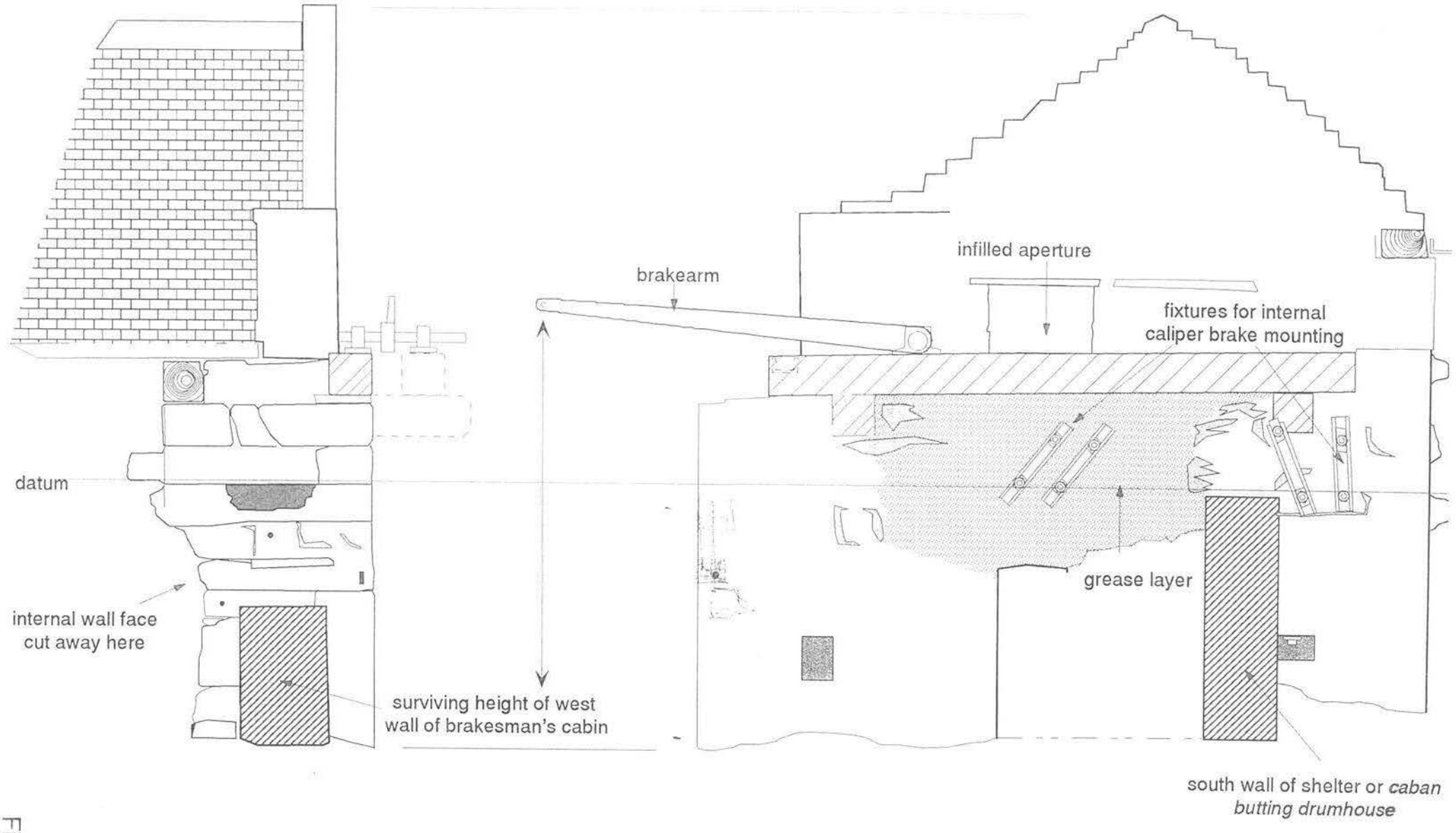
Title	Vivian No.2 (V2) Incline - Archaeological and Topographical Survey				
Project no	G1402	Drwg no	1450/02	Client	Pierianwyr Ymgynghorol POSFORD DUVIVIER Consulting Engineers
Scale	1:500	Date	24.02.97		
Surveyed by	LAD/DMTL	Drawn by	LAD		

V2 incline drum winding house - west external elevation. Scale 1:40

Fig. 2



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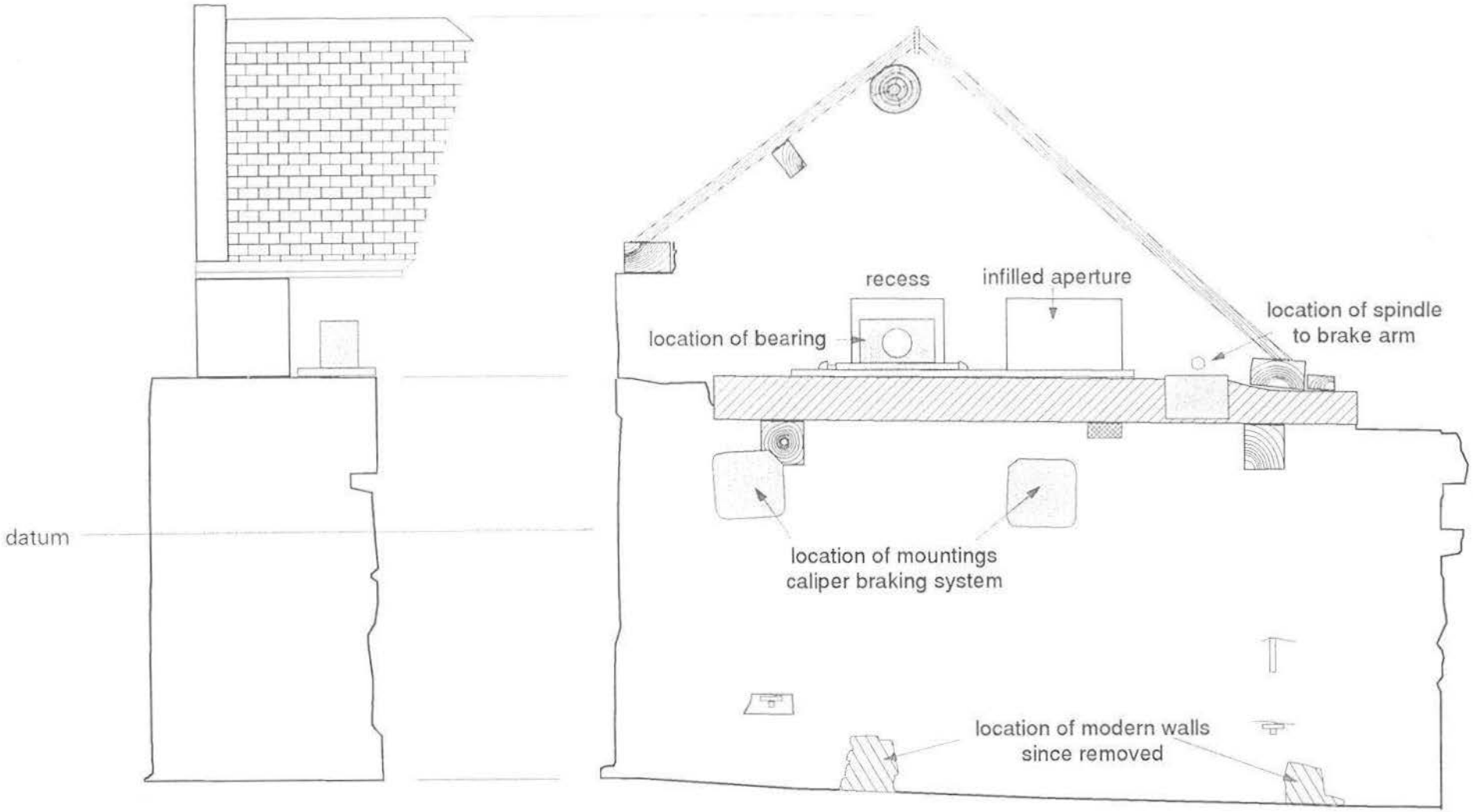
V2 INCLINE DRUM WINDING HOUSE - SOUTH END AND EASTERN EXTERNAL ELEVATION. scale 1:40



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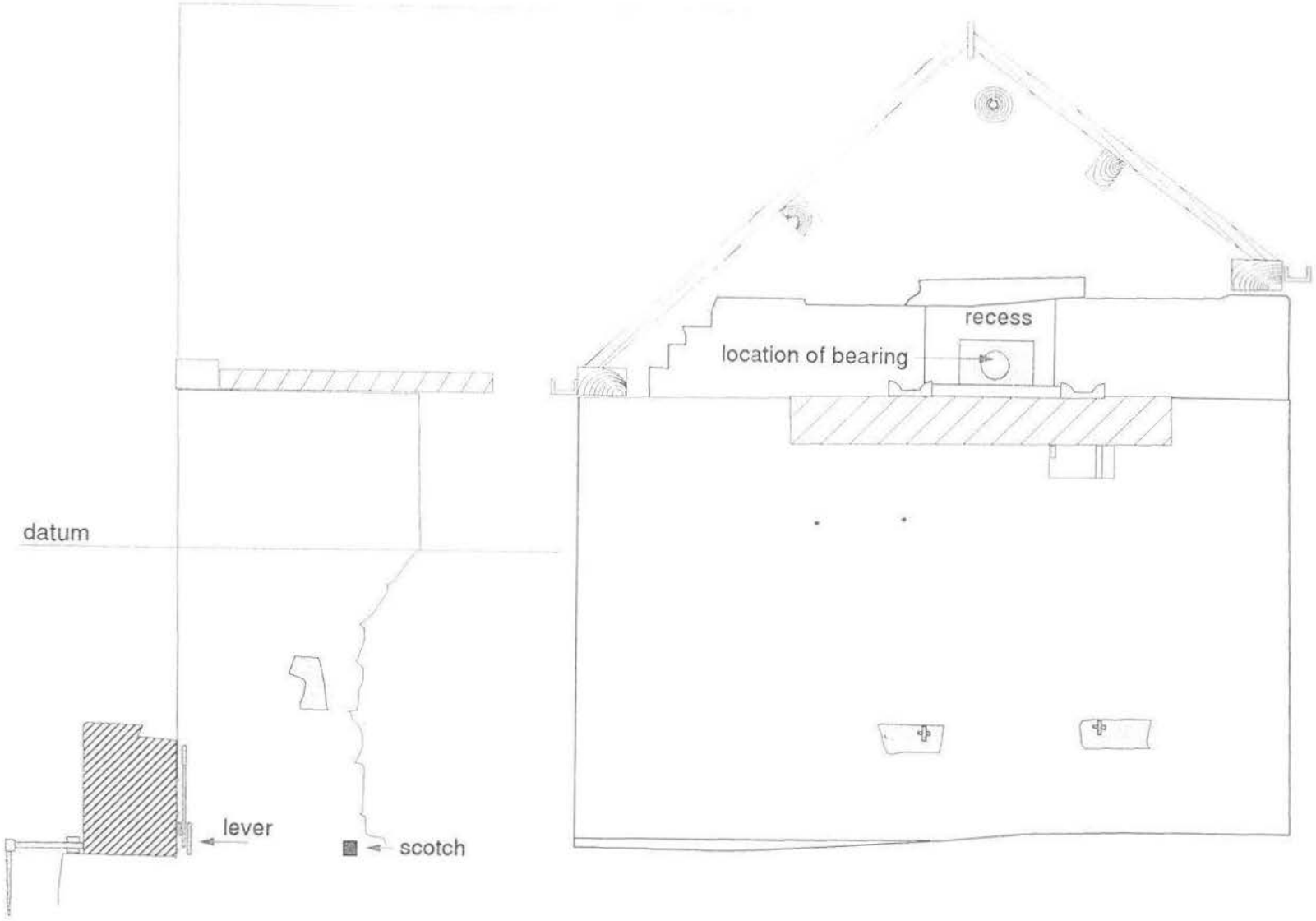

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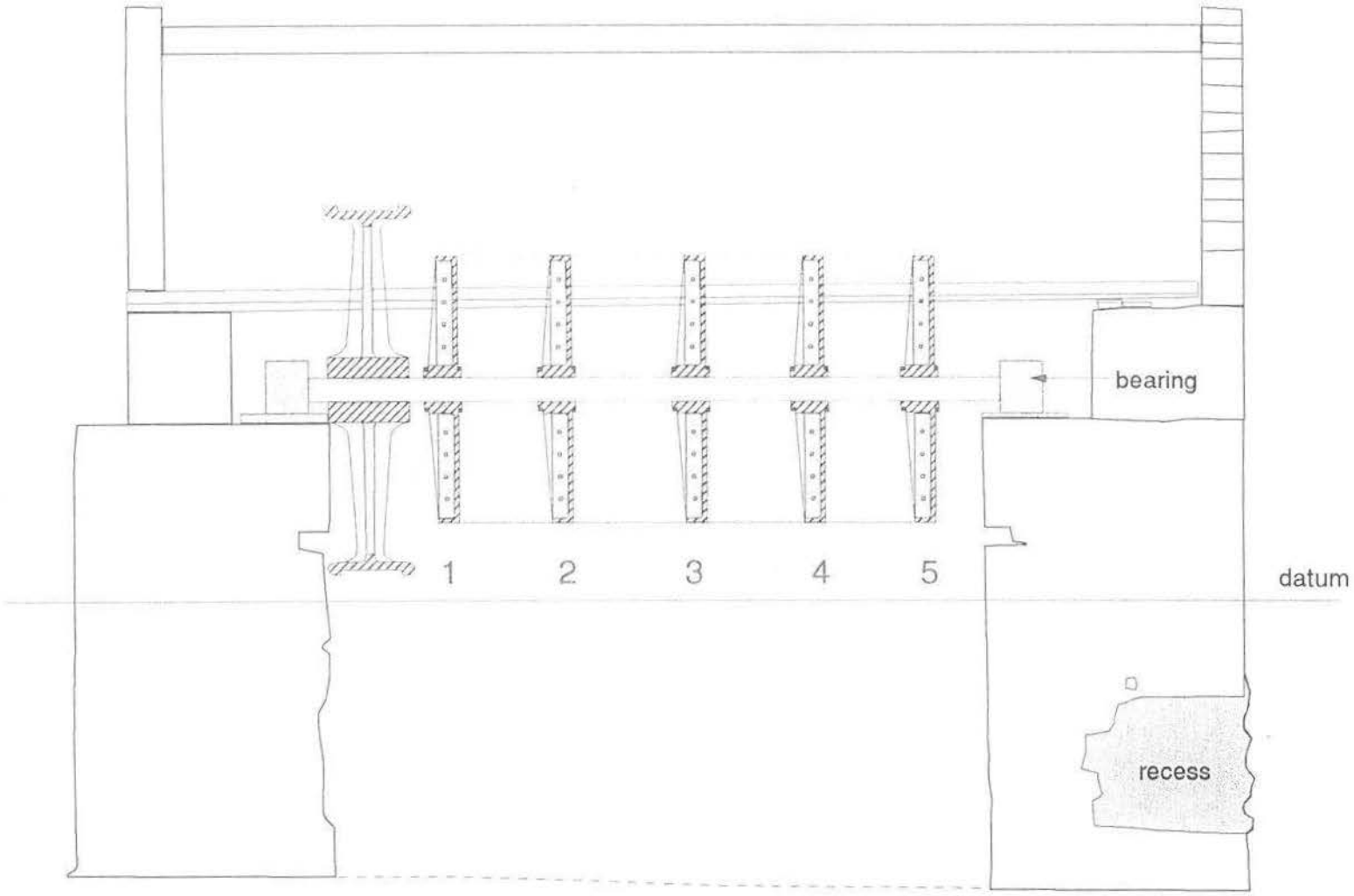


V2 incline drum winding house - north end profile & elevations
including drum configuration and brake mechanism. Scale 1:40

Fig. 6

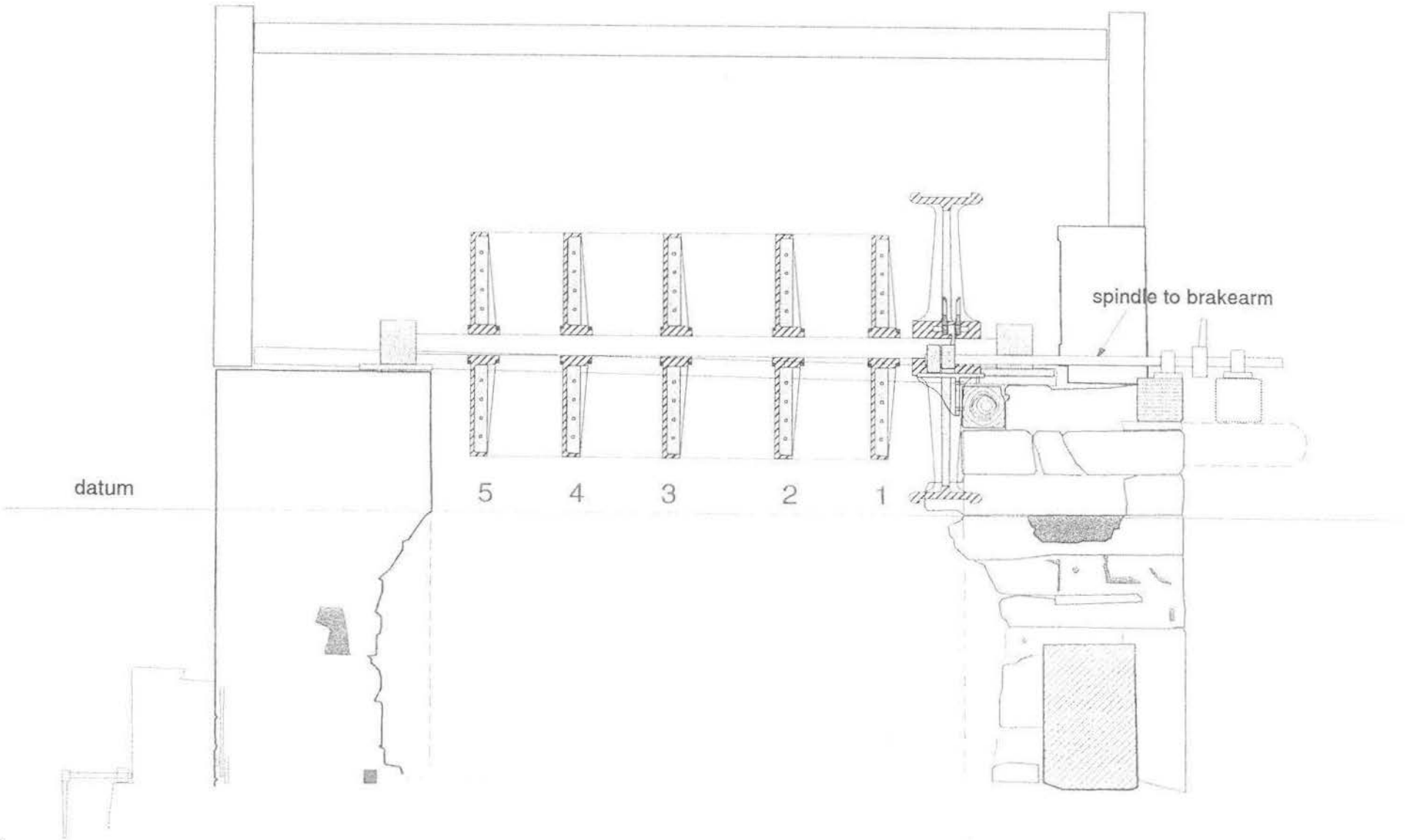
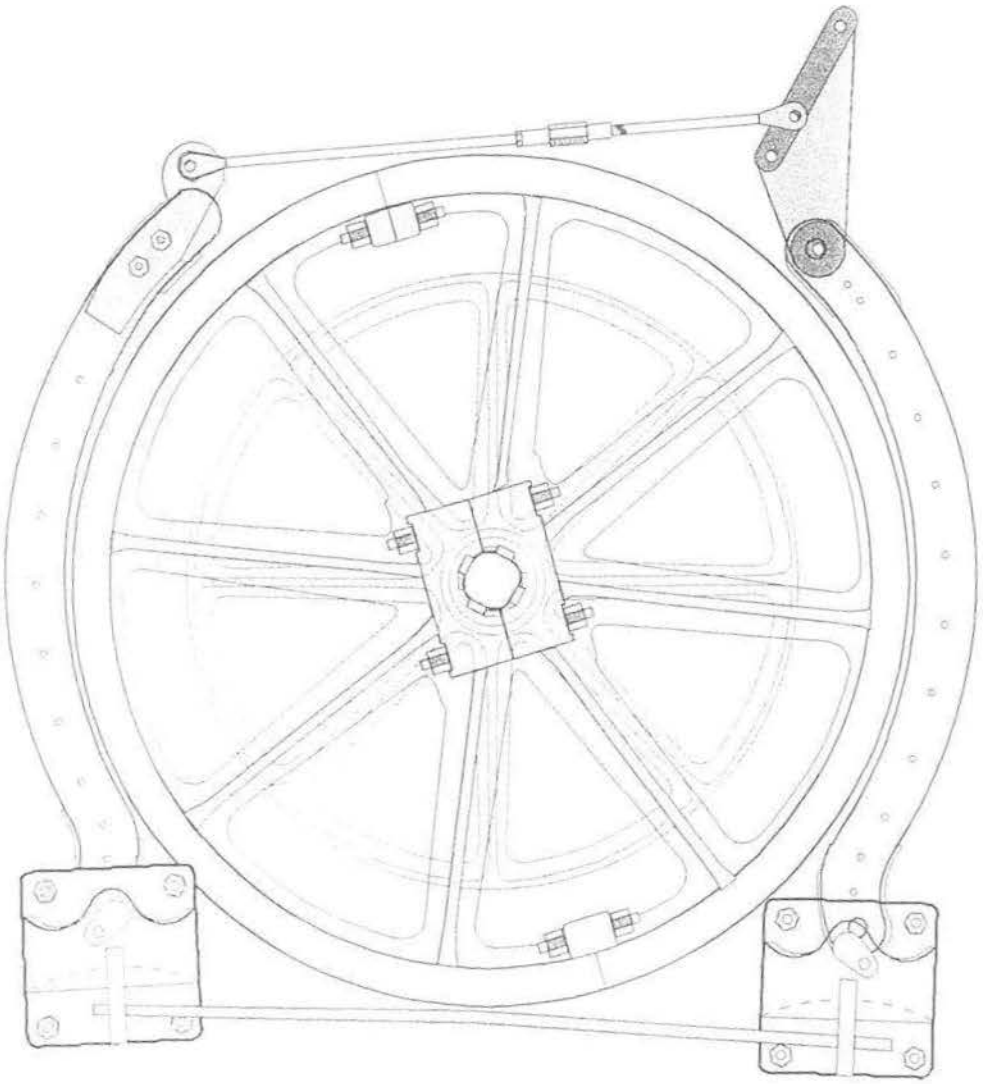


Fig.7

V2 incline drum winding house - south end profile and elevations including drum configuration and brake mechanism Scale 1:40



The caliper brake mechanism - internal elevation - scale 1:20
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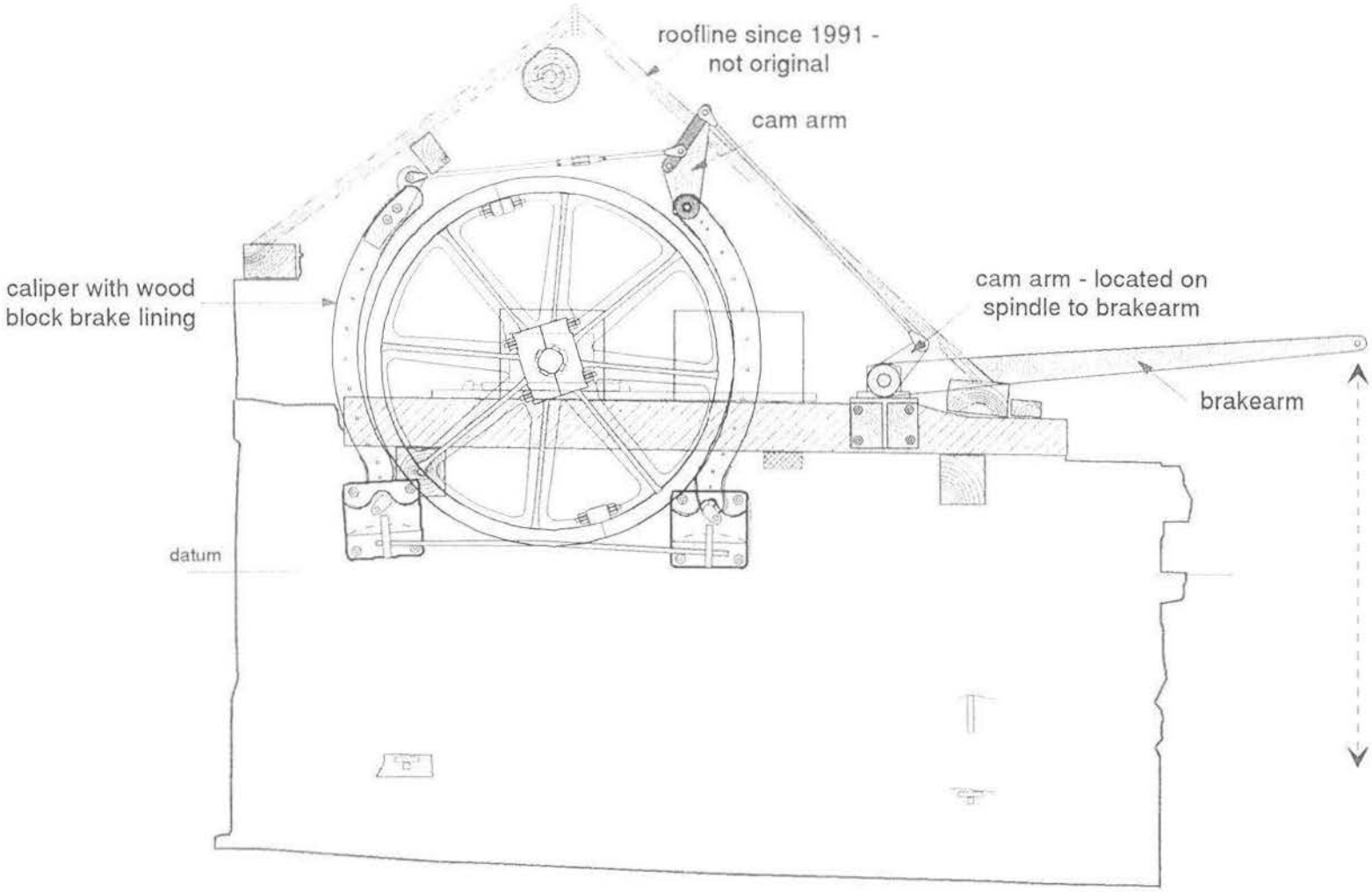
Fig 8



V2 incline drum winding house - west wall internal elevation
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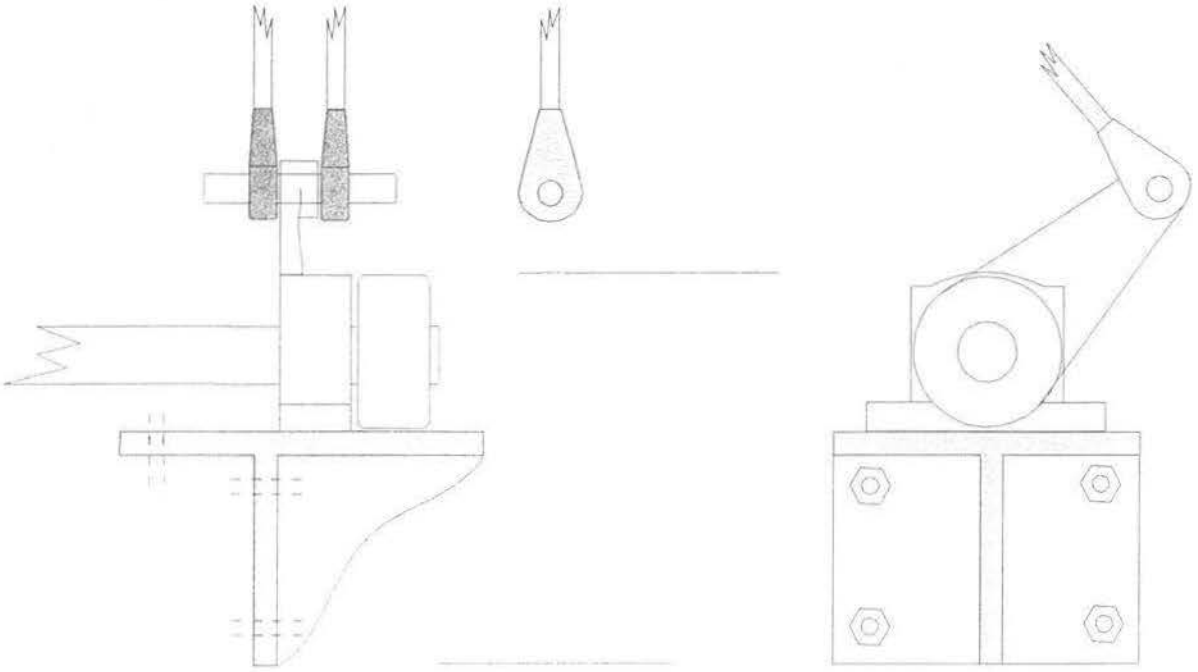

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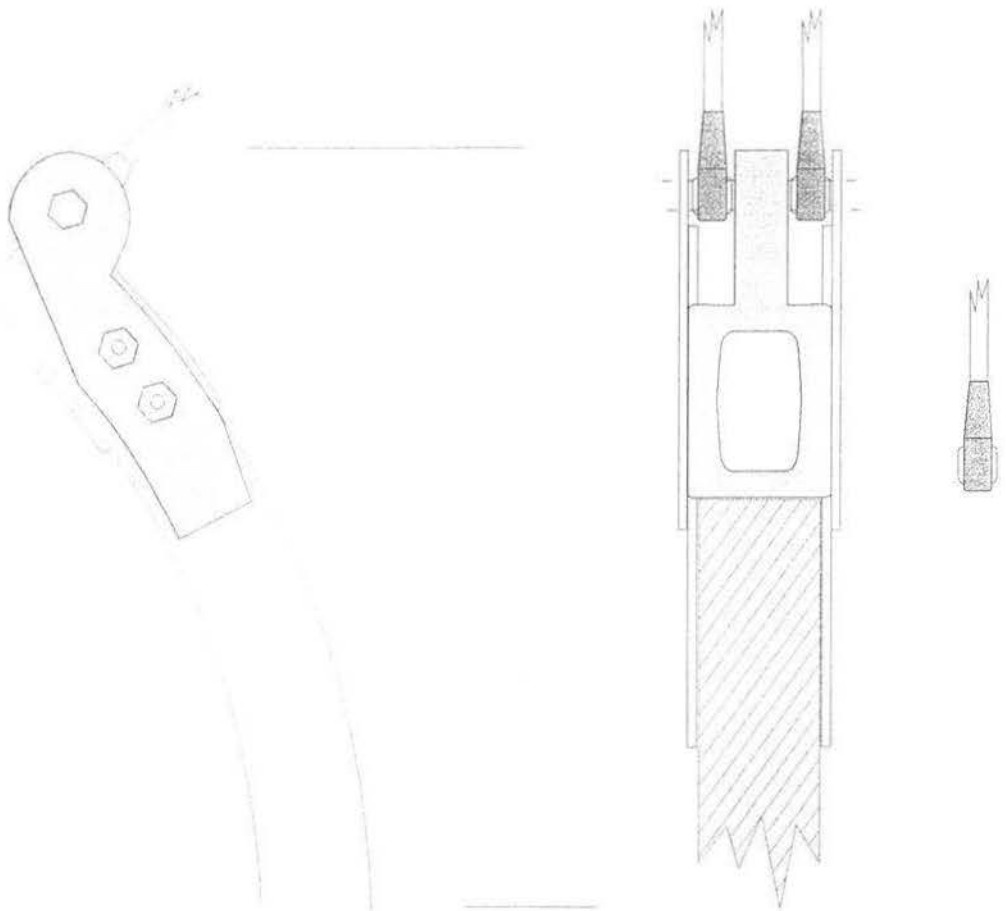
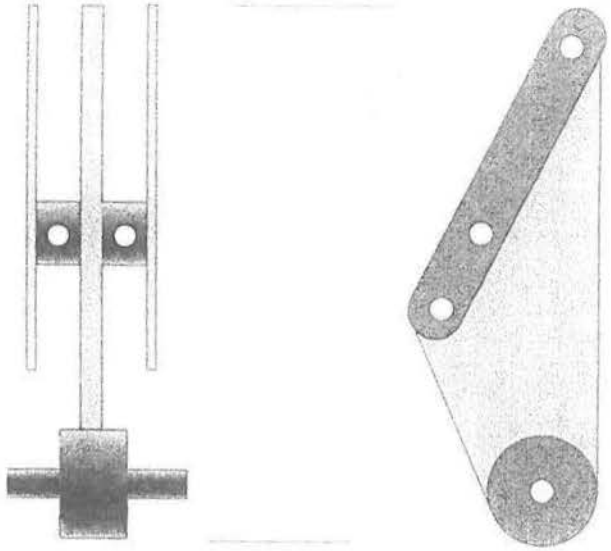


Elevations of brake caliper arm, brake block retainer and draw rod fastening. - scale 1:10

Fig. 10



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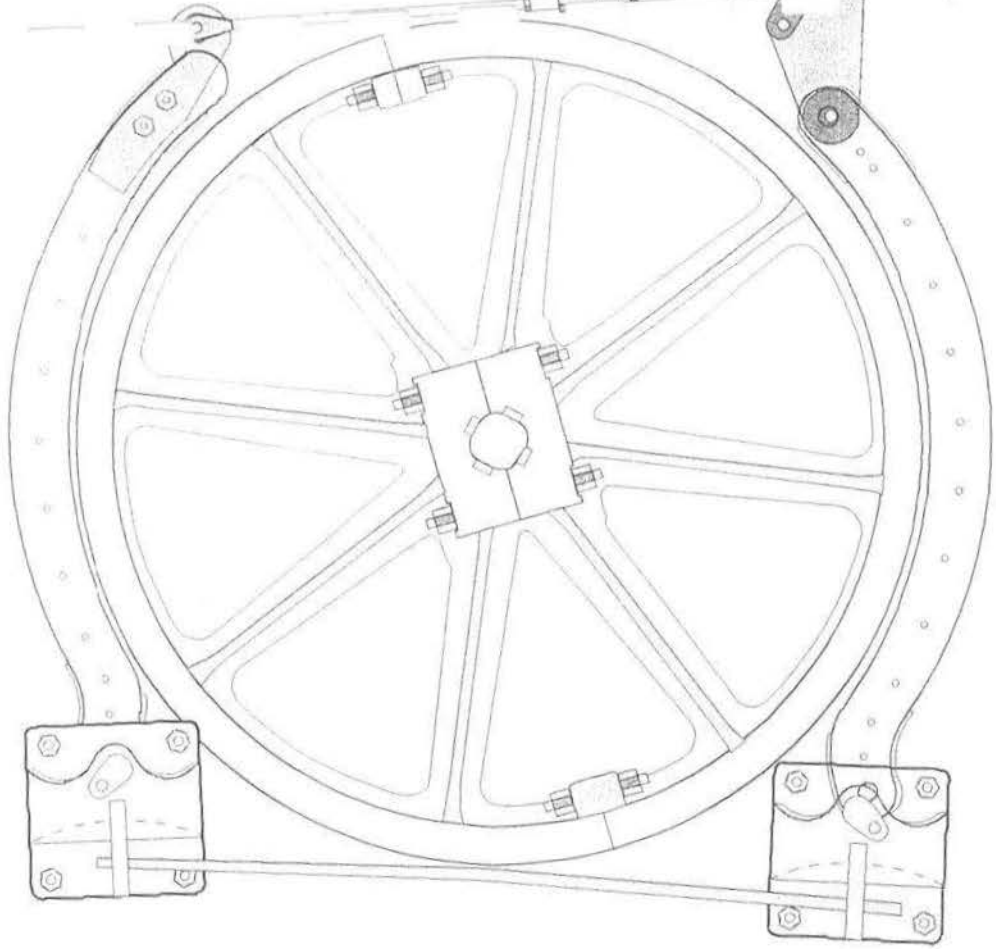
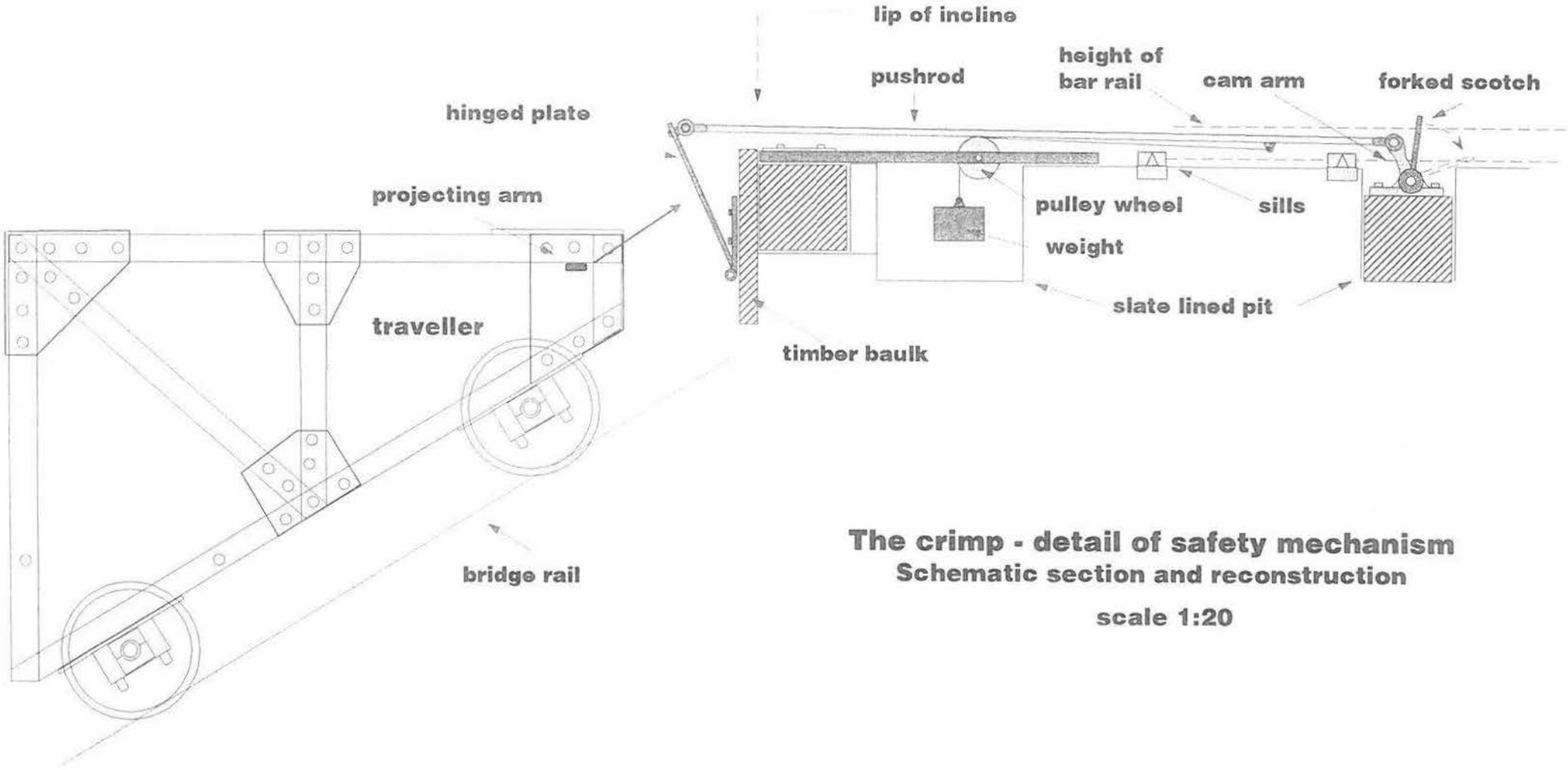


Composite side elevation of brake mechanism - scale 1:20
- note two piece casting of brake wheel

Fig. 11



The crimp - detail of safety mechanism
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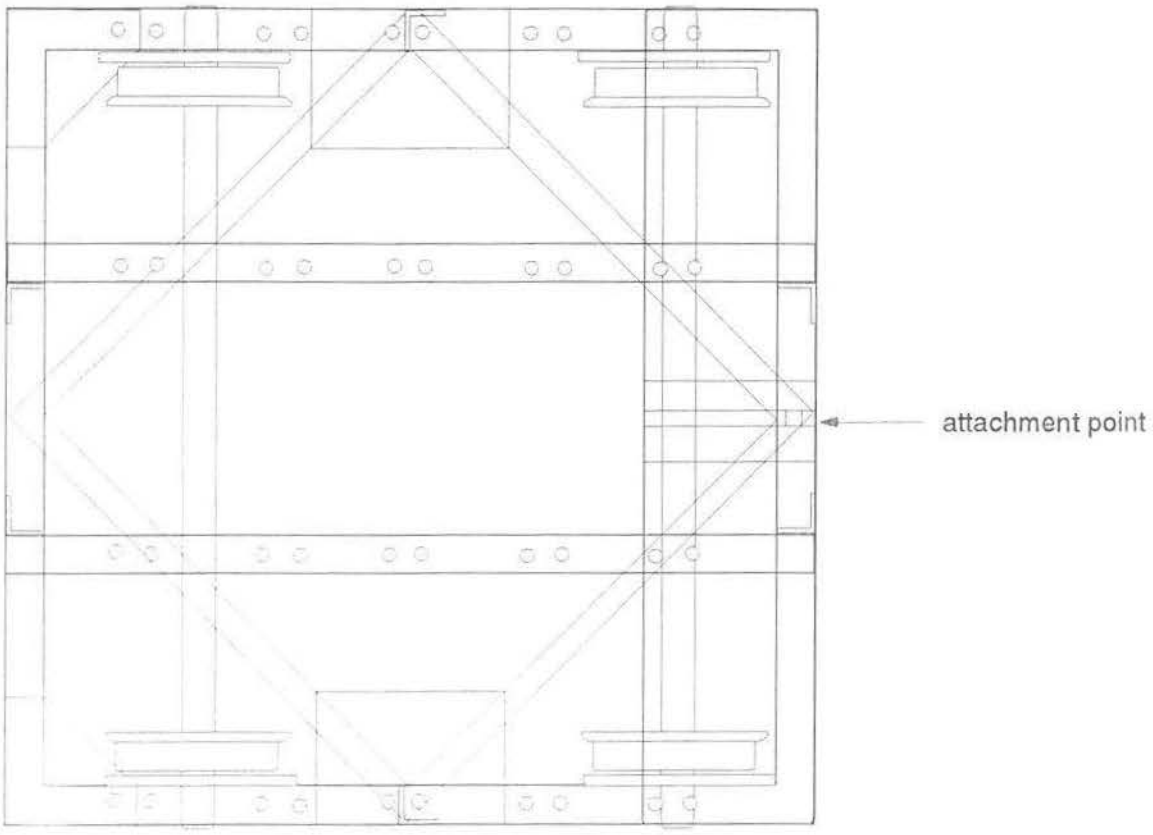
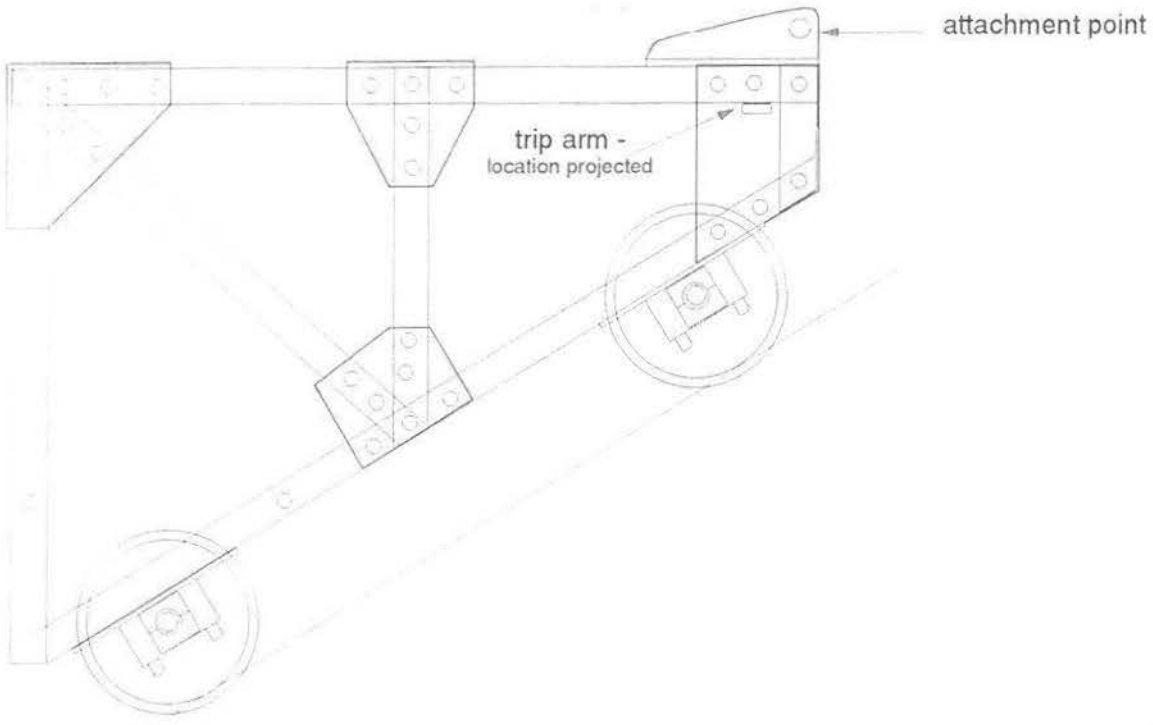
Fig. 12

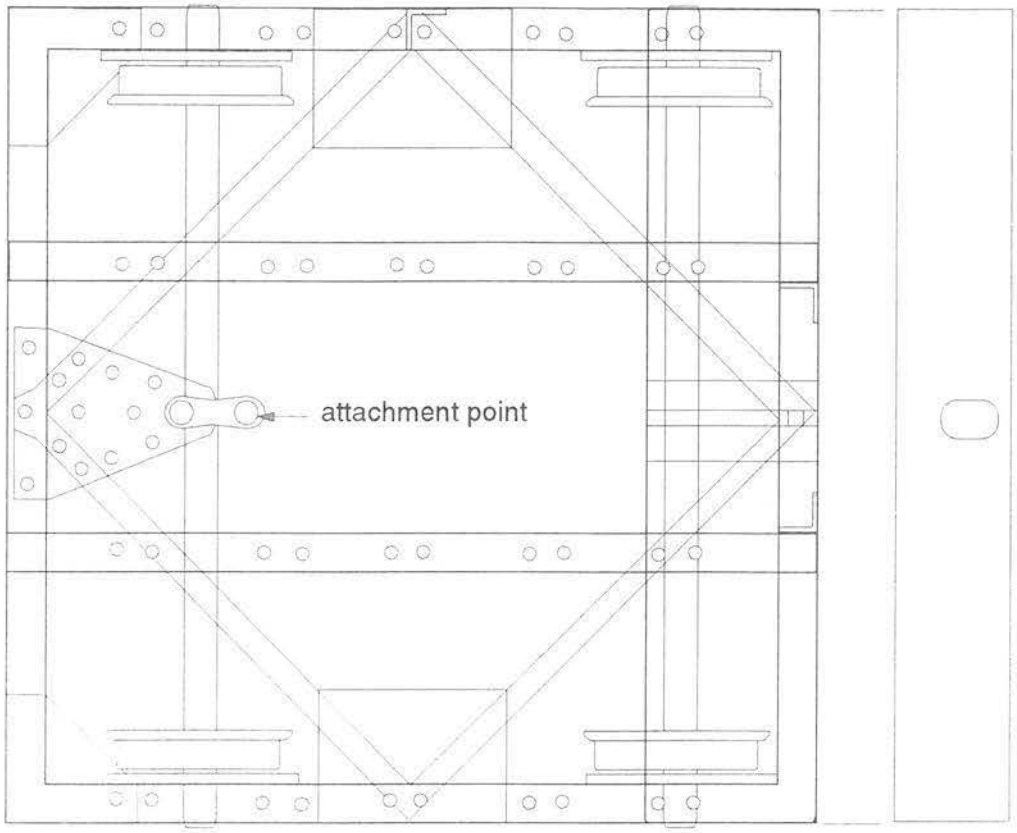


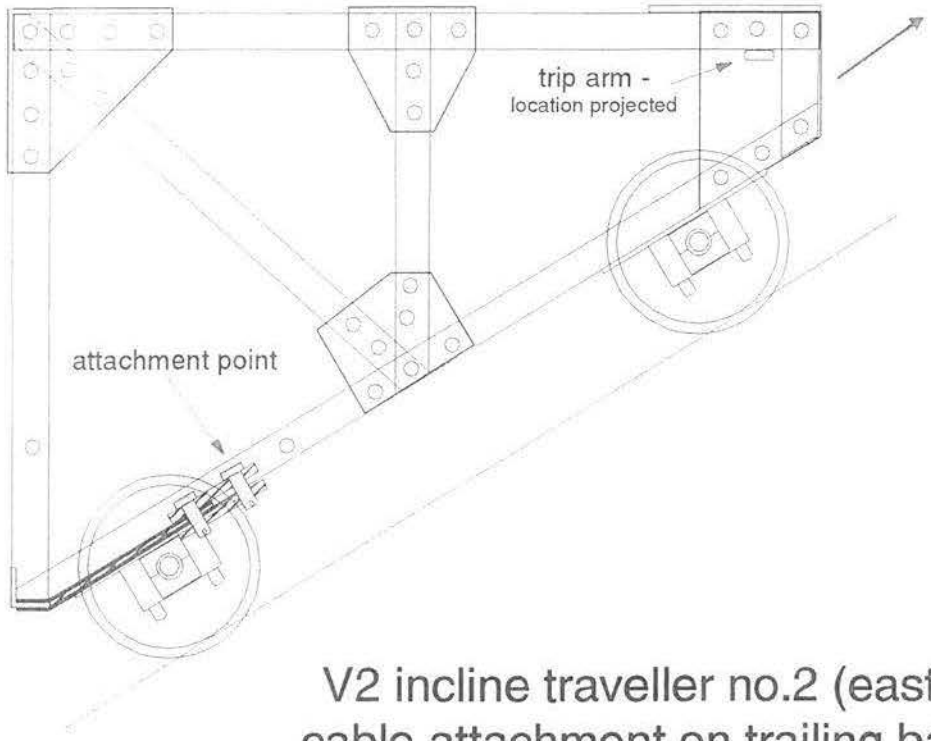


V2 incline traveller no.1 (west side) -
cable attachment on leading top edge

Scale 1:20

Fig. 13

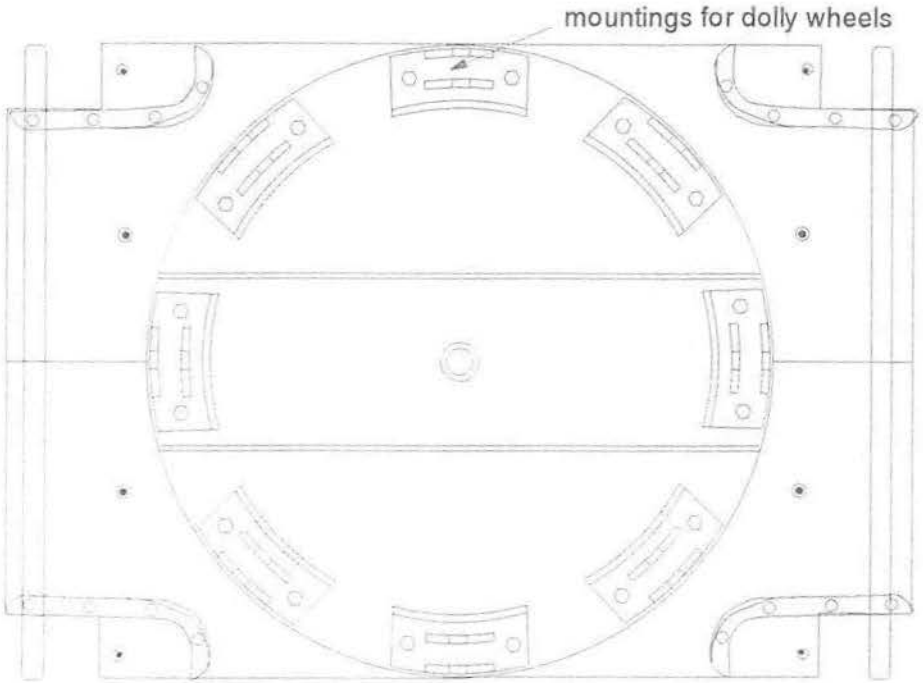




V2 incline traveller no.2 (east side) -
cable attachment on trailing back edge

Scale 1:20

Fig. 14



Plan of turntable traverser located inside V2 drumhouse prior to excavation - scale 1:10
An axle at each end would have held wheels with an internal flange. An estimated gauge of 37"is compatible with this traverser having been used in the pit (T2) adjacent to where ıe traverser was located.

Fig. 15

1 INTRODUCTION

The National Museums and Galleries of Wales propose to restore as a working exhibit the V2 incline in the Vivian department of the former Dinorwic Quarries, Llanberis, Gwynedd. As the site is a Scheduled Ancient Monument, Cadw: Welsh Historic Monuments will need to authorise all works in advance. Gwynedd Archaeological Trust was asked by Posford Duvivier as Consulting Engineers to record the site by survey and photography, aided by archive research and the examination of similar surviving features.

Gwynedd Archaeological Trust's brief for recording of the V2 incline envisaged the following components:

1 A history of the site
2 A description of the remains
3 Plans and section-drawings at relevant scales
4 Photographic coverage
5 Interpretation drawings and description
6 Recommendations for further work
7 Conclusion and summary
8 List of references

An initial report confirmed that some of the site-features required the turf and topsoil to be removed before full recording could be carried out. It is the purpose of this document to describe what this clearance work has revealed of the V2 incline.

2 METHODOLOGY

2.1 Desktop study

Desk-top study of the Vivian incline and of the development of the Dinorwic Quarries as a whole was carried out in the Caernarfon Record Office (henceforth CRO) of the Gwynedd Archives service. The surviving archive of the quarries themselves was consulted, as were Vaynol estate records, in particular the extensive and detailed survey of the estate carried out in 1869, and official maps and plans carried out by the ordnance survey and by the London and North Western Railway. The Porth yr Aur manuscripts at the University of Wales, Bangor (UWB), were searched for references to Dinorwic's possible early incline system in 1788. Use was also made of a private copy of a photograph of the incline in 1896, of which another copy is preserved in the CRO.

2.2 Survey and excavation

The first stage of the work involved a topographical survey of the site, which was carried out using a Geodimeter Total Station; survey results were processed using Survey Control Centre 2.5 (Steanne Solutions) and presented through FastCAD3. Archive photographs were taken on black

and white film. Building elevations, structural details and individual features were recorded by measured survey, supplemented by colour prints and slides, and were subsequently redrawn and processed through Micrografix Designer version 6 and FastCAD3. A list of the drawn record not included with this report is given in **appendix 1**.

3 HISTORICAL SUMMARY

3.1 The Gwynedd slate industry

Slates have been worked in Gwynedd since Roman times, and by the Early Modern period a small but flourishing export trade is recorded with the ports of England and Ireland. More systematic exploitation of the local slate veins came with the acquisition of the Penrhyn estate in Dyffryn Ogwen by Richard Pennant, a Liverpool merchant, between 1765 and the early 1780s, who reinvested the capital from his Jamaican sugar estates in the quarry at Cae Braich y Cafn. The example was not lost on other local landowners, including Assheton-Smith of Vaynol (in Welsh, Faenol), who began to develop his Dinorwic Quarries from 1787, whilst incoming capitalists and entrepreneurs assumed control of the existing workings in the Nantlle and Blaenau Ffestiniog districts. These four areas dominated slate production in Gwynedd, which dominated slate production world-wide until decline set in at the beginning of the twentieth century, and which led to the closure of some of the surviving major quarries, including Dinorwic, in the late 1960s (Lindsay 1974).

3.2 Dinorwic Slate Quarries

The various workings on the western slopes of Elidir Fawr which went by the name of the Dinorwic Slate Quarries and which included the Vivian quarry, formed part of the extensive Vaynol estate, and were first exploited systematically by its owner, Thomas Assheton Smith (1752-1828) from 1787, when his agent set up a company to work them. Other lessees followed until 1821, when Thomas Assheton Smith II began to work the quarry directly.

Early operations had been hampered by poor transport; one route for the finished slates involved carting them down a steep road through Fachwen woods to one of the quarry's quays at Gilfach Ddu, where they were boated over to a stockpile at Cwm y Glo, whence further carts took them to Caernarfon (Illsley and Roberts 1979). It has been suggested that an incline was used at this early date, and that its course lay under the later Vivian inclines (Carrington 1994); this seems unlikely. From 1825 a 2' gauge railway took the slates to the sea at a purpose-built port at y Felinheli, to be replaced by a more substantial system on a different alignment, partly along the shore of Llyn Padarn and passing near the foot of the V2 incline, to the 4' gauge, in 1843. Five years later, two locomotives arrived to work it (Boyd 1986), and steam power was also put to sawing the slate blocks in the quarry for the first time (Eardley Wilmot 1859).

A massive programme of investment in the quarries from 1869 onwards led to the construction of a huge quadrangular workshops complex at Gilfach Ddu, near the eighteenth century quay, where tipping of slate rubble in the waters of Llyn Padarn had created a virgin site. From around this

time, a new quarry was opened in the Fachwen woods overlooking this site, which came to be known as the Vivian quarry after Louisa Alice Duff Assheton Smith married Charles Crespigny, third Baron Vivian, of Plas Gwyn, Pentraeth, Anglesey in 1876 (*Burke's Peerage*) - a connection strengthened when her husband's half-brother, the Hon. Walter Warwick Vivian, was taken onto the quarry payroll in 1880-1, and became Manager in 1884 (XDQ 2479, *Minutes of Evidence Taken Before the Royal Commission on Labour*, p. 236, col. b).

3.3 Development of railed transport

The use of railed vehicles in extractive industries dates from the early years of the sixteenth century, with the expansion of continental mining. A primitive wooden railway carried coals at Wollaton in Nottinghamshire from 1604 and from the same period railways of narrow gauge operated in mines along the banks of the Severn near the site of the future Ironbridge, running directly from the coal-face to the surface and then down to the river bank on an arrangement that may have involved inclines operated by a windlass (Lewis 1970). The introduction of cast-iron rails from the 1780s onwards enabled these railways to carry a more substantial payload, and it was in this form that internal railways, to a nominal 2' gauge, first appeared at Dinorwic in 1811 (UWB Porth yr Aur 30435), making use of an oval-section rail devised at Penrhyn Slate Quarry *c.* 1800, on which wagons with double-flanged wheels ran. It was this material that was also used for Dinorwic Quarries' first exit railway to the Menai Straits at y Felinheli, opened in March 1825. Wrought-iron rails, whose value was demonstrated at the opening of the Stockton and Darlington Railway in 1825, thereafter rapidly became commonplace on railways throughout the United Kingdom, and superseded earlier forms of rail at Dinorwic as elsewhere.

The counter-balance incline, in which loaded wagons drew up empties on parallel track, was patented in 1750 by the Edinburgh advocate Michael Meinzies, though the first recorded examples were to be found in the Siberian mining field from the same period (Lewis 1970). One was proposed for the Bryn Glas quarry at Dinorwic in 1788, but it seems not to have been built (UWB Porth yr Aur 29080, Lindsay 1974), and the suggestion that its formation paralleled or underlay the formation of the V2 incline (Carrington 1994) is unlikely in the extreme. Three counterbalance inclines were constructed on the Penrhyn Quarry Railways in 1800-1801, and others were at work in Penrhyn Quarry itself by 1804 (Bingley 1804). Inclined planes were in use at Dinorwic by 1829, probably operated by horse-whims, and there is no definite record of a counter-balance until 1840 (*Caernarfonshire Record Office Bulletin* 3, 1970, p. 3, Carrington 1994).

Most inclines, whether powered or counter-balanced, hauled the trucks on their own wheels; however, the V2 incline, like several other inclines in the Dinorwic complex, including examples from Vivian, was a transporter incline, in which the wagons were carried on wedge-shaped travellers on broader gauge rails. The earliest example of such a system is recorded at the Cyfarthfa ironworks, Merthyr Tydfil, in the late eighteenth century (Hughes 1991) and they were found in all of the major Gwynedd slate quarrying areas. They had the advantage that the slate wagons themselves did not have to be attached to, and disconnected from, the haulage rope but could simply be wheeled on and off the transporter.

DATE PLAQUE 1886.

3.4 The V2 incline

The lowest gallery in Vivian quarry was in production by 1873, but the upper workings are not marked on a plan of that year (CRO X Plans R 72). A valuation dated 1877 (CRO: XD 40 1 4) refers to the Vivian 1 tank incline and the Vivian 2 tank incline - since V1 is not a tank but a conventional incline, it may be that these were numbered from the levels which they served, and that therefore the 1 tank incline is the V2 incline. In any case, a date between 1873 and 1877 is indicated for the construction of the V2.

The same source also puts a value of £100 on the bridge at the foot of the V2 incline, which took waste blocks from the quarry across the 4' gauge quarry railway to y Felinheli to tips in the lake. From the evidence of old photographs, unfortunately undated, this appears to have been a timber construction, later replaced by an iron bridge.

As built, therefore, it carried finished slate from the galleries of Vivian Quarry to the marshalling yard at Gilfach Ddu, and slate rubble (generally more than 90% of the rock extracted) from the gallery at the level of its own drum-house to a tip at its foot.

The 1889 25" ordnance survey (Caerns. XVI 8) shows inclines V1 to V5 in place, and the 1900 shows V1 to V7; V6 and V7 appear to have been at the planning stage in 1888 (CRO: XDQ 1914).

A number of changes are known to have taken place to the form and function of the V2 incline. In 1900 a railway was completed from its summit to a high-level tip near the quarry hospital to the north, crossing the Padarn railway on a substantial slate-built arch. This rendered the iron bridge redundant and it had been removed at the time of the 1914 ordnance survey. From this time the V2 incline ceased to carry rubble. At some stage the wooden travellers were replaced by steel ones; the originals are shown on a photograph of 1896 (CRO: XCHS 1072 134), but the quarry's yard book records the purchase on 11 March 1904 of "double plates, red paint, rivets, bolts and bar iron" for the "Vivian tanks" (CRO: XDQ 253 p. 295), which may record the change-over.

The Vivian quarry continued to produce slates until February 1960 (CRO: DQ 18) though the records do not specify the gallery, and it is believed that the inclines had already become disused by this stage. It has been suggested that the inclines were disused as early as 1936 (pers. comm. from former Dinorwic quarrymen).

3.4 Terminology

In Dinorwic the travellers were known the quarrymen as *tanciau*, s. *tanc*, and the inclines themselves were known as *gelltydd*, s. *gallt*; the more common Welsh word *inclên* was not used here (Jones E 1962).

4 DESCRIPTION AND INTERPRETATION OF THE UPSTANDING FEATURES OF THE V2 INCLINE

Structure 1: the incline

This spans an earlier road – there is a date plaque of 1886 above the east side archway, which may date from a reconstruction of the bridge evidenced in the stonework; there is a marked contrast between the use, or possible re-use, of hand dressed slate blocks and sawn slate blocks. This is most apparent in the upper sections of the incline, north and above the bridge arch.

Much of the physical evidence for the construction of the two incline tracks is now lacking. Remnant *bridge rail* beneath the pair of iron and steel travellers, now both residing in the pit at the base of the incline, indicate a gauge of 5'6. Each rail was supported on sections of timber set longitudinally, interspersed by at least seventeen shorter timbers, set perpendicular and at right angles to them. These shorter timbers, which created 'box' sections with the longer timbers, served as both a brace and a platform into which slate blocks were laid, thereby creating a solid stable unit. The timbers were secured to each other by steel tie-bars which ran through the length of the shorter timbers. Additional stability may have been gained by the presence of other timbers set horizontally into the incline structure, and so providing fixing points for the timbers laid on the incline bed; some evidence for this survives on the V3 incline. There are no dimensions available for the timbers.

Structure 2: the drum house

A substantial structure built of large, mainly hand dressed, slate blocks, although both gables above the level of the bearing are of smaller blocks. The drumhouse is open ended to the north facing the V3 incline, and to the south facing the head of the V2 incline. It is butted on the east side by a *brakesman's cabin*, (structure 3) to the south, and by a *shelter*, (structure 4), to the north. The structure was slate-roofed; the pitch of the original roof was probably slightly altered during restoration works in 1991.

There is evidence of change to both the structure (see excavation summary) and to the drum braking mechanism housed within.

The drum comprises five cast iron spoked wheels (1-5) mounted on a 5" diameter spindle. A bearing at each end held the spindle for drum and brake. There are three casting variations, grouped as 1,4 – 2,5 and 3 : Two have broken spokes - 3 and 5, and 4 have been repaired. There are no surviving planks on the drum but wheel spacing suggests that the drum was single.
The incline drumhouse (in the Welsh of the Arfon quarries, *rowler,* from the English "roller") is in its form and construction substantially similar to other features in Dinorwic and in North Wales slate and stone quarries generally. Most inclines made use of a single drum, consisting of planks of timber attached longitudinally to cast-iron spoked wheels running on a substantial spindle. These were generally mounted above the level of the rails, though examples have been noted where they have been placed in a pit below - as at Lernion level in Dinorwic quarry, where the equipment survives largely intact. Others made use of a subterranean sheave on a vertical axis, as on the V1

incline.

The brake is a twin caliper type mounted directly onto the spindle inside the drumhouse.

There is evidence, both structural and archival, that this is not the original arrangement in the drumhouse. An archive photograph of 1896 (CRO: XCHS 1072 134) suggest that a braking system and/or gearing for such was located outside the drumhouse, on the east side, apparently covered by a wooden hood separate from the existing slate roof. Both were supported on twin mounting beams, the outer being carried on a cantilever built into the drumhouse wall.

An aperture, now blocked, would have given access to the internal bearing. Such an arrangement is still visible, for instance at the V3 incline drumhouse.

Further evidence of an externally mounted wheel, or wheels, is the area of the wall coated with grease, long since hardened. The extant braking system supercedes any arrangement represented by the grease coating, as all fixtures and mountings retaining the brake clearly overlie or are cut through this feature. It is reasonable to assume that the evident changes were contemporary with any structural modifications to the drumhouse and reconfiguration of the floor arrangements. (see **5 Excavation summary**)

Inclines were most commonly braked by a simple caliper brake, operated by a hand-lever, a job which required constant vigilance on the part of the brakesman, as premature breaking could cause the wagons to jam before they had finished their journey and too lax an application could cause the loads, and even the wagons, to shatter at the end of their journeys.

Structure 3: the brakesman's cabin

Located to the south east of the drumhouse on the same orientation, the cabin is built on the edge of the artificial terrace that has subsided slightly in the past – although little of the building now survives, it is clear that it was mortar-bonded and that some, if not all, of the internal elevations were rendered. The cabin is broadly contemporary with the incline being built over against some features of the drumhouse itself. The ground-plan of the cabin was recovered by clearance and limited excavation. One doorway is evident on the west side facing the crimp, butting the drumhouse – this is now infilled. There may have been another doorway at the north-eastern corner although the building is completely robbed away on this side. Two windows are evident from archive sources, one adjacent to the doorway to the west and another facing down the incline to the south. A fireplace was located in the centre of the south wall. The original floor surface has been removed but the level may be determined by presence of two massive slate slabs that served as an anchor for the "ship's wheel" capstan that controlled the movement of the brake arm. The setting for the capstan is recessed into the two slabs above which the connecting rod would have entered through the roof directly above. Although there is no surviving structural evidence, the archive photograph of 1896 shows that the roof was single pitched to the height of the eaves of the drumhouse roof.

The V2 incline control, whereby the brake was operated by a ship's wheel control, appears to

have been unique to Dinorwic, and again a surviving example may be noted at Lernion level.

Structure 4: shelter or caban

Located north of, and butting, the north end of the east of the drumhouse wall; aligned 23° east of drumhouse orientation. The structure, essentially drystone, stands probably almost to its original height of <2.0m. The building, originally roofed, was single pitched with the eave on the east side, like the brakesman's cabin. There is an entrance adjacent to the drumhouse but no windows and there are traces of internal rendering. The building just overlies the south-east corner of the traverser pit (feature 1; see **5.2 Excavation synopsis**), and was built after the extant braking system was installed, evidenced by the location of its south end wall. The original floor surface was not uncovered. The building was probably a shelter for the drumhouse crew.

Structure 5: caban

Located at the foot of the V2 incline, north and east of the traveller pit. The building has been partially restored, and has a door at the south-east corner and a single window on the south wall. There is a fireplace and chimney in the east gable. The roof is twin pitched and slate roofed. Traces of a smaller single pitched building can be seen on the external west gable against which it was butted. The archive photograph of 1896 shows that this was furnished with a door and single window, also in the south wall.

5 EXCAVATION OF THE V2 INCLINE AND ASSOCIATED FEATURES

5.1 Location

The VR incline is situated immediately to the north-west of the open slate workings known as Vivian quarry in the Padarn Country Park within the community of Llanddeiniolen. It rises through a wooded hillside, formerly part of the Fachwen plantation, and crosses over a metalled road which gives access to the Quarry Hospital, open to the public as part of the Padarn Country Park.

5.2 Excavation synopsis

Uncovering/excavation was carried out at two discrete locations, the first (A) at the head of the V2 incline which encompassed the ground surface within and immediately adjacent to the drumhouse, and the second (B) immediately south and east of the traveller pit at the base of the incline, the former intersection of the V1 and V2 inclines with the now demolished iron bridge that once spanned the exit railway to Y Felinheli.

Area A revealed extensive evidence of the latter-day configuration of the *crimp* on the south side of the drumhouse and to the north an infilled *traverser* pit was revealed . The location of the former rail tracks between V2 and V3 and within the drumhouse itself was also discerned.

Area B provided evidence of another traverser pit located between the V2 traveller pit and the still extant bridge abutment. This pit too had been backfilled and a later wall built across the west end of the feature.

Area A - excavation

Three short stretches of drystone walling were removed to allow complete access to the floor deposits both within the drumhouse and at the head of the incline. These are recent features, the location of which are shown on the topographical survey. The wall constructed at the lip of the incline, already substantially slighted, was built in conjunction with the limited restoration work carried out by Cadw in 1991. The surface upon which these features had been constructed was a patchy mixture of topsoil and fragmented slate bound together by plant roots. This was removed to an average depth of < 0.15m but > 0.10m across the entire area to reveal the working floor associated with the latter period of the incline's working life.

Most of the original features, fixtures and fittings relating to the operation of the incline winding house, and uncovered beneath later floor deposits, had survived fairly well and there is therefore little ambiguity in understanding the working arrangement. However, study of the upstanding remains coupled with the archaeological evidence indicates two distinct phases of construction, the latter phase relating to both structural alterations to the drumhouse itself and a corresponding change in the layout of the arrangement of the rails running to the incline head. The reasons for this will be discussed elsewhere in this report. Recording of the internal floor arrangement therefore reflects the later period of use only.

The features recorded within Area A are as follows; the location and function of each will be described from north to south (*i.e.* starting from the foot of the V3 incline moving towards the foot of the V2) or as otherwise appropriate. *Overall dimensions in metres are approximate.*

Feature 1: traverser pit

6.8m x 2.0m. orientation east-west, 13 degrees off parallel to drumhouse orientation - located outside the north end of the drumhouse. The pit had been infilled by slate waste and was turf covered. Excavation suggests the following method of construction; that this was a *cut* feature, roughly square sided, perhaps originally some 0.4m deep. Two wooden beams (8" x 6" approx.) were then laid parallel onto a slate slab bed. These were revetted along the outer side by slate blocks and slabs forming a *bench*, approximately 0.3m wide x 0.25 m deep extending some 0.1m above the height of the beams. Between the beams was a well compacted infill of slate debris and subsoil surmounted by slate slabs forming solid packing to hold the beams in place. Onto the beams were mounted lengths of rail, set 37" apart, held in place by nails. The *benches* were surmounted by other beams (12" x 5" approx., totalling some 21' in length) making their top surface flush with ground level. These in turn were held in place by cross-members at each end (6' x 12" x 5" approx.) held together by means of an L shaped bracket at the junction of the vertical external surfaces. At the west end of the feature a broken section of guide plate, bolted through the cross-member was still in place. Little of the upper timbers survived except at the west end and may have been removed completely along the northern edge. Similar guide plates,

or perhaps *chairs* may have once existed along the other edges also. Immediately north of the traverser pit, evidence for rails between the V3 and the V2 was discovered.

Traverser pit - discussion

The pit appeared to have been backfilled when the *caban* located at the east end of the pit was still in use. This is suggested by the presence of a number of carefully laid slabs, forming a path, which comprised the upper part of the fill at that end of the pit. The pit clearly pre-dates the *caban,* which is built across the south-east corner of the pit. Archaeology supports the documentary evidence that the pit was end-loading to the west and side-loading to the north and south. There was no evidence to suggest that the pit had been end-loading to the east at any time prior to the construction of the *caban.*

This area would have formed a complex focal point for three different types of traffic movement (finished slate passing from the V3 to the V2, finished slate passing from the V2 level on to the V2 incline, rubble from the V2 level passing to the V2 tip or [before 1900] passing down the V2 incline). The use of a railed traverser can be paralleled elsewhere in Dinorwic, but is rare in the North Wales slate industry.

Feature 2: rail gauges, rails, sills, chairs and sleepers

The gauge of all the extant and postulated courses of surface railtrack uncovered was 1' $10^{3}/_{4}$". (This does not apply to the gauge of the rail sections laid in the two traverser pits which is non-standard [Areas A and B]. The gauge within the pit between V3 and V2 appears to have been 37" whereas the pit at the base of the incline is 33").

For the most part, and certainly within the drumhouse itself, the rails were carried on cast-iron sills laid straight onto a contemporary ground surface. In some instances it was apparent that these had been held in place by iron spikes or nails inserted into the ground along the long edges of the sills. There was no provision for fixing through the casting itself. Some twenty-four sills were recorded *in situ*; most were broken and heavily corroded. Two types of sill casting were recognised, one being narrower than the other but stylistically similar. Chairs were in evidence in some places where sills were absent, similarly laid directly onto the ground surface, in general however, these castings were most evident at locations where they had been attached to wooden beams (not necessarily sleepers) *i.e.* at the lip of the incline or on the mounting beam for the safety mechanism (or scotch) on the crimp. Three stylistically different castings of chair were recorded, each provided with two holes for driving spikes through. There was no evidence of any of the aforementioned castings having been set onto wooden or slate sleepers within Area A although a broken section of a slate sleeper was recovered from clearance of later walls prior to excavation.

There were latterly four lanes of track between the traverser pit (2) and the lip of the incline. The layout of the tracks within the drumhouse were recovered by projecting the line of the rails between surviving elements ie: sills and chairs. The type of rail employed within the drumhouse, and from example, on most of the levels, were rectangular section bar rail 3"x ½", commonly

occurring in 6', 12' and 18' lengths. A 6' length of rail survives on the west side of track 2 adjacent to the lip of the incline. All tracks cross over and are incorporated with a safety mechanism (3 and 4) countersunk into the ground on the south side of the drumhouse. The track terminated at the lip of the incline, originally defined by a single timber beam, estimated at 12" square and some 20' in length. The juxtaposition of six chairs lying above the remains of the rotted timber surviving at this location suggests that the rails were firmly anchored to the beam at the incline head.

The gauge derives from a change in the conventions used to describe permanent way. For a hybrid railway (*i.e.* one from the period 1800-1830 and showing characteristics of both earlier and modern types) using double-flanged wheels, as Dinorwic did from 1811, the obvious way to measure the gauge was centre-to-centre. Later railway practice was to measure the gauge from the inside faces of the rails, a convention which Dinorwic was obliged to adopt from 1870, when it began to use locomotives with single-flanged wheels from Hunslet of Leeds. One set of rails then in use yielded the 1' $10^{3}/_{4}$" gauge, and this was the dimension used when ordering locomotives.

The distinctive form of rail used here was typical of Dinorwic practice. Rectangular-section bar rails (originally simple lengths of merchant bar, later steel bars) were held in cast-iron sills (sleeper chairs), a method which derives from industrial railway practice of the 1820s, and which was introduced to Dinorwic in the following decade, where it remained until the end. It was one of the various types of rail extensively used in the quarry wherever man-power or horse-power was used to propel the wagons; where locomotives were employed, a more conventional bull-head section in chairs on wooden sleepers was used. The use of bar-rail in chairs spiked to slate slab or timber sleepers was also evolved in the 1820s and arrived in Dinorwic in the following decade (Boyd 1986).

Feature 3 – 4: the safety mechanism

Although much corroded, the largely ferrous remains of the safety apparatus was revealed to be substantially intact. This ingenious but simple arrangement consists of two essentially identical mechanisms operating in direct conjunction with the movement of the incline travellers.

Each mechanism consisted of an axle mounted on a wooden beam (12" square) by means of three bearings, the whole being set into a slate lined pit some 4.0m long. Attached to the axle were two forked prongs which when in an upright position protruded above the ground surface and accommodated the bar rails which ran neatly between the forks; in this position trucks within the drumhouse were prevented from passing out to the lip of the incline. (The width between the fork apertures corresponds to the gauge of the rail track, *i.e.* 1' $10^{3}/_{4}$".) A fixed cam situated at one end governed rotation of the axle, the cam being hinged to a push-rod, the other end being connected to a two-piece hinged plate located on the front of the beam forming the lip of the incline. The original position in which the hinged plate was once fixed to the beam may be surmised by the surviving configuration of the entire mechanism. In an 'idle' state the mechanism was always in an 'on' position due to the provision of a counterweight attached to the underside of the push-rod by means of a cable. This cable ran over a pulley wheel located, by means of a

mounting attached to the forward beam, directly above a slate-lined pit (5 and 6) in which the counterweight was housed. The counterweight caused the push-rod to be pulled forward forcing the central element of the hinged plate to be angled outward from its position on the beam at the lip of the incline. The mechanism was released by the forward angled plate being pushed back by an offset arm projecting from a traveller as it arrived at the top of the incline, thus allowing trucks to be loaded and offloaded. The return of the traveller to the base of the incline allowed the counterweight to re-engage the safety mechanism. The mechanism was designed so that the operating parts were offset to one side of the dual tracks serving each of the two incline travellers. In the case of the V2 incline each mechanism was triggered by an arm on the right side of the traveller, looking downslope.

The V2 system appears to be unique to Dinorwic's transporters - though nowhere else do transporter inclines survive in such good condition, and it is possible the system was found in other quarries. It is possible that this system was introduced when, as has been suggested, the inclines were equipped with iron travellers at the beginning of the century; a sketch of such a system in the Dinorwic archives is dated 1904 (CRO: XDQ 3244).

Elsewhere in Dinorwic and in other slate quarries, different forms of safety device have been noted - a substantial hinged bar across the drum-house at waist height, or catch points to derail runaways before they reached the drum. At one incline in Penrhyn Quarry scotches were operated by a lever to allow wagons to pass; at Maenofferen a lever operated a scotch (Boyd n.d.).

Feature 7 – 8: the incline lip

A wooden beam (20' x 12" x 12") running across its entire width defined the lip of the incline. The beam was located upon a recessed bench (7), an integral part of the slate construction of the incline head. On the west side the beam was retained by an iron bracket (8) that was anchored to the foundations of the drumhouse wall. The bracket encased a smaller beam set into a slate lined pit that intersected at right angles the pit enclosing the mounting beam for the safety mechanism, thus maintaining the stability of both elements along this axis. On the east side the beam was apparently retained under the east wall of the brakesmans' shelter and the incline abutment. Surviving vestiges of the forward beam along the length of the bench suggest that this element may have been rebated from the edge, suggesting that the hinged plates releasing the safety mechanism were mounted proud of this on separate timber baulks, thereby accounting for the location of the projecting trip arms on the side of the travellers

Feature 9: the guide wheel and pit

On the east side of the incline head was small, slate-lined pit (0.65m x 0.3m x 0.4m deep). This feature originally accommodated a 2' diameter cast iron pulley wheel, the hub of which was mounted onto timbers built into, and flush with, the top of the pit, at ground level. The purpose of this wheel was to guide the cable coming off the *bottom* of the winding drum, and connecting to the chassis of the traveller (T2) occupying the east side of the incline.

The incline head - discussion

The extant layout of the track arrangements within the drumhouse and the crimp area suggest that the surviving configuration is not original and this is supported by evidence of structural modification to the drumhouse itself. It is clear that available space for the provision of four tracks within the drumhouse was, and is, at a premium; at the south end of the drumhouse both internal wall faces have been cut back, allowing the tracks to fan out across the crimp to the lip of the incline; sills had to be inter-spaced with each other and at ground level the ledge created by cutting back the wall facing had to be recessed to accept one sill; the internal wall faces of the drumhouse are scraped smooth in places where passing trucks had abraded them.

Alterations seen to have been carried out to the surviving elements of the safety mechanism are more ambiguous. It seems unlikely that either unit was entirely repositioned, although it was noticed that the outer prong of the west side unit had been twisted to accommodate the course of the rail which ran through it. On the same side the push-rod too had been angled out to account for the line of the track.

A number of possibilities could account for the modifications that were evident - Internally the drumhouse is smaller than other incline winding houses on the same rake. As this lower drumhouse was the first to be built, it may have been designed only to accommodate a single track to each of the incline travellers, both rails of which could then have passed through the prongs of each individual safety mechanism; the latter arrangement shares a single prong with each set of rails. The widening of the drumhouse structure itself lends some weight to this idea, although the replacement of the original wooden travellers with iron versions may in itself have some bearing. Certainly any difference in the dimensions of the later travellers, and the corresponding location of the trip arm for the safety mechanism, was more simply dealt with: But was the gauge of the incline itself modified at any time?

Area B – excavation

Excavation was limited to an area immediately south and east of the traveller pit at the base of the incline. A traveller pit (11) was partially exposed and some indication of the arrangement for loading and unloading trucks at this location was determined.

Feature 11: traverser pit - excavation

The overall dimensions of the traverser pit at this location are projected due to constraints within the area of excavation – 7.8m x 1.9m x 0.3m deep. The construction of this feature differs in some ways to that investigated at the top of the V2 incline (1). In the first place the feature does not appear to be cut into the ground surface but rather constructed with the surrounding surfaces laid around it, ie. the feature is essentially integral with the man-made level, adjacent traveller pit and bridge abutment. In common with (1), the basis for the feature would have depended on a timber framework, although this was configured differently. The rail-bearing timbers take the form of sleepers in this case, perhaps ten in all (3'6" x 4" x 6" deep) laid laterally across the base of the pit. There were almost certainly wooden baulks, since rotted, interspersed between the sleepers along the edge of the feature, now defined by a series of linear hollows in the hardcore packed between the timbers. Further evidence for such an arrangement may be seen in the

regularity of the vertical facing of the slate benches that carried the longitudinal timbers (estimated 12" x 5") which defined the surface edge.

The rails in this case were 2" square section bar rail, provided with holes at intervals to take spikes for fixing to the timber frame and sleepers tapered at one end. The gauge of the rails was 33", of which two 18' sections survived at the east end of the pit .

There was no direct evidence for loading locations in the form of, for instance, iron guide plates along the pit edges, although the length of the pit relative to the width of the traveller pit to the north is an indication that the pit was probably side-loading rather than end-loading. The eastern extent of the pit provides space for a loop(s) to enter from the top of the V1 thereby allowing the trucks to be correctly orientated to the V2 incline travellers, and the bridge, without requiring a turntable.

Feature 12: loading area

Between the traveller pit and the traverser pit (11) was an area of distinctly uneven made ground, partially grassed over. Investigation was confined to the area bounding the south and east sides of the traveller pit adjacent to the *in situ* No.2 traveller. Excavation showed that the uneven surface was largely due to the subsidence of stone packing around subsequently rotted timbers. One timber was originally located along the outside loading edge of the traveller pit and within the area uncovered there was evidence for two others perpendicular to this set between the traveller and traverser pits. The latter timbers originally bore track between these features, evidenced by a single surviving sill and the impression of rails left in the hardcore spread.

There was no direct evidence to indicate the means by which traffic from the incline crossed the traverser pit onto the bridge but it seems likely that a traverser itself would have served this purpose.

The surfaces immediately to the east side of the traveller pit have been partially disturbed by recent structural alterations both to the base of the incline and the edge of the traveller pit ; this has effectively rendered both travellers captive within the pit. It is still clear, however, that this side, in proximity to the traveller pit was originally surfaced with substantial slate slabs as can still be seen on the west side of both the traveller and traverser pits.

6 SUMMARY

The V2 incline was constructed to serve the Vivian department of Dinorwic Slate Quarries at an unknown date between 1873 and 1877, and remained in use until perhaps 1936. It may have been rebuilt in 1904 with iron travellers instead of the original wooden ones. In some respects it is a typical example of a type of feature once found throughout the North Wales slate industry, but it preserves many very distinctive features that were unique to Dinorwic Quarry. The upstanding structures survive in sufficiently good condition for an initial assessment of the functions it served and the methods used to operate it, and excavation has amplified understanding of the feature.

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7.3 Maps

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Appendix 1: Primary drawn records held by Gwynedd Archaeological Trust

* indicates redrawn in digital format

Fig. 1 1:20

Structure 2 (drumhouse) elevation - interior of west wall

Fig. 2* 1:20

Structure 2 (drumhouse) elevation - south end of west wall showing cut away section to interior

Fig. 3* 1:20

Structure 2 (drumhouse) elevation - exterior of west wall

Fig. 4* 1:20

Structure 2 (drumhouse) elevation - north end of west wall

Fig. 5 1:20

Structure 2 (drumhouse) elevation - interior of east wall

Fig. 6* 1:20

Structure 2 (drumhouse) elevation - north end of east wall

Fig 7* 1:20

Structure 2 (drumhouse) elevation - exterior of east wall

Fig. 8* 1:20

Structure 2 (drumhouse) elevation - south end of east wall

Fig. 9 1:20

Structure 5 (caban) south elevation

Fig. 10 1:20

Structure 5 (caban) north elevation

Fig. 11 1:20

Structure 5 (caban) west elevation

Fig. 12 1:20

Structure 5 (caban) east elevation

Fig. 13* 1:10

Structure 2 (drumhouse) details of brake arm and caliper - plan and elevation

Fig. 14 1:10

Structure 2 (drumhouse) plan and elevation of main bearing for brake and drum

Fig. 15* 1:10

Structure 2 (drumhouse) plan and elevation of main bearing caliper and rods of brake wheel

Fig. 16* 1:10

Structure 2 (drumhouse) plan and elevation of drum and brake wheels

Fig. 17* 1:10

Structure 2 (drumhouse) plan and elevation detail of drum wheel

Fig. 18 1:10

Structure 2 (drumhouse) plan and elevation of details of drum wheel

Fig. 19 1:10

Structure 2 (drumhouse) plan and details of safety mechanism

Fig. 20* 1:10

Structure 2 (drumhouse) elevation of safety mechanism

Fig. 21* 1:10

Structure 2 (drumhouse) details of weight mechanism, guide wheel and sleepers

Fig. 22 1:10

Structure 2 (drumhouse) section and plan of traverser pit to north

Fig. 23 1:10

Structure 1 (incline) plan of incline traveller

Fig. 24* 1:10

Structure 1 (incline) elevation of incline travellers and wheel detail

Fig. 25 1:20

Structure 1 (incline) detail of incline traveller 2

Fig. 26 1:20

Area B (traverser no 2) plan and detail

Fig. 27 1:20

Structure 2 (drumhouse) plan of area to north of traverser pit

Fig. 28 1:20

Structure 2 (drumhouse) plan of drum cable guide wheel pit

Topographical plans from total station survey:

1460/01 - pre-excavation survey

1460/02 - post-excavation additions to above, areas A and B