Plan of Roman Civitas
Discovered at
Wilderspool
1898 by
Thos May, F.R.S.

This Plan contains all discoveries up to end of 1900.
EXCAVATIONS ON THE SITE OF THE ROMANO-BRITISH CIVITAS AT WILDERSPOOL, YEARS 1899-1900.

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Read 15th November, 1900.

This report describes the main results of two seasons' diggings (1899-1900) at Wilderspool, on the site of what has hitherto been termed the Roman station, but what has now been found to be mainly occupied by a civil population engaged in various industries, and not a regular military encampment, and must consequently, in future, be spoken of as a Romano-British civitas, or walled town.

As in previous years, a grant from the Museum Committee of the Warrington Museum, and private subscriptions from Messrs. F. Monks, John Crossfield, T. G. Rylands, L. Greening, R. Davies, W. Owen, A. Bennett, T. May, R. W. Rowson, R. Pierpoint, M.P., and F. R. Roberts, have enabled one experienced and reliable excavator, Mr. John Hallows, to be employed, who has also prepared the photographs and lantern slides used in connection with the report.
Excavations at Wilderspool.

The landowners, Messrs. Greenall, Whitley and Co., have again very kindly allowed access to every part of their home paddock for the purpose of the excavations.

Structural Remains.

Rampart.

West Side.—Since its discovery, in September, 1898, the foundation of the western rampart throughout its entire length, a distance of nearly 100 yards, has been explored. Its outer face and several widths have been uncovered, and cross cuts made to ascertain its construction. At 53\(\frac{1}{4}\) feet from the southern boundary of the enclosure, and for a distance of 15 feet northwards, there are two courses of outer facing stones, consisting of squared sandstone blocks laid lengthwise, those of the lower course averaging 16 inches in length by 9 inches in width and depth, and those of the upper 11 inches by 6 inches. From this point a single layer of larger dimensions, varying from 13 to 26 inches in length, and 9 to 14 inches in width and depth, continues 75 feet in the same direction. A photograph of this portion is reproduced on plate II, No. 1.

The facing stones on the inner side of the rampart, along the edge of the via, which were laid bare in the various cross-sections and for a distance of 27 feet from the N.W. angle, are about 11 inches square by 6 inches deep. The average width of the foundation between the outer edges of these two marginal rows is 9 feet, but in many sections north and south of those just described the squared kerbstones are much tumbled or altogether removed.

The wide joints which occasionally occur between the ends of these roughly hammer-dressed blocks are filled with flakes of the same kind of soft local
Excavations at Wilderspool.

red sandstone closely wedged between them. There is no trace of their having been laid in lime mortar; but the quantity of interlacing roots observed between the interstices has led to the inference that lime or alluvial clay was employed for securing them.

The space between the two rows of facing stones is closely packed with rubble, consolidated with gravel and loamy sand, to a depth of one or two feet.

Beneath the stone foundations there is a bedding, 6 to 9 inches thick, of cobble stones and sandstone rubble, well pounded down upon an equal thickness of made-ground, consisting of sand mixed with black mud or loam, probably derived from the adjoining bank of the river. Little depth of foundation is needed in this locality, the dense glacial sand-bed, forming the subsoil to a depth of about 30 feet, affording a sure basis.

Variations from this mode of construction were observed in three places:—(1) At 143 feet from the south fence of the enclosure, where the foundation of an external wall abuts upon the outer face of the rampart and strikes off at right angles westward; and where also the outer row of facing stones inclines inwards and lies obliquely, partly across the line of the main wall. The footings of the external wall (which will be described later, under the head of "exterior buildings") are of similar construction, and are laid parallel to those of the rampart for a distance of 8 feet, thereby forming a culvert or drain 1 foot 4 inches wide and 9 inches deep, with a floor of squared stones, at the angle of junction of the two walls. (2) At 25 feet further northward the line of the rampart is crossed by a pavement 9 feet in width and 20 feet in length, composed of surface-worn sandstone blocks, about 9 inches square by 5 or 6
Excavations at Wilderspool.

inches thick, covered with gravel. This pavement unites the principal *via* running north and south (just inside the rampart) with a narrow byway or *street* running westward at right angles. (3) At 27 feet from the north-west angle, as stated in my previous report, the marginal blocks of the rampart are of larger size, and the interval between them is filled with a 9-inch layer of boulder-clay, well rammed down upon about a foot of rubble.

*Gateway.*—Near to the north-west angle, where another stone causeway branches off westward along the bank of the river, there are deeper foundations and some traces of bedding for the side-posts of a gateway crossing the rampart, but these traces are very indefinite.

*Ballistarium.*—At 130 feet from the south fence, and extending 13 feet to just within the angle of the external wall above mentioned, there is the foundation of an expansion or buttress, 5 to 7 feet wide, built up against the outside of the rampart. It descends to a depth of 6 or 7 feet, and consists of a bedding, 11 inches thick, of very stiff yellow boulder-clay, overlaid with roughly squared hammer-dressed blocks of sandstone, broken stones from the quarry, and boulders, built up with wide joints, and consolidated with boulder-clay to a further height of 4 feet 3 inches.

*North Side.*—Very little additional information has been obtained with regard to the remains of the rampart on the other three sides beyond what has been recorded in my two previous reports. On the north side, along the summit of the sloping bank of the river, the stone foundation suddenly ceases in a broken line close to the north-west angle, and all traces of the fortification have been removed for a distance of fully 100 feet further, where a roadway has been cut through them. For some distance beyond this fall of the ground only
the hard-rammed bedding of loamy sand and cobble-stones or broken rubble remain, the squared stones having been removed where they were easily accessible along the old Chester road (now Greenall’s Avenue), which passes between the northern rampart and the river. The stone bottoming or platform was again met with at 282 feet eastward from the north-west angle, and its inner and outer facing stones were uncovered for a distance of 24 feet. The space between was found, in three cross trenches, to be packed and consolidated with rubble and loamy sand; and the total width, in two of the trenches, 12 and 13 feet respectively. The facing stones on the outside were smaller than those previously described, and were in several courses, as will be seen in the photograph reproduced on plate II, No. 2.

A presumed gateway in the north-east angle, and the adjoining portions of the rampart on the north and east sides, if they are still in existence, are enclosed within the boundary of a private lawn, and are therefore inaccessible.

East Side.—On the east side, for a distance of 74\(\frac{3}{4}\) feet from the lawn fence, both sides of the foundation of the rampart were uncovered to a point on its outer face situated at 232 feet from the south fence of the field, and 397 feet from the outer face of the rampart on the opposite (west) side in a straight line. Its width in six cross trenches was found to vary from 9 to 10 feet, and there were no squared facing stones remaining on this portion, which was only about a foot below the surface of what was formerly a garden or shrubbery.

A number of trenches were cut in searching for remains of the rampart on the same line beyond this, but nothing more than the hard bedding of pounded gravel and loamy sand, or boulder-clay (in one instance), was met with.
Excavations at Wilderspool.

Ballistarium.—The foundation of what appeared to be a lean-to or rectangular enlargement, built up against the inside of the eastern rampart, was situated at 31 feet from the fence of the lawn, and 248 feet from the south fence. The three walls forming it were 2 feet 6 inches thick, one of which was 26 feet in length parallel to the rampart, and the two return walls, abutting upon the latter, were 10 feet in length (outside measurement), the enclosed space being filled with boulder-clay.

This enlargement, as well as the external expansion upon the western rampart (though only half the size) and the strengthening core of boulder-clay inserted close to the north-west angle, were probably for a similar purpose, viz.: to support platforms for the artillery (tormenta) of the defenders, and to prevent the walls from being shaken to pieces by their concussion when discharged.

In support of this explanation of their purpose, the following similar instances may be cited:—At Housesteads (Borcovicus), one of the stations of the Wall of Hadrian, the thickness of the north wall, west of the gateway, has been increased to 10 feet by stones bedded in clay, between the double casing of facing stones; and a solid platform of masonry 20 feet square is situated on the north of the east gateway. They are supposed to be ballistaria, as several stones of about 1 cwt. to 1½ cwt. roughly cut into a rounded or conical form, were lying near the former.¹ The earthen rampart surrounding the station at High Rochester (Bremenium) on the Watling Street, just north of the Great Wall, averaging 16½ feet, thickens in two places to 25 and 28 feet, and in the centre of them is a mass of clay about 4 feet thick. Here also a number of large roughly rounded stones were found, which

¹ Bruce's Roman Wall, ed. 1867, p. 189.
were evidently intended to be used in the ballistae, and there was proof of the presence of ballistaria in an inscribed slab. At York (Eboracum), towers about 18 feet square were erected at intervals of 125 feet along the summit of the great earthen rampart which was piled up in the rear of the stone wall, and at the bottom, near the sides of one of the towers, "the stones were worn into a "sort of channel, as if some heavy machine had "been frequently moved upon them." The roughly semicircular expansions, about 20 feet across, which occur periodically along the south face of the Antonine Wall (two being found at Croy some 80 Roman paces apart), are likewise deemed to be the "heaped-up sod platforms" of Ammianus, xxiii, 4. and tribunalia of Hyginus, sec. 58, erected to support the artillery (tormenta) for mural defence, such as onagri, carroballistae, &c. One of the stone missiles found near Croy is from 13½ to 14½ inches in diameter, and weighs 3½ lbs.

STRUCTURE OF THE RAMPART.

On consideration of the foregoing details and their comparison with those of the fortifications of other Romano-British stations, definite conclusions may now be drawn as to the character of the superstructure of the rampart at Wilderspool. Here the immediate subsoil is a glacial sand-bed of great thickness, and the heathy sod upon its original surface and the earth thrown from the ditch would be equally unsuitable for constructing an earthen rampart or turf wall (murus cespiticicus). The supposition that it was a wall of squared stones laid in lime-mortar or cement is equally untenable,
since the specimens of lime-mortar and characteristic grouting (opus signinum) collected during five years' recent digging can be held in the palm of one hand. The thickness of the foundations (9 to 12 feet) also militates against this theory, since it even exceeds that of the Great Wall of Hadrian (6 to 9 feet). On the other hand, boulder and alluvial clay have been encountered in all parts of the civitas, in the form of floors, furnaces, the bedding of walls and pugging of wells, and in the soil covering the foundations, where it has necessitated the constant use of a pick and greatly hindered the progress of the excavations. Abundance of alluvial clay was obtainable from the adjoining banks of the river, but immense quantities of boulder-clay were also brought in for building purposes from a natural deposit at Stockton Heath, a quarter of a mile distant, where it was utilized and prepared by the Romano-British potters, one of whose kilns, constructed of the same material, was uncovered during the past season (1900), and falls to be described in my next report. The difference between the two kinds of clay is that the former (alluvial clay) readily absorbs water and becomes mud; while the latter (boulder-clay) retains its natural consistency, and refuses to absorb further moisture, even when spread thinly over the bottom of a canal or pond. Throughout these excavations it has been found that, whereas alluvial clay presents no definite outline, boulder-clay or till has retained its original position and shape, except where disturbed by force. It may, therefore, be assumed that, in structures hereafter described as being made of clay, the latter kind only is meant.

Where such an abundance of clay, sandstone rubble, broken bricks, and other rude materials is present, some fragments of other and finer materials, had they ever existed, would likewise have
Excavations at Wilderspool.

been traced. We consequently arrive at the conclusion that the over-walling of the rampart consisted mainly of sandstone rubble embedded in clay, covered on the outside with squared facing stones of no great size or uniform shape, in which latter respect only is it different from that of the Romano-British town at Wroxeter, as described by Wright (Uriconium, p. 97), which had no facing stones. Vide previous report. 5

It appears from the report of Mr. John Garstang, B.A., in the Journal of the Derbyshire Archæolog. and Nat. Hist. Soc., 1901, just issued, that the rampart of the recently excavated camp of Melandra Castle, near Glossop, was faced around on its outer side with a stone wall, little more than a foot thick, which was backed by a mound of rubble, earth and marl, the whole width of the base of the mound being 20 feet or more. There was no trace of an inner retaining wall. According to Mr. Haverfield, F.S.A., the ramparts at Gelligaer, near Cardiff, are somewhat similar, and earthen ramparts seem to have been commonest in the first century A.D.

ROADS.

As previously stated, there is a narrow by-way or street leaving the station near the middle of the west side, and running westward at right angles to the main via for a distance of nearly 20 yards. Here it breaks off suddenly near the edge of an old sand-pit, the digging of which has produced a fall of 9 feet in the ground and removed every trace of Roman occupation that had ever existed beyond. The roadway consists merely of a layer of gravel a few inches thick, skirted by rude kerb-stones, the outer edges of which are 9 feet apart, lying at a depth of about a foot below the sod.

Excavations at Wilderspool.

There is also on the west side a bed of rubble 8 to 11 feet wide, partly consolidated with alluvial clay, leaving the via close to the north-west angle, and extending across the ditch and along what was once the sloping bank of the river for a distance of 85 feet in a westerly direction. This was described in my previous paper ⁶ as an external wall, but by further excavation during the present year (1900) it has been proved to be a stone causeway, built up for carrying a road, with two external buttresses to keep it from slipping down the bank; the gravel upon its surface being the principal indication which distinguishes it from the foundations of a wall. It is, therefore, the commencement of a Roman via that has been traced at various intervals along the line of the present highway through Frodsham and Halton to Chester, which it entered by the northern gateway.

The eastern branch of the main via has also been traced for 300 yards inside and beyond the civitas, and found to be merely a layer of gravel 24 feet wide and a few inches thick, without the usual bedding of sandstone rubble underneath, at 1 foot 3 inches to 1 foot 6 inches below the present surface.

EXTERIOR BUILDINGS.

West Walls.—As shown upon the revised plan, there are three external walls abutting upon the outer face of the western rampart at right angles, and starting from it at 64, 143, and 230 feet from the south fence, the intervals between them being 71 and 77 feet. They extend westward for distances of 47, 50, and 45 feet respectively. There are no return walls at their outer extremities, but they terminate in ragged edges near the top of the slope of an old sand-pit above mentioned. The widths

of these foundations, taken in the same order, are 7, 9, and $6\frac{1}{2}$ feet, and they are bedded upon a thick layer of boulder-clay, upon which they are carried across the external fosse or gromatic ditch, after the latter has been filled up. They are nearly as massive as those of the main rampart, and are apparently the remains of two later extensions, each one of which was in the form of a fortified external annexe.

INTERIOR BUILDINGS.

East Side.—A walled enclosure uncovered during 1899 on the east side, marked INSULA III on the general plan, appears to have been built as a pentice or lean-to against the inside of the rampart, there being no other wall on that side. It encloses the extension of the latter, supposed to be a ballistarium, already described. From its south-west angle to the fence of the lawn, where excavation ceases, the length is 73 feet, and its width is from 18 to 20 feet. The following are the internal dimensions of its various divisions: (1) 42 feet by $5\frac{1}{2}$ feet, with extensions at each end, $15$ feet by 10 feet and 10 feet by 3 feet respectively; (2) 20 feet by 10 feet; (3) 10 feet by 6 feet, with one extension 10 feet by 3 feet; (4) 8 feet by $6\frac{1}{2}$ feet. Both the inner and outer walls vary in thickness from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet, and are formed of sandstone rubble without any mortar or cement, which may, however, have entirely disappeared.

Furnaces, &c.—In the floor of the southern division (1), lying only a foot below the surface at one end of the contracted passage between the two extensions, was a bed of clay measuring about 10 feet in length, $3\frac{1}{2}$ feet in width, and 1 foot in thickness; inside which was enclosed the hearth of a furnace for heating a cauldron or melting-pot. The clay lining of the furnace and stoke-hole was
calcined and blanched to a light buff colour, and the soft clay beneath was reddened to a depth of 6 inches by long exposure to heat. The tile floor in front was similarly reduced to a dirty grey by the hot ashes; and the soil from within the upright stone slabs enclosing the latter was impregnated with charcoal. (See plan and section, plate III, No. 1.)

The following are the interior dimensions of the furnace: oval hearth, 2 feet 3 inches long by 1 foot 5 inches to 1 foot 8 inches wide; stoke-hole, 3 feet 3 inches long by 1 foot 4½ inches wide; upright sides, 8 inches to 1 foot high. In the bottom of the furnace, on the left side, there was a blow-hole or twyer leading from the outside of the bed of clay.

In the floor of the adjoining division (2), lying closely alongside the rampart, there was a similar bed of clay, 10 feet 6 inches long by 4 feet 6 inches wide, enclosing a central oblong chamber, which may possibly have been the central pit of a composite hypocaust, used for warming the apartment, seeing that the whole interior lining was calcined by heat, and there was a narrow flue leading obliquely from one corner and traces of a stoke-hole at the opposite end. If this supposition as to its purpose be correct, there would originally be a hard burnt clay floor covering the chamber, of the same kind as was found in a more complete example discovered on the west side during the present year (1900), described subsequently.

The interior dimensions were: central chamber, length 5 feet, width 1 foot 6 inches to 2 feet; height of upright sides, 9 inches; horizontal flue, length 2 to 3 feet, width 10 inches, depth 5 inches.

Outside the walled enclosure, in nearly a direct line westward from those just described, there were two beds of clay of somewhat larger area—(1) 8 feet by 6 feet, (2) 11 feet by 6 feet—which enclosed in their reddened and calcined interior the bases of a
No. 1

BASES OF FURNACES, PIT AND SQUARE WELL (PLAN AND SECTION)
ROMANO-BRITISH CIVITAS AT WILDERSPOOL

No. 2

IRON SMELTING FURNACES FOUND AT WILDERSPOOL 1839

Fig. 1

Fig. 3

Fig. 4

Fig. 2

Fig. 5

Fig. 6

GENERAL PLAN AND SECTIONS OF IRON SMELTING FURNACES
AND SUPPOSED GLASS FURNACES (NORTH SIDE)
WILDERSPOOL, NEAR WARRINGTON
heating furnace or central pit of a composite hypocaust, the walls of which were too much broken down for their intended purpose to be recognised.

The dimensions of the enclosed chambers were: (1) length, 4 feet 6 inches, width, 2 feet, (2) diameter, 3 feet.

A rare medallion of Domitian, much corroded, was found directly underneath the north end of the clay floor (2).

Outside the south-west angle of the enclosure, a square pit or well, 3 feet 6 inches across, and 7 feet 8 inches deep, below the present surface, steined with unhewn sandstone blocks about halfway up, when cleared was found to contain, besides the usual potsherds of common soft red and black unglazed ware and a few pieces of Samian, fragments of a grey vase with raised frilled edges covering the bulge in a sort of honeycomb pattern, little bits of Castor ware with raised knobs in slip, two inch iron nails, bits of lead and bone, and a piece of Roman mirror about 1\(\frac{1}{2}\) inch square, containing so large a proportion of silver in its composition as to be still smooth and polished on its front surface.

During the past three seasons (1898-9-1900), no fewer than twenty similar artificial stages or floors, built up of massive boulder-clay, and enclosing the remains of furnaces, flues, hypocausts, ovens, &c., have been examined and recorded. They afford traces of various industries, and differ from anything previously described. The possibility of explaining their destination is as much due to the light they throw upon one another as to the associated "finds," which are purely Romano-British in character.

In addition to those previously noted, only four others were uncovered during 1899, but these are of sufficient importance and complexity to occupy the remainder of this report.
Excavations at Wilderspool.

HAND-BLOOMERY.

Melting Furnace I.—The plan and sections drawn to scale on plate III, No. 2, and photographs taken from the east and west, reproduced on plate IV, illustrate the construction and appearance of what was evidently an iron smelting furnace. This was situated within the southmost of the two external annexes adjoining the western rampart, at 27 feet west from the latter, and 31 feet north from the Ship Canal boundary, beneath only from 6 to 9 inches of soil. Its massiveness had enabled it to defy the action of time and every effort to uproot it with the plough or spade.

The built-up stage or platform of clay containing the furnace was in the shape of two oblongs conjoined, measuring 13 feet 4 inches by 5 feet, and 9 feet 6 inches by 6 feet respectively, their longer axes lying north and south. In the midst of the former there was a circular furnace cavity, with a fantail-shaped flue or stokehole leading from it northwards; and along the middle portion of the other limb of the platform there was a branch of the flue at right angles, opening at 1 foot 3 inches from the mouth of the circular hearth, and sloping downwards and widening outwards to the end, which was closed up with clay, thus forming a V-shaped gutter and basin for guiding and collecting the molten stream from the furnace. A return pipe or covered duct, 7 inches in diameter, passed through the clay floor from the outer edge of the flue to the top of the sloping trough, and served to convey any molten metal into the latter which had run past its open mouth.

The calcined interior lining of these cavities, which was blanched by heat to a dirty grey or light buff colour to a depth of two inches, was the cause of their preservation, and the sole means whereby their formation could be traced.
BASE OF SMELTING FURNACE (WEST VIEW), ROMANO-BRITISH CIVITAS, WILDERSPOOL, NEAR WARRINGTON

BASE OF IRON SMELTING HEARTH (EAST VIEW), ROMANO-BRITISH CIVITAS AT WILDERSPOOL
Their interior dimensions were the following:—
Circular furnace: diameter, 2 feet 4 inches; height of upright sides, 3 inches to 4 inches. Flue or stokehole: length, 4 feet 4 inches; width increasing from 1 foot to 2 feet 1 inch; height of upright sides, 4 inches, decreasing to 1 inch. Sloping trough: length, 6 feet 6 inches, width increasing from 1 foot to 1 foot 11 inches; depth increasing from 6 inches to 1 foot 6 inches below the level of the hearth.

There was doubtless a shaft of greater or less elevation surrounding the circular hearth, and the flue and sloping trough were also partly or entirely overarched. A mass of clay reddened by heat, and fragments of the calcined upper crust were found choking the latter, but all traces of the superstructure had elsewhere disappeared. The solidity of the base of the furnace indicates that it was a permanent structure, and its shape proves that iron was smelted by a continuous process, whereby the products of the circular hearth were run down to the basin at the bottom of the V-shaped gutter, and there separated. The slag floating upon the surface was probably removed by levigation or skimming over the lip of the basin, and the heavier iron lifted out by means of ladles and poured into clay moulds.

These conclusions as to the mode of working, drawn from the shape of the furnace, were confirmed by the position just outside the rim of the basin, at from 2 feet to 2 feet 6 inches from the surface, of a deposit fully 9 feet in diameter and 6 inches deep of slag, mixed with cannel coal and ordinary mineral coal in little cubes, both derived from the Wigan coal measures, less than twelve miles away; as well as two pieces of red haematite from the Cumberland district, and as many nodules of clay-ironstone, with a nucleus of sand, probably brought in from Staffordshire.
The following is a list of miscellaneous objects from the vicinity of the furnace last described:— (1) Plain bronze ring, \( \frac{3}{4} \)-inch in diameter; (2) iron knife; (3) a number of iron nails, about 2 inches in length; (4) flat disc-shaped spindle-whorl of lead, 1 inch in diameter, \( \frac{1}{4} \) inch hole, \( \frac{1}{4} \) inch thick. Pottery—Small broken and distorted hand-lamp (lucerna), of common soft red paste (plate X, No. 2); two whole members of a triple vase of the same kind of ware, washed over with thin white clay slip, with internal communication, globular in shape, 2\( \frac{1}{2} \) inches high, with slightly everted rims 2 inches across; portion of mortarium of white Broseley clay, broken and worn away at the base, stamped with potter’s name, Genialis, across the rim, found 2 feet below the clay floor adjoining the flue or stokehole of the furnace; broken handle of amphora stamped with potter’s name, Qasasert; fragment of base of amphora, scratched with number lxiiis (63\( \frac{1}{4} \) ounces), indicating the weight of the empty vessel; fragments of so-called Samian, embossed and plain; necks of ampullae of red and white paste; many fragments of ollae and patellae of common soft red and black smoke-tinted ware; brick, measuring 7\( \frac{1}{4} \) by 7\( \frac{1}{8} \) by 2\( \frac{1}{4} \) inches, or two-thirds of a Roman foot, being an example of the laterculus bessalis (bes=\( \frac{3}{8} \)) of Vitruvius (De Architectura, lib. v, cap. 10), one surface ornamented with gracefully curving diagonal lines, terminating at the four corners in leaf-shaped loops; broken pieces of stone roofing slabs.

Crucible Furnace I.—A purifying or smithy hearth discovered last year is represented by a photograph reproduced (plate V, No. 1), and by a drawing in plan and section (plate V, No. 2 and 3). The surroundings of this ancient farriery (ferraria), so named from the material (ferrum) iron, are partly visible in the photograph; the principal via running north and south is in the
PLATE V.  

H. S. OF L. AND C. 

IRON PURIFYING FURNACE OR SMITHY HEARTH, ROMANO-BRITISH CIVITAS AT WILDERPOOL  
NO. 1 

NO. 2—PLAN 

NO. 3—SECTION
Excavations at Wilderspool.

background; the foundation of a wall, 2 feet 6 inches thick, extending from the *via* eastward at right angles for a distance of 80 feet, is on the left; the foundation of another wall parallel to the former and of equal width, commencing at 21 feet from the *via* and extending only to the hearth, a distance of about 40 feet, is on the right; a rough pavement formed of small slabs of sandstone and broken tiles, which extended 12 feet 6 inches westward from the hearth, is seen in the middle of the picture. The foundations are of rubble consolidated with boulder-clay, on a layer 3 or 4 inches thick of the same kind of clay and an equal thickness of gravel. The distance between the two walls is from 4 to 7 feet (widening towards the paved portion), thus forming a narrow corridor or alley, 60 feet long, giving access to the smithy from the *via*.

The hearth itself was a roughly semicircular stage or platform, built up of broken tiles and bricks in five courses, set in stiff boulder-clay with wide joints for mortar, and enclosing a cylindrical pit or crucible (*catinus*), the interior of which was lined with calcined clay. Dimensions: platform, length (diameter) 3 feet 6 inches, width (radius) 2 feet 6 inches, vertical height 1 foot 10 inches to 2 feet 2 inches; fire-seat or crucible, diameter 11 inches, depth 9 inches.

Pieces 4 to 6 inches square of flanged roofing tiles, scored revetting tiles, flue tiles and bricks, 1 inch to 2½ inches thick, of ordinary Roman character, were employed. One entire brick from the base of the hearth (measuring 1 foot 3½ inches by 10½ inches by 2½ inches) is a specimen of the Lydium or sesquipedalian of Vitruvius (1½ by 1 Roman foot), and from its thickness a late date, about the fourth century, may be attributed to the remains.
Excavations at Wilderspool.

There was a vertical funnel-shaped opening extending 7 inches downwards from the base of the crucible, 6 inches wide at the top and 2 inches at the bottom, lined round with three courses of broken tiles, and communicating with the front of the hearth by a narrow gap, $2\frac{1}{2}$ inches wide, between the tiles. This appears to have been the tap-hole for running out the cinder. In front of the hearth, 1 foot 8 inches below its summit, there was a semi-circular floor of clay, 2 or 3 inches thick, and about 2 feet 6 inches in diameter. The floor and platform were surrounded by a light yellow powdery layer of burnt soil.

Close to the outside of the clay floor, and only 4 to 6 feet east from the hearth, there was a deposit, $2\frac{1}{2}$ to 3 feet wide, of unspent charcoal in lumps still showing the grain of the original wood. A few bits of cannel coal were also met with.

Only one lump of heavy slag was found in the immediate vicinity of the furnace, but there was a deposit of light "cinder" (silicate of iron) outside the south-east angle of the adjoining house, at 35 feet south from the furnace; and in the wall of the crucible, underneath the calcined lining, there was a small globule of glassy "cinder," the analysis of which is given below, indicating that the purification of iron was the purpose for which the furnace was used. There was also a block of cast-iron (about 2 inches by 1 inch by 1 inch) the analysis of which is also given later. The iron objects found close at hand were (1) fourteen nails, 2 to 3 inches in length, with round flat heads; (2) three hob-nails, $\frac{1}{2}$ inch in length, with conical heads; (3) two clamps; (4) hook; (5) about half of a box-lock of thin iron plate, coated with a non-corrosive lacquer or varnish, $3\frac{1}{2}$ inches wide by 1 inch deep, the cover plate in one piece, with edges turned down $\frac{1}{4}$ of an inch at right angles, to retain the side-plates formed by a
Excavations at Wilderspool.

separate strip. It was fastened to the door by two round-headed iron nails, 3 inches long, which were driven obliquely through two holes in the corners of the cover-plate, and retained a portion of the wood, saturated and preserved from decay by oxide of iron, adhering to them; (6) handle of an iron knife or dagger, 4 inches in length, $\frac{3}{4}$ inch in diameter, formed out of a flat middle plate of iron and two half-round outer plates of bone, fastened together by two iron rivets, 1 inch apart, passing through them. The pommel or projecting end of the middle plate is perforated for suspension by a lanyard. The two outer plates of bone are ornamented with incuse lines in three encircling bands, $\frac{3}{8}$ of an inch wide, forming a trellis pattern or diamond lattice at both ends and a chevron in the middle. The blade is broken off close to the hilt, which has no enlargement. What appear to be two portions of the broken blade, which fit together at the broken ends, but are coated with a thick mass of consolidated sand, oxide of iron, and portions of a wooden sheath, measure $6\frac{1}{2}$ inches in length when conjoined, making a total length of blade and handle, $10\frac{1}{2}$ inches, (found under the deposit of charcoal and a thin layer of clay.)

MISCELLANEOUS OBJECTS.

Lead.—Two spindle-whorls, slightly conical, (1), 1 inch in diameter, $\frac{1}{2}$ inch thick, the bore tapering from $\frac{1}{4}$ to $\frac{1}{16}$ of an inch; (2), $\frac{13}{16}$ of an inch in diameter, $\frac{1}{4}$ of an inch thick, bore $\frac{1}{4}$ of an inch.

Pottery.—Potsherds of common soft red and black smoke-tinted unglazed wares, and a few fragments of bright red glazed Samian. A whole dish or plate, cracked half across, 11 inches in diameter, $1\frac{1}{4}$ inch deep, $3\frac{1}{8}$ inch thick, rim $1\frac{3}{8}$ inch wide, with a graceful ogee curve and deep groove round the edge, found in the clay floor in front of the furnace.
Excavations at Wilderspool.

Two coins, a first brass of Domitian and a second brass of Trajan, found along the edge of the long wall adjoining, at 1 foot 3 inches and 1 foot 6 inches from the surface respectively.

No fewer than 60 iron nails of various sizes were found in a rubbish pit, opened out at a distance of 45 feet nearly in a direct line south from the furnace.

The most interesting find close to the furnace was an iron tube, about 8 inches in length, \( \frac{1}{8} \) inch external and \( \frac{3}{8} \) inch internal diameter, \( \frac{1}{4} \) inch thick, hollow inside, but coated on the outside with a thick concretion of sand and rust. The tube itself was too much oxydized for analysis. It appears to have been the nozzle of the bellows for working the crucible, and was probably introduced over the top.

The analysis of specimens Nos. 1 and 2, two small pieces of haematite ore; No. 3, several lumps of slag; No. 4, a portion of the calcined clay interior, from the melting furnace I, by Mr. Andrew Harley of the Coalbrookdale Iron Works (through the intervention of Mr. F. W. Monks, of Monks, Hall & Co.), gave:

<table>
<thead>
<tr>
<th>Iron ORE</th>
<th>No. 1</th>
<th>No. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferric oxide</td>
<td>90.560</td>
<td>96.12</td>
</tr>
<tr>
<td>Iron pyrites</td>
<td>—</td>
<td>1.05</td>
</tr>
<tr>
<td>Alumina</td>
<td>—</td>
<td>slight trace</td>
</tr>
<tr>
<td>Lime</td>
<td>slight trace</td>
<td>—</td>
</tr>
<tr>
<td>Magnesia</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Manganic acid</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Siliceous matters</td>
<td>9.384</td>
<td>1.75</td>
</tr>
</tbody>
</table>

They were both red when ground, No. 1 containing more impurity, and No. 2 very hard and slightly crystalline on edges. They are evidently specimens of the purest Cumberland ore.
The samples of slag were found very much alike, and the particulars of one only need be stated.

<table>
<thead>
<tr>
<th>Slag Composition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>59.65</td>
</tr>
<tr>
<td>Alumina</td>
<td>13.41</td>
</tr>
<tr>
<td>Manganic oxide</td>
<td>2.0</td>
</tr>
<tr>
<td>Ferrons oxide</td>
<td>18.14</td>
</tr>
<tr>
<td>Ferric oxide</td>
<td>3.84</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>4.0</td>
</tr>
<tr>
<td>Iron pyrites</td>
<td>1.46</td>
</tr>
<tr>
<td>Carbonaceous matter and moisture</td>
<td>3.18</td>
</tr>
</tbody>
</table>

In the opinion of Mr. F. G. Ruddock, F.I.C., analytical chemist and lecturer on chemistry at the Warrington Technical Institute, an expert of long experience in the analysis of iron and its ores, "Such a composition of slag could only be produced "direct from the ore, at a high temperature, in a "smelting furnace."

The composition of the calcined clay, No. 4, from the interior of the furnace, was as follows:—

Silica 45.65, alumina 8.84, lime 13.36, magnesia 8.912, oxide of iron 2.64, iron pyrites 7.5, carbonic acid, coaly matters, &c., 19.1.

The analysis of three specimens of iron and slag from the crucible furnace I, by Mr. Ruddock, gave the following results:—

1. A squarish block of iron (about 2 x 1½ x 1 inch), coated with scale.
   - Carbon, combined ... ... ... 0.230
   - Carbon, as graphite ... ... ... 3.0
   - Silicon ... ... ... ... ... 1.050
   - Sulphur ... ... ... ... ... 0.485
   - Phosphorus ... ... ... ... ... 0.756
   - Manganese ... ... ... ... ... 0.403
   - Iron, by difference ... ... ... 94.076

This he described as a sample of cast iron, extremely brittle, smelted with coal from an impure ore, probably spathic, owing to the high phosphorus; and with a sulphurous coal, owing to the remarkably high sulphur.
(2) A piece of wrought iron resembling a cotter or lynch pin.

<table>
<thead>
<tr>
<th>Element</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.090</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.60</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.93</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>2.57</td>
</tr>
<tr>
<td>Manganese</td>
<td>trace</td>
</tr>
</tbody>
</table>
| Iron, by difference | 99.56%

The high proportion of phosphorus led him to conclude that it was produced from an impure ore, and that it was probably made from cast iron and not direct from the ore.

(3) A small globule of cinder from the wall of the furnace, underneath the calcined lining.

<table>
<thead>
<tr>
<th>Element</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>73.80%</td>
</tr>
<tr>
<td>Ferrons oxide</td>
<td>17.6</td>
</tr>
<tr>
<td>Ferric oxide</td>
<td>1.2</td>
</tr>
<tr>
<td>Alumina</td>
<td>1.7</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.55</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>0.724</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>1.650</td>
</tr>
<tr>
<td>Alkalies, &amp;c.</td>
<td>2.876</td>
</tr>
</tbody>
</table>

Such a slag as this, he inferred, would be obtained by reducing an ore containing appreciable quantities of phosphorus and sulphur.

**General Conclusions.**

The foregoing details of (1) the construction and surroundings of two different furnaces, viz., a melting hearth and a crucible or purifying hearth; (2) two kinds of fuel, cannel coal and ordinary mineral coal in the former, and charcoal in the latter, for the manufacture of iron; (3) the results of analysis of specimens of ore, slag, cinder, crude or cast iron, and finished iron derived from these furnaces; and (4) the opinion of an expert in regard to them, are strong evidence in support of the view that an indirect method of producing crude or cast iron in one furnace, and reheating it with charcoal to convert it into pure or malleable iron in another, was practised in this locality. This view
IRON SMELTING FURNACE FOR IMPURE ORES
ILLUSTRATION TAKEN FROM AGRICOLA

NO. 1

SIXTEENTH CENTURY GLASS FURNACE
THE ILLUSTRATION IS TAKEN FROM AGRICOLA

NO. 2
receives further support from the discovery last season on the north side of the civitas of another similar pair of furnaces, which, however, fall to be described in next year's report.

The earliest writer upon the subject, Agricola, De Re Metallica, lib. ix, p. 337-339, gives a very clear description of two separate furnaces, the melting hearth (rinnherd) and the crucible hearth (schmidherd), employed in the 16th century for iron smelting. The latter was used in the production of soft malleable iron or "blooms," direct from the purer ores by a single heat, with charcoal for fuel, in conjunction with a forced draft by bellows and a tilt-hammer, both driven by a water-wheel. The hearth was $3\frac{1}{2}$ feet high, 5 feet long and broad, in the middle of which was a crucible (catinus) a foot high and a foot and a half wide, the dimensions, however, varying according to requirements. The crucible appears to have been lined with powdered charcoal (two parts), powdered earth (one part), mixed together and moistened with water, and then beaten down with a pile or rammer in such a way as to form a circular cavity a foot wide, 8 inches deep. Ore and charcoal in alternate layers were heaped up and the fire lighted inside the crucible, combustion being forced by means of a tube introduced over its edge connected with bellows.

Impure ores not only underwent a preliminary process of roasting, washing, and powdering, but were actually melted by prolonged heating in a much larger furnace (a representation of which, taken from Agricola, is given on plate VI, No. 1), before being removed to the crucible furnace for purification with charcoal and welding into blooms. The pot or crucible for receiving the molten metal will be seen in the illustration directly in front of the furnace. Agricola's description of the process is
Excavations at Wilderspool.

sufficiently brief and explicit to be quoted in extenso:—

Sed ad ferri venam, quæ vel ærosa est, vel cocta difficulter liquescit, majore opera et acriore igni nobis opus est; etenim ejus partes, in quibus metallum inest, non modo a reliquis, quæ nullum in se continent metallum, oportet secernere, et pilis siccis frangere; sed et urere, ut alia metalla atque succos nocivos exha-lent; et lavare, ut levia quæque ab eis separentur. Excoquantur vero in fornice primi assimili, verum multo ampliore et altiore, ut multam venam, multosque carbones continere possit; nam partim venæ fragmentis, quæ majora nuce non sint, partim carbonibus compleatur; quas res excococtores gradibus, qui sint ad alterum latus fornicis, ascendentes incoctant. At ex tali vena modo semel, modo bis cocta conflatur ferrum, quod idoneum est ut in foco fornicis ferrariae recaeliat, et magno illo malleo ferreo subjectum dilatetur, atque ferro acuto in partes secetur.

"More labour and a fiercer heat are requisite for cuprous or refractory ores, since the portion containing the metal has not only to be divided from the rest and disintegrated with dry stamps, but it must also be roasted to sublimate other metals and noxious salts, and washed to separate the lighter portions. It is to be smelted in a furnace similar to the first (shaft fur-nace), but much larger and loftier, to contain much more ore and charcoal, and to be charged alternately with ore in fragments no larger than a nut and with charcoal, which are thrown in by the smelters, who ascend the steps on one side of the furnace. From such ore, sometimes once, sometimes twice, roasted, iron is melted suitable for being re-heated in the smithy furnace, and beaten out beneath that great iron hammer, and cut into pieces with a sharp edge."

One of the latest and most instructive writers on "Early Metallurgy, &c.", Mr. Wm. Gowland, F.S.A., F.C.S.,7 considers it as very surprising that no debris of any furnace, sufficiently perfect to enable us to deduce from it its original form, has yet been unearthed among the extensive remains of the iron industry during the Roman occupation of Britain. In forming the opinion that in these early furnaces "the metal was never melted, but was always obtained in the form of a solid mass of malleable iron," this writer seems to have

overlooked the fact that, from the impure clay-ironstone ores, smelted in such enormous quantities in Sussex during the Roman period, it would have been impracticable to extract soft malleable iron suitable for forging at a single heat.

The discoveries at Wilderspool confirm Wright's surmise, that the Roman smelting furnace was "a wall and covering of clay, with holes in the "bottom for letting in the draught, and allowing "the metal to run out. For this purpose they were "usually placed on sloping ground. Rude bellows "were perhaps used, worked by different con-
"trivances."

Mineral coal is also well known to have been in general use throughout the Roman encampments along the line of the walls of Hadrian and Antonine, and elsewhere. It was certainly employed at Wilderspool for iron-smelting, notwithstanding the oft-repeated assertion that "charcoal was the "only fuel used in smelting till 1618, when Lord "Dudley introduced coal for this purpose." The fragments of cannel coal found in all parts at Wilderspool have been collected and deposited, along with the other relics, in the Warrington Museum.

The Romans are well known to have employed bellows, conical ducts, and other artificial modes of creating a blast in their furnaces. Sir William Fairbairn, in his work on Iron, its History, &c., p. 7, points out that "whenever the blast was sufficiently "powerful the iron would be fused, and a partial "carburation would take place. The resulting "metal would undergo a rude process of refining, "by which the metal was again heated with char-
"coal, and the blast directed over its surface, so "that the carbon would be burned out, and the iron "become tough and malleable. These two pro-
Excavations at Wilderspool.

"cesses, he considers, might form two successive stages of one operation, as at present practised with the Catalan forge." The Wilderspool discoveries prove that this is what actually took place.

Year 1900.

Inside the fortified area the foundations of only four walled enclosures which could have belonged to ordinary dwelling-houses have been traced; but several clay floors, consisting of three-inch layers of stiff, well-puddled boulder-clay, burnt on the surface, or sprinkled with crushed tiles to harden them (opus testaceum), have been uncovered. They all are in alignment with the via on the west and north sides, and adjoining the rampart on the east side. The presence of only slight traces of enclosing walls or partitions, and of quite a number of iron nails and fragments of stone roofing tiles in their vicinity, indicates that their superstructures were mainly of wood. As the subsoil over the entire site is a pure glacial sand bed, the presence of clay is always a sure indication of local industry, and the material for the clay floors has in every instance been previously prepared and brought in by the neighbouring potters. This is proved by numerous enclosed fragments of a kind of earthenware which was manufactured in a potter's kiln discovered, in July, 1900, at Stockton Heath, a quarter of a mile direct south from the fortification.

Potter's Kiln.—The kiln referred to was come upon accidentally in digging a sand pit, but was carefully explored and measured before being destroyed. The structure was entirely built up of massive boulder-clay in two separate parts, with no direct communication between them, namely, (1) a heating furnace and kiln floor above it, and (2) a globular oven or drying chamber in the rear of the former.
Roman Potter's Kiln Found at Stockton Heath, Near Warrington.
In shape the furnace resembled the top of the skull of some animal having a low forehead, and three apertures underneath opening into a hollow dome-shaped interior, the plan being square in front and semicircular behind. Its appearance when first uncovered is shown in the accompanying photographic plate. (Plate VII.)

The two piers supporting the roof, and dividing the inside into three separate fire-holes, were 1 foot 8 inches long and 4 inches thick. The extreme length of the interior was 3 feet 4 inches, and therefore the hollow chamber at the back, where the fire from the three fire holes was concentrated, measured 1 foot 8 inches from front to back. The external dimensions were:—Vertical height, 2 feet to 2 feet 4 inches; width, 5 feet; original length, 6 feet, the front portion having been broken down for a distance of 2 feet, as shown by the red colour of the adjoining sand bed. The thickness of the encircling walls varied from 2 inches to 9 inches.

The heat was conveyed through the roof into the kiln, where the vessels were arranged for baking, by two holes 2\(\frac{1}{4}\) inches in diameter, placed a foot apart at 6 inches from the ends of the piers, and there was a flue 4 inches in diameter in the rear of the right hand stoke hole.

Nothing remained of the circular wall of the kiln except a single block of hammer-dressed sandstone, measuring 1 foot by 10 inches by 3 inches.

Six feet from the front of the fire-holes, and three feet from the present surface, there was a dense mass of fragments of broken and distorted vessels of soft red unglazed ware, of well-known shapes, intended only for useful purposes; *patellae*, *patinae*, *ollae*, *urcei*, *lagonae*, *ampullae*, *urnae*, and *mortaria* or *pelves*. Many of the larger fragments have been removed to the Warrington Museum, where there is a large collection of whole and restored vessels.
from the locality, evidently of the same kind of ware. Among the latter are four mortaria, stamped across the rim with the names of two of the local potters, Bruci (for Brucus) and Bricos, in rude and reversed characters.

Clay Floor (I).—The largest of the above-mentioned clay floors was situated at the west end of Insula II, on the north side of the fortification, 8 to 10 feet from the inside edge of the via, with a frontage along the latter of 42 feet and an average width of 30 feet. There were between it and the via several patches of a cobble-stone pavement (measuring in one instance 15 feet by 3 feet), which appeared to have covered the greater portion of the interval. On the east side it was bounded by the tumbled foundations of a dwelling-house, uncovered in 1898, and described in my preceding report.

Wall.—On the west side there was the foundation of an enclosing wall, 5 to 6 feet wide, formed by a bedding of gravel overlaid by boulder-clay and sandstone rubble, extending at least 26 feet at right angles to the via.

Pavement.—On the surface of the floor and along the inside of the last-mentioned wall there was a level pavement, apparently of secondary construction, 22 feet in length and 18 feet in width, formed of unshaped blocks of sandstone, which may have covered an enclosed court-yard, or a street running north and south. The vertical sections given (figs. 3 and 4, plate III, No. 3) show that the stones of this pavement lay at a depth of only 6 to 8 inches below the present surface. A wall of rude and indefinite construction and no depth of foundation appears to have skirted the paved area along the east side.

Though structural remains were wanting along the south side of the clay floor, the soil was blackened with charcoal for a depth of from 1 to 4 feet,
PLATE VIII.

PLAN

SECTIONS

DOUBLE FURNACES AND IRON SMELTING HEARTH
and several pieces of glass and other interesting objects, to be presently described, were recovered from the lower portion of the stratum.

*Amphora Floor.*—There was an isolated patch of rude pavement, 11 feet long by 9 feet wide, of small hammer-dressed sandstone slabs and broken tiles, situated at 19 feet from the clay floor on this side. Underneath was a double layer, 2 feet 6 inches long by 1 foot 4 inches wide, of fragments of *amphora* evenly and closely laid, separated by a thick bed of charcoal. Nothing was found to indicate the special purpose of the latter; but it may be remarked that broken *amphorae* have been frequently employed for structural purposes in this locality.

The clay floor (1) itself—though undoubtedly of Roman origin, a coin of Trajan being found upon it, at 1 foot 6 inches from the present surface—was concluded to be of secondary construction, from the fact that a similar floor of less area and the bases of a number of furnaces were found beneath, the latter being of primary interest and importance as traces of local industry.

*Iron Smelting Hearth* (II).—A brief account must be given of two iron smelting hearths, already referred to, situated on the surface of the clay floor, as shown in plan and section, plate III, No. 3 fig. 2, and plate VIII, figs. 1 and 2.

In plan the eastmost of the two hearths (plate VIII, figs. 1 and 2) was in the form of a foot-print or two intersecting ovals, each about 2 feet 6 inches in diameter, their conjoined length being 6 feet 4 inches. The interior surface was calcined and blanched to a depth of 3 inches, and the soft clay underneath reddened to a further depth of a foot by the intense heat. By constructing the base of the furnace with a double batter, from both sides inwards towards the axis and along the latter towards the east end, it was formed into a sloping trough or gutter, leading down to a tubular duct, 1 foot 10 inches in length.
and 4½ inches in diameter, through the wall of the clay platform at right angles, by which the molten metal was drawn off, as evidenced by its calcined interior lining. The purpose for which the hearth was employed is proved by the discovery of a much oxidised strip of iron deeply imbedded in a crack along the middle line of the trough near the exit, where it had doubtless lain since the last charge was smelted; and by the discovery of a mass of red hæmatite ore, of several pounds weight, in the clay platform of an earlier furnace, existing partly underneath the former and partly along its edge, whence the mass had apparently fallen. The results of analysis of the iron strip by Mr. Ruddock are the following:

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, combined</td>
<td>0.060</td>
</tr>
<tr>
<td>Silicon</td>
<td>trace</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.027</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.037</td>
</tr>
<tr>
<td>Manganese</td>
<td>trace</td>
</tr>
<tr>
<td>Iron, by difference</td>
<td>99.876</td>
</tr>
</tbody>
</table>

In his opinion this specimen was a pure variety of soft iron made from magnetic ore or red hæmatite, and purified from cast iron, as such a low percentage of carbon would have been practically impossible if made direct from the ore in this rude furnace.

**Crucible Furnace (II).**—Twelve feet westward from the iron smelting hearth II, just described, on the surface of the same clay floor and at the same level (1 foot below the sod), there was a circular hearth 4 feet 6 inches in diameter, surrounding the mouth of a pit or crucible of cylindrical shape, 1 foot 8 inches in diameter and 1 foot 3 inches deep. This was of the same shape, and had evidently been employed for the same purpose as the smaller crucible in smithy hearth I, namely, for purifying...
or decarbonising impure iron by means of a coal fire driven by an artificial blast, and producing lumps of soft malleable iron or "blooms" for hammering. The surrounding surface and interior lining of the crucible were calcined, and the clay underneath reddened by long exposure to intense heat. The blanched appearance of the former caused it to become known as the "white hearth."

**Beds of Cinder and Charcoal.**—Between the clay floor and the *via*, in the angle of the enclosing wall, there was a layer, 9 feet wide, of the black glossy cinder produced in the purification of iron, a specimen of which was found, on analysis by Mr. Ruddock, to be essentially silicate of iron; and adjoining the layer of cinder on the east side the soil was blackened by spent charcoal over an area about 4 feet in diameter. The following are the relics of Romano-British origin with which these deposits were impregnated:—(1) a large iron nail, of \( \frac{3}{4} \) inch square section, 9 inches in length, with a round head 2 inches in diameter; (2) a strip of iron \( \frac{3}{4} \) inch to \( \frac{7}{8} \) inch wide, \( \frac{1}{4} \) inch thick, perforated at one end; (3) the figure of an animal, possibly a rude representation of the wild boar of the 20th Legion, formed of sheet lead about \( \frac{1}{4} \) inch thick; (4) two small strips of sheet lead of about the same thickness; (5) a fragment of a common black smoke-tinted unglazed earthenware *olla*, (resembling Upchurch ware), with a hole about \( \frac{1}{4} \) inch across, wastefully patched with a plug of lead weighing 2 ounces, projecting on both sides—(this leaden plug indicating, not the high value attached to the black pot, but the abundance of lead in the locality)—(6) an ordinary melon-shaped ribbed bead, of grey vitreous paste, coated with blue glaze, \( \frac{1}{4} \) inch in diameter, and \( \frac{1}{4} \) inch bore; (7) the broken half of a similar bead; (8) a first bronze coin of Trajan, much corroded, found at a depth of 2 feet
6 inches; (g) a second bronze coin, too much corroded to be deciphered, found in the upcast soil; (10) an iron stylus, 4½ inches in length, ¼ inch thick, pointed at one end and spatular at the other; (11) several round headed nails, about 2 inches in length, much oxidised; (12) several fragments of so-called Samian and ordinary black and red unglazed earthenware, and a small fragment of a melting-pot or crucible; (13) the neck and portions of the handles of a large amphora.

**Base of Furnace.**—Directly adjoining the "white hearth" on the north side, but at a slightly lower level, there was a circular depression in the clay floor, 1 foot 8 inches in diameter and about 7 inches deep, forming the base of a furnace, with a fan-shaped stoke-hole opening from it on one side, 1 foot 9 inches in length and from 1 foot 4 inches to 2 feet 2 inches in width. A tile hearth in front of the latter was cracked and burnt to a dirty grey by the hot ashes.

One foot three inches further north from the latter there was another similar depression, 6 inches deep and 1 foot 6 inches in diameter, but without any outlet except a small hole on one side, 3 inches in diameter, which may have served as a blow-hole or twyer for the nozzle of a pair of bellows.

**Clay Floor (II).**—As already stated there was an earlier floor of less area (about half), but of the same material, *opus testaceum*, situated underneath the floor I, and separated from it by a layer of sand and gravel 4 inches thick.

**Supposed Glass Furnaces.**

At the level of floor II, and at a total depth of 2 feet, three platforms, built up of boulder-clay, placed a few feet apart and nearly in line with the north *via*, were uncovered. Each platform enclosed a pair of furnaces, separately represented by photo-
No. 1
SUPPOSED GLASS FURNACES, SOCKET AND SHARPENING STONES
WILDERPOOL, WARRINGTON

No. 2
PAIR OF SUPPOSED GLASS FURNACES
WILDERPOOL, NEAR WARRINGTON

No. 3
PAIR OF SUPPOSED GLASS FURNACES
WILDERPOOL, NEAR WARRINGTON
Excavations at Wilderspool.

Graphs, plate IX, Nos. 1, 2, and 3; and by a plan and sections, figs. 1, 3, 4, 5 and 6, on plate III, No. 3, which must have been constructed in this peculiar fashion for some special purpose. They differ from the numerous other furnaces which have been recorded, and considered along with the associated relics, they form the most complete, exceptional, and interesting of the recent discoveries at Wilderspool.

In constructing the platforms a level bed of pounded sand and gravel and a single layer of cobble-stones or sandstone rubble was prepared, and upon it the tempered clay was built up to a depth exceeding that of the upright sides of the enclosed furnace by 3 or 4 inches, and to an area extending beyond them on all sides by about a foot. An equal width of clay separated each of the two adjoining furnaces. The plan of the central pit was circular or oval, and on one side there was a fan-shaped stoke-hole opening from it through the clay towards the front of the platform, where there was a carefully laid hearth of the same material.

The following are the interior dimensions of the furnaces and the stokeholes leading from them:

<table>
<thead>
<tr>
<th>Platform</th>
<th>Furnace</th>
<th>Length (ft. ins.)</th>
<th>Breadth (ft. ins.)</th>
<th>Height of upright sides (ft. ins.)</th>
<th>Stoke-holes</th>
<th>Length (ft. ins.)</th>
<th>Breadth (ft. ins.)</th>
<th>Depth below surface of top of platform (ft. ins.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>3 8</td>
<td>2 6</td>
<td>0 5</td>
<td>Stone</td>
<td>1 11</td>
<td>1 4</td>
<td>2 9</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2 4</td>
<td>1 4</td>
<td>0 6</td>
<td>Slab</td>
<td>1 8</td>
<td>1 1</td>
<td>2 0</td>
</tr>
<tr>
<td>II</td>
<td>Square</td>
<td>1 8</td>
<td>0 8</td>
<td>0 8</td>
<td>Stone</td>
<td>1 11</td>
<td>1 0</td>
<td>1 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 3</td>
<td>1 10</td>
<td>1 4</td>
<td>Slab</td>
<td>1 8</td>
<td>1 1</td>
<td>2 0</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>2 6</td>
<td>1 6</td>
<td>1 0</td>
<td>Stone</td>
<td>1 11</td>
<td>0 8</td>
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<tr>
<td></td>
<td>2</td>
<td>2 8</td>
<td>1 4</td>
<td>0 10</td>
<td>Slab</td>
<td>1 11</td>
<td>0 8</td>
<td>2 0</td>
</tr>
</tbody>
</table>

The enclosed furnace (1) in platform I, resembled the base of an ordinary oven. From the thickness and red colour of the superincumbent mass of clay
and the quantity of fragments of calcined inner lining covering the floor, it was inferred to have been originally overarched. The adjoining furnace (2) seems to have been intended for heating a caldron or melting-pot.

The fire-places enclosed in platform II were likewise different in shape and intended purpose. Furnace (1) was shallower than the other and nearly square, and had an upright flag of sandstone, 7 inches high, across the mouth. The long oval shape of the adjoining furnace (2) showed that it was not the seat of a circular caldron or melting-pot, and a mass of red plastic clay with which the interior was choked, numerous fragments of vitrified clay in contact with the floor, and a ring of soft clay exposed round its upper margin, where the calcined interior lining had been broken away, suggested that it had originally been overarched.

Underneath the fireplace it possessed three separate floors, the lower ones divided by a 2-inch layer of sand and gravel, and the upper ones by a cavity 1 foot 4 inches square and 2½ inches deep, filled with charcoal. Near the middle of the cavity there were two holes, measuring 7 inches by 1½ inch and 2 inches by 1¼ inch, evenly and symmetrically formed, communicating through the floor with the interior of the fire-place; and on one side, by an opening through the clay wall, communicating with the outside. By these openings it was possible to introduce an artificial blast, from a pair of bellows, into the centre of the fire, and it is difficult to conceive any other purpose the holes could have served.

The additional floors appeared to have been introduced for the purpose of raising the fire level and economising fuel, and were certainly not for the purpose of patching, the lower floors being complete and unworn. The stoke-hole was steined and overarched; it widened outwards, and in front of it
was a well-laid hearth of burnt clay, nearly semi-circular in shape, 2 feet 4 inches across. Surrounding the hearth and at the same level was a layer of fine white sand, such as is not met with elsewhere upon the site, but forms a natural deposit in one of the adjoining fields, whence it has been carted to Warrington for glass-making in recent years. This artificial deposit of white sand first suggested the idea that these peculiar furnaces were employed in the making of glass.

The furnaces in platform III (plate IX, No. 3, and plate VIII) were of similar dimensions and long oval shape. A hearth of burnt clay, of semi-circular shape, laid symmetrically in front of both their openings, was ornamented by a number of rings, 1\(\frac{1}{4}\) inch inside and 1\(\frac{3}{4}\) inch outside diameter, evenly stamped on the soft clay previously to baking.

The "finds" on the surface of floor II, and in the vicinity of the three platforms, will now be described and considered as indications of the date, origin, and purpose of the ovens or furnaces.

(1)—A silver "consular" denarius of Augustus (C. Octavius), damaged by heat, but identified by Mr. Barclay V. Head, F.S.A., of the British Museum, and described thus:—Obv., Head of Venus to r. Rev., Octavius in military costume marching to l, his right arm extended and holding a spear in his left, CAESAR DIVI F.; found a few feet south-west of the crucible II (which penetrated both floors), at 1 foot 10 inches below the present surface.

(2)—A second bronze coin of Trajan, blackened by heat, but otherwise in an almost perfect condition: Obv., Radiated bust of emperor to r., IMP. NERV. TRAIANO AUG. GER. DAC. COS. VIII. Rev., draped female figure standing front, holding a cornucopia in left and a pair of scales in extended right; SPQR. OPTIMO PRINCIPI, SC in field; along with (3) a fragment of an embossed Samian
bowl, having upright sides ornamented with a figure of Minerva armed in fine relief, found directly underneath the crucible II, at depths of 2 feet 4 inches and 2 feet 6 inches respectively; (4) a bronze ring, plain, \(\frac{1}{8}\) inch thick, \(\frac{1}{2}\) inch bore (for supporting the handle of a situla?); (5) a disc of black opaque glass, like obsidian, of plano-convex shape, \(\frac{3}{4}\) inch in diameter, \(\frac{1}{4}\) inch thick in the middle (plate X, No. 1, fig. 2), found near the northern edge of floor II, along with the ring (4), about 2 feet down; (6) two cusps of molars of wild boar (\textit{sus scrofa}), identified by Mr. Wm. E. Hoyle, M.A., director of the Owens College Museum, found about 4 feet down in the clay bedding of the enclosing wall on the west side of floor I; (7) a large coloured glass bead, of oblate spheroidal shape, \(\frac{4}{5}\) inches in circumference, or \(\frac{1}{2}\) inch in diameter across what may be termed the equator, and \(\frac{1}{4}\) inch through the bore. The body is of semi-transparent pale pea-green glass, ornamented with three inlaid rings, about \(\frac{1}{4}\) inch wide, one round the middle of cable pattern, pale blue and bluish white strands alternating, and two at the intermediate zones of opaque white enamel. A photograph of this bead is reproduced on plate X, No. 1, fig. 12. It was found at a distance of only 3 feet 6 inches south from platform I, and at a depth of 1 foot 6 inches. A somewhat smaller but similarly shaped and ornamented bead, with red, white, and blue strands alternating in the encircling cable, was found in the camp at South Shields; (8) an amorphous lump of copper, \(1\frac{1}{2}\) ounce in weight; (9) two squarish pieces of lead; (10) a lump of chalk, weighing about a pound, found in the immediate vicinity of platform II, directly over and in contact with one of the enclosed furnaces. It will be observed that these are all three materials
PLATE X.
H. S. OF L. AND C.

No. 1
For description see text

No. 2
A lump of glassy slag or scum

No. 3
Hand lamp (Lucerna) of common red ware and leaden holder

No. 4
Harp shaped fibula
3 views
used in the making of glass, and that the deposit of white glass-maker's sand was found at the same spot. In the blackened soil along the south side of the floor I, only a few feet distant, were found the numerous fragments of Roman glass and other interesting objects hereunder mentioned; (11) a triangular fragment (size 1½ inch by 1 by ¼ inch) of thin, clear, greenish glass, with the letters AL blown in a mould in relief on one side and indented on the other. It forms part of the word VALE inscribed over the three defeated competitors represented in relief on one of those "rare and curious" chariot race cups, which will be found fully described and illustrated in C. R. Smith's Catalogue of London Antiquities, p. 48, in The Celt, the Roman, and the Saxon, p. 285, and in the account of Old English Glasses, p. 11, by Alfred Hartshorne, F.S.A., who, along with Schermerans, considers that the balance of evidence is in favour of England as their place of origin, and of their date being rather in the second than the first century (No. 11); (11a) a piece of twisted crystal glass rod, about 2 inches in length, supposed to be a portion of one of the wands of office which, when complete, were about a foot in length, and had a kind of knob at one end. This valuable specimen has been lost, but a similar one, found previously, is in the Warrington Museum. (12) three amorphous lumps of different kinds of glass—common greenish tinted (No. 6), opaque white (No. 10), and clear glass (crystallum)—each weighing about one ounce, and evidently formed by an artificial process and not by accidental conflagration; (13) a small tubular bead or bugle, of dark green opaque glass, ⅛ inch long by ¼ inch thick (No. 6); (14) a triangular fragment of dull olive green glass, from the bulge of a globular vessel; (15) a fragment of unannealed pale green

Two similar fragments of greenish glass, evidently broken from *massae*, have been found this season—1901.
Excavations at Wilderspool.

glass, \( \frac{1}{4} \) inch thick, from the rim of a *patera*; (16) several fragments of the sides and moulded bases of square and round bodied *ampullae*, of bluish and greenish glass, so often met with and employed as cinerary urns in Roman cemeteries; (16a) a small bit of opaque cobalt blue enamel or frit.

Along with these glass fragments of a number of vessels, which would obviously have formed a notable collection if found complete, there were the following specimens in lead:—(17) a leaden weight, with corroded remains of the staple of an iron ring, marked \( \text{XIII} \) by slightly indented lines on the shoulder, and weighing 7lbs. 14\( \frac{1}{2} \) ounces; (18) a leaden disc, weighing 8\( \frac{1}{2} \) ounces; (19) several strips of sheet lead, 3\( \frac{1}{2} \) to 4 inches in length by about \( \frac{1}{2} \) inch in width and \( \frac{1}{16} \) inch in thickness. (20) In addition to the above there were several fragments of querns, of vesicular lava from the Eifel; (21) a much-corroded second bronze coin of Trajan, (legend undecipherable); (22) a lump of glassy slag or "scum," apparently waste from a broken "pot," composed of whitish opaque glass mixed with clay. (Fig. 2.)

In recording these glass specimens it should be recalled to mind that a melon-shaped ribbed bead, \( \frac{1}{2} \) inch in diameter, of cobalt blue translucent glass, along with the unique specimen of embossed Samian, which was figured and described in my preceding report (plate IV, fig. 15, and p. 27, Trans., vol. xiv, n.s.), was found in the tumbled foundations of a house on the east side of the clay floor I.

Fragments of Roman cut glass, of an equally interesting character, were found in the clay floor of the annex, situated outside the rampart on the west side of the *civitas*. Those represented on plate X, No. 1, figs. 1, 3, and 7, are portions of crystal glass drinking cups or goblets with upright sides, ornamented by angular cordons and encircling bands of incuse oval facets, such as have been fully illustrated
Plates XI. H. S. of L. and C.

No. 3

Ease of furnace and annealing oven with ring-marked hearth, Romano-British civitas at Wilderspool

No. 1

Base of furnace and annealing oven with ring-marked hearth, Romano-British civitas at Wilderspool
and described by Apsley Pellat in his *Curiosities of Glass Making*, p. 136, plate III, fig. 3; and by Dr. Anderson and Mr. James Curle, jun., in the *Proc. of the Scot. Soc. of Antiquaries*, 1896, p. 189, et seq. The pattern on that represented by No. 3, is formed by deeply-cut intersecting grooves, with intervening cones and ridges. One of the facets only is polished, showing that the vessel was rejected owing to a breakage during the operation, and that the process was being performed near the same spot.

**OVAL FURNACES OR LEARS.**

All three specimens were met with in the soft clay surrounding two large oval furnaces or ovens, which were each enclosed in a separate platform of heaped-up boulder-clay, such as has already been described. The shape of each was likewise preserved and traced by means of their calcined interior lining. They were peculiar in having two openings, a stoke-hole at one end and a horizontal flue or channel at the other, or upon one side. Closely adjoining the stoke-hole of No. I (plate XI, Nos. 1 and 3) there was the base of a small circular furnace for heating a caldron or melting-pot, and in front of both openings an ornamental hearth stamped with twenty-one indented rings 2½ inches in diameter. The hearth in front of No. II was carefully laid with stone flags and a Roman brick, cracked and broken by heat, measuring 15 inches by 11 inches by 2½ inches. Crossing diagonally underneath the floor and platform surrounding the latter (No. II) was a circular flue, 6 to 7 inches in diameter, resembling a rabbit-burrow, which commenced at a small clay furnace or fire-hole beneath the N.E. angle, and ended in two exits on either side of the opposite S.W. angle, at a total distance of at least 32 feet, the flue being still open and blackened with soot internally throughout its entire length. Close to the side of the stoke-
hole of the oven II, the flue expanded into a chamber 1 foot wide, which was covered over with fragments of amphorae, carefully set in stiff clay.

The interior dimensions of the two ovens, stokeholes, flues, and furnace were:—

Oven I.—Length 4 feet 6 inches, breadth 2 feet, height of upright sides 10 inches. Stoke-hole—Length 2 feet, breadth 1 foot 3 inches. Channel or flue—Length 2 feet, breadth 9 inches.

Oven II.—Length 5 feet, breadth 2 feet 3 inches, height of upright sides 4 1/2 inches. Stoke-hole and flue—Length 2 feet, breadth 10 inches.

Furnace—Length 2 feet 6 inches, breadth 1 foot 2 inches to 1 foot 4 inches.

They are both represented in plan and section on plate XI, No. I by a photograph. The special purpose of these ovens and the small furnace adjoining No. I is very difficult to define. The position of the hearths inside the area of the clay floors, and the provision of a separate underground flue for heating purposes beneath the floor of No. II, negative the hypothesis that they correspond to the central pit or chamber of a channelled or composite hypocaust. The most feasible explanation of them appears to be that the small furnace was employed for heating a glass-melting pot, and the adjoining ovens as "lears," into which the newly-fashioned glass vessels, while still hot, were immediately placed, in order to be annealed, i.e., gradually cooled, by being slowly withdrawn from the region of the fire by means of a flat wooden shovel or "peel."

Also, judging from the abundance of glass fragments found upon the site of the workshop on the north side of the fortified area, and the presence of glass-making materials without the usual proportion of potsherds and other ordinary Romano-British remains, it would appear evident that the three pairs of furnaces there situated were similarly employed
and that the glass specimens met with were not imported but actually made on the same spot.

Mr. J. Paul Rylands, F.S.A., who has collected objects from the adjoining sand-pits and interested himself in these discoveries for many years, in discussing the above suggestion, writes:

In 1869-70 I had 16 plates drawn in water-colours of objects found at that time at Longbank, Wilderspool; some of these objects then in the collection of the late Dr. Kendrick and the rest in my own collection, afterwards incorporated in that of Dr. Kendrick. These coloured plates are now before me.

Among the objects thus illustrated are two which seem to me to suggest that there was a Roman manufactory of coloured glass at Wilderspool; one of these is a piece of molten glass—green, blue, and white, and the other appears to be a fragment of a large crucible of buff-coloured material, having on one side (part of the interior of the crucible) a thin deposit of glaze of two colours—lapis lazuli and golden yellow.

Although it is nearly 30 years since I had this fragment in my hand, I well remember it on account of the importance I attached to its discovery.

The above letter supplies the only missing link in the chain of evidence required for proving the existence of a Roman glass manufactory at Wilderspool. The raw materials, the melting furnaces and crucibles, the finished and unfinished specimens, and waste, have all been traced and recorded, and the drawings and portable objects arranged and deposited in the Warrington Museum.

Mr. A. Hartshorne, F.S.A., *Old English Glasses*, p. 15, holds that since glass-making was carried on in a multitude of small furnaces throughout the Roman dominions, there is no kind of reason why the Romans should not have made it in Britain as they made it in Gaul, or why such places as *Salenae* (Droitwich) in the Midlands were passed unheeded by, and their products not utilised on the spot. This suggestion equally applies to *Saline* (Northwich), a great salt-producing centre only 9 miles from Wilderspool.
Probably the earliest known glass-furnaces are those described and illustrated by Agricola, *De Re Metallica*, *lib*. xii, p. 470, *et seq.*, as existing when chemistry was an empirical science and the industrial arts still in their infancy during the sixteenth century. The simplest form of furnace described by him was merely a two-storied, bee-hive-shaped brick oven, the upper chamber of which was 6 feet long, 4 feet wide, and 2 feet high, having on one side an opening, through which the ground materials were charged and a fierce fire of dry wood maintained, until the former, consisting mainly of silica and alkali, were fused into lumps of impure glass or *massa*. These lumps on cooling were broken up and re-heated in fire-clay pots, 2 inches thick, 2 feet high, and 1 foot 6 inches in diameter across the bulge, which were arranged upon the "siege" or middle floor of a more elaborately constructed furnace, which is represented on plate VI, No. 2, by a photograph from one of Agricola’s illustrations.

The simplest form of modern furnace, known as the "crib-furnace," which the early furnaces would probably most nearly resemble, is merely a rectangular casing of brick, through the front of which several long fire-clay cylinders, 2 inches thick and 9 or 10 inches in diameter, are inserted in a slanting position, so as to be easily accessible. Fire is introduced through a small opening at the bottom of the crib, and plays all round the crucibles until the "batch," composed of pure sand, alkali, "cullet," and other ingredients in due proportion, with which they are charged, is completely fused. A draught is obtained by means of a flue from the top of the "crib" to the main chimney.

*Ovens or Hypocausts.*—There were two of these oval chambers enclosed in massive boulder-clay platforms, but having external fire-places, situated inside the fortified area, upon the west side, 41 feet
CROSS SECTION OF NO. 1 HYPOCAUST IN LONG CORRIDOR HOUSE, ROMANO-BRITISH CIVITAS AT WILDERSPOOL
Excavations at Wilderspool.

from the *via*, and 12 to 14 feet from the south wall of the long corridor. They had their roofs or vaulted covers complete, and are therefore of special interest, as illustrating the original shape of all the others which were found in a collapsed condition (except the furnace of the potter's kiln uncovered at Stockton Heath). Plans and sections of these two structures, which were supposed to be hypocausts, and also a photograph of the cross-section of No. I, are given on plate XII, Nos. 1 and 2.

The two platforms were placed lengthwise across the east and west ends of what appeared to be the floor of a room, their surface being level with that of the floor, which was a layer, 3 to 5 inches thick, of well-pounded clay *opus testaceum*). The approximate dimensions of the floor and chamber were 18 feet by 9 or 10 feet, but there were no indications of enclosing walls, which were probably of wood and had disappeared. The measurements of the platforms were—I (west end), length 9 feet, breadth 5 feet, depth 1 foot 8 inches; II (east end), length 9 feet 6 inches, breadth 5 feet 6 inches, depth 2 feet 10 inches. The furnace of I projected on the west side 4 feet 4 inches, its width being 3 feet 2 inches, and height 1 foot 6 inches; the side walls were of clay, well calcined; the cover of slabs of sandstone and limestone, the former reddened and the latter reduced to a white powder on the inside by heat. The fire-hole was 1 foot 10 inches wide by 1 foot 6 inches high, and the flue at the back, for carrying the heat into the enclosed chamber, length 1 foot 4 inches, breadth 10 inches, depth 6 inches. The furnace of II was entirely of clay, and extended 4 feet 6 inches from the north end of the platform, tapering, like a pig's snout, from a height and width of 5 feet to about half, with two circular flues or fire-holes, 6 inches and 8 inches in diameter respectively, passing through
Excavations at Wilderspool.

it, and branching off in an irregular way, so that they could not be definitely traced.

There were also two small round flues, 7 inches in diameter, formed of clay, joining the two platforms and running underneath the floor on either side like rabbit burrows.

The interior dimensions of the heating chambers were—I, length 5 feet, breadth 2 feet 6 inches, depth 9 inches; II, length 7 feet, breadth 2 feet 8 inches, depth 1 foot 10 inches. The dense clay surrounding them was burned into a very hard mass of red brick or terra cotta, which accounted for their preservation. The thickness of the clay cover varied from 5 to 6 inches over the centre of the dome to 1 foot 1 inch or 1 foot 2 inches, the vault springing directly from the base all round the inside. Incorporated with the hard burnt clay forming the roof of I, in order to strengthen it, were three slabs of sandstone uptilted on one end and supported by a pillar of small stones on the other end. These rude structures were supposed to correspond to the central pit of composite hypocausts, but they may have been merely ovens.

MISCELLANEOUS OBJECTS.

Many of the more important objects found during the excavations have already been referred to in connection with the structural remains. The following is a list of the ornaments, implements, glass objects, potter's stamps, graffiti, and coins which remain to be described.

BRONZE.

Harp-shaped fibula, 3½ inches in length, richly ornamented over the entire surface, with incuse spirals enclosing triangles on the massive trumpet-shaped head, a moulding of half-round, plain, and
Excavations at Wilderspool.

beaded cordons and grooves encircling the middle of the bow, and traces of black enamel on the outside of the bow, near the foot. The spiral spring of the acus is complete with five coils of bronze wire on one side of the central retaining loop and three coils on the other. The presence of a much oxidised iron or steel pipe, for receiving the butt-end of the acus, leads to the belief that the acus itself was of the same material. Plate X, No. 4.

A gold fibula of similar shape but plain surface, discovered at Ribchester (Bremetennacum), and preserved in the Blackburn Museum, is considered by Mr. Arthur J. Evans, M.A., F.S.A., to belong to the second century of our era.

Circular flat fibula, seven-eighths of an inch in diameter, with central boss and six surrounding studs arranged hexagonally, encircled by a slightly raised rim, all of bronze, much corroded; the intervening surface filled with black enamel, still hard and glossy. On the back there are slight traces of the hinge and catch for the acus.

Fibula, of greyish bronze or other non-corrosive alloy, two inches in length, shaped like an animal’s hind leg; the paw divided into five claws by radiating grooves; the hip or widest portion hollow and five-eighths of an inch in width. The acus and its attachments are wanting.

Heart-shaped ornament of a hair-pin, with a small portion of the pin attached. A central wheel-cross in front had the quadrants between the arms of the cross inlaid with an opalescent pale grey enamel, of which slight traces are visible.

Two halves of a much-corroded bow-shaped fibula.

Bangle or armlet of plain bronze wire, about one-eighth of an inch thick, broken at the joint, but
with both ends tongued to overlap, and pierced with two rivet-holes. One of the rivets remaining is no larger than the head of the smallest pin in present use.

**Six plain bronze rings** of round wire, one-eighth to three-sixteenths of an inch thick, and half to seven-tenths of an inch opening.

**Slightly tapering bronze pin**, one-eighth of an inch thick at the butt-end, and two and a-half inches in length.

**Bolt of a lock** (identified by Mr. H. L. Grueber, F.S.A., of the British Museum,) of plate bronze, (dimensions 2\(\frac{1}{4}\) by \(\frac{3}{8}\) by \(\frac{1}{10}\) inches) having three slots for admission of the bits of the key.

**Flat wire hook** for suspending a steelyard (statera), having a loop at one end, formed by bending back the wire and twisting the end twice round the stem to give it firm attachment.

**Thick bronze hook** of cast metal, about one inch in length, tapering to a flat everted point. It has a flat top and tang pierced with a nail hole.

**Hook**, for the chain or handle of a situla, with trefoil-shaped plate, pierced with three holes for the rivets by which it was attached to the rim of the vessel. One of the lobes is broken across the rivet-hole.

**Two fragments of metal mirrors**, with an uncorroded, smooth-polished, silvery surface on one side. (1) measuring one inch and a-half square, and having one edge straight and slightly bevelled originally, (2) measuring three-quarters of an inch by half an inch, and one-sixteenth of an inch thick.

**Buckle of cast bronze**, three-quarters of an inch long by half an inch broad, the middle bar replaced by two short projections.
Small bronze key (or horse-trapping), with broken ring, square stem, and web or bit turned at right angles, the latter grooved and pierced for fastening by means of wire or thread. (Though shaped like a key its purpose is doubtful.)

Sheath of sheet bronze, $2\frac{1}{4}$ inches in length, and tapering from $\frac{3}{8}$ to $\frac{1}{16}$ of an inch in width; imperfect through corrosion.

Six pieces of sheet bronze, in strips, disc shaped, or irregular.

IRON.

The list of iron objects not already referred to, includes:

Two keys, (1) 4 inches in length, with two bits, (2) 5 inches in length, with two bits.

Three knives, with straight backs, tapering to a point, (1) 6 to 7 inches in length, with socketed handle, (2) blade $3\frac{1}{4}$ inches long, 1 inch wide, tang $2\frac{1}{8}$ inches in length, (3) blade $2\frac{1}{2}$ inches long, $1\frac{1}{2}$ inch wide, spindle tang 2 inches long.

Loop hinge, with flat fastening plate 5 inches in length, and one rivet in position.

Two clamps, 4 inches and 10 inches long.

The number of iron nails, 2 to 3 inches long, obtained from all parts, has been very great.

LEAD.

Lamp stand, cut and hammered out of sheet lead about $\frac{1}{4}$ of an inch thick, in one piece originally, consists of a flat circular dish, $3\frac{3}{4}$ inches in diameter, with nearly upright sides, $\frac{3}{4}$ of an inch in height; a semi-circular spout projecting about an inch on one side of the rim, and on the opposite side a loop handle, formed by a folded strip about an inch wide, terminating in a crescent-shaped holder, which
Excavations at Wilderspool.

spreads directly over the middle of the dish. It was used for supporting one of the small terra-cotta hand-lamps (lucerna) so common in all Roman sites, and evidently served the threefold purpose of raising the lamp above the table, preventing it from being upset, and catching any oil dripping from the wick or spilling when it was carried about. The owner's mark, IV, is scratched on the inside. Plate X, No. 3.

Disc, 2\frac{1}{2} inches in diameter, \frac{1}{4} to \frac{1}{2} inch thick, weight 8\frac{1}{2} ounces, rounded on one side and flat on the other, with edges slightly turned by falling or throwing.

Flat disc, 1\frac{1}{8} inch in diameter, \frac{3}{8} of an inch thick, weighing 442 grains.

Pentagonal plate, beaten out with a square-headed hammer or punch to a thickness of \frac{1}{16} of an inch, each side 2 inches in length. There are nail holes in each of the angles, and two of the round heads of iron nails in position.

Many small strips and pieces of lead, with marks of use upon them, have been collected, but no shapeless masses which have been melted and run abroad, such as are found in localities which have been destroyed by "a general conflagration."

GLASS.

In addition to the various glass specimens which have already been described, there are a few which require to be mentioned separately, and a large number of small fragments of the ordinary kinds and shapes, undefinable.

Melon-shaped ribbed head of vitreous paste (fig. 9, plate X), coated with blue glaze, \frac{1}{3} inch in diameter, \frac{8}{32} inch bore.

Small tubular bead or bugle (fig. 5), of pale green opaque glass, \frac{3}{20} inch in length, \frac{1}{8} inch in diameter.
Piece of window glass, 3 inches square, dull on one side, where it has been in contact with a flat stone mould, and fire-polished on the other. One of the edges is also shaped by the upright side of the mould. Many smaller fragments of similar flat, greenish, translucent glass, about \( \frac{1}{15} \) of an inch thick, such as was found in one of the windows at Pompeii, have been obtained.

Small globule of dark blue, spongy, opaque glass, orenamel.

Piece of the base of a square bottle, of greenish glass, with moulded pattern of three concentric rings; another, with moulded pattern of a ring and four leaf-shaped loops arranged cross-wise round the circumference. Many fragments of the sides of similar vessels.

Several small fragments of very thin, hollow-sided vessels, of the purest and clearest glistening glass; and one roundish lump, probably the end of a loop handle, of the same kind of glass (crystallum).

Fragments of pale brown amber, olive green, pea green, milky blue, and ordinary bluish and greenish glass.

Potters' Stamps.

The following is a list of potters' names found stamped inside the base of vessels of so-called Samian ware; several are not included in any previous list:—

BELATVNSVS . F, patera.
CALLIMAXVS, patera.
CELTA, , patera, C.I.L. 285, Celtas,
Excavations at Wilderspool.

DATI . M, poculum.
DONATI . MA (MA ligulate), C.I.L. 430-2. Three examples from Wilderspool.
FILVIRA, poculum, (LV ligulate).
MACRINI (MA ligulate), C.I.L. 603-4.
MANV, C.R.S. Nanus F.
... CEPHOR. C.I.L. 758, Nicephori.
PECULIAR, (PE; VL, AR ligulate), patera, C.I.L. 824, &c., Peculiaris F.
OF SILVINI, poculum, C.I.L. 1069, &c.
SILVIO, poculum, C.I.L. 1078, Silvi of.
OF L• X, poculum.

Owners' marks scratched on the outside of similar vessels:—

MII/IC, C.I.L. 59, amphora, Melissa.
V C X R I, patera, Umari.

Potters' stamps on the handles of amphorae:—

III MIN
IGIOR
A•N
QRPHY
QSASER, C.I.L. 106, Q Saser(na).

Marks and names scratched on the outside of similar vessels:—

YYY in letters more than three inches in length, as if done with blunt stick or the back of the little finger nail on the soft clay. Similar letters were found on a tile at Melandra Castle (Zerdotalia). Is this the
Excavations at Wilderspool.

mark of the famous 20th Legion, the Valerian Victorious?

\[\text{\textit{LIVCN}}\text{\textit{S}}\] (Jucuns).
\[\text{\textit{TTMTR}}\] (undecipherable).
\[\text{\textit{Z VTH TR}}\] (undecipherable).
\[\text{\textit{CNGN}}\] (probably signifying the contents of the vessel, 102 lagenae, vide Life of the Greeks and Romans, Guhl and Koner, p. 459).

\[\text{\textit{LXIII}}\text{\textit{S}}\] (= \textit{LXIIISemis}). This was submitted to Prof. Dr. Bôhn, of Berlin, editor of the Gaulish and Germanic \textit{Amphora Stilo Inscriptæ}, for vol. xiii of the Corpus Inscri. Latin., and considered by him to signify the weight of the empty vessel, 63\frac{1}{2} ounces. He states in his communication to Mr. R. Blair, F.S.A., through whom it was sent, "I have shown for quite a number of vessels, which were so far preserved that their present weight could be compared with that furnished in the number, that such specifications of the weight of the empty vessel are frequently made."

Potters' stamps on the rims of \textit{mortaria}:

\textbf{GENIALI}, (London List, \textit{Genialis Feci}).
Found also on Samian vessels, \textit{c.i.l.}, 482-3.

\textbf{ARNVS}, Arinus.

\[\text{\textit{C ATTIVS MARINVS FECIT}}\]
Excavations at Wilderspool.

Found also at Isca (Caerleon-on-Usk), *Archæo. Cambrensis*, iii, 1856, p. 77, tab. 2, fig 4; and *Isca*, p. 42, tab. 23, fig. 1.

**B R C**

**B V B**, retrograde, twice, (Bricos).

As stated above, these three are believed to be the names of local potters.

Naturally, the quantity of animal remains recovered was extremely small, but cusps of horses' teeth were found in all parts of the Roman stratum; and the cusps of molars of wild boar in four instances, in addition to the one mentioned on page 36.

The complete list of coins to date includes 3 consular or family denarii, 5 coins of Vespasian, 3 of Domitian, 24 of Trajan, 12 of Hadrian, 2 of Antoninus Pius, 2 of Marcus Aurelius, 2 of Commodus, and one each of Faustina, Lucius Verus, Lucilla, Severus, and Constantine the Great.