IRISH COPPER CELTS.

BY GEORGE COFFEY, M.R.I.A.

[WITH PLATES XXI-XXXIV.]

THE late Sir William Wilde was, I believe, the first to make a separate classification of the copper celts found in Ireland as distinguished from those of bronze. In his *Catalogue of the Museum of the Royal Irish Academy*, he describes or mentions thirty specimens. The collection of copper celts in the Dublin Museum now numbers 84.[1] At the date of Wilde's *Catalogue*, 1861, only one specimen had been analyzed, No. 16, analyzed by J. W. Mallet about 1853,[2] the rest were classified by "the physical properties and ostensible colour of the metal." The appearance of the metal will seem a doubtful method of classification, but the yellow glint of bronze is very noticeable when contrasted with the red lustre of copper. It may be of interest to mention that in arranging the Dublin collection of celts, I selected those of copper in the first instance by the copper look of the metal. The subsequent analyses of eleven specimens in no case showed the selection at fault. Some of the specimens approach the type of the flat celt of bronze, and I fully expected from type considerations that in these instances a considerable percentage of tin would be found, notwithstanding their copper look. This did not prove to be the case, showing that the colour and lustre of the metal was a fairly safe guide, and that the selection had not been unconsciously directed by type.

The distribution of copper celts in Ireland is not confined to particular localities. Specimens have been found in the following counties: Donegal, Londonderry, Antrim, Tyrone, Sligo, Mayo, Galway, Fermanagh, Cavan, Louth, King's, Kilkenny, Tipperary, Limerick, Waterford, Cork, Kerry, counties which embrace the extreme north and south, and east and west of the Island, and include inland and central counties.[3]

[1] Mr. Day, Cork, has 24; the Museum of the Nat. Hist. and Phil. Soc., Belfast, 10; the Public Museum, Belfast (Grainger Collection), 5; Mr. Knowles, Ballymena, 6; the Murray Collection (now at Cambridge), 8. The number found in Ireland up to the present is probably, therefore, not short of 150.

[2] *Trans. R.I.A.*, vol. xxii, p. 325.

[3] Dublin Collection—Donegal, 1; Londonderry, 1; Antrim, 1; Tyrone, 1; Mayo, 1; Galway, 4; Cavan, 2; Louth, 1; Tipperary, 1; Waterford, 1; Cork, 1.

Day Collection (Cork)—Fermanagh, 1; Kilkenny, 1; King's, 5; Limerick, 2; Cork, 4; Kerry, 3.

Knowles Collection (Ballymena)—Antrim, 3.

Evans's "Bronze Implements"—Fermanagh, 1; Cork, 1.

Sir John Leslie (Glaslough, co. Armagh)—Sligo, 2.

Before proceeding to the description of types, it will be convenient to discuss the analyses.

In 1899 Mr. J. Holms Pollok, B.Sc., Assistant Chemist, Royal College of Science, Ireland, kindly analyzed eight specimens for me, the results were communicated to the British Association, at the Dover meeting in that year.[1] Mr. Pollok unfortunately did not separate the tin and antimony. When I subsequently drew his attention to this, it was found that the residues containing the tin and antimony had been thrown together, so that it was not possible to determine the tin and antimony separately for each specimen without fresh analyses. It was thought preferable to analyze three additional specimens, selected from the beginning, middle, and end of the type series, as giving as well as the separate determination of the tin and antimony in these specimens, a larger range of analyses for comparison. Two of the specimens were analyzed by Mr. Pollok, the third by Mr. D. S. Jardin, A.R.C.S.I.

In addition to the eleven specimens mentioned and that analyzed by Mallet, a flat copper celt from Ireland, in the British Museum, has been analyzed by Mr. W. Gowland, F.S.A., F.S.C. In all therefore, thirteen specimens have been analyzed. The analyses are set out in the following table—the Museum reference is given, and the locality, when known. (See p. 267.)[2]

Making the maximum assumption that the determinations returned by Mr. Pollok as "Tin and Antimony" are wholly tin, it will be seen that in ten specimens out of the thirteen the percentage of tin does not exceed 0·51. In seven specimens it does not exceed 0·1 per cent. In one specimen only (W. 16, Mallet) does it exceed (by a small fraction) 1 per cent.

The analyses, as will be seen from the table, agree substantially among themselves and with those of copper celts from other parts of Europe.[3]

The presence of a small percentage of tin in these celts, as also frequently found in examples from other parts of Europe, raises the question whether the tin is to be regarded as intentionally added or as derived from the copper ore? In other words, whether such celts are to be classed as copper or poor bronze? A good deal of doubt still exists among archæologists on this point.

[1] *Proceedings of the British Association*, 1899 (Dover), p. 872–3.

[2] With the exception of the specimens analyzed by Mallet and Gowland (sulphur, nil and trace), the sulphur has not been estimated. It has been supposed that the presence of sulphur indicated that the copper had been obtained from sulphide ores. Mr. Gowland has, however, shown that this is not necessarily so; the most oxidized ores contain small proportions of iron and copper sulphides, and when reduced, the copper will contain quite as much sulphur as analyses of copper implements show. No point, therefore, turns on the sulphur. *Archæologia*, vol. lvi, p. 275.

[3] See Montelius, *Die Chronologie der ältesten Bronze-zeit in Nord-Deutschland.* The only specimen out of line is Fig. 26 (W 10 Waterford), which contains an unusual amount of lead (2·74). Lead is frequently associated with copper, and the copper deposits in the district from which this celt comes are penetrated in many places by lodes and strings of lead. The celt is well shaped and finished, but the metal is noticeably soft compared with the other specimens analyzed. It is, therefore, probable that the high percentage of lead is accidental.

	Copper.	Tin.	Anti-mony.	Arsenic.	Lead.	Zinc.	Nickel.	Silver.	Gold.	Iron.	Bismuth.	Total.	
Fig. 2 (1897, 1,313)	99·78	0·03	trace	nil	nil	—	nil	0·15	—	nil	—	99·96	Jardin.
„ 14 (1881, 136), Cork ...	98·73	0·10*	—*	0·18	0·07	nil	nil	0·13	—	nil	—	99·21	Pollok.
„ 15 (W. 3), Londonderry ...	98·43	trace*	—*	0·76	0·05	nil	nil	0·25	—	nil	—	99·49	„
„ 22 (R. 1,633)	98·76	0·05	0·61	0·78	nil	—	nil	0·17	nil	nil	nil	100·37	„
„ 26 (W. 10), Waterford ...	96·46	0·05*	—*	trace	2·74	nil	0·21	nil	—	0·25	—	99·71	„
„ 27 (1870, 20)	98·24	0·83*	—*	0·13	0·12	nil	nil	0·07	—	nil	—	99·31	„
„ 28 (W. 16)	98·74	1·09	nil	nil	nil	nil	—	0·06	trace	0·08	—	99·97	Mallet (sulphur, nil; cobalt, nil).
„ 30 (1897, 112), Tyrone ...	97·25	0·51*	—*	1·56	0·17	nil	nil	0·25	—	0·10	—	99·84	Pollok.
„ 34 (1896, 7)	97·17	0·27*	—*	1·86	0·17	nil	nil	0·11	—	nil	—	99·58	„
„ 39 (1875, 20)	98·24	0·83*	—*	0·13	0·12	nil	nil	0·07	—	nil	—	99·39	„
„ 41 (W. 96)	99·44	0·06	0·01	0·28	nil	—	0·12	trace	nil	0·08	nil	99·99	„
„ 45 (1874, 38), Galway ...	97·68	0·79*	—*	0·76	nil	0·44	nil	0·18	—	nil	—	99·85	„
(British Museum) ...	98·22	0·12	nil	1·04	trace	—	nil	0·16	—	0·17	—	99·71	Gowland (sulphur, trace).†

* Tin and antimony. † This analysis has not been published previously.

The chemists do not venture to decide the question. Dr. Gladstone, writing in this *Journal* in reference to the presence of small quantities of tin in some Egyptian implements, observes: "There can be little doubt that the admixture of tin was made for the purpose of hardening the copper, like the arsenic and antimony, and small as it is would have an appreciable effect. That so little was employed in these very early days was probably due to its costliness. It is possible also that it existed originally in small quantities in some copper ores; which would in consequence be much sought after as producing a good hard metal."[1]

Without discussing the particular case of Egypt, it appears to me, from the analyses available, that, as regards Europe, the presence of a small percentage of tin is a more common impurity in copper ores than is generally supposed. The analyses of coarse coppers, both as regards tin and other impurities (arsenic, antimony, etc.), agree closely in many instances with the analyses of the copper celts. In the case of the coarse coppers it is known that the tin and other impurities are derived from the ore. A *prima facie* case is, therefore, I think, made out for the derivation of the tin from the ore, and I do not see that there is a sufficient reason to differentiate the tin from the other impurities in the copper celts. Arsenic and antimony are common impurities in copper ore, and the question of their intentional addition cannot arise unless the quantities are larger than may be expected from the ore. Of two explanations we should accept the simpler, and only when it has been shown that the local ores, from which it may be presumed the copper was obtained, are free from tin, does it seem allowable to argue that the tin has been added, and even then the possibility that the coppers or implements were imported has to be considered.

It has been stated that the copper ores of Europe do not contain tin, at least, those which do not come from tin districts.[2] What is a tin district is a question of degree. Outside Cornwall tin is found in paying quantities, or is known to have been worked in former times in the north-west of Spain, Saxony and Bohemia, near Limoges in France, and in more than one locality in Brittany. In addition to these localities it is known to occur in Silesia and at Findbo in Sweden.[3] The list could be extended, we may add Wicklow in Ireland.

In reference to the presence of tin in copper ores from non-tin districts, Dr. W. K. Sullivan observes: "Even in districts where tin ores are not found, at least in any quantity, some tin may occur in copper ores, such as Gray Copper. According to an analysis made by Herr G. vom Rath, the Fahlerz of Kotterbach contains 0·64 to 0·75 of tin."[4]

[1] *Journ. Anthrop. Inst.*, xxvi, p. 312.

[2] Morlot, *Mem. Soc. Antiquaires du Nord*, vol. v, p. 25.

[3] I take these localities from Sullivan's chapter on the "Sources and Composition of the Ancient Bronzes of Europe," in his Introduction to O'Curry's *Manners and Customs of the Ancient Irish*, p. 419.

[4] p. 414. An analysis of fredricite, a variety of tennantite, gives tin 1·41. This mineral occurs at Falu, Sweden. Dana's *Mineralogy*, Appendix III.

As instances of tin in copper, Sullivan quotes an analysis by Genth of *refined* Norway copper containing 0·27 tin, and an analysis of Swedish *black copper*, analyzed at the Mining School of Fahlun, containing 0·07 tin.[1]

The investigations of the brothers Siret have established the presence of tin to the extent of 0·4 to 0·5 per cent. in copper ore from the south-east of Spain. This is not a tin district, and, though searched for, no tin ore was found in the localities from which the copper ores were taken. This case is of the first importance, as the evidence is full and definite.

At Parazuelos, ore collected for smelting by the prehistoric inhabitants of the site was identified by analysis with the local ore, chiefly blue and green carbonate of copper. Analyses of the ore and slag left by the ancient smelters gave the following results:—

	Ore.	Slag.
Copper (CuO)	25·93	15·32
Tin (SnO)	0·10	0·06
Lead (PbO)...	0·60	1·84
Arsenic (As_2O_3)	1·86	0·25
Antimony (Sb_2O_3)	0·62	0·20
Gold	trace	—
Silver	trace	trace
Sulphur	trace	0·64
Iron (Fe_2O_3)	39·56	56·73
Nickel (NiO)	0·40	0·61
Non-metallic elements (details, see Sirets)	31·43	24·35
	100·00	100·00

At another station, Campos, the ore and slag gave—

	Ore.	Slag.
Copper (CuO)	55·58	30·56
Tin (SnO)	0·29	0·28
Lead (PbO)...	trace	trace

[1] These analyses are also set out in Percy's *Metallurgy*, and other works on metallurgy.

Isolating the copper and tin, the figures correspond to—

——	PARAZUELOS.		CAMPOS.	
	Ore.	Slag.	Ore.	Slag.
Metallic copper	20 72	12·24	44·44	24·42
„ tin	0·08	0·05	0·25	0·25

These figures indicate that the process of smelting was primitive and imperfect. Allowing 10 per cent. for volatilization of other substances in the ore, the Sirets estimate, as the figures show, that the prehistoric smelters were only able to extract about 52 per cent. of the metal from the ore.

The figures further show that at Parazuelos these metals form an alloy in the ore containing 0·38 tin, and in the slag 0·41 tin. It follows from this that the copper resulting from the reduction of the ore should contain about 0·40 tin. In the same way, the ore from Campos should yield a copper containing up to 0·5 tin.[1]

As regards the absence of tin ore in the district the Sirets state :—

"Du moins aujourd'hui n'en connaît-on aucun gisement. M. Moldenhauer, qui depuis de longues années a fait un nombre considérable d'analyses des roches et minerais les plus divers, nous assure que jamais il n'a rencontré un seul fragment contenant de l'étain dans des proportions tant soit peu importantes. Nous-mêmes avons parcouru le pays en tous sens, visité presque tous les gisements métallifères analysé un grand nombre de minerais, nous n'avons jamais rencontré d'étain." [2]

In Cornwall, as is well known, tin occurs in considerable quantities in some of the copper ores. They are distinguished by the smelters as tinny ores. The following quotation from Napier may be recalled in this connection. Many of the distinguishing characters of an ore "depend more upon the foreign matters mixed mechanically with the copper mineral than forming a chemical constituent of it. . . . The minerals composing a vein are generally of a great variety of kinds, containing often copper, tin, antimony, bismuth, iron, nickel, cobalt, arsenic, manganese, silver, etc., besides what are termed the earthy minerals or matrix, such as quartz, lime, slate, etc. In mining, the contents of the vein are taken out, so far as it contains any of the metal or metals sought after; so that what is technically termed a copper ore is often a mixture of everything that the vein contains." [3]

[1] *Les Premiers Ages du Métal dans le sud-est de l'Espagne*, p. 215.
[2] p. 217.
[3] Napier on Copper Smelting, *Phil. Mag.*, iv (1852), p. 47.

Refined English copper often contains a small percentage of tin. But it is with unrefined coppers that we should compare the celts. The following nine analyses of coarse and blistered coppers are taken from Napier.[1] Blistered copper is the purest form of copper obtained by smelting and requires no further treatment but refining. Re-fusion of coarse copper brings it to the quality of blistered copper.

—	Coarse copper.						Blistered copper.		
Copper	95·6	92·5	90·0	93·4	94·8	89·4	97·4	98·0	98·5
Iron	0·3	1·2	1·4	2·4	2·0	2·0	0·7	0·5	0·8
Sulphur	0·4	2·5	1·5	0·6	0·6	2·4	0·2	0·3	0·1
Silica	0·2	0·4	2·6	0·7	0·3	2·4	—	—	—
Tin and antimony	2·1	2·0	0·3	0·5	1·1	1·3	1·0	0·7	—
Lead	—	—	—	0·5	—	—	—	—	—
Oxygen and loss	1·4	1·4	4·2	2·9	1·2	2·5	0·6	0·5	0·6
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

The tin and antimony are not separated in these analyses, but we may presume that an appreciable percentage of tin is present.[2]

In the south-east of Spain, as we have seen, the primitive smelters were not able to extract more than 52 per cent. of the copper and tin in the ore. The loss of tin in the smelting, it will be observed, was comparatively small. It appeared to me, therefore, desirable to ascertain the percentage of tin which might occur in copper ore from a rich tin district. I accordingly wrote to Messrs. Vivian, of Swansea, on the subject in October, 1899. The Messrs. Vivian most kindly offered to have their next consignment of Cornish ores tested for tin. Subsequently, under date January 17th, 1900, Mr. Odo Vivian wrote to me:—

"A short time ago we promised to let you have a few facts with regard to the contents of tin found in the Cornish ores which we used to treat." Mr. Vivian then sets out the following table of wet assays:—

[1] Vol. v, p. 351.

[2] An analysis by Le Play of *black copper* smelted at Swansea gives: Copper, 86·5; iron, manganese and nickel, 3·2; tin, 0·7; arsenic, 1·8; sulphur, 6·9. Two samples of *blistered copper* also by Le Play: (1) Copper, 98·4; iron, 0·7; nickel, cobalt, manganese, 0·3; tin and arsenic, 0·4; sulphur, 0·2. (2) Copper, 97·5; iron, 0·7; nickel, cobalt, manganese, 0·9; tin and arsenic, 0·8; sulphur, 0·1. (The tin possibly includes antimony.) *Annals des Mines*, 4 Sér. XIII, pp. 453 and 486. See also Percy.

——	Tons.	Copper.	Tin.
		per cent.	per cent.
1. Mixture of Levant ...	54, 55, 56, 68, 69, 70	12·3	0·94
2. „ „ „ ...	20, 41, 42	10·4	trace
3. C. B. and Tin Croft ...	55	7·4	trace
4. Devon Great Consols ...	50	6·4	0·75
5. Dolcoath	6	11·9	trace

Mr. Vivian adds, from Nos. 1 and 4: "It will appear that the tin may have been left in the metal after the smelting operations, and not necessarily added in the form of alloy."

It will be observed that tin is present in all these assays. Isolating the copper and tin in Nos. 1 and 4 it will be found that the proportions of copper to tin are, in the first case, 92·76 copper to 7·24 tin, and in the second, 89·52 copper to 10·48 tin.

If we can apply to these figures the results of the analyses of ores and slag obtained by the Sirets; that is, if the presence of a large proportion of tin and the character of the ore do not seriously affect the conditions; it follows from the figures for the Cornish ores that the copper obtained by primitive methods of smelting from the ores of a rich tin district might contain a considerable proportion of tin, a proportion in fact greater than that found in the copper celts. The copper ores of Saxony and Bohemia would probably yield results comparable as regards tin to the Cornish ores.

I am not at present able to offer direct evidence as regards the presence of tin in Irish copper ores. The Irish copper mines have not been worked for some years, and I have found difficulties in prosecuting that portion of the inquiry. I hope, however, before long, to be able to complete this branch of the subject.

Copper is found in many parts of Ireland. The chief mining districts are on the south-east and south coasts, in the counties of Wicklow, Waterford, Cork and Kerry. It has also been mined on a small scale in Clare, Limerick, Galway, Leitrim, etc.

Tin has been found in considerable quantity in the Goldmines River, Ovoca, in the copper district of Wicklow. Mallet says: "The occurrence of this mineral (tin) in the sand is mentioned by Weaver in his reports on the gold stream-works, but he does not seem to have been at all aware of the large quantities in which it exists." He adds that he obtained $3\frac{1}{2}$ lbs. of tin from about 150 lbs. of sand.[1]

[1] *Journ. Geol. Soc. Dublin*, vol. iv (1848-50), p. 272. W. W. Smyth, *Records of the School of Mines*, vol. i, p. 404.

This is a very high return, and if at all general would have placed the Wicklow tin in the first rank of stream-works. Tin has also been found at Dalkey in the co. Dublin, where it occurs in a lode with lead and zinc. The lode has been worked for lead and is now exhausted.[1]

Nennius mentions tin at Killarney (Loch Leane), co. Kerry, and Dr. Smith, author of the *History of Kerry*, states that he picked up small specimens of ore at Killarney which contained some tin,[2] but this locality requires confirmation.

From what has already been established as to the occurrence of tin in copper ore, and from the fact that tin has been found in quantity in at least one locality in Ireland, it is I think more than probable that it will be found in some of the Irish copper ores. Indeed, the presumption from the general evidence appears to be so strong, that a few negative analyses would not upset it.[3]

Mr. Gowland has pointed out that the ores which would be first sought for copper, would be the oxidized ores—oxides and carbonates. This he infers from the fact that they are surface ores, and are more easily reduced than the sulphides. The oxidized ores require only the single operation of smelting, whereas the sulphides must be first calcined. Malachite occurs at Tinnehely in Wicklow, close to the tin, and carbonate and black oxide of copper at Barnavore. In the Upper Cronbane and the Connary mines, in the same county, the principal deposits of copper consist largely of black oxide, of which the portions near the surface chiefly consist.[4] Large deposits of the carbonates of copper occur in the Cork and Kerry mines.[5]

TYPES.

Figs. 1 to 10 represent the rudest forms of copper celts. They closely resemble the stone celt forms found in Ireland. A few of the latter are illustrated for comparison (Figs. 59, 60, 63 (p. 274) and Plate XXXIV). Fig. 1 furnishes particular evidence on this head, the pointed butt being distinctive of a class of stone celts, an example of which is shown in Fig. 62. This is the only

[1] Kinahan, "Irish Metal Mining," *Journ. Roy. Geol. Soc. Ireland*, vol. viii, p. 11.

[2] *History of Kerry*, p. 125.

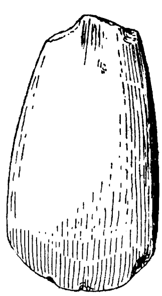
[3] Gray copper ore is frequently mentioned in the *Geological Survey Memoirs*, especially for the Cork and Kerry districts, but this appears to be chiefly vitreous copper (chalcocite, Cu_2S), and not true Gray Copper. For this use of the term see Kane, *Industrial Resources of Ireland*, 2nd Edition, p. 185, and Percy, p. 310. Kane mentions a large deposit of this ore near Dungannon, co. Tyrone (a northern locality), p. 200. True Gray Copper, arsenical variety, occurs in quantity in the Ardtully lode, Kenmare Valley, co. Cork. An analysis of the ore from this lode does not contain tin, but it is not clear that it was looked for. *Journ. Geol. Soc. Dublin*, vol. vi, p. 212.

[4] Smyth, *Records of the School of Mines*, vol. i, pp. 362, 380, 383.

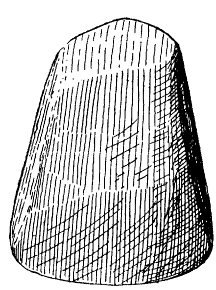
[5] *Geological Survey Memoirs*, Sheets 197 and 198, "Green carbonate of copper occurs abundantly between the dark purple slates and yellow shales of what may be called the passage beds between the old red and yellow sandstones, in a vast number of localities in the south of Ireland." Sheet 184, p. 37.

instance of a copper celt of this form which I know of from Ireland. The majority of the other examples resemble common forms of Irish celts, more or less ovate and thinned down to both ends.

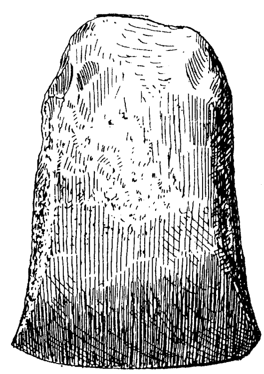
It may seem doubtful whether these stone celt forms are to be regarded as ingots cast in the traditional form of the stone celt, or unfinished implements. In several instances no attempt has been made to grind them to an edge (Figs. 1, 2, 3, and 8). In other cases, however, the celt has been rubbed down more or less over the body and the edge ground for use (Figs. 4 to 7). The range in size, moreover, appears to support the intention of their being implements. Figs. 6 and 7 may be compared with the small stone celt (Fig. 59). In Figs. 11 to 13 we see the beginning of the development of the metal type, with expanded cutting edge. These three examples must, I think, be regarded as unfinished implements, the edge of Fig. 13 is ground and sharp, while the marks of casting have been left untouched over the body of the celt, so that in this respect it resembles the stone celt types. This tends to support the view that the rude celts (Figs. 1 to 8) are implements cast in the prevailing types of the stone celts, rather than ingots cast in a traditional form. In fact, the examples referred to (Figs. 11–13) show a departure in form. Fig. 10 may be compared with the small highly polished



59. (W. 199.)



60. (W. 194.)



63. (1897, 289) NORTH OF IRELAND.

STONE CELTS FROM IRELAND (cf. PLATE XXXIV) FOR COMPARISON WITH PRIMITIVE COPPER CELTS.

stone celt (Fig. 60), a type not uncommon in Ireland. Copper celts of the stone type are relatively rare. The Dublin collection contains ten of this class.

The developed metal form is seen in the examples beginning with Fig. 15. I have placed this celt at the head of the series as it retains the proportions of the stone form. It is of nearly pure copper containing only a trace of tin, and has been rubbed down to an even surface, to which may be attributed the sharp and irregular form of the butt end.

In the development of the metal form, the most distinctive feature of which is the expanded cutting edge, two types appear, diverging gradually one from the other. The thick, square, rectangular butt end is common to both, and is the normal form of butt of the developed copper celt, Type I is relatively broad compared with the length (Figs. 16 to 28). The expansion or flare of the cutting edge in some of the larger examples is a very noticeable feature, and the concave curves of the sides are correspondingly marked, giving the celt a broad battle-axe appearance. This type would seem to lead up through examples such as Figs. 24 and 25 to the broad bronze celts with widely expanded cutting edge. (Wilde, Fig. 247).

Type II. The cutting edge is relatively narrower and the sides straighter, the form as a whole presenting a longer and more slender appearance (Figs. 29 to 42). This type appears to lead up to the common flat celt type of bronze. (Wilde, Fig. 248).

In many specimens types I and II over-lap, so that it is not possible to make a strict classification, but taking the series as a whole, the tendency to evolve the two types, as described, is, I think, apparent.

As the copper celts approach the type of the flat bronze celts, it will be noticed that there is a tendency to thin down the butt end and also to round it off, instead of the straight-across termination of the middle members of the series. This is better represented in type II than in type I.

The nearly equal thickness and flat faces of the middle members of the series also gives way to a gradual swelling of the body of the celt from both ends (in section), the thickest part of the celt at the same time moving up from the cutting edge towards the centre. These features mark the transition in the section from the stone to the metal form. In stone the thickest part of a celt is generally below the middle line, it being necessary, owing to the nature of the material, to allow as much substance as practicable at the cutting edge. In metal the thickest part of a blade is the back, corresponding, in a celt, to the middle of the implement; the thinning off from the middle line to the butt end being for the purpose of hafting, need not be taken into account. In a few instances indications of rudimentary flanges will be noticed (Figs. 40, 43, 44 and 54). These can, indeed, hardly be called flanges, being only a slight upsetting of the sides, afterwards rubbed flat. It is usually only noticeable on one face. Thus in Figs. 44 and 54 there is hardly any trace of an upset on the faces which are not shown in the figures.

Reviewing the evidence of type, it may, I think, be claimed that a development of form is found within the copper series. At one end are rude and heavy forms which look backward to the stone axe, at the other forms which approach more and more closely the early bronze celts. If this is granted, it excludes an explanation which has often been put forward to account for the copper celts, namely, that they represent merely local or temporary scarcity of tin. We are compelled by type-reasons to place them at the head of the metal series.

Collateral evidence supports this conclusion. (*a*) The expanded cutting edge is essentially a metal form. It has reacted on the stone celt, presumably in the period of transition between stone and metal. Figs. 63 and 64 illustrate two specimens of stone celts in the Dublin collection in which this is apparent. There are other examples in the collection. Considering the series of stone celts apart, celts of this class must be placed typologically at the close of the series. We thus have on the one hand the evidence of the stone celts in which the form has been influenced by the metal type, and, on the other, the evidence of the copper celts in which the influence of the stone form has survived. From both sides, therefore, evidence of transition is forthcoming.

(*b*) The copper celts never show any trace of a stop-ridge. This feature first appears, in a rudimentary form, in the bronze celts frequently accompanied by rudimentary flanges.

(*c*) The copper celts are never ornamented, whereas the flat bronze celts are often richly decorated with simple punched patterns.[1]

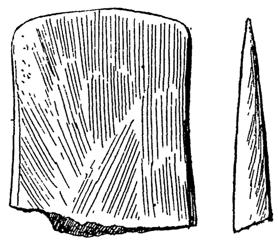
FINDS.

The greater number of the copper celts in the Dublin collection were acquired at a time when little attention was paid to the circumstances of the finds and association of objects, or formed part of private collections, bought from time to time, to which the same remark applies.

The following are the only finds of which I have been able to obtain information:—

(1) Three copper celts, three copper awls, and a copper knife, found in 1874, in a bog at Knocknague, Kilbannon, co. Galway. Purchased by Royal Irish Academy from the finder, Michael Rafferty. Figs. 44–48. One of the celts (Fig. 45) has been analyzed (tin and antimony 0·79). The metal of all the implements in this find is identical in colour and surface lustre, and there can be no doubt that it is of the same quality.

(2) Three copper celts, a fragment of a fourth (butt end), a copper halberd, and a short blade of copper of somewhat similar form, found in 1892, near Birr, King's Co. (Figs. 52–57). They were brought to a Mr. Morrison of Birr, from whom they were obtained by Mr. Robert Day of Cork, in whose collection they now are. The finder stated that they were found under the bog in the white clay. The metal of these six objects is red copper, and appears to be of the same quality in all the specimens. None of them have been analyzed, but the following extract from Mr. Morrison's letter to Mr. Day, at the time they were discovered, may be given as an independent opinion: "They are certainly not bronze but seem



55

[1] This applies generally to copper celts. The only exceptions to the contrary, with which I am acquainted, are six copper celts found near Malmö, Sweden, the faces of which are decorated with concentric lines. These celts were portion of a large find which included bronze celts and other bronze objects. The celts in question are of advanced early bronze type, with well marked flanges (Montelius, *Chronologie der ältesten Bronzezeit*, p. 55). How

to be all copper." The fragment (Fig. 55) has been rubbed down to a sharp edge at the butt, apparently for use as a small implement.

(3) Three copper celts (of type Figs. 23 and 24), found in 1868, when ploughing at Cullinagh, near Beaufort, Killarney, co. Kerry. Day collection, obtained through a friend from the finder.

The evidence of these finds is very consistent. They do not include any object of a late type. The celts in No. 1 are of good copper type, the awls are of an early form, and the knife I consider also to be an early type. It was evidently secured in the handle by a whipping of some sort of cord. This form of hafting may be regarded as derived from the stone age. Two other copper knives of this type have been found in Ireland (Fig. 49, found in a bog at Boho, co. Fermanagh, and Fig. 50, the locality of which is not known). The copper knife or dagger with single rivet-hole, Fig. 51 (locality not known), may perhaps be placed in the same class. These four examples are the only blades of copper, exclusive of halberds, in the Dublin collection.

The halberd in find No. 2 is admittedly an early form. It probably belongs to the close of the copper or beginning of the bronze period. Only one halberd in Dublin collection has been analyzed. It contained 2·78 per cent. of tin. Until a sufficient number of specimens have been analyzed we cannot draw a conclusion. It will be observed, however, that the celts in this find are of late copper type, compare Fig. 39 of the type series.

The remaining find calls for no special remark. But it is important in conjunction with the other finds as evidence of a number of copper implements having been found together without any association of bronze in widely separated localities.

In conclusion, reverting to the distribution of copper celts mentioned at the beginning of this paper, it will now be seen that the fact that they have been found over, we may say, the whole of Ireland, is significant.

Only three explanations are possible:—

(1) The copper celts were made of copper for a special purpose. The development of type within the celt series negatives this explanation.

(2) They represent local costliness or want of tin. The type series negatives this explanation also.

(3) They represent a period in which copper was in general use throughout Ireland, before bronze was known. This explanation meets the facts, and is enforced by the finds of associated copper implements.

I should perhaps note that all the figures in the text and the plates are reduced from my own full-sized drawings to one-half natural size, or approximately $\frac{2}{3}$ linear. The specimens with asterisk have been analyzed. Museum references are given in each case. My thanks are due to Messrs. Day and Knowles for kindly placing their rich collections at my disposal.

these celts come to be of copper (tin 0·04 and 0·31) we cannot say, but they cannot be held to impair the general statement, which is absolutely true for copper celts of copper type.

NOTE A.

The high percentage of tin in some of the Cornish copper ores (no doubt also to be found in some of the copper ores of Central Europe) may have a bearing on the question of the origin of bronze. In *Prehistoric Times* (Appendix) Lord Avebury quotes the opinions of experts against the probability, if not possibility, of bronze having been produced from a mixture of copper and tin ores, or from a mixed ore. These opinions, however, are chiefly directed to the question of how the ancient bronze was produced (what we may call the normal bronze of the Bronze Age), and not to the question of its discovery, which is a different question. The opinions of experts based on the experience of modern smelting, the object of which is to obtain a clean slag, are of doubtful value on that point. As far as I can see, the question turns on whether the loss of tin in the more or less open furnace of a primitive smelter would be compensated for, and to what extent, by its retention in the metal due to the low temperature of the furnace; and by the impossibility, therefore, of extracting more than about 50 per cent. of the metal from the ore by a primitive process of smelting. We require direct experiments on this point.

NOTE B.

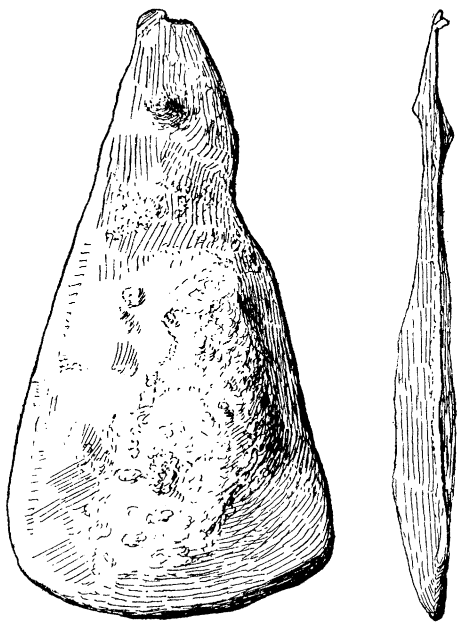
As far as I am aware, no copper celts have been published from England or Scotland. I am able to place the following on record. (1) A copper celt in the British Museum (copper 98·67, tin 0·05) stated (*Archæologia*, vol. vii, p. 283) to be Irish: Mr. Gowland has since ascertained that the locality is incorrect; the specimen is from Durham. (2) Cambridge Museum, two specimens in local collection, from the Fens. (3) Taunton Museum, a flat triangular copper celt from Staple Fitzpaine, Somerset; noted by Hon. John Abercromby, F.S.A.S. (4–7) National Museum, Edinburgh, four examples: Da. 1 (Wigtownshire), 14 (no locality), 43 (Colonsay), 58 (Perthshire). Also some other specimens of which I am doubtful without closer examination. None of above, with the exception of the specimen from Durham, have been analyzed, but I feel confident, from the appearance of the metal, and from the type, that they belong to the copper series. Other specimens will probably be found in local and private collections if looked for.

DISCUSSION.

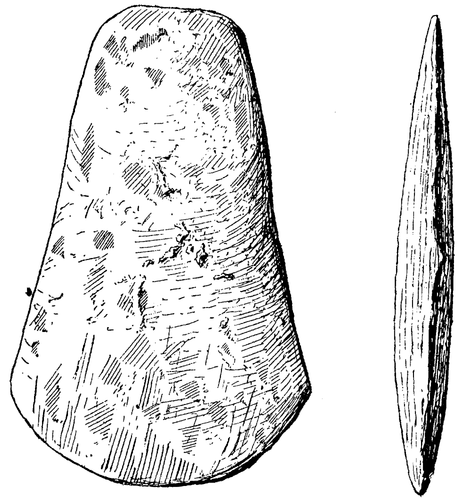
Mr. MYRES referred briefly to the confirmation of Mr. Coffey's conclusions which is supplied by the series of early copper and bronze implements in the Eastern Mediterranean. He laid special emphasis on the necessity, within the latter area, of noting the occurrence of rivetless hafted knives, which he had occasionally observed in Cypriote examples, but which had too often been put aside as imperfect or corroded specimens. An analogous example of a stone celt (from Melos) which shows clear traces of the influence of metallic types, will be found in *Journ. Anthr. Inst.*, XXVII, Pl. xi, 2.

Mr. BALFOUR: Mr. Coffey's interesting paper deals in a practical and scientific manner with a very important problem in the study of the development of human culture, and the evidence which he brings forward tends greatly to confirm the belief in the existence of a definite Copper Age in Europe, bridging over the gap separating the Neolithic and Bronze Ages. On logical grounds it has long been assumed that such an intermediate period must have existed, as through such a stage alone would there be evidence of that continuity in the development of the human arts which there is reason to believe in great measure occurred from neolithic times onward. A certain amount of direct evidence in support of this view has been steadily accumulating, and, although not as yet conclusive, must command the serious attention of archæologists. It seems likely that we may look forward to a time in the near future when all doubt as to this continuity in the advancement from the Stone to the Metal Ages will be set at rest. Mr. Coffey, no doubt through an oversight, made no reference to a paper of the first importance which, although read before a learned society so long ago as 1869, clearly foreshadowed, in no uncertain terms, the views which Mr. Coffey has so ably expressed. I refer to the lecture delivered by General Pitt Rivers on June 18th, 1869, before the Royal United Service Institution, being the second of his classical series of lectures on "Primitive Warfare." In this General Pitt Rivers deals at length with the development of the "celts" of the Bronze Age, and the successive stages through which the highest and latest forms were gradually evolved from the primitive and simple ones. He made a strong point of the fact of the most primitive types, whose resemblance to and probable derivation from typical neolithic shapes he drew attention to, being of pure or nearly pure copper. From the specimens and information which he possessed he was able to make this clear, particularly in regard to Irish bronze "celts," but such evidence as he had from other countries supported his views. He published an ingenious and most valuable diagram-table illustrating his remarks, and I venture to think that in dealing with this subject the researches of General Pitt Rivers, eminently characteristic as they are of that brilliant investigator, should on no account be overlooked. It is greatly to his credit that the views expressed in a lecture delivered over thirty years ago should practically hold good at the present day, and are supported by the most recent investigations.

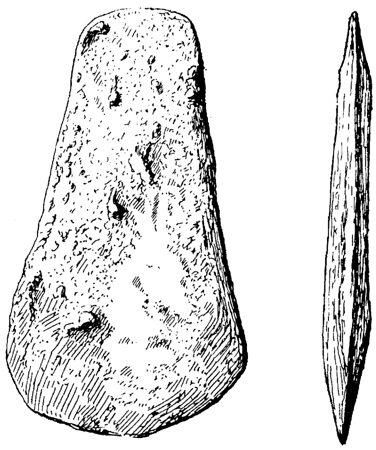
Dr. Gladstone expressed his admiration of the manner in which Mr. Coffey had worked out his research into the composition and probable source of these very ancient Irish celts. He has greatly strengthened our reasons for considering that the small amounts of tin which are found in ancient metallic tools in the countries of antiquity were not added intentionally, but were derived from the ores. If these very small quantities of tin, antimony or arsenic do really increase the hardness of copper, the employers of such weapons would find out where the best article came from, and thus these most valuable implements would be in the greatest demand among the ancient nations.



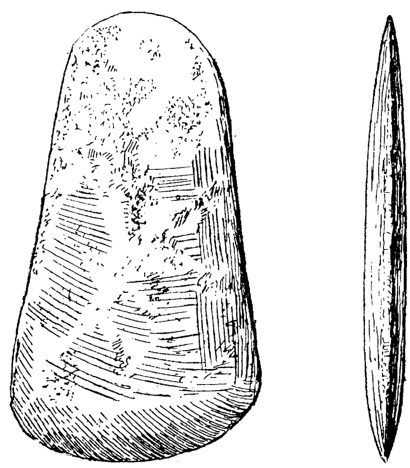
1. (W. 5.)



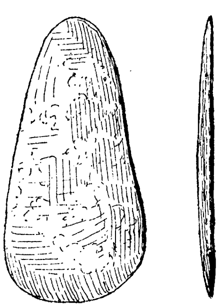
2.* (1897, 1313.)



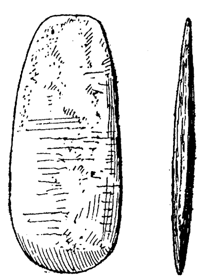
3. (1897, 111), CO. ANTRIM.



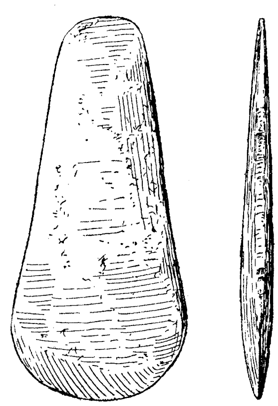
4. (W. 1.)



6. (1885, 348.)



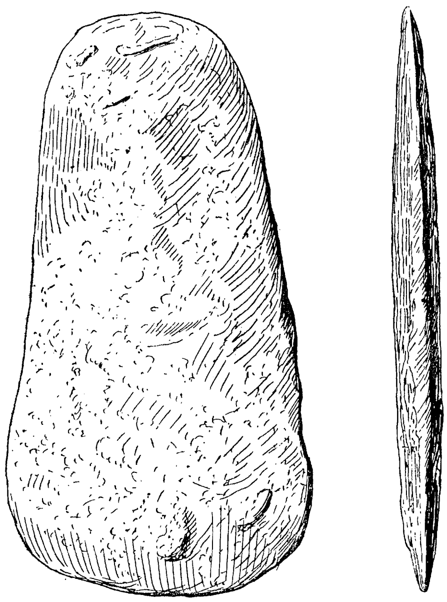
7. (W. 1, QQ.)



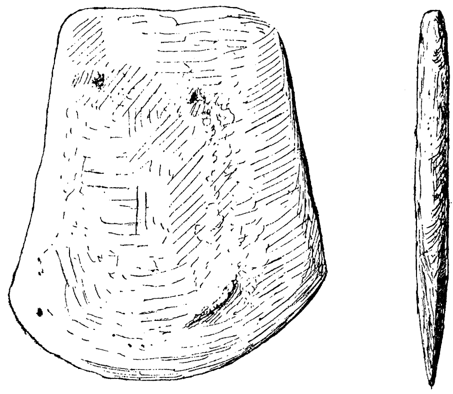
5. (W. 10, QQ.)

IRISH COPPER CELTS.

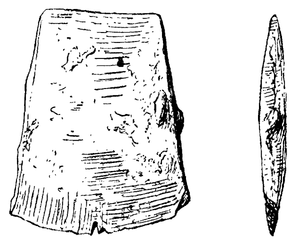
G.C. $\frac{2}{3}$ linear.



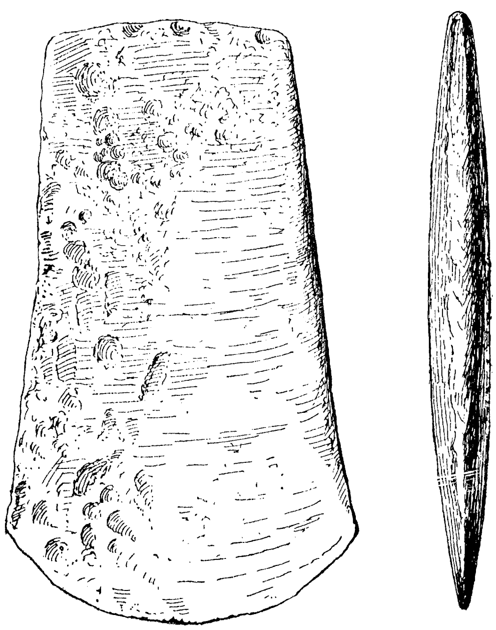
8. JERPOINT, CO. KILKENNY, *Day Collection.*



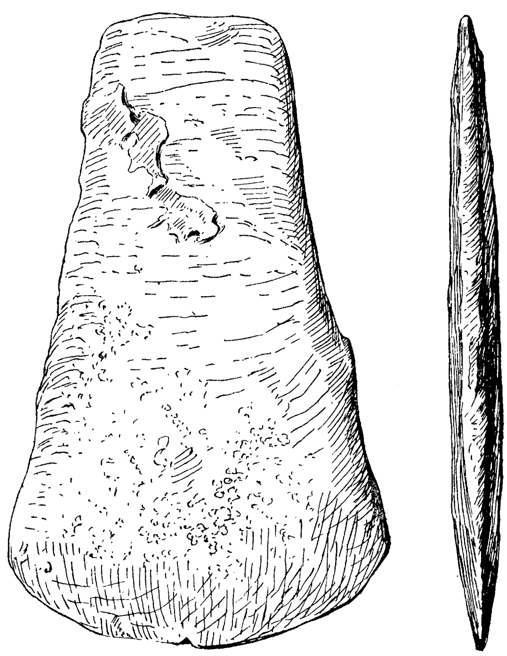
9. BALLYMENA, CO. ANTRIM, *Knowles Collection.*



10 (w. 591.)



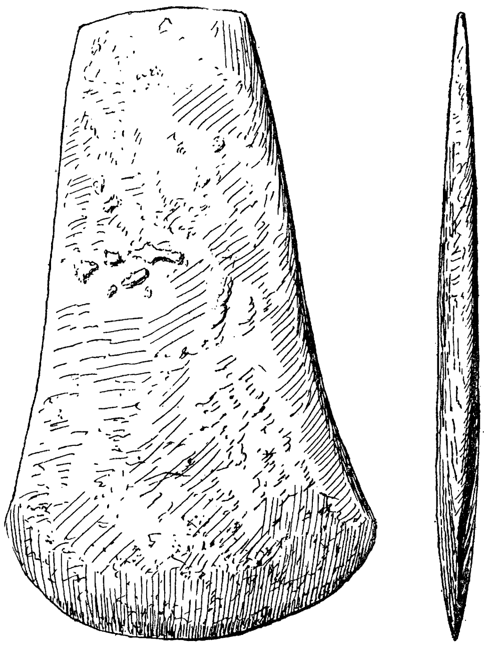
11. (w. 18.)



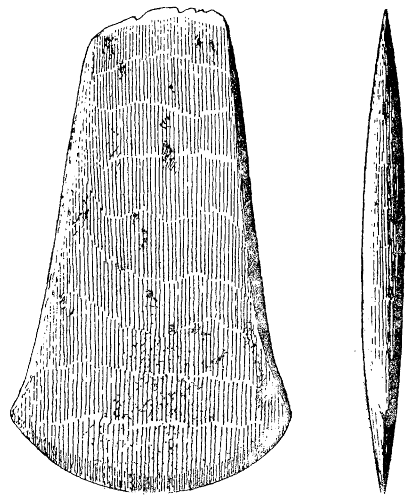
12. *Day Collection.*

IRISH COPPER CELTS.

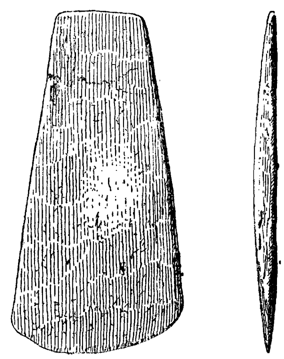
G.C. $\frac{2}{3}$ linear.



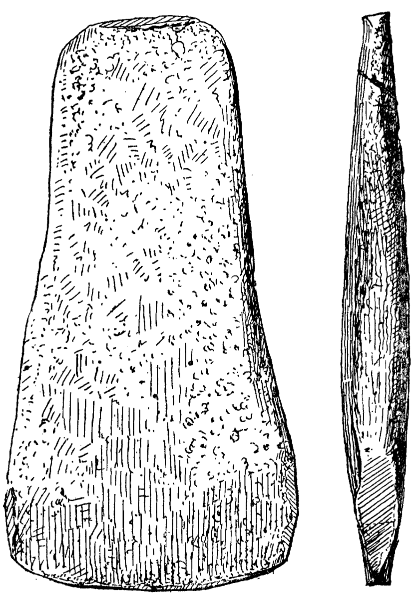
13. DUNMANWAY, CO. CORK (*Day Collection*).
Ground at edge, and sharp.



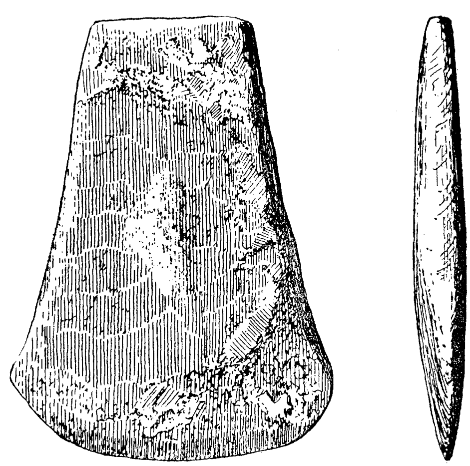
15*. (W. 3.) CO. LONDONDERRY.



15A. (W. 6 QQ.)



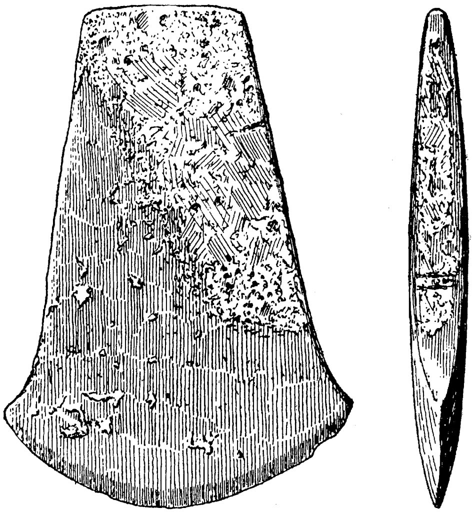
14*. (1881, 136.) CO. CORK.



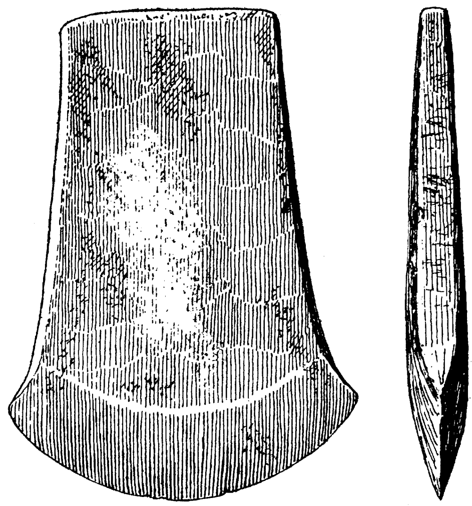
16. (W. 23.)

IRISH COPPER CELTS.

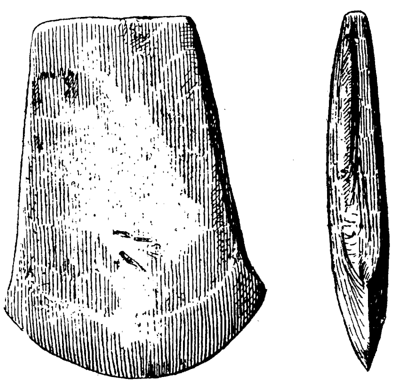
G.C. $\frac{2}{3}$ linear.



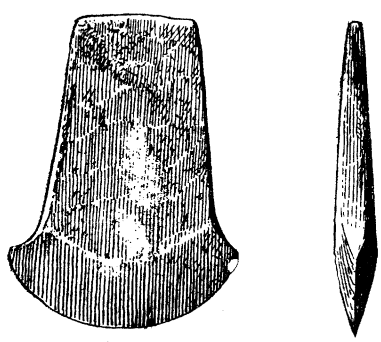
17. (R. 2294.)



18. (R. 2063.)



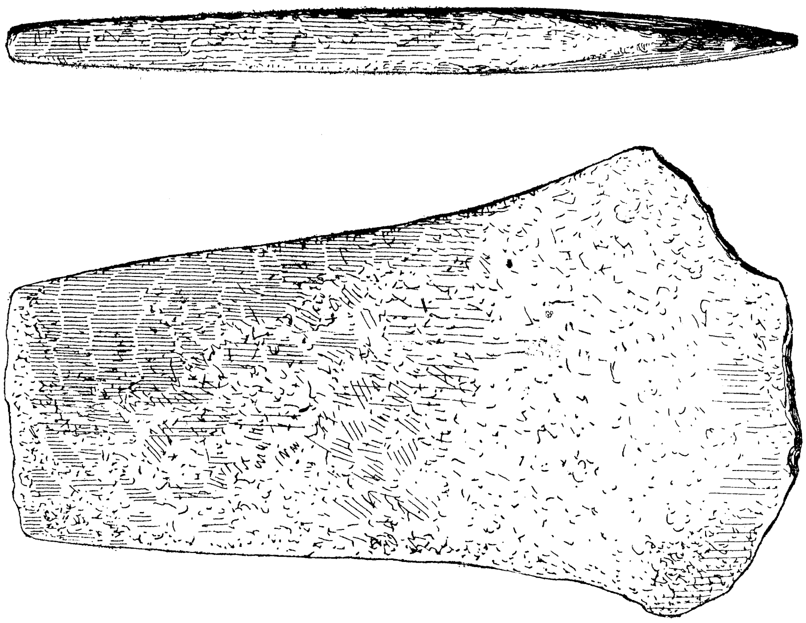
19. (1881, 137.)



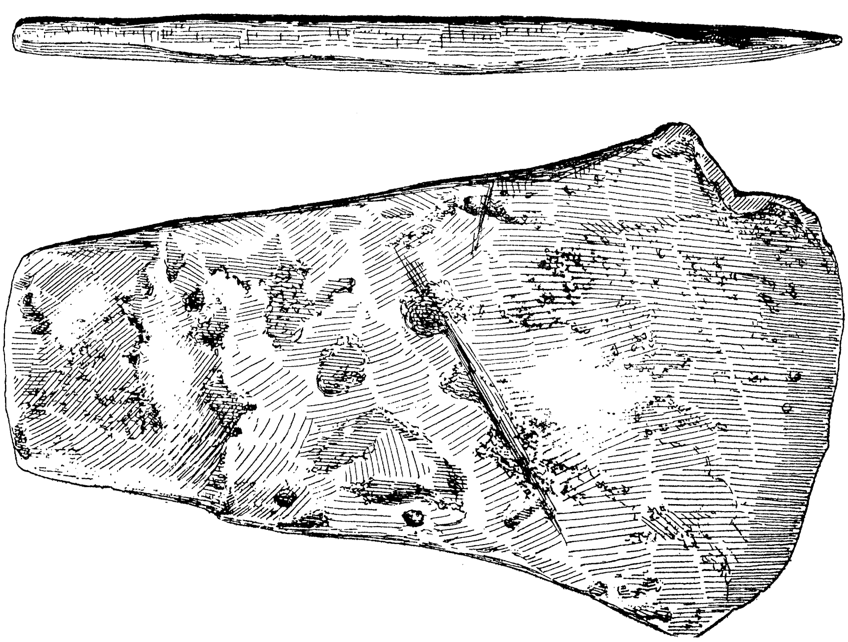
20. (W. 7, QQ.)

G.C. $\frac{2}{3}$ linear.

IRISH COPPER CELTS. TYPE I.



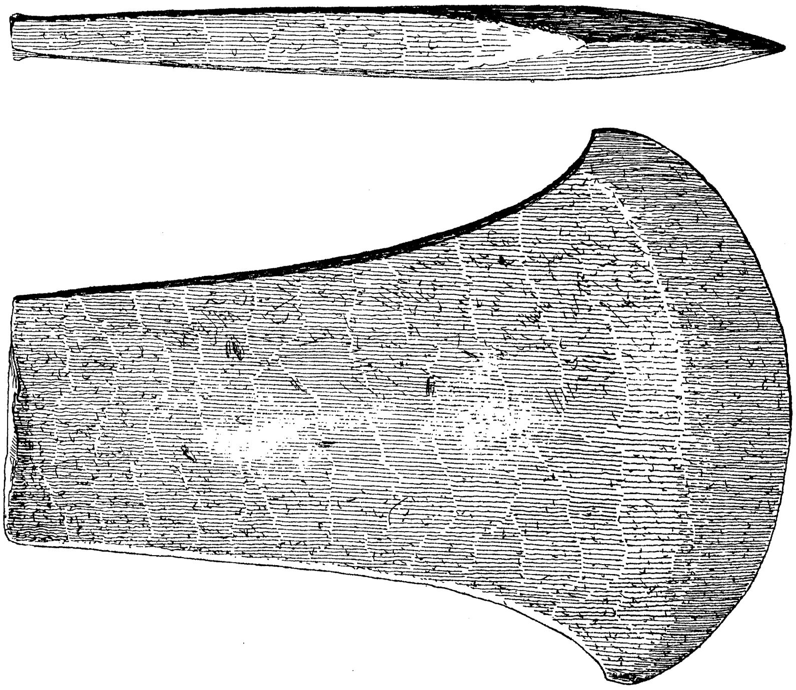
22.* (R. 1633.)



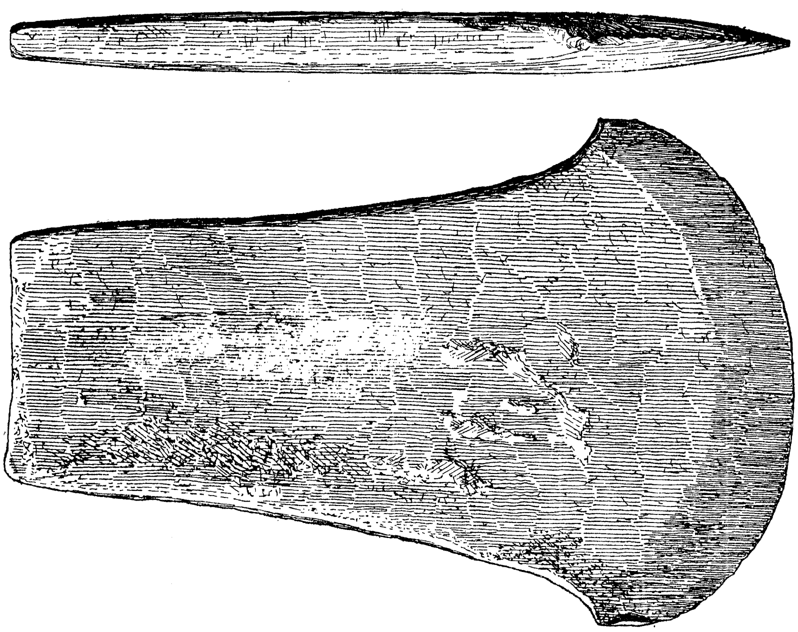
21. (1881, 133), CO. TIPPERARY.

IRISH COPPER CELTS. G.C. ⅔ linear.

Journal of the Anthropological Institute, Vol. XXXI. Plate XXVI.

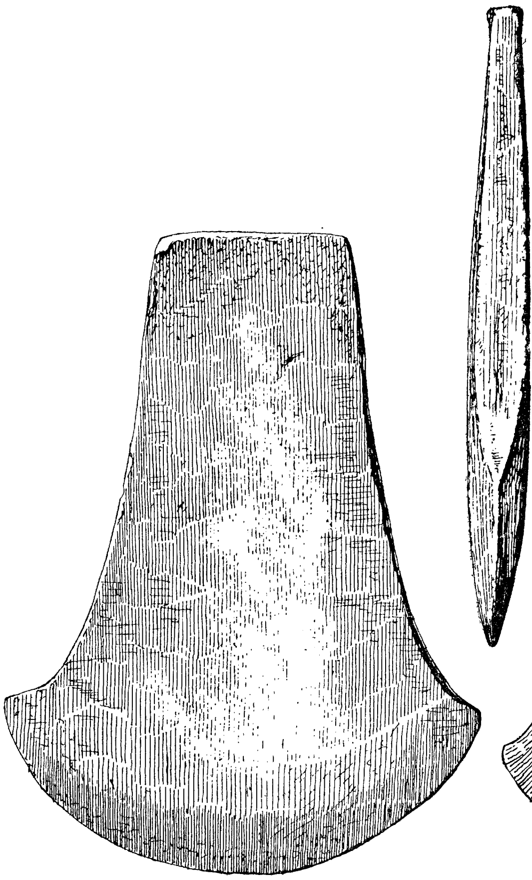


24. (1883, 303.)

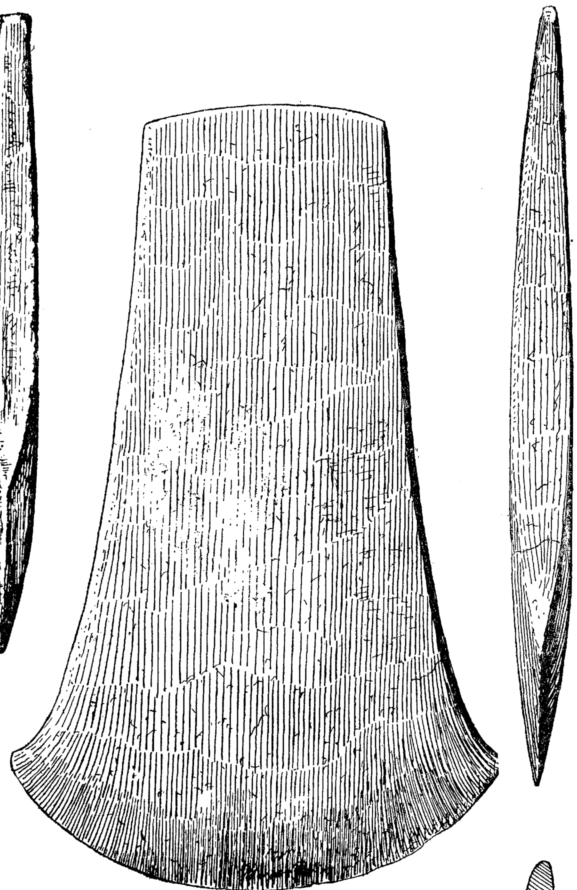


23. (w. 14.)

IRISH COPPER CELTS. G.C. $\frac{2}{3}$ linear.

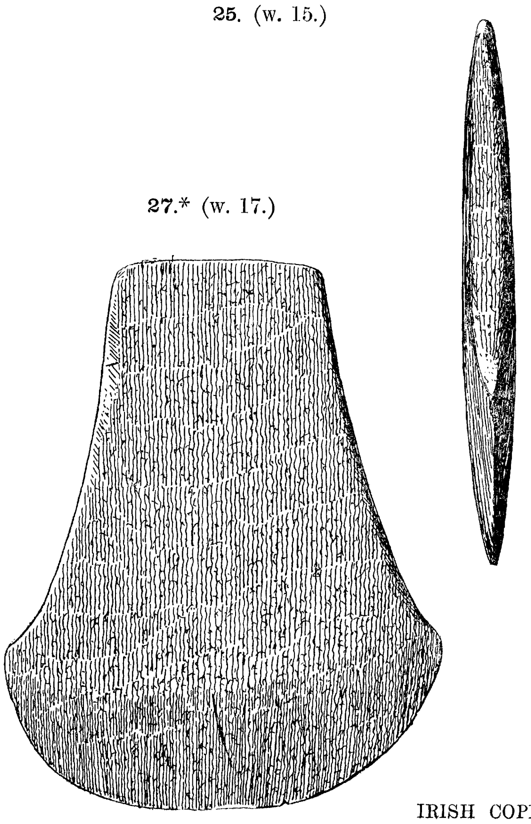


25. (w. 15.)

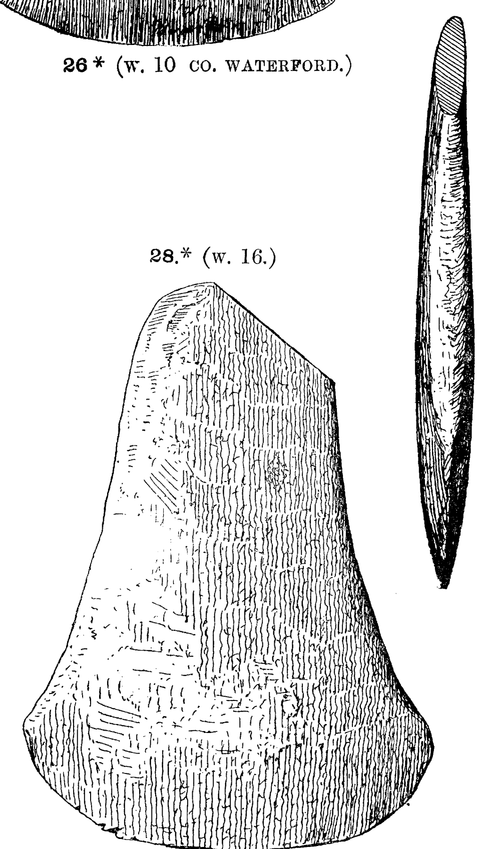


26 * (w. 10 CO. WATERFORD.)

27.* (w. 17.)

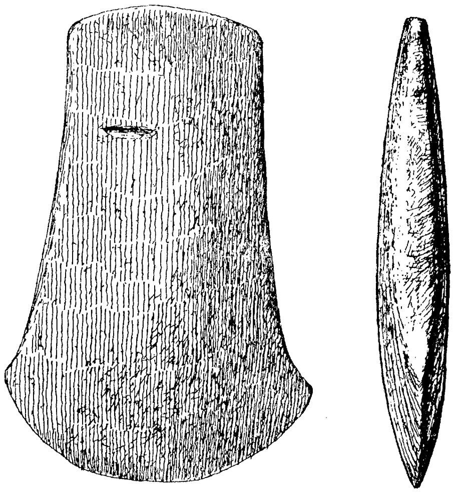


28.* (w. 16.)

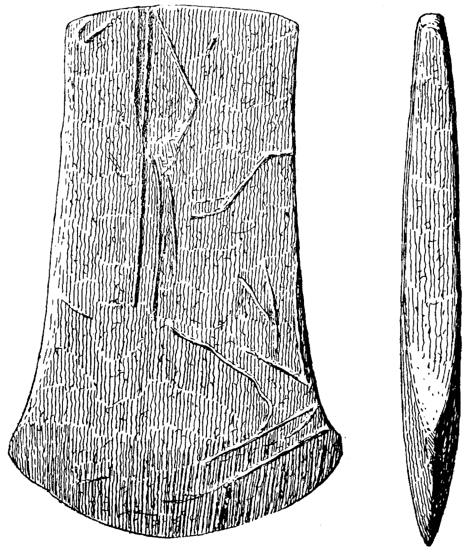


IRISH COPPER CELTS.

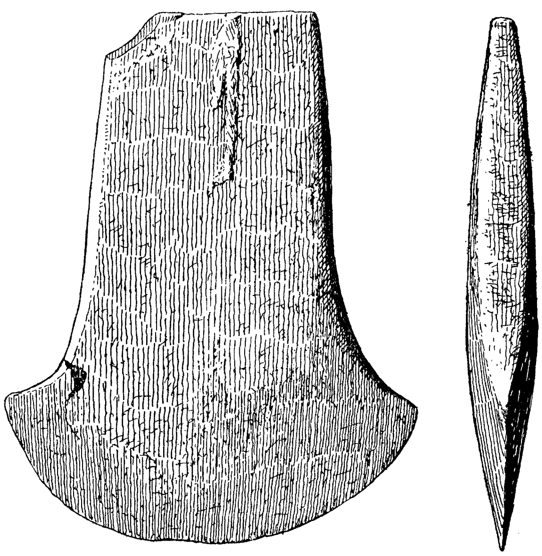
G.C. $\frac{2}{3}$ linear.



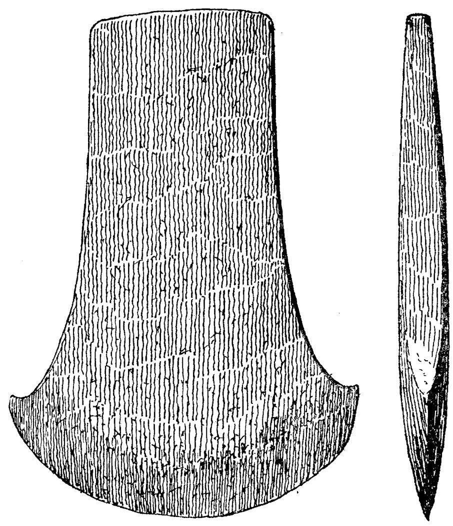
29. (W. 21.)



30*. (1897 112), CO TYRONE.



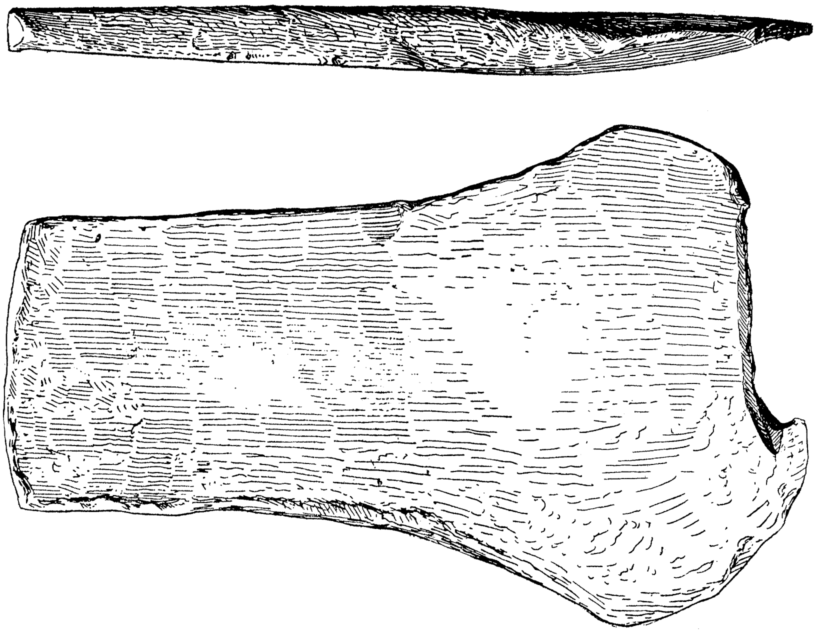
31. (W. 19.)



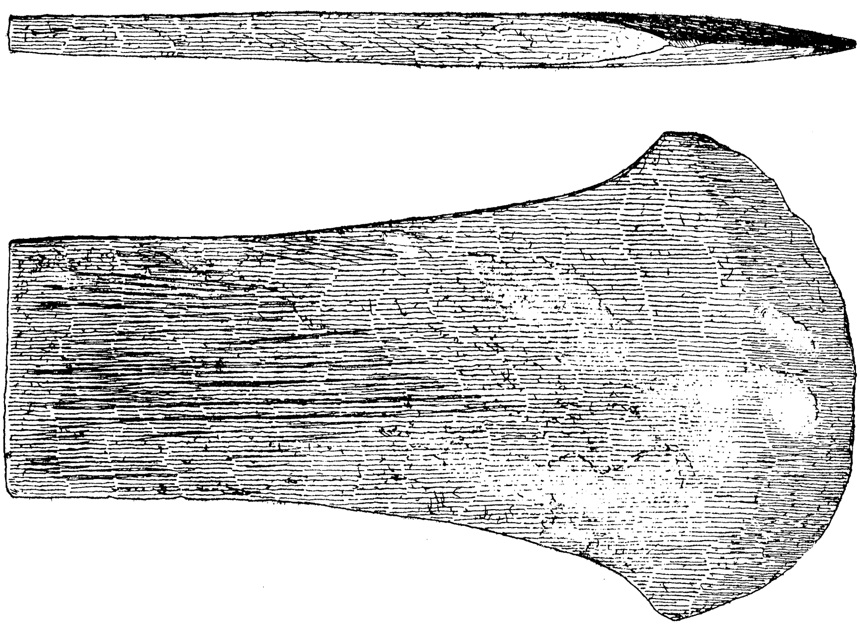
32. CO. ANTRIM, *Knowles Collection.*

G.C. ⅔ linear.

IRISH COPPER CELTS. TYPE II.



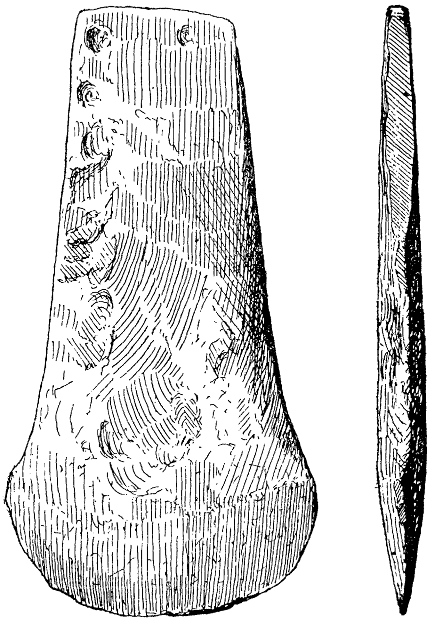
34*. (1896-7.)



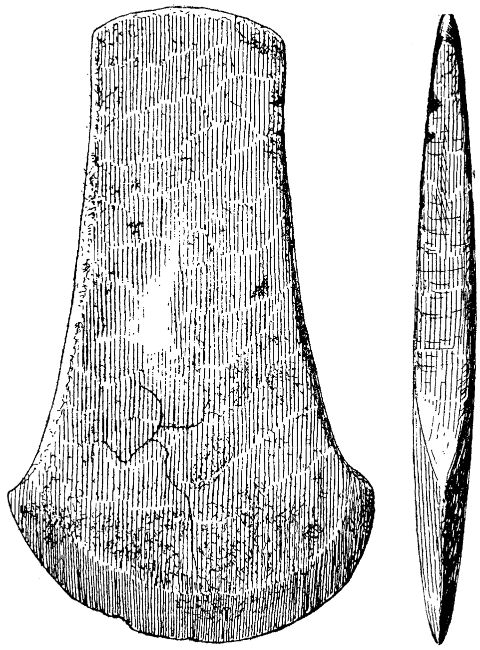
33. (P. 368.)

G C. $\frac{2}{3}$ linear.

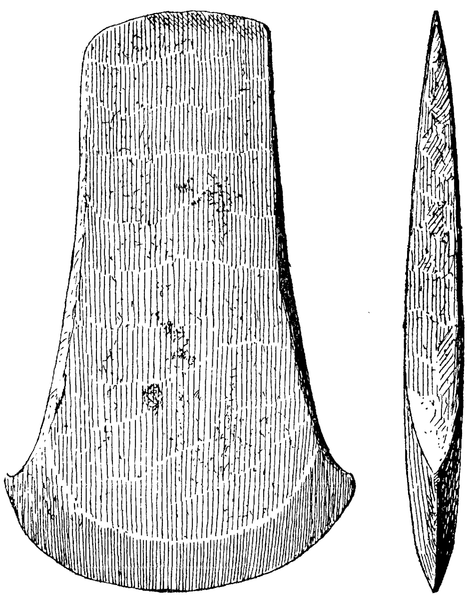
IRISH COPPER CELTS.



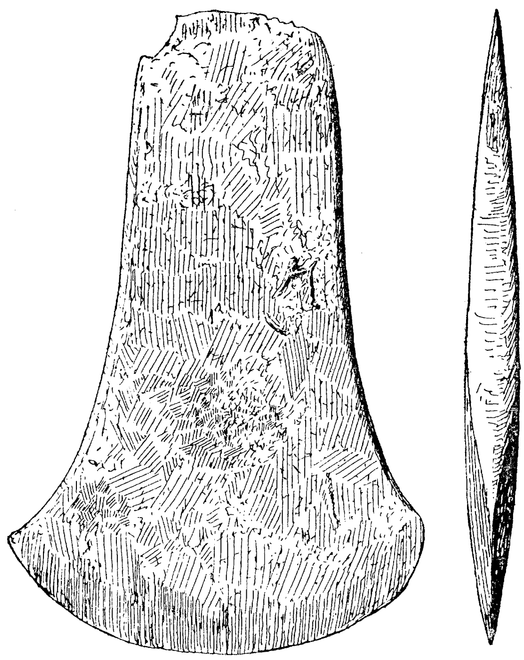
35. (1897, 29.)



36 (1896, 8.)



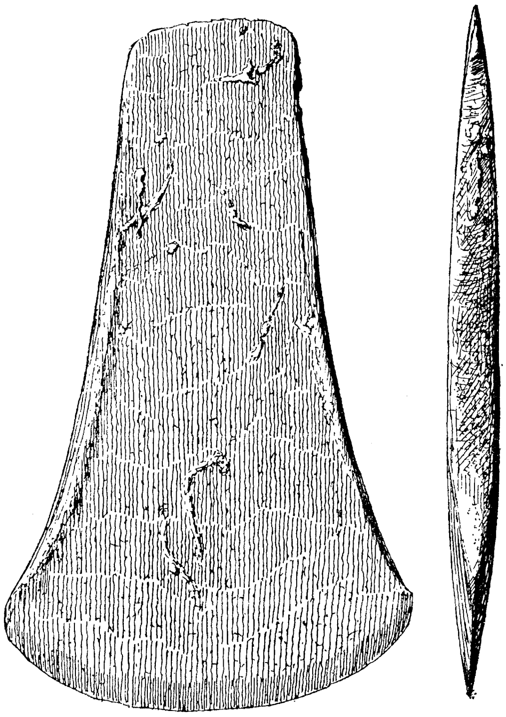
37. (1876, 26.)



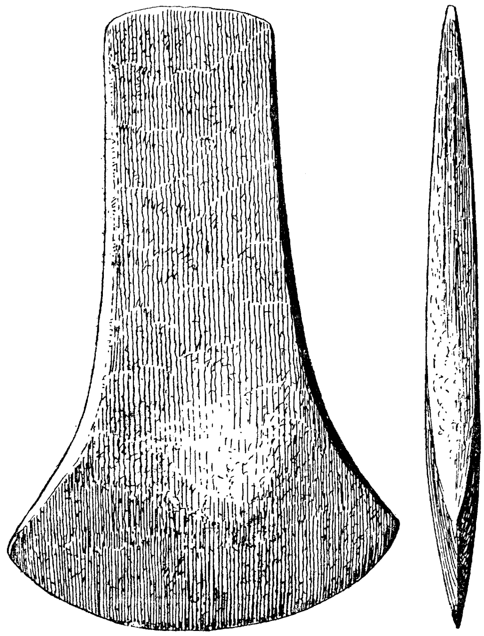
38. (w. 603.)

IRISH COPPER CELTS.

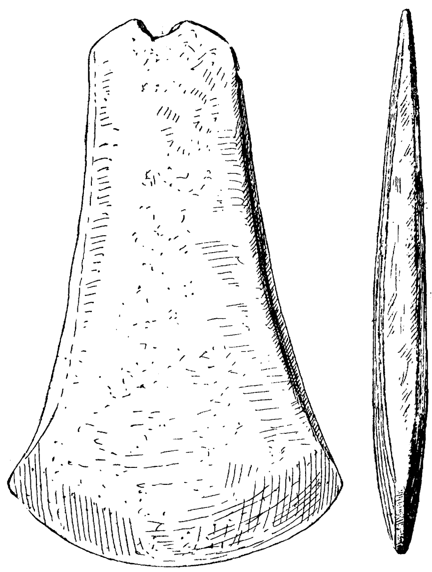
G.C. $\frac{2}{3}$ linear.



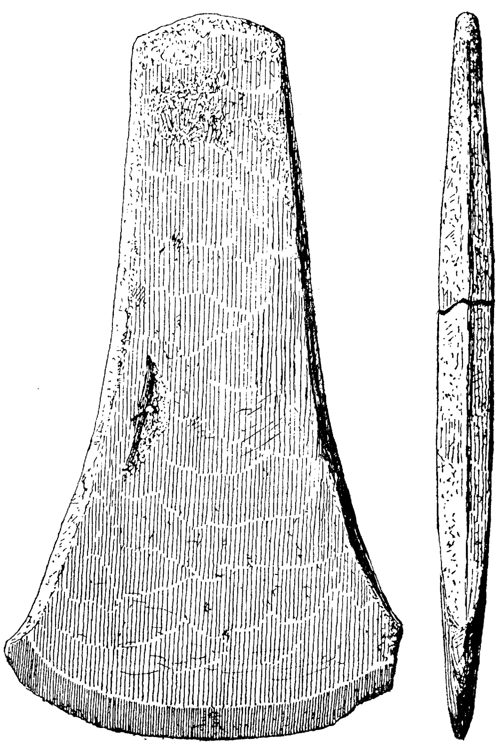
40. (w. 76.)



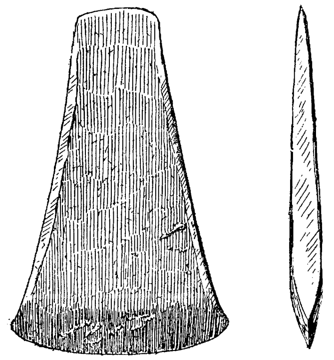
39.* (1875, 20.)



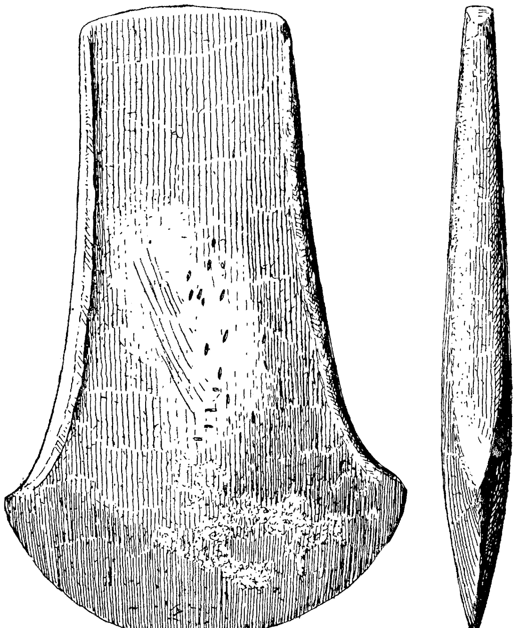
42. BAILLYBEG, CO. CORK. (*Day Collection.*)



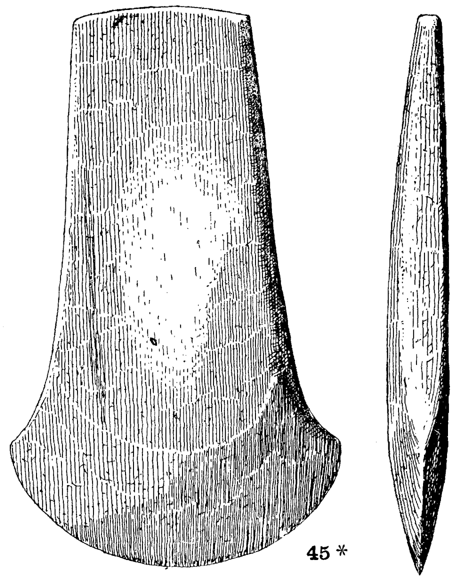
G.C. $\frac{2}{3}$ linear. **41***. (w. 96.)



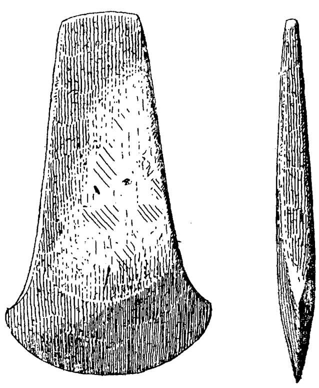
43. *Day Collection.*



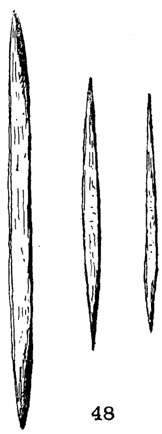
44.



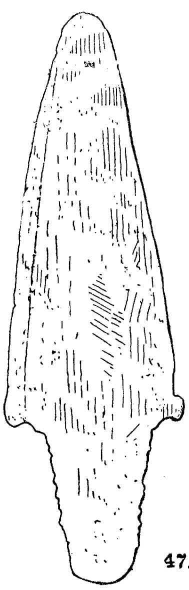
45 *



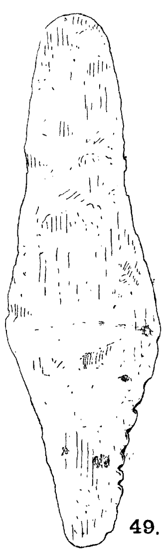
46



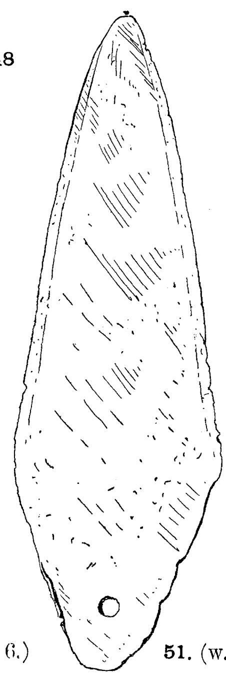
48



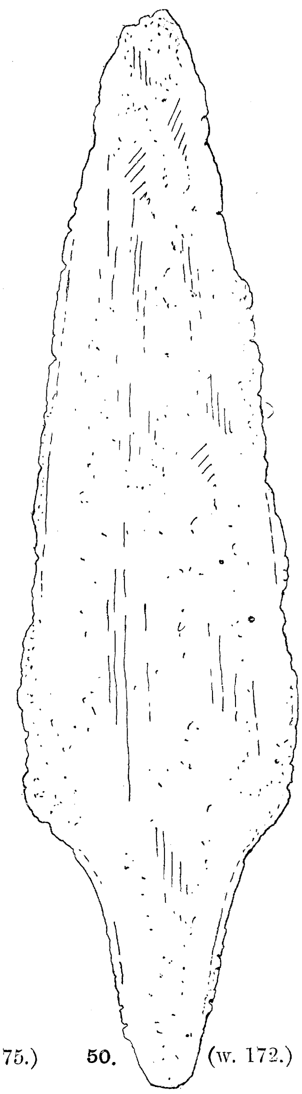
47.



49. (1900, 6.)



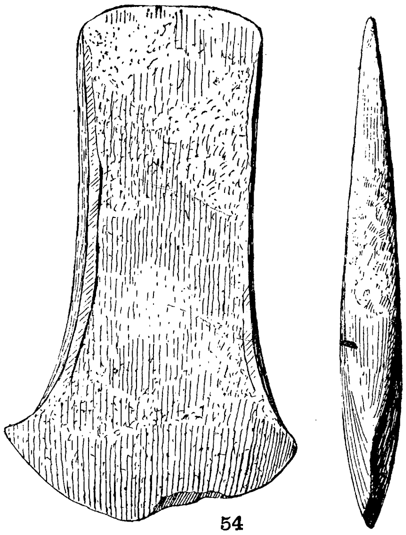
51. (w. 175.)



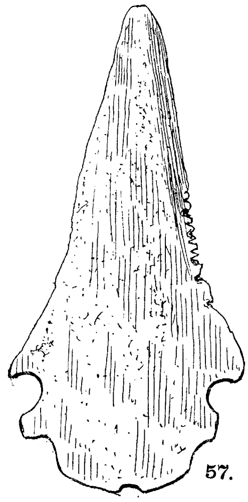
50. (w. 172.)

Nos 44–48 were found together in co. Galway (*see* p. 276).

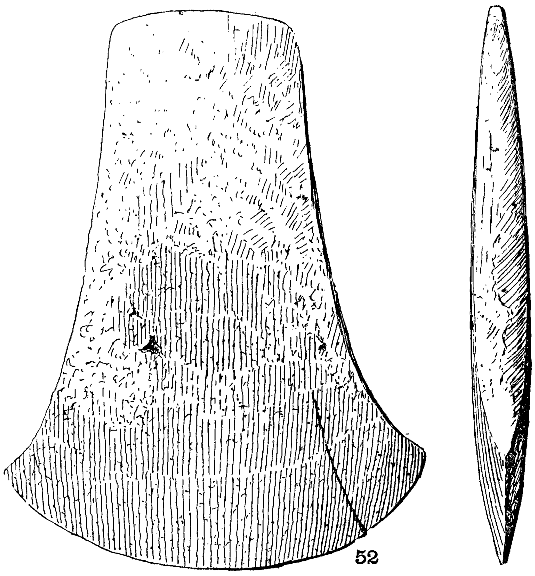
G.C. $\frac{2}{3}$ linear.



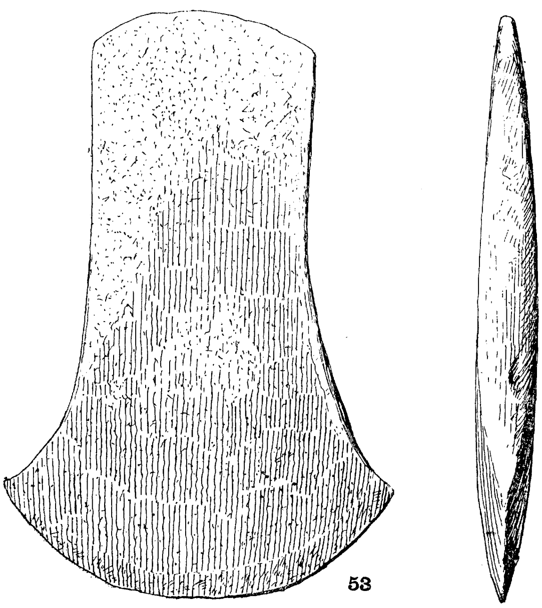
54



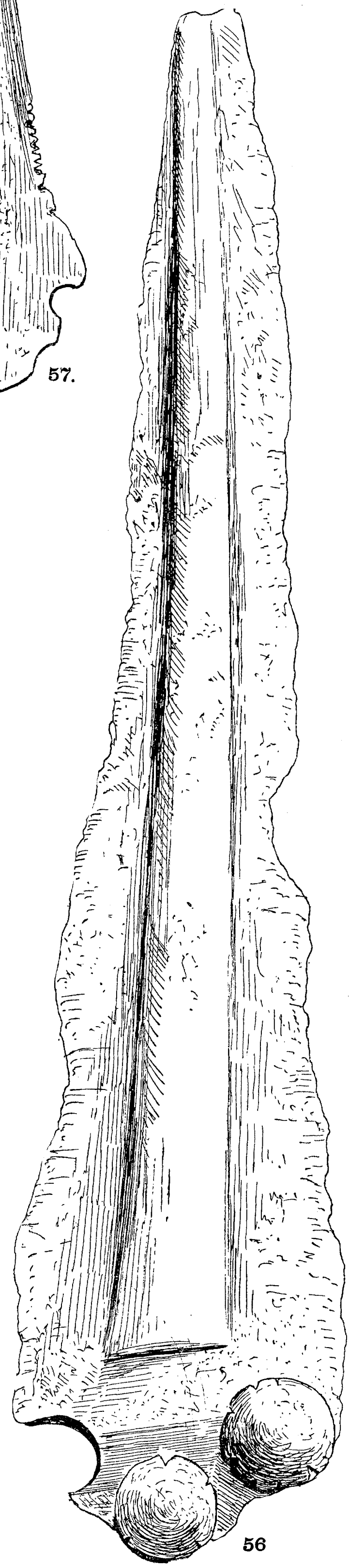
57.



52

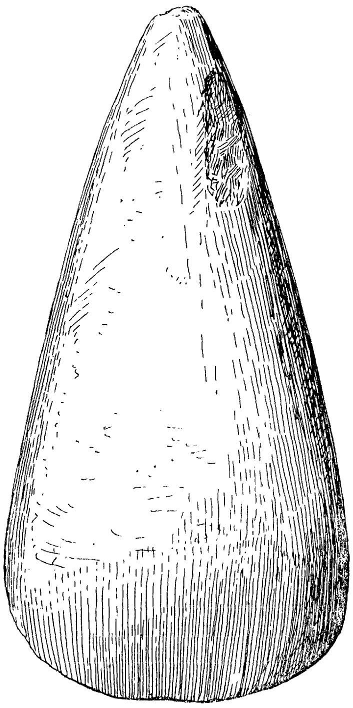


53

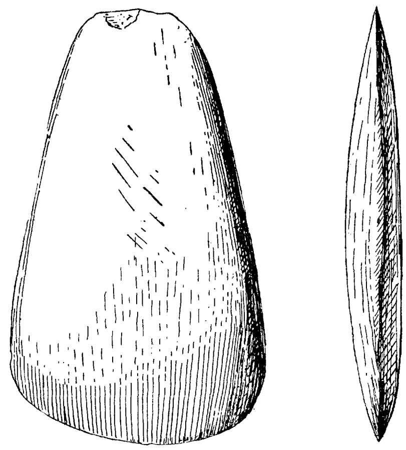


56

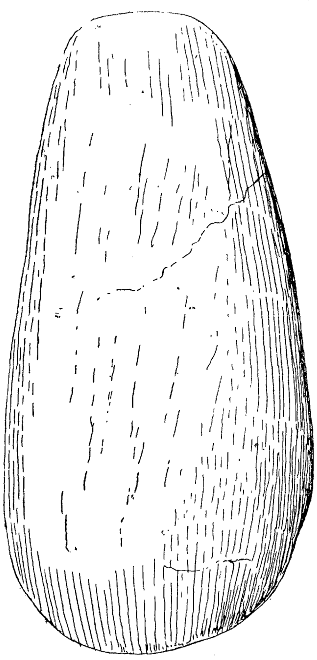
G.C. ⅔ linear. Nos. 54-57 found together, Birr, King's co. (*Day Collection*). See p. 276



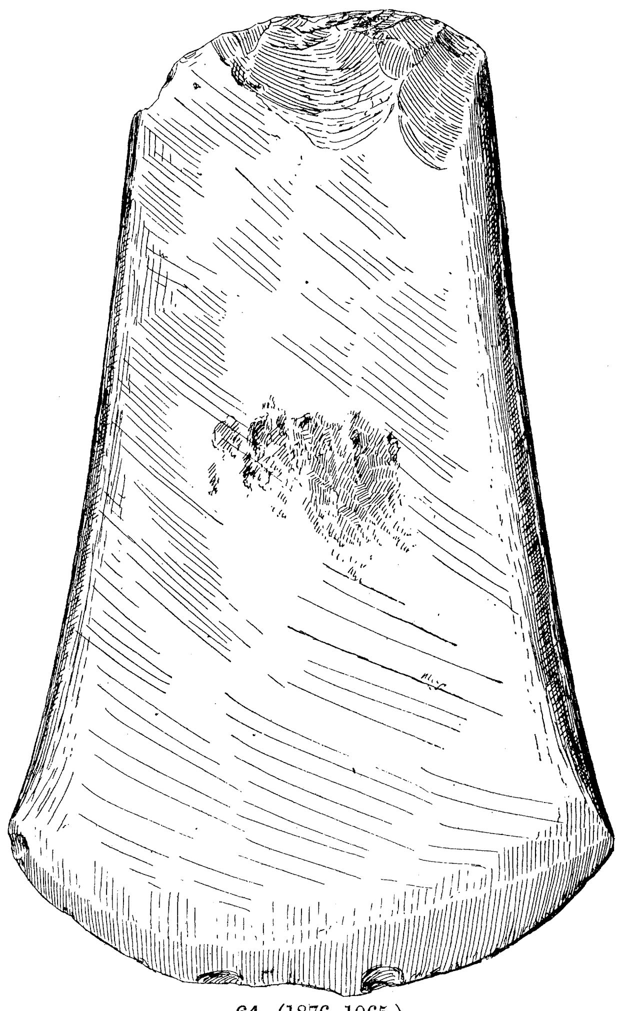
62. (R. 1852), CO. MEATH



58. (1878, 14, CO. FERMANAGH.)



61. (1899, 49), CO. LONDONDERRY.



64. (1876, 1065.)

G.C. $\frac{2}{3}$ linear.

IRISH STONE CELTS FOR COMPARISON.