



Lynn White, Jr.

medieval technology and social change



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CHAPTER II

The Agricultural Revolution of the Early Middle Ages

FROM the Neolithic Age until about two centuries ago, agriculture was fundamental to most other human concerns. Before the late 1700's there was probably no settled community in which at least nine-tenths of the population were not directly engaged in tillage. Rulers and priests, craftsmen and merchants, scholars and artists, were a tiny minority of mankind standing on the shoulders of the peasants. Under such circumstances any lasting change in climate, soil fertility, technology, or the other conditions affecting agriculture would necessarily modify the whole of society: population, wealth, political relationships, leisure, and cultural expression.

Yet this has not been obvious to the world of scholars: nowhere are the urban roots of the word 'civilization' more evident than in the neglect which historians have lavished upon the rustic and his works and days. While the peasant has normally been a lively and enterprising fellow, quite unlike the tragic caricature of combined brutishness and abused virtue presented in Millet's and Markham's 'Man with the Hoe',¹ he has seldom been literate. Not only histories but documents in general were produced by social groups which took the peasant and his labours largely for granted. Therefore while our libraries groan with data on the ownership of land, there is an astonishing dearth of information about the various, and often changing, methods of cultivation which made the land worth owning.²

¹ F. Martini, *Das Bauerntum im deutschen Schrifttum von den Anfängen bis zum 16. Jahrhundert* (Halle, 1944), esp. 390-3, analyses the very old elements entering into the modern stereotype of the peasant as they emerge in the works of medieval poets and preachers. On the one hand, the peasant is obtuse, grotesque, at times dangerous; on the other, he is hardworking, attached to the good old traditions, the supplier of food for all mankind, and loved of God for his humility. When the actualities rather than the fictions of rural life are examined, they appear as kaleidoscopic as those of any other form of human activity; cf. C. Parain, 'La Notion de régime agraire', *Mois d'ethnographie française*, iv (1950), 99, and 'Les Anciennes techniques agricoles', *Revue de synthèse*, lxxviii (1957), 326.

² For example, A. Dopsch, 'Die Herausgabe von Quellen zur Agrargeschichte des Mittelalters: ein Arbeitsprogramm', in *Verfassungs- und Wirtschaftsgeschichte des Mittelalters* (Vienna, 1928), 516-42, is entirely legal and institutional in emphasis.

To be sure, we have heard that in the late seventeenth and eighteenth centuries 'Turnip' Townshend and a few other adventurous agronomists in Britain and on the continent developed root and fodder crops, reformed agriculture, and thus provided the surplus food which permitted labour to leave the fields and to man the factories of the so-called Industrial Revolution. Yet it is practically unknown that northern Europe from the sixth to the ninth century witnessed an earlier agricultural revolution which was equally decisive in its historical effects.

In the nature of things there is much which we do not know about these matters and perhaps can never know with certainty. For example, the habit among prehistorians of establishing an Iron Age in a region as soon as they turn up the earliest scrap of iron may distort our view of the actualities. Iron was long a rare and costly metal, used almost exclusively for arms and for cutting edges. While there was much iron in Pompeii, one's total impression of its remains is that in the later first century even so prosperous a Roman city was still living more in a Bronze than in an Iron Age. Northern Europe—Noricum especially—was far richer in iron resources than was the Mediterranean. It would seem, from the finds, that more iron was used in the Roman period for plough parts, spade-tips, sickles, and the like north of the Alps than to the south, despite the fact that we should expect the damper boreal climate to have destroyed the northern evidences of iron more often by corrosion.

One aspect of the rapid development of northern Europe in Carolingian times was the opening up of great new iron mines,¹ which presumably made that metal cheaper and therefore more available to common uses as well as to the military. Writing in the later ninth century, the Monk of St. Gall tells us how in 773 Charlemagne and his host mounted an assault against Pavia, the capital of the Lombard realm. Coming out upon his walls to view the enemy, King Desiderius was overwhelmed by the spectacle of the massed and glittering Frankish armour and weapons: 'Oh, the iron! Alas, the iron!' he cried, and the captain with him fell fainting.² While the Monk of St. Gall is notoriously a novelist rather than an historian, nevertheless in this episode he symbolizes, even if he does not record, Europe's effective transition, under Charlemagne, to the Iron Age.

¹ See p. 153.

² 'O ferrum! heu ferrum!', *Gesta Karoli*, ii. 17, ed. H. Pertz, in *MGH, Scriptores*, ii (1829), 760.

While no statistical proof is possible, it is the consensus among historians of agriculture that the medieval peasantry used an amount of iron which would have seemed inconceivable to any earlier rural population, and that the smithy became integral to every village.¹ What this meant for increased productivity cannot be demonstrated; it must be imagined.

In general the history of tools and implements is still rudimentary. For example, it is believed that a new type of felling axe, developed in the tenth century, does much to account for the great new extension of arable land beginning about that time² But so few archaeologists or historians can view an axe with the eye of a professional woodsman judging the balance of the blade and the length and angle of the haft in terms of the job to be done, that the matter remains uncertain. A few tools, however, notably the plough, have been studied in much detail.

I

The Plough and the Manorial System

In 1895 A. Meitzen realized that the form of plough chiefly used in Germany might explain many peculiarities in the arrangement of fields and in the co-operative agriculture often found in medieval villages.³ A generation of scholarly activity not only in Germany but in France, Britain, Scandinavia, and the United States produced in 1931 a synthesis from the pen of Marc Bloch which was the more persuasive because his convictions were so gracefully garnished with his doubts, expressed not only at the time but during the following decade in a brilliant shower of essays and reviews of books.⁴

The plough was the first application of non-human power to agriculture. The earliest plough was essentially an enlarged digging-stick dragged by a pair of oxen. This primitive scratch-plough is still widely used around the Mediterranean and in the arid lands to the east where it is reasonably effective in terms of soil and climate. Its conical or triangular share does not normally turn over the soil,

¹ e.g. G. Duby, 'La Révolution agricole médiévale', *Revue de géographie de Lyon*, xxix (1954), 361, 364; H. Mottek, *Wirtschaftsgeschichte Deutschlands* (Berlin, 1957), 68.

² Duby, *op. cit.* 363.

³ A. Meitzen, *Siedlung und Agrarwesen der Westgermanen und Ostgermanen, der Kelten, Römer, Finnen und Slaven* (Berlin, 1895), i. 272-84.

⁴ M. Bloch, *Les Caractères originaux de l'histoire rurale française* (Oslo, 1931), reprinted (Paris, 1955) with a supplementary volume (1956) in which Bloch's later comments and modifications are compiled by R. Dauvergne.

and it leaves a wedge of undisturbed earth between each furrow. Thus cross-ploughing is necessary, with the result that, in regions where the scratch-plough is used, fields tend to be squarish in shape, roughly as wide as they are long. Cross-ploughing pulverizes the soil, and this both prevents undue evaporation of moisture in dry climates and helps to keep the fields fertile by bringing subsoil minerals to the surface by capillary attraction.

But this kind of plough and cultivation was not well suited to much of northern Europe, with its wet summers and generally heavier soils. As agriculture spread into the higher latitudes, inevitably it was largely confined to well-drained uplands with light soils, which were inherently less productive than the alluvial lowlands: the scratch-plough could not cope with these richer terrains. Northern Europe had to develop a new agricultural technique and above all a new plough.

One of the obstacles was that heavy, moist soils offer so much more resistance to a plough than does light, dry earth, that two oxen often are not able to provide enough pulling power to be effective. Our first secure evidence that a new kind of plough was being used comes in the middle of the first century after Christ when Pliny contrasts the light plough found in Syria with the fact that 'multifaram in Italia octoni boves ad singulos vomeres anhelent'.¹ We may safely assume that he was referring not to all of Italy but to the Po Valley, the only part of Italy where, for reasons of soil and climate, the heavy plough was much used in later times. In his next paragraph Pliny may be speaking of this same plough when he tells us that 'Non pridem inventum in Raetia Galliae [that is, the foothills of the Italian Alps] duas adderent tali rotulas, quod genus vocant plaumorati'.² Here we would seem to have the 'medieval' eight-ox, wheeled, heavy plough. And if we can accept the emendation³ of the unintelligible 'plaumorati' to 'ploum Raeti', we have the first appearance of the non-classical word 'plough' (as distinct from 'aratrum' for scratch-plough), and an indication that Pliny's heavy plough in the Po Valley is a reflection of great innovations taking place among the barbarians north of the Alps.

The wheels on the typical heavy plough both make it more mobile

¹ Pliny, *Naturalis historia*, xviii. 18, ed. C. Mayhoff (Leipzig, 1882), iii. 189.

² Ed. cit. iii. 190.

³ First proposed by G. Baist, 'Ploum-plaumorati', *Archiv für lateinische Lexikographie und Grammatik*, iii (1886), 285-6.

in going from field to field and assist the ploughman to regulate the depth of his furrow—a matter more difficult with several yokes than with a single team. But to understand why the heavy plough eventually affected the whole of northern European life, one must understand how it attacks the soil. Unlike the scratch-plough, the share of which simply burrows through the turf, flinging it to either side, the heavy plough has three functioning parts. The first is a coulter, or heavy knife set in the plough-pole and cutting vertically into the sod. The second is a flat ploughshare set at right angles to the coulter and cutting the earth horizontally at the grass-roots. The third is a mouldboard designed to turn the slice of turf either to the right or to the left, depending on how it is attached. Clearly, this is a far more formidable weapon against the soil than is the scratch-plough.

For purposes of northern European agriculture, its advantages were three.

First, the heavy plough handled the clods with such violence that there was no need for cross-ploughing. This saved the peasant's labour and thus increased the area of land which he might cultivate. The heavy plough was an agricultural engine which substituted animal-power for human energy and time.

Second, the new plough, by eliminating cross-ploughing, tended to change the shape of fields in northern Europe from squarish to long and narrow, with a slightly rounded vertical cross-section for each strip-field which had salutary effects on drainage in that moist climate. These strips were normally ploughed clockwise, with the sod turning over and inward to the right. As a result, with the passage of the years, each strip became a long low ridge, assuring a crop on the crest even in the wettest years, and in the intervening long depression, or furrow, in the driest seasons.

The third advantage of the heavy plough derived from the first two: without such a plough it was difficult to exploit the dense, rich, alluvial bottom lands which, if properly handled, would give the peasant far better crops than he could get from the light soils of the uplands. It was believed, for example, that the Anglo-Saxons had brought the heavy Germanic plough to Celtic Britain in the fifth century; thanks to it, the forests began to be cleared from the heavy soils, and the square, so-called 'Celtic' fields, which had long been cultivated on the uplands with the scratch-plough, were abandoned, and generally remain deserted today.

The saving of peasant labour, then, together with the improvement

of field drainage and the opening up of the most fertile soils, all of which were made possible by the heavy plough, combined to expand production and make possible that accumulation of surplus food which is the presupposition of population growth, specialization of function, urbanization, and the growth of leisure.

But the heavy plough, according to Bloch, did more than stimulate northern Europe by raising the level of productivity: it played a decisive part in reshaping the peasant society of the north. The manor as a co-operative agricultural community was, in fact, typical not of the Mediterranean lands but only of areas which employed the heavy plough, and there appeared to be a causal connexion between plough and manor.

As we have seen, this plough, with its coulter, share, and mould-board, offered much greater resistance to the soil than had the scratch-plough, and thus, at least in its earlier forms, it needed not one yoke but four—that is, as Pliny pointed out, eight oxen. Few peasants owned eight oxen. If they wished to use the new and more profitable plough, they would therefore pool their teams. But such a pooling would involve a revolution in the pattern of a peasant group. The old square shape of fields was inappropriate to the new plough: to use it effectively all the lands of a village had to be reorganized into vast, fenceless 'open fields' ploughed in long narrow strips. Moreover, the only practical way to distribute these strips was to assign them in sequence to the various peasants who owned the plough and the oxen constituting the co-operative team. Thus a peasant might 'own' and harvest fifty or sixty small strips scattered over the entire arable of the village.

Obviously such tiny parcels could not be operated individually, each man planting what and when he would. The result was the growth of a powerful village council of peasants to settle disputes and to decide in detail how the total lands of the community should be managed. These arrangements were the essence of the manorial economy in northern Europe. They are intelligible only in terms of the heavy plough. South of the Loire and the Alps, where a drier climate encouraged the older method of scratch-ploughing, the social structure was very different, and much more individualistic. In 1931 Bloch still perceived the landscape of his native France divided into two regions in terms of these two traditions of agronomy.¹

¹ E. Juillard and A. Meynier, *Die Agrarlandschaft in Frankreich: Forschungsergebnisse der letzten zwanzig Jahre* (Regensburg, 1955), 10-12.

No one was more aware than Bloch of the lacunae and confusions in the evidence supporting his grand hypothesis, or more conscious of the difficulty of dating precisely the stages of the development which he had described. In the decades since his book was published, serious doubt has been cast upon nearly every part of his interpretation; yet no alternate synthesis has been proposed.

The plough turns out to be an almost infinitely varied implement which refuses to fall neatly into the two species of scratch ('symmetrical') and heavy ('asymmetrical'), if only because modern observation shows that by tilting a scratch plough the ploughman can turn the sod,¹ and the greater wear on one side of certain archaeological specimens of symmetrical shares proves that this in fact was done in early times, at least occasionally.² Pliny's wheeled, eight-ox plough becomes a bit clearer: on the basis of archaeological data we now know that the Romans had a wheeled scratch-plough,³ presumably designed to get deeper tillage and therefore needing more power. If its action were sufficiently violent, with adequate harrowing perhaps no cross-ploughing would be needed. Since, unlike the medieval wheeled plough, this Roman apparatus had a curved rather than a straight plough-pole, we can identify it with the *currus* mentioned by Virgil, a native of the Po Valley, in the first century B.C.⁴ As for the eight oxen, it appears that at just this time the ability to harness animals in file was developing simultaneously all over Eurasia: a Gallo-Roman relief in the museum at Langres shows two teams of horses harnessed in sequence;⁵ a single brick from Szechuan, dated not later than the second century, shows a four-wheeled cart—a

¹ F. G. Payne, 'The plough in ancient Britain', *Archaeological Journal*, civ (1947), 93, pl. VIIa.

² F. G. Payne, 'The British plough', *Agricultural History Review*, v (1957), 75-76; A. Steensberg, 'Northwest European plough-types of pre-historic times and the Middle Ages', *Acta archaeologica* (Copenhagen), vii (1936), 258; P. V. Glob, 'Plows of the Dørstrup type found in Denmark', *ibid.* xvi (1945), 97, 104; A. G. Haudricourt and M. J. B. Delamarre, *L'Homme et la charrue* (Paris, 1955), 98.

³ B. Bratanič, 'On the antiquity of the one-sided plough in Europe, especially among the Slavic peoples', *Laos*, ii (1952), 52-53, fig. 4; Haudricourt and Delamarre, *op. cit.* 111-12.

⁴ *Georgica*, i. 174. Lacking the more recent finds, A. S. F. Gow, 'The ancient plow', *Journal of Hellenic Studies*, xxxiv (1914), 274, denied that this could be a wheeled plough. It was, however, so identified by Servius, Virgil's great commentator, in the early fifth century as then being in use in the Po region; cf. *Servii grammatici qui feruntur in Vergilii Bucolica et Georgica commentarii*, ed. G. Thilo (Leipzig, 1887), III. i. 173: 'Currus autem dixit propter morem provinciae suae, in qua aratra habent rotas, quibus iuvantur.'

⁵ See p. 153.

great rarity for Han China—being drawn by two horses tandem;¹ while an ancient Indian document, difficult to date, states that 'this barley they did plough vigorously with yokes of eight and yokes of six'.²

Following the publication of Bloch's book there were a few years of scholarly euphoria in which it was widely believed that the interrelation of the parts of a plough was so necessary that from a fragment one could reconstruct the whole, as a palaeontologist rebuilds a mastodont from a single bone. A square-framed plough found in a Danish bog at Tømmerby was reconstructed with wheels³ even though there was no evidence of them; the discovery of Belgic and Roman coulter in Britain immediately credited the Celtic Belgic invasion of c. 75 B.C. with having introduced the full wheeled plough, the strip system of ploughing, and perhaps even the open fields.⁴ But while wheeled ploughs are certainly associated with moist climates, as their distribution in Iberia exclusively on the Portuguese, Galician, and Basque coasts illustrates,⁵ some of the most effective heavy ploughs, particularly for very wet soils, do not have wheels.⁶ Moreover, coulter have been used on scratch-ploughs, and in no way imply the heavy plough.⁷ Indeed, the Romans may have mounted the coulter on a separate frame which went ahead of the scratch-plough.⁸

And while Bloch had elaborated the two basic equations of Meitzen, first, that scratch-plough = squarish fields, and second, that coulter+horizontal share+mouldboard+wheels = strips = open-fields = communal agriculture, it quickly became clear that there is no absolute correlation between field-shape and plough-form. Although from the earliest times scratch-ploughs cross-ploughed, sometimes in surprisingly sticky soil,⁹ they also ploughed strips, one

¹ R. C. Rudolph, *Han Tomb Art in Western China* (Los Angeles, 1951), 33-34, pl. 84.

² See p. 154.

³ See p. 154.

⁴ J. B. P. Karslake, 'Plough coulter from Silchester', *Antiquaries Journal*, xiii (1933), 455-63; R. G. Collingwood, 'Roman Britain', in *An Economic Survey of Ancient Rome*, ed. T. Frank (Baltimore, 1937), 74, 77-78.

⁵ J. Dias, 'Die portugiesischen und spanischen Pflüge', *Laos*, i (1951), 130, fig. 12; cf. 132-3.

⁶ Payne, in *Archaeological Journal*, civ. 97.

⁷ R. Lennard, 'From Roman Britain to Anglo-Saxon England', in *Wirtschaft und Kultur: Festschrift A. Dopsch* (Baden bei Wien, 1938), 69-70; Payne, op. cit. 92, 96.

⁸ Haudricourt and Delamarre, op. cit. 108-10.

⁹ P. Kjaerum, 'Criss-cross furrows: plough furrows under a Stone Age barrow in Jutland', *Kuml* (1954), 28.

surviving specimen being twenty-two times as long as it is wide.¹ While such strips were usually simply adjacent to squarish fields, in Finland scratch-ploughs long cultivated elaborate strip-systems,² as they do today in Syria³ and Sardinia,⁴ in this latter case with a full panoply of open fields and communal control. In pre-conquest Mexico, the Nahua Indians, quite without any plough, produced open fields of privately cultivated strips;⁵ while in the Early Iron Age certain long narrow fields in the Netherlands were turned not with a plough but with a hoe.⁶ For such reasons the scanty indications⁷ of strip cultivation in Roman Britain cannot be used to prove the presence of any particular form of plough.

Wherever the system of inheritance permits division of land among heirs, there is a tendency towards strips. Indeed, in complete reaction against the Meitzen thesis, it has now even been suggested that this principle of inheritance may have produced a plough appropriate to the cultivation of strips.⁸ It follows that there is no absolute connexion between strip cultivation and open fields or communal agriculture. The strip has been much more widespread than the open fields, and dominates areas which have never had communal cultivation.⁹

¹ G. Hatt, *Oldtidsagre* (Copenhagen, 1949), 156-7; K. Wührer, 'Die agrargeschichtliche Forschung in Skandinavien seit 1945', *Zeitschrift für Agrargeschichte und Agrarsoziologie*, v (1957), 77; D. Hannerberg, 'Die Parzellierung vorgeschichtlicher Kammerfluren und deren späterer Neuparzellierung durch "Bolskifte" und "Solksifte"', *ibid.* vi (1958), 26.

² E. Jutikkala, 'How the open fields came to be divided into numerous selions', *Sitzungsberichte der Finnischen Akademie der Wissenschaften* (1952), 140.

³ A. Latron, *La Vie rurale en Syrie et au Liban* (Beirut, 1936), 20.

⁴ M. LeLannou, 'Sur les origines de l'openfield', *Livre jubilaire offert à Maurice Zimmermann* (Lyons, 1949), 111-18.

⁵ O. Schmieder, *The Settlements of the Zapotec and the Mije Indians, State of Oaxaca, Mexico* (Berkeley, 1930), 27-29, fig. 3; 82, plan 2.

⁶ Hatt, *Oldtidsagre*, 166.

⁷ L. Aufrère, 'Les Systèmes agraires dans les Isles Britanniques', *Annales de géographie*, xlv (1935), 398, fig. 5; J. D. M. Stuart and J. M. Birkbeck, 'A Celtic village on Twyford Down', *Proceedings of the Hampshire Field Club and Archaeological Society*, xiii (1938), 188-200; O. G. S. Crawford, *Archaeology in the Field* (London, 1953), 206-7, fig. 37.

⁸ H. Mortensen, 'Die mittelalterliche deutsche Kulturlandschaft und ihr Verhältnis zur Gegenwart', *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte*, xlv (1958), 30.

⁹ J. Tricart and M. Rochefort, 'Le Problème du champ allongé', *Comptes rendus du Congrès International de Géographie, Lisbonne 1949*, iii (1951), 495-6; E. Otremba, 'Die Entwicklungsgeschichte der Fluren im oberdeutschen Altsiedelland', *Berichte zur deutschen Landeskunde*, ix (1951), 371, 378; H. L. Gray, *English Field Systems* (Cambridge, Mass., 1915), 272-304; D. C. Douglas, *Social Structure of East Anglia* (Oxford, 1927), 105-6.

Likewise the strip and the ridge-and-furrow should not be confused: in many regions of light soil strips have been cultivated flat.¹ The essential purpose of ridge-and-furrow was drainage,² and perhaps secondarily, in some soils, the ploughing up of subsoil minerals from the furrow.³ The influence of terrain and of handling water seems usually to have been decisive. In the region of Osnabrück, for example, the oldest fields occupy relatively high and dry locations, and ridges tend to run with the slope to facilitate the removal of water.⁴ In Lower Normandy there is a general, but not invariable, correlation between strip and open-field cultivation and the more level and heavy soils.⁵ The same kind of plough may have been used differently in different contexts.

It appears, then, that in plough structure and field arrangement there are many elements, no two of which have any constant and necessary relationship. But while everything might vary according to local climate, soils, topography, rules of inheritance, tradition, taste, or personal whim, in practice one finds many normally constant relationships. Scholars like Meitzen and Bloch had a keen sense of fact, and they observed the averages. On the continent, north of the Loire and the Alps, heavy ploughs normally had the full equipment of coulter, horizontal share, mouldboard, and wheels. The regions which used such ploughs are almost always, or were until recently, cultivated in strips. A high proportion of the area arranged in strips was also organized in terms of open fields, which involved communal husbandry. This was the 'typical' manorial economy which, by the end of the Middle Ages, extended, with interruptions in particular areas because of special circumstances, from Ireland on the west to southern Sweden and the Slavic lands on the east.

The scholarly increment in agrarian history during recent decades has been not only new information but also an increased caution in weighing evidence. Is it possible as yet to trace the growth, coalescence into normal patterns of relationship, and spread of the various elements involved in ploughs and fields?

¹ E. Kerridge, 'Ridge and furrow and agrarian history', *Economic History Review*, 2nd series, iv (1951), 18-19.

² See p. 154.

³ See p. 155.

⁴ G. Wrede, 'Die Langstreifenfluren in Osnabrücker Lande: ein Beitrag zur ältesten Siedlungsgeschichte im frühen Mittelalter', *Osnabrücker Mitteilungen*, lxi (1954), 59-60.

⁵ P. Brunet, 'Problèmes relatifs aux structures agraires dans la Basse-Normandie', *Annales de Normandie*, v (1955), 120-1. According to M. de Boüard, 'Paysage agraire et problèmes de vocabulaire: le bocage et la plaine dans la Normandie médiévale', *Revue historique de droit français et étranger*, xxxi (1953), 327-8, the dispersal of separate holdings in the open fields did not occur in Normandy until the thirteenth century.

As we have seen, in the Po Valley at least, the Romans sometimes used large teams and wheeled scratch-ploughs. North of the Alps they sometimes used coulter, but we do not know to what sorts of ploughs they were attached, if indeed they were not separated from the plough. Occasionally the Romans used a plough with two symmetrical wings or flanges to open a furrow,¹ presumably when ploughing for drainage. It is inconceivable to the modern mind that they did not have a single-wing plough designed to push the sod simply to one side. Yet apparently Antiquity had nothing approaching a mouldboard.² The few traces of what may be long fields in Roman Britain are ambiguous: if they were experiments with a new agricultural method, their influence did not spread, even in Britain. In that island the Romans and Celts continued to farm the lighter soils, avoiding the more demanding but more rewarding areas.³ Despite a certain ferment of new ideas, the Romans made little progress in solving the distinctive agricultural problems of the north.

Important new evidence on the origin of the heavy plough comes from philology. Plough terminology in the Teutonic, Celtic, and Romanic languages is singularly chaotic. But B. Bratanič of the University of Zagreb has shown that twenty-six technical terms connected with the heavy plough and methods of ploughing with it (including the words for ways of laying out ridge-and-furrow) are found in all three of the great Slavic linguistic groups, the eastern, western, and southern. This means that the heavy plough and its use for both strip cultivation and ridging were familiar to the unified Slavs before their separation in the later sixth century.⁴ Moreover, this entire vocabulary is Slavic, except for the key-word *plug*, or 'plough'. This last belongs to a mysterious group of *p*-words (such as 'path' and 'penny') which are apparently neither Slavic, Teutonic, Celtic, nor Romanic in origin.⁵ Bratanič does not claim the invention

¹ Payne, *Archaeological Journal*, civ, 97, pl. viii; *History of Technology*, ed. Singer, ii (1956), fig. 49.

² F. Harrison, 'The crooked plough', *Classical Journal*, xi (1915-16), 323-32.

³ S. Applebaum, 'Agriculture in Roman Britain', *Agricultural History Review*, vi (1958), 69; Collingwood, *op. cit.* 75.

⁴ B. Bratanič, 'On the antiquity of the one-sided plough in Europe, especially among the Slavic peoples', *Laos*, ii (1952), 56-58; cf. J. Janko, 'Über Berührung der alten Slaven mit Turko-tataren und Germanen, vom sprachwissenschaftlichen Standpunkt', *Wörter und Sachen*, i (1909), 105; M. Bloch, 'Champs et villages', *Annales d'histoire économique et sociale*, vi (1934), 475.

⁵ *Oxford English Dictionary*, s.v. 'plough'; cf. H. Schneider, *Germanische Altertumskunde*, 2nd edn. (Munich, 1951), 92. The effort of E. Werth, *Grabstock, Hacke und Pflug*

of the heavy plough for the Slavs, but for 'some northern peasant culture' as yet unidentified. Since the Slavic vocabulary surrounding *plug* probably would have developed very rapidly, once the Slavs got the heavy plough, we have no reason to date its arrival among them very long before the Avar invasion of 568 severed the south Slavs from frequent contact with peoples speaking other varieties of that linguistic family.

In their tribal wandering the Goths had close contact with the Slavs, and when these latter had some superior object, the Goths tended to adopt both the thing and the word for it: e.g. the admirable Slavic laminated swords led them to take over the word *meki* for 'sword'.¹ In the fifth century the Goths in Transylvania had coulter² but evidently they were used either as a separate apparatus or with scratch-ploughs because the Gothic word for plough is *hōha*,³ a cognate of 'hoe'. When the Angles and Saxons invaded Britain in waves between 449 and 584, they apparently took with them only some form of scratch-plough which they called *sulh*,⁴ a cognate of the Latin *sulcus* or 'furrow'. In the Rhineland, in the *Lex salica* of c. 507-11, the word *carruca*, which later means 'wheeled plough' (French *charrue*), still means 'two-wheeled cart' rather than 'plough'.⁵ If we reject the questionable emendation of the Pliny text's *plauromoti*,⁶ the word 'plough' first appears in 643, in north Italy, as the latinized Lombard *plovum*.⁷ In 724-30 the *Lex Alemannorum* shows that in south-west Germany *carruca* has come to mean a plough with two wheels in front,⁸ while by the early ninth century the new (Ludwigsburg, 1954), 193-4, to prove the origin of the wheeled plough in southern Germany by showing its modern occurrence east, west, and north, is indecisive.

*¹ Cf. B. P. Lozinski in *Speculum*, xxxiii (1958), 420.

² Cf. A. Bashmakoff, 'L'Évolution de la charrue à travers les siècles au point de vue ethnographique', *L'Anthropologie*, xlii (1932), 86, for a find at Szilágy-Serulyo.

³ OED, loc. cit.; W. Mitzka, 'Pflügen und seine Wortgeographie', *Zeitschrift für Agrargeschichte und Agrarsoziologie*, vi (1958), 113.

⁴ OED, loc. cit.

⁵ H. Geffcken, *Lex salica* (Leipzig, 1898), 139; on the date, cf. R. Buchner, *Die Rechtsquellen*, Beiheft of *Deutschlands Geschichtsquellen im Mittelalter*, ed. W. Wattenbach and W. Levison (Weimar, 1953), 17. T. Frings, 'Deutsch Karch "Wagen", französisch *charrue* "Pflug"', *Zeitschrift für Volkskunde*, xl (1930), 100-5, presents further philological evidence that the heavy plough was introduced into southern and western Germany in Frankish times.

⁶ *Supra*, p. 42, n. 3.

⁷ *Edictus Rotharii*, in *MGH, Leges*, iv, 69, 373; on date, cf. Buchner, op. cit. 34. In view of the Slavic evidence, one need not take seriously the contention of L. Franz, 'La Terra natale dell'aratro a carrello, l'Italia', *Rivista di scienze preistoriche*, v (1950), 95-96, that the Lombards learned this word in Italy.

⁸ *Lex Alemannorum*, xcvi, § 2: 'si carrucam inviolat, aut rumpit rotas primarias'; another version reads: '. . . rotas de davante', in *MGH, Leges*, iii, 80, 116; on date, cf. Buchner, op. cit. 31.

meaning had generally overlaid, if not entirely displaced, the older one, at least in the northern parts of the Frankish realm.¹

Across the Channel insufficient attention has been paid to the derivation of English 'plough' from Old Norse *plógr*.² Although the Anglo-Saxon form *ploh* has not been found earlier than c. 1100,³ the Norse term was presumably introduced to Britain during the Danish invasion and settlement of north-eastern England from the middle ninth into the eleventh century. The significance of these linguistic facts has been obscured by the opinion⁴ that the existence among the Anglo-Saxons of open fields composed of strips is documented by the laws of King Ine of Wessex datable 688-94, and that such an arrangement implied a heavy plough which had doubtless, therefore, been brought over by the first Germanic invaders, if not by the Celtic Belgae five centuries earlier.

But Kirbis has pointed out, first, that the extant text of the laws of Ine is a reissue by Alfred the Great (871-901), presumably updated in some respects; second, that the Alfredian version of Ine's laws does not mention open fields or co-operative village agriculture, but only strips and common pasture.⁵ There is some evidence that the fields of the early Germanic settlers in England were arranged in strips,⁶ but we have seen above that strips may be cultivated by a scratch-plough. Open fields are not securely documented among the Anglo-Saxons until the tenth century.⁷ About 945 the Welsh laws of Hywel Dda⁸ speak clearly of the heavy plough and of

¹ K. Verhein, 'Studien zu den Quellen zum Reichsgut der Karolingerzeit', *Deutsches Archiv für Erforschung des Mittelalters*, x (1953-4), 352-5, esp. n. 229.

² OED, loc. cit.

³ *Leechdoms, Wortcunning, and Starcraft of Early England*, ed. O. Cockayne (London, 1866), iii. 286.

⁴ F. Seebohm, *The English Village Community*, 4th edn. (London, 1890), 109; Gray, op. cit. 61-62; R. Trow-Smith, *English Husbandry* (London, 1951), 38, who, however, 34-35, emphasizes that we know almost nothing about the development of Anglo-Saxon agriculture. We can only judge its end result—that the England of *Domesday Book* of 1086 is vastly better cultivated than the Britain which Rome abandoned. We are as yet unable to judge exactly when, during the intervening period, the chief advance was made.

⁵ W. Kirbis, 'Siedlungs- und Flurformen germanischer Länder, besonders Großbritanniens, im Lichte der deutschen Siedlungsforschung', *Göttinger geographisch Abhandlungen*, x (1952), 45-47.

⁶ Ibid. 29-30.

⁷ Gray, *English Field Systems*, 57, lists charters the language of which indicates open fields: the first dates from 904, the next from 953; thereafter they are frequent; cf. J. M. Kemble, *Codex diplomaticus aevi saxonici* (London, 1839-48), nos. 339, 1169.

⁸ A. Owen, *Ancient Laws and Institutions of Wales* (London, 1841), i. 153; cf. F. G. Payne, 'The Plough in ancient Britain', *Archaeological Journal*, civ (1947), 84-85. While

ploughing in strips in open fields under community control: each plough-team is to plough at least twelve acre-strips before it breaks up, assigning one strip apiece to the ploughman, the driver, the owner of the plough-irons, the owner of the plough-frame, and to the owner of each of the eight oxen. When the invading Danes brought with them a plough so distinctive that the Anglo-Saxons felt impelled to take its name from the alien tongue, there is no reason to believe that either they or the Welsh would delay in adopting the thing itself in areas where it could be used profitably.

There is further evidence that the fully developed heavy plough was a Danish introduction to Britain. To judge from Bede and all the other early Northumbrian writers, the Anglo-Saxons consistently distributed lands in units of the 'hide', that is, enough to support a family: 'terra unius familiae'.¹ In Scandinavia, clearly in terms of the heavy eight-ox plough, a different type of land division developed: the basic unit was the *bol*, divided into eighths or *ättingar*;² the ordinary peasant holding seems to have been thought of as the *mark*, or two *ättingar*, i.e. the equivalent of a yoke of oxen. No text mentions the *bol* earlier than 1085,³ but since traces of it are to be found in communities settled c. 900 by the Norse in Normandy,⁴ it must be of the Viking age. In 1936 Homans pointed out that while the Danish terminology is not found in Britain, the regions most subject to Danish settlement and influence show a system of land division which is in complete contrast to the traditional Anglo-Saxon hide system but exactly corresponding to *bol* and *ättingar*, now called 'ploughland' and 'oxgang'. He concluded that this is intelligible only

in most areas this system of distribution eventually fell into disuse, and individuals gained permanent ownership of specific strips, in early times it was apparently very widespread, since, as Trow-Smith, *op. cit.* 46, points out, late records show that the pattern of ownership in a field is often repeated: 'B's lands always lie between A's and C's.' In 1682 in Westmeath County, Ireland, strips were still being allotted according to the individual's contribution to the plough-team; cf. D. McCort, 'Infield and outfield in Ireland', *Economic History Review*, 2nd series, vii (1954-5), 373.

¹ R. Lennard, 'The origin of the fiscal carrucate', *Economic History Review*, xiv (1944), 58.

² D. Hannerberg, *Die älteren skandinavischen Ackermasser* (Lund, 1955), *passim*, indicates that, like all such land measurements, the *bol* eventually lost its relation to its functional origin: because of the change in the ell from 1½ to 2 feet, the *bol* came to consist not of 8 but of 6 *ättingar*.

³ C. Parain, 'Travaux récents sur l'histoire rurale de Danemark', *Annales de Normandie*, ii (1952), 127.

⁴ A. Steensberg, 'Modern research on agrarian history in Denmark', *Laos*, i (1951), 198; Parain, *loc. cit.*

as a Danish importation.¹ In 1066 the Norman conquerors recognized a type of land division familiar to them in Normandy,² and spontaneously applied the latinized term 'carrucate' to the basic unit, which was divided into eight 'bovates', these 'bovates' normally being grouped by pairs to form four 'virgates' in each carrucate. Since this particular form of land division, in contrast to division by hides, depends technologically upon the heavy eight-ox plough operating in open fields in terms of communal agriculture, we must conclude that the *plógr* was in fact a novelty introduced by the Danish invaders of the later ninth and early tenth centuries. Probably the new plough spread quickly to areas where the older land divisions continued to be used despite the novel agrarian technology. It is significant of peasant preference that when, after the fearful devastation of 1069, Yorkshire was resettled in the early twelfth century, the bovates and virgates of the Danelaw, rather than the hide, were used as the customary units of tenements.³

What, then, do we now know about the origin of the heavy plough? It came to the Slavs from an unknown source, but apparently they did not yet have it in the early fifth century when they were still in contact with the Goths. However, they had received it by the later sixth century and had completely developed its implications for ploughing not only strips but strips which consisted of ridge-and-furrow. There is every reason to believe that such a development would occur very quickly in a favourable environment. We therefore cannot safely date the heavy plough earlier than the sixth century.

In judging its diffusion, we must recognize that while the new productivity which it made possible would rather quickly increase population, it could only be adopted in areas already enjoying a certain density of settlement.⁴ It was costly in itself, and costly to operate.⁵ An isolated family could not use it; the normal hamlet of

¹ G. C. Homans, 'Terroirs ordonnés et champs orientés: une hypothèse sur le village anglais', *Annales d'histoire économique et sociale*, viii (1936), 438-48; cf. Steensberg, *op. cit.* 195.

² Lennard, *op. cit.* 62, n. 3.

³ A. M. Bishop, 'Assarting and the growth of the open fields', *Economic History Review*, vi (1935), 17.

⁴ Thinness of population in the forests of Poland and upon the plains of Hungary may account for the fact that an agriculture of the plough was not thriving even in ninth-century Poland, while there is no evidence of the heavy plough in Hungary until the eleventh century; cf. W. Hensel, 'Agriculture of the Slavs in Poland in the early Middle Ages', *Sprawozdania Państwowe Museum Archeologicznego* (Warsaw), iv. iii (1951), 45; M. Belényesi, 'Die Grundfragen der Entwicklung des Ackerbaues im XIV. Jahrhundert', *Ethnographia*, lxv (1954), 415.

⁵ The fact that no medieval picture shows a plough being drawn by more than four

four to ten families would find it difficult to manage such a venture. Only in areas already having some village settlement was the new plough likely to be adopted. And even here there was a great psychological obstacle: for its most efficient use the new plough demanded open fields, and, to establish these, all previous rights of ownership in specific blocks or strips must be abolished.

In recent years German historical geographers have concluded that probably towards the end of the sixth century, and certainly in the seventh century, in central and south-western Germany and the Rhineland there began a remarkable increase of population, assarting and colonization which gradually spread to other regions,¹ and that this expansion seems connected with the growth of open fields.² In one area it is estimated that by the end of the seventh century the population was quadruple that under the Roman Empire.³ The shift which we have noted in the meaning of the word *carruca* in the Rhine basin at about this time indicates that the heavy plough was an essential element in this process of growth, and does much to account for the bursting vitality of the Carolingian realm in the eighth century. While the arrival of the new plough in Scandinavia cannot yet be dated, one suspects that its effect upon population may be seen in the Viking outpouring which began c. 800. In any case, the Norse took the heavy plough and the method of land division most appropriate to it with them when, in the later ninth century, they settled the Danelaw in England, and then in Normandy.

While doubtless strip-fields were common before the heavy plough,

oxen has led some scholars to consider the eight-ox plough a fiction. However, granting that often ploughs were drawn by smaller—and larger—teams, the widespread division of the basic ploughland unit into eight sections, and the reversed-S curve of so many strips (*infra*, p. 55, n. 2), which is scarcely intelligible in terms of a team of less than four yokes, makes it probable that the eight-ox plough was normal in the early period after the introduction of the heavy plough.

¹ F. Steinbach, 'Geschichtliche Siedlungsformen in der Rheinprovinz', *Zeitschrift des Rheinischen Vereins für Denkmalpflege und Heimatschutz*, xxx. ii (1937), 19; L. Franz, 'Zur Bevölkerungsgeschichte des frühen Mittelalters', *Deutsches Archiv für Landes- und Volksforschung*, ii (1938), 404-16; F. Firbas, *Spät- und nacheiszeitliche Waldgeschichte Mitteleuropas nördlich der Alpen* (Jena, 1949), i. 366; H. Dannenbauer, 'Bevölkerung und Besiedlung Alemanniens in der fränkischen Zeit', *Zeitschrift für württembergische Landesgeschichte*, xiii (1954), 13-14; A. Timm, *Studien zur Siedlungs- und Agrargeschichte Mitteldeutschlands* (Cologne, 1956), 17-18; J. C. Russell, 'Late ancient and medieval population', *Transactions of the American Philosophical Society*, XLVIII. iii (1958), 42, 140.

² H. Mortensen, 'Die mittelalterliche deutsche Kulturlandschaft und ihr Verhältnis zur Gegenwart', *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte*, xlv (1958), 31-32.

³ H. Stoll, 'Bevölkerungszahlen aus frühgeschichtliche Zeit', *Die Welt als Geschichte*, viii (1942), 72.

it is unlikely that the lighter plough normally produced the ridge-and-furrow form of acre which, in soils needing drainage, was characteristic of the improved type of cultivation. If fossil fields of such ridges could be dated archaeologically, our knowledge of the plough's diffusion would be aided.¹ In particular the dating of any strips slightly curved in S-shape would be helpful, since this curve was produced by manœuvring the large team of a plough as it approached the end of the strip.² If they were spread over the whole of northern Europe, the methods of English local historians might teach us much about the exact diffusion of the system of open fields, and why in certain areas the plan was not adopted.³

But as Sardinia shows,⁴ the heavy plough may not have been the sole impulse for setting up open fields. Indeed, in agriculture there are usually at least two reasons for doing everything. One of the chief functions of the open-field system was to increase the facilities for rearing cattle while at the same time putting maximum arable into grain. Even after their migration into Gaul, the Franks continued to favour herding over agriculture.⁵ So long as there was a thin population in relation to available land, there was no great competition between the two régimes: the animals were in perpetual pasture. But with growing population, tillage spread at the expense of forest, swamp, and meadow.⁶ So long as each peasant was managing his own fields to suit himself, these could not be used for grazing, when fallow, without great expense for fencing, hedging, or herders. The open-field system, by concentrating crops in either one or two big fields at any given moment, made the whole sweep of the fallow available for browsing and at the same time provided maximum protection of crops against cattle. In addition, it assured that the

¹ Little progress in this matter has been made since the classic work of C. Frank, *Die Hochäcker* (Kaufbeuren, 1912), summarized in C. Frank, 'Forschungen zur Frage der alten Hochäcker: Zusammenfassung und Ergebnisse', *Deutsche Gaeue*, xiii (1912), 35-40, which showed that all ridge-and-furrow in Bavaria is post-Roman.

² S. R. Eyre, 'The curving plough-strip and its historical implications', *Agricultural History Review*, iii (1955), 80-94. K. Scharlau, 'S-Formen und umgekehrte S-Formen unter den deutschen und englischen Langstreifenfluren', *Zeitschrift für Agrargeschichte und Agrarsoziologie*, iv (1956), 19-29, offers important supplementary evidence from Germany. F. Imberdis, 'Le Problème des champs courbes', *Annales: économie, sociétés, civilisations*, vi (1951), 77-81, presents an entirely different problem: fields in the region of Langres having irregularly curved boundaries which defy explanation in terms of topography, soils, or ploughing methods.

³ See p. 155.

⁴ *Supra*, p. 47, n. 4.

⁵ J. Boussard, 'Essai sur le peuplement de la Touraine du I^{er} au VIII^e siècle', *Moyen âge*, lx (1954), 286-91.

⁶ See p. 155.

manure would not be wasted on wild pasture but would be deposited on next year's arable.¹

As noted above, this balanced system of animal and cereal production, in conjunction with the heavy plough, was apparently developed into a normal and accepted system during the seventh century in the Frankish heartland. It helps to account for the relative prosperity and vigour of the Carolingian Age.

Moreover, the heavy plough and its consequence of distribution of strips in the open fields helped to change the northern peasants' attitude towards nature, and thus our own. From time immemorial land was held by peasants in allotments at least theoretically sufficient to support a family. Although most peasants paid rent, usually in produce and services, the assumption was subsistence farming. Then in northern Europe, and there alone, the heavy plough changed the basis of allotment: peasants now held strips of land at least theoretically in proportion to their contribution to the plough-team. Thus the standard of land distribution ceased to be the needs of a family and became the ability of a power-engine to till the earth. No more fundamental change in the idea of man's relation to the soil can be imagined: once man had been part of nature; now he became her exploiter.

We see the emergence of this not only in Charlemagne's effort to re-name the months in terms of human activities—June was to be 'Ploughing Month', July 'Haying Month', August 'Harvest Month'²—but more particularly in the change which occurs in illustrated calendars beginning shortly before 830.³ The old Roman calendars had occasionally shown genre scenes of human activity, but the dominant tradition (which continued in Byzantium) was to depict the months as passive personifications bearing symbols of attributes. The new Carolingian calendars, which set the pattern for the Middle

¹ H. Mortensen, 'Zur Entstehung der Gewinnflur', *Zeitschrift für Agrargeschichte und Agrarsoziologie*, iii (1955), 38–41. W. Abel, *Agrarpolitik*, 2nd edn. (Göttingen, 1958), 144–5, emphasizes the great advantages of pooling once scattered individual resources in terms of the heavy plough and open fields under group control.

² Einhard, *Vita Karoli magni*, c. 29, ed. H. Pertz, *MGH, Scriptores*, ii (1829), 458: 'Junium Brachmanoth, Julium Heuvimanoth, Augustum Aranmanoth.'

³ J. C. Webster, *The Labors of the Months in Antique and Mediaeval Art to the End of the Twelfth Century* (Evanston, 1938); cf. M. Schapiro in *Speculum*, xvi (1941), 131–7; also H. Stern, *Le Calendrier de 354: étude sur son texte et sur les illustrations* (Paris, 1953), 356–7, and his masterly 'Poésies et représentations' (cf. *infra*, p. 155), esp. 164–6; N. E. Enkvist, *The Seasons of the Year: Chapters on a Motif from Beowulf to the Shepherd's Calendar* (Helsinki, 1957), 46–47.

Ages, are very different: they show a coercive attitude towards natural resources. They are definitely northern in origin; for the olive, which loomed so large in the Roman cycles, has now vanished.¹ The pictures change to scenes of ploughing, harvesting, wood-chopping, people knocking down acorns for the pigs, pig-slaughtering. Man and nature are now two things, and man is master.

II

The Discovery of Horse-Power

The wide application of the heavy plough in northern Europe was only the first major element in the agricultural revolution of the early Middle Ages. The second step was to develop a harness which, together with the nailed horseshoe, would make the horse an economic as well as a military asset.

For the long haul, a draught animal is only as good as its hooves. Oxen seem to have less hoof-breakage than either horses or mules. The feet of horses are particularly sensitive to moisture: it is said that whereas in dry lands like Spain their hooves remain so hard that they can gallop unshod over rocky terrain, in northern Europe the hoof becomes soft, and is quickly worn and easily damaged.²

Recoiling before an appalling bibliography on the horseshoe which he had assembled, the most learned archaeologist in the field of the early Middle Ages, Dom Henri Leclercq, struck his colours, remarking: 'En ce qui regarde la ferrure des chevaux, nous laissons ce sujet à ceux qui ont des loisirs.'³

There is no present firm evidence of the nailed horseshoe before the end of the ninth century. The most authoritative statement to the contrary is Sir Mortimer Wheeler's insistence that at Maiden Castle he excavated 'clearly stratified' nailed horseshoes 'incontestably of late fourth and early fifth century date'.⁴ Doubt is permissible. Of all archaeological objects, one should be most cautious about the stratification of horseshoes: a horse stepping into a rodent's burrow easily deposits one which the denizen of the burrow may draw still deeper; horses bogging in mud often lose shoes 2 or 3 feet below

¹ Stern, 'Poésies', 166.

² L. Palmer, 'Feet and shoeing', in *In My Opinion*, ed. W. E. Lyon (London, 1928), 283.

³ See p. 156.

⁴ R. E. M. Wheeler, 'Maiden Castle, Dorset', *Reports of the Society of Antiquaries of London*, xii (1943), 290, pl. 30B.

the surface. In such circumstances the results of excavation must be subject to special control by information from other sources.

There is no literary evidence that the Greeks, Romans, or Franks had the horseshoe: the closest they came were hipposandals and *soleae*¹ attached with thongs or wires either for ornamentation or to help the healing of a broken hoof. Since the veterinary care of horses was of much concern to military writers, their failure to mention the shoe has more force than have most arguments from silence. Likewise there is no ancient or early medieval representation of horseshoes: the famous little statue of Charlemagne mounted, now in the Carnevalet Museum, may be contemporary, but the horse with its nailed shoes is probably a reconstruction of 1507.² And surely cavalry was not shod in 873 when a sudden freeze congealed the mud of the roads of Aquitaine and ruined the horses' feet.³

As for archaeology, many pagan peoples buried horses with their chieftains, yet in a fairly wide study of such rider-graves in Europe I have found only one supposed horseshoe, a 'Hufeisenstück mit Nagel' listed from grave I at Pfahlheim,⁴ probably of the seventh century. One wonders first about the identification of this fragment; second, where the other three shoes are; third, whether some medieval horse may not have intruded it.

The earliest unambiguous excavated evidence of horseshoes comes from nomadic rider-graves of the Yenisei region in Siberia in the ninth to tenth centuries.⁵ Simultaneously, nailed horseshoes are mentioned in the Byzantine *Tactica* of the Emperor Leo VI,⁶ who reigned from 886 to 911. And in the West we probably hear the first sound of shod hooves in the last decade of the ninth century

¹ Despite *History of Technology*, ed. C. Singer, ii (1956), 561, it is merely to a *solea*, and not to a shoe, that Catullus, xvii. l. 26 refers; cf. R. Ellis, *Commentary on Catullus*, 2nd edn. (Oxford, 1889), 66.

² P. E. Schramm, *Die zeitgenössischen Bildnisse Karls des Großen* (Leipzig, 1928), 36.

³ 'Primo quidem pluviarum inundantia plurimarum; deinde humectationem terrae glaciali astringente rigore, quae adeo noxia fuit, ut subtritis pedibus equinis, rarus quisque foret qui vectatione equorum uteretur' (*Vita Hludovici imperatoris*, cap. 47, ed. G. H. Pertz, in *MGH, Scriptores*, ii [1829], 635).

⁴ K. M. Kurtz, 'Die alemannischen Grabfunde von Pfalheim', *Mitteilungen des Germanischen Nationalmuseums, Nürnberg*, 1. ii (1884-6), 171; cf. W. Veeck, *Die Alamannen in Württemberg* (Berlin, 1931), i. 166.

⁵ R. Girshman, in *Artibus Asiae*, xiv (1951), 187.

⁶ *Leonis imperatoris Tactica*, v. 3, ed. R. Vári (Budapest, 1917), i. 92: 'πέδικλα, σελήναια σιδηρὰ μετὰ καρφίων αὐτῶν.' The appendix to Book I of the *De ceremoniis* of Constantine Porphyrogenitus (d. 957) likewise mentions them; cf. *Patrologia graeca*, ed. J. P. Migne, cxii. 852. But A. Vogt, *Livre des cérémonies* (Paris, 1935), i, p. xvii, suspects that these appendixes are later accretions.

when Ekkehard's *Waltharius* says 'ferrata sonum daret ungula equorum'.¹ In 973 Gerhard's *Miracula Sancti Oudalrici* speaks of nailed shoes as being habitual for those going on journeys.² In 1038 Boniface of Tuscany was exhibiting his status by using silver nails in his horse's shoes.³ By the later eleventh century they must have been very common, for under Edward the Confessor (d. 1066) six smiths at Hereford annually each produced 120 shoes from the king's iron as part of their taxes.⁴ Moreover, clear nailed shoes appear in at least one miniature of the middle eleventh century.⁵ We may safely assume that by the eleventh century the virtues of horse-shoeing would be as evident to the peasant as to the lord, and that the peasants could afford the iron for shoes.

But even a shod horse is of little use for ploughing or hauling unless he is harnessed in such a way as to utilize his pulling power. Thanks to the studies of Richard Lefebvre des Noëttes, it is now recognized that Antiquity harnessed horses in a singularly inefficient way. The yoke harness, which was well suited to oxen,⁶ was applied to horses in such a way that from each end of the yoke two flexible straps encircled the belly and the neck of the beast. The result was that as soon as the horse began to pull, the neck-strap pressed on its jugular vein and windpipe, tending to suffocate it and to cut off the flow of blood to its head. Moreover, the point of traction came at the withers, mechanically too high for maximum effect. In contrast, the modern harness consists of a rigid padded collar resting on the shoulders of the horse so as to permit free breathing and circulation

¹ *Waltharius*, ed. K. Strecker in *MGH, Poetae aevi carolini*, vi, fasc. 1 (1951), l. 1203; for the date, cf. F. J. E. Raby, *History of Secular Latin Poetry in the Middle Ages*, 2nd edn. (Oxford, 1957), i. 263.

² Cap. 29, ed. G. Waitz, *MGH, Scriptores*, iv (1894), 424.

³ *Vita Matildis, scripta a Donizone presbytero*, c. 10, ed. L. Simonei, in *Rerum italicarum scriptores*, new edn. (Bologna, 1930), 33.

⁴ *Herefordshire Domesday, c. 1160-1170*, ed. V. H. Galbraith and J. Tait (London, 1950), 2. While compiled a century later, this document records obligations under Edward.

⁵ R. Lefebvre des Noëttes, *L'Attelage et le cheval de selle à travers les âges* (Paris, 1931), fig. 448; the dating of the miniatures in figs. 190, 191, and 446 is in error. For the date of fig. 448, cf. R. Stettiner, *Die illustrierte Prudentius Handschriften* (Berlin, 1895), 130; A. Katzenellenbogen, *Allegories of the Virtues and Vices in Mediaeval Art* (London, 1939), 4.

⁶ However, late Antiquity saw an advance with the invention of the horns-yoke, the earliest specimen of which comes from Ireland, but is not exactly datable; cf. W. Jacobeit, 'Ein eisenzeitliches Joch aus Nordirland', *Ethnographisch-archaeologische Forschungen*, i (1953), 95-97; cf. *Cambridge Economic History of Europe*, ed. J. H. Clapham and E. Power, i (Cambridge, 1941), 134.

of the blood. This collar is attached to the load either by lateral traces or by shafts in such a way that the horse can throw its whole weight into the task of pulling. Lefebvre des Noëttes proved experimentally that a team of horses can pull only about 1,000 pounds with the yoke-harness, whereas with collar-harness the same team can pull four or five times that weight.¹ Obviously, until the modern harness was available, peasants could not use the swifter horse in place of the plodding ox for ploughing,² harrowing, or heavy hauling.

Lefebvre des Noëttes examined various Roman, Han, and Byzantine efforts to overcome the disadvantage of yoke-harness by means of variations of the breast-strap (which had the defect of chafing), at times combined with lateral shafts.³ Of particular importance among more recent finds are a Roman bronze fibula from Cologne, probably of the third century, in the form of a withers yoke for a single animal to be harnessed to shafts⁴ and a small withers yoke of the second or third century, discovered at Pforzheim, to be used with shafts.⁵ Moreover, a late Roman mosaic in Ostia shows a mule attached between shafts with what appears to be a rigid collar, although it rests high upon the neck.⁶ That such experiments with harness were gradually perfected is shown by a tapestry of the first half of the ninth century, found in the Oseberg ship near Oslo, illustrating horses harnessed with a single small withers yoke, a breast strap, and lateral traces extending from the junctures of the breast-strap with the yoke.⁷ We might thus be confident that the modern harness was the product of a slow development in the Occident, were it not for

¹ See p. 156.

² See p. 156.

³ e.g. for Gaul, cf. Espérandieu, *Recueil*, nos. 4031, 7685, 7725; H. Dragendorff and E. Krüger, *Das Grabmal von Igel* (Trier, 1924), pl. 12, i.

⁴ G. Behrens, 'Die sogenannten Mithras-Symbole', *Germania*, xxiii (1939), 57, fig. 6.

⁵ A. Dauber, 'Römische Holzfunde aus Pforzheim', *ibid.* xxviii (1944-50), 230-4; W. Jacobeit, 'Zur Rekonstruktion der Anschirrweise am Pforzheimer Joch', *ibid.* xxx (1952), 205-7.

⁶ G. Calza and G. Becatti, *Ostia*, 4th edn. (Rome, 1957), 22; 65, fig. 5. Two extant representations from the late second or early third century show a Celtic grain-stripper pushed by a single horse or mule between shafts, but the harness cannot be judged in detail; cf. M. Renard, 'Technique et agriculture en pays trévire et remois', *Latomus*, xviii (1959), 91, fig. 7; pl. XVI. 1; XVII. 1; J. Mertens, 'Eine antike Mähmaschine', *Zeitschrift für Agrargeschichte und Agrarsoziologie*, vii (1959), 1-3.

⁷ W. Holmqvist, 'Germanic art during the first millennium A.D.', *Kungl. Vitterhets, Historie och Antikvitets Akademiens Handlingar*, xc (1955), fig. 134. On the basis of the Oseberg material, R. Grand, 'Vues sur l'origine de l'attelage moderne', *Comptes rendus de l'Académie d'Agriculture de France*, xxxiii (1947), 706, and in *Bulletin de la Société Nationale des Antiquaires de France* (1947), 259, suggests a Norse origin for the modern harness.

reports of philological evidence, still too inadequately published to be judged, that English 'hames' and German *Kommut* are of Turkic origin¹ implying a diffusion from Central Asia. It is also asserted that while the breast-strap was borrowed from the Germans by the Slavs before the great Slavic diaspora of the sixth century, the horse-collar (and its Turkic name) was borrowed by the Germans in the eighth-ninth century.²

This latter date fits well with other new evidence. While Lefebvre des Noëttes pointed to three Frankish miniatures of the early tenth century³ as the first indication of the new horse-collar, there is a picture of it a century earlier in the Trier *Apocalypse* (Fig. 3) which was illuminated in the heart of the Frankish realm about the year 800.⁴ Metal mountings for horse-collars have been found in Sweden from graves of the middle and later ninth century.⁵ Likewise in the late ninth century Alfred the Great notes, clearly with surprise, that on the northern coast of Norway horses were used for ploughing.⁶

What was the advantage to the peasant of having horses rather than oxen for agricultural labour? The studies by modern agronomists on the relative merits of horses and oxen may be slightly misleading because their tests were not made with medieval horses and oxen. Although it cannot yet be proved, it is probable that from the

¹ See p. 157.

² A. G. Haudricourt and M. J. B. Delamarre, *L'Homme et la charrue à travers le monde* (Paris, 1955), 174, 178; Haudricourt, 'Contribution à la géographie et l'ethnologie de la voiture', *Revue de géographie humaine et d'ethnologie*, 1. i (1948), 62. A type of rudimentary horse-collar on the analogy of Siberian reindeer harness and involving bone or horn T-shaped plates with a hole in each extremity, has been reconstructed by L. Gyula, 'Beiträge zur Volkskunde der Avaren, III', *Archaeologiai Értesítő*, 3rd series, iii (1942), 341-6, fig. 4 and pl. LVIII. These are found in seventh-ninth-century Hungary and Bohemia, ninth-tenth-century Ukraine, and tenth-eleventh-century Poland; cf. J. Zak, 'Parties en corne au harnais de cheval', *Slavia antiqua*, iii (1942), 201, fig. 9.

³ Op. cit. 123, figs. 140-2; cf. *History of Technology*, ed. C. Singer, ii (1956), 554, fig. 508.

⁴ Trier, City Library, MS. 31, fol. 58r. For date, cf. P. Clemen, *Die romanische Monumentalmalerei in dem Rheinland* (Düsseldorf, 1916), i. 67; A. Goldschmidt, *Die deutsche Buchmalerei*, i: *Die karolingische Buchmalerei* (Florence, 1928), 50; M. R. James, *The Apocalypse in Art* (London, 1931), 21; W. Neuss, *Die Apocalypse des Hl. Johannes in der altspanischen und altchristlichen Bibel-illustrationen* (Münster i. W., 1931), 249; J. de Borchgrave d'Altena in *Bulletin des Musées Royaux d'Art et d'Histoire, Bruxelles*, xviii (1946), 42; H. Swarzenski, *Monuments of Romanesque Art* (London, 1954), 57. The corresponding folio of the closely related Apocalypse of Cambrai, Municipal Library, MS. 386, is missing; cf. Neuss, op. cit. 262.

⁵ See p. 157.

⁶ *King Alfred's Orosius*, ed. H. Sweet (London, 1883), i. 18; A. S. C. Ross, *The Terfinnas and Bearmas of Othhere* (Leeds, 1940), 20.

eighth century onward the increasing weight of armour created a knightly demand for more powerful horses, and that these were bred systematically¹ before any such selective breeding was developed for cattle. While there was a contrast between the *destrier* of the baron and the farm-horse of the peasant, the occasional mixing of the two would soon tend to upgrade the farm-horses. As compared with horses, it is safe to assume that cattle were relatively weaker in the Middle Ages than they are today. We must conclude that any modern advantage which can be shown for the use of the horse in farming should be augmented as applied to the Middle Ages.

Modern experiments show that while horse and ox exert roughly the same pull, the horse moves so much more rapidly that he produces 50 per cent. more foot-pounds per second.² Moreover, a horse has more endurance than an ox, and can work one or two hours longer each day.³ This greater speed and staying-power of the horse is particularly important in the temperamental climate of northern Europe where the success of a crop may depend on ploughing and planting under favourable circumstances. Moreover, the speed of a horse greatly facilitated harrowing, which was of more importance in the north than near the Mediterranean where cross-ploughing broke up the clods fairly well.

It is these elements which cast suspicion upon the cost-accounting of thirteenth-century agricultural writers like Walter of Henley who favour the ox as plough-beast on the grounds that a horse eats much more than an ox, and whereas an old horse is worth only his hide, an old ox can be fattened up and sold to the butcher.⁴ Modern agronomists, aware of the rapid depreciation of the horse as tending to counterbalance its greater efficiency as a worker, nevertheless have calculated that, for a day's work, an ox is thirty per cent. more expensive than a horse.⁵ What medieval peasants thought of the

¹ I have found no evidence of deliberate selective breeding for the chevalric market earlier than 1341 in Milan, when the contemporary Gualvaneo de la Flamma, *De gestis Azonis vicecomitis*, ed. L. A. Muratori, *Rerum italicarum scriptores*, xii (Milan, 1728), 1038, records that 'equos emissarios equabus magnis commiscuerunt, et procreati sunt in nostro territorio dextrarii nobiles, qui in magno pretio habentur. Item canes Alanos altae staturae, et mirabilis fortitudinis nutrire studuerunt.'

² Usher, op. cit. 156; R. J. Forbes, *Studies in Ancient Technology* (Leiden, 1955), ii. 83.

³ G. Krafft, *Lehrbuch der Landwirtschaft*, iv: *Die Betriebslehre*, 12th edn. rev. by F. Falke (Berlin, 1920), 67.

⁴ Walter of Henley, *Husbandry*, ed. E. Lamond (London, 1890), 12. N. Harvey, 'Walter of Henley and the old farming', *Agriculture, the Journal of the Ministry of Agriculture*, lix (1952-3), 491, is puzzled by Walter's shortsightedness in the matter of plough-teams.

⁵ Krafft, op. cit. 70.

matter is shown by the fact that in the twelfth century, in the Slavic lands east of Germany, the ploughland measurement consisted of as much as could be worked by a pair of oxen or by one horse;¹ an advantage of 100 per cent. for the horse.

In view of the evidence from Norway in the late ninth century it is curious that we have no pictures of horses working the fields until 200 years or more later, when two appear: the border of the Bayeux Tapestry, probably made in Kent *c.* 1077-82,² shows a horse pulling a harrow, and a mule harnessed to a wheeled plough; while from the early twelfth century comes a tapestry of the Apocalypse, now in the cathedral of Gerona but showing northern influences, which illustrates the month of April with a team of horses doing the spring ploughing with a wheeled plough.³

However, by the end of the eleventh century the plough horse must have been a common sight on Europe's northern plains; for in 1095, at the Council of Claremont which launched the First Crusade, Urban II placed under the protection of the Peace of God 'oxen and plough horses (*equi arantes*) and the men who guide ploughs and harrows, and the horses with which they harrow (*equi de quibus hercant*).⁴ And a conversation recorded near Kiev in 1103 indicates that in the Ukraine the peasants were doing all of their ploughing with horses⁵—perhaps one key to the precocity of Kievan culture in that period.

Once the world of scholars has realized that the widespread replacement of oxen by horses marked an epoch in the application of power to agriculture, examination of local records will enable us to tell how rapidly, and in exactly what regions, the change took place. The state of the archives in England, for example, is such that much information should emerge; yet thus far we know little. Whether or not the attribution of the Bayeux Tapestry to Kent is correct, the

¹ Helmold, *Chronicle of the Slavs*, tr. F. J. Tschan (New York, 1935), 73, 75; but cf. 234. J. Matuszewski, 'Les Origines de l'attelage moderne', *Kwartalnik historii kulturny materialnej*, ii (1954), 836, states that in twelfth-century Poland a farm-horse cost as much as two oxen.

² *The Bayeux Tapestry*, ed. F. Stenton (New York, 1957), fig. 12; cf. pp. 11, 33.

³ C. Zervas, *L'Art de la Catalogne* (Paris, 1937), pl. 4, dates it tenth to eleventh centuries, but cf. Webster, *op. cit.* 79-84, 165, pls. LI, LII(A); R. Tatlock, *Spanish Art* (New York, 1927), 67-68, pl. 10.

⁴ See p. 157.

⁵ *The Russian Primary Chronicle, Laurentian Text*, tr. S. H. Cross and O. P. Sherbowitz-Wetzor (Cambridge, Mass., 1953), 200. The *Chronicle* was completed *c.* 1113; cf. *ibid.* 21. The earliest Russian reference to the horse-collar appears in twelfth-century letters on birch-bark found at Novgorod; cf. R. Smith, 'Some recent discoveries in Novgorod', *Past and Present*, v (1954), 5.

Tapestry indicates that the Anglo-Normans were familiar with horses in agriculture. Yet in the *Domesday Book* of 1086 there is no hint of plough-horses: with suspicious uniformity the clerks of William the Conqueror's exchequer speak of eight-ox ploughs; but the way they round off fractions indicates that they are using the eight-ox plough as a rather abstract measure of taxable land values.¹ Careful examination shows that in fact English ploughs in 1086 were often drawn by more or fewer oxen, probably according to the prosperity of the specific manor or the variations of soil and topography.² In the *Liber niger* of Peterborough, c. 1125, Trow-Smith has found a horse harrowing, but none ploughing.³ In 1167 an Oxfordshire royal manor was restocked with forty-eight oxen for six plough-teams, and five horses⁴ who seem destined for carting and harrowing rather than for ploughing. Yet not many years later a description of the Friday horse-market at Smithfield, outside the gates of London, speaks of horses 'for the cart, dray or plough'.⁵ Both in the Durham survey of 1183⁶ and the Templars' inquest of 1185,⁷ we find horses only harrowing, but c. 1191 we discover Abbot Samson of Bury St. Edmunds granting lands equipped in one case with a plough of two oxen and three horses (presumably one of them for harrowing), in another case a team of six oxen and two horses, in another manor two more teams similarly made and a third plough-team of eight horses.⁸ In the late twelfth century surveys of twenty-three manors of Ramsey Abbey in which one can judge the nature of the plough-teams, nine used oxen only, whereas fourteen used mixed teams.⁹

¹ H. P. R. Finberg, 'The Domesday plough-team', *English Historical Review*, lxxvi (1941), 67-71.

² R. Lennard, 'Domesday plough-teams: the southwestern evidence', *ibid.* lx (1945), 217-33.

³ *Op. cit.* 91.

⁴ A. L. Poole, *From Domesday Book to Magna Carta*, 2nd edn. (Oxford, 1955), 52.

⁵ William Fitzstephen, *Descriptio nobilissimae civitatis Londoniae*, in J. Stow, *Survey of London* (London, 1603), 574.

⁶ *Boldon Buke, or Survey of the Possessions of the See of Durham, made by Order of Bishop Hugh Pudsey in the Year 1183*, ed. W. Greenwell (Durham, 1852), 8, 19; 17 mentions a 'molendinum equorum'.

⁷ *Records of the Templars in England: the Inquest of 1185* (London, 1935), 11; the six ironshod horses on p. 9 may or may not pull the three ploughs there mentioned; p. cxviii has a 'molendinum chevaleraz'.

⁸ *The Kalendar of Abbot Samson of Bury St. Edmunds*, ed. R. H. C. Davis (London, 1954), 119, 127-8.

⁹ J. A. Raftis, *The Estates of Ramsey Abbey* (Toronto, 1957), 314. For some thirteenth-century materials, cf. H. G. Richardson, 'The mediaeval plough-team', *History*, xxvi (1942), 288.

These are random notices to which many more will undoubtedly be added as time passes. But their tendency is clear: in late twelfth-century England, at least in some regions which cannot yet be defined,¹ the horse was taking over the plough. Normandy was in advance of Britain: two thirteenth-century documents indicate that in the Duchy peasants were doing all of their ploughing with horses,² and a century later Nicholas Oresmus, who died Bishop of Lisieux in 1382, takes it for granted that ploughing is done by horses.³

Perhaps one reason for the technological lag in England was that while in France direct exploitation of the demesne dwindled steadily in favour of rents, thirteenth-century England witnessed a decided revival of the demesne and of labour services.⁴ Walter of Henley's treatise was one of the textbooks designed to aid this revival,⁵ and the real reason for his favouring the ox at the plough emerges when he remarks that 'the malice of the ploughmen does not permit a horse-drawn plough to go any faster than one pulled by oxen'.⁶ This kind of 'slow-down' may have affected the ploughing of demesne lands done reluctantly under manorial obligation (it was such ploughing which, by its nature, was recorded) but it would not apply when the peasants were working their own fields. And in area and productive significance for the total economy, the peasant holdings were far greater than the demesne.

¹ As this book goes to press, R. Lennard, 'The composition of demesne plough-teams in twelfth-century England', *English Historical Review*, lxxv (1960), 193-207, adds considerable new evidence of the increasing use of the plough-horse in the later twelfth century, and shows (p. 201) that the change first occurred 'in eastern and east Midland England'.

² L. Delisle, *Étude sur la condition de la classe agricole et l'état de l'agriculture en Normandie au moyen âge* (Évreux, 1851), 135, n. 36: 'omnes illi qui associabunt equos ad carucam . . .'. Eudes Rigaud, *Registrum visitationum archiepiscopi Rothomagensis (1248-1269)*, ed. T. Bonnin (Rouen, 1852), 375, records that when, in 1260, he was riding from Meudon to Giset on the feast of St. Matthew, 'invenimus carrucas operantes et arrantes, quarum equos adduci fecimus ad Meullentum, pro eo quod in festo tanti Sancti presumpserint irreverenter operari'.

³ L. Thorndike, *History of Magic and Experimental Science*, iii (New York, 1934), 466.

⁴ R. Grand, 'Les Moyens de résoudre dans le haut moyen âge les problèmes ruraux', *Settimane di Studio del Centro Italiano di Studi sull'Alto Medioevo*, ii (1955), 528-9; M. M. Postan, 'The chronology of labour services', *Transactions of the Royal Historical Society*, 4th series, xx (1937), 186-9.

⁵ Cf. D. Oschinsky, 'Medieval treatises on estate management', *Economic History Review*, 2nd series, viii (1955-6), 296-309. Something of the same sort must have been happening in Germany; for the thirteenth-century satirist Seifried Helbling, ed. J. Seemüller (Halle a. S., 1886), 1: 399, 820; 3: 124; 7: 1209; 15: 87, lampoons knights who leave the army to care for their estates, who think about nothing but crops and profits, who worry about cheese, eggs, and the price of grain.

⁶ Op. cit. 12.

Not only ploughing but the speed and expense of land transport were profoundly modified in the peasants' favour by the new harness and nailed shoes. In Roman times the overland haulage of bulky goods doubled the price about every hundred miles.¹ The result was that latifundia even close to Rome, but without water transport to compete with Egyptian, North African, and Sicilian shipments, could not afford to raise grain for the Roman market.² In contrast, in the thirteenth century the cost of grain seems to have increased only 30 per cent. for each hundred miles of overland carriage³—still high, but more than three times better than the Roman situation. Now it was becoming possible for peasants not situated along navigable streams to think less in terms of subsistence and more about a surplus of cash crops.

We still know very little in detail about the improvement of wagons which followed the invention of modern harness—the development of pivoted front axles,⁴ adequate brakes, whipple-trees,⁵ and the like. Most Roman vehicles, except ceremonial equippages and post-chaises, seem to have been two-wheeled. But beginning with the first half of the twelfth century we find a large, horse-drawn, four-wheeled 'longa caretta' capable of hauling heavy loads,⁶ and by the middle of the thirteenth century a wagon normally had four wheels:⁷ Friar Salimbene records that in 1248, at Hyères in Provence, Friar Peter of Apulia replied when asked what he thought of Joachim of Flora's teachings, 'I care as little for Joachim as for the

¹ C. A. Yeo, 'Land and sea transportation in Imperial Italy', *Transactions and Proceedings of the American Philological Society*, lxxvii (1946), 222.

² *Ibid.* 224; cf. E. R. Grosser, 'The significance of two new fragments of the Edict of Diocletian', *ibid.* lxxi (1940), 162.

³ R. J. Forbes, 'Land transport and road-building (1000-1900)', *Janus*, xli (1957), 109.

⁴ The fact that the front wheels in the Trier *Apocalypse* of c. 800 (*supra*, p. 61, n. 4 and Fig. 3) are smaller than the rear wheels indicates a pivoted front axle. For the later medieval evidence, see M. N. Boyer, 'Medieval pivoted axles', *Technology and Culture*, i (1960), 128-38, and *infra*, n. 7.

⁵ I know of no whipple-tree earlier than those on the bronze doors of Novgorod Cathedral made at Magdeburg in Saxony in 1152-4; cf. A. Goldschmidt, *Die Bronzetüren von Novgorod und Gnesen* (Marburg a. L., 1932), 8, pl. 26.

⁶ Cf. A. L. Kellogg, 'Langland and two scriptural texts', *Traditio*, xiv (1958), 392-6.

⁷ *A Book of Old Testament Illustrations of the Middle of the Thirteenth-Century sent by Cardinal Bernard Maciejowski to Shah Abbas the Great, King of Persia, now in the Pierpont Morgan Library*, ed. S. C. Cockerell, M. R. James, and C. J. Foulkes (Cambridge, 1927), a manuscript of c. 1250, probably Parisian, which is very detailed in technical matters (showing, for example, fol. 21b, pivoted front axle, whipple-tree, and horn-harness for oxen), illustrates four-wheeled wagons on fols. 5b, 6b, 9a, 12a, 21b, 23a, 27b, 39a, and 44b, but no two-wheeled carts.

fifth wheel of a wagon'.¹ Not only merchants but peasants were now able to get more goods to better markets.

In still another way the new harness affected the life of the northern peasants. When historical geographers began to study abandoned fields and settlements in Germany, they assumed that these had been deserted either during the Thirty Years War or after the Black Death of 1348-50. To their astonishment they found that abandonment of settlements, but not of fields, began in the eleventh century and occurred with great frequency in the thirteenth.² Not only were peasants moving to neighbouring cities while still going out each day to their fields: villages were absorbing the inhabitants of the hamlets in their vicinity. In a period when the total population of Europe was increasing rapidly,³ places long inhabited⁴ were losing their identity because of a 'balling' of peasants into larger and larger villages.

Despite the fact that one scholar has bewailed the resulting 'spiritual urbanization' of the peasants of the thirteenth century,⁵ the personal advantages of such concentration are evident: a hamlet with five to ten cottages led a restricted life. In a big village of two or three hundred families there would be not only better defence in emergency, but a tavern, a fine big church, maybe a school run by the priest in which the boys could learn their letters, certainly more suitors for your daughters, and not merely peddlers with packs but merchants with wagons and news of distant parts. But these virtues of a more 'urban' life would always have attracted countrymen. How

¹ 'Tantum curo de Ioachym quantum de quinta rota plaustrī', *Cronica Fratris Salimbene de Adam*, ed. O. Holder-Egger, *MGH, Scriptores*, xxxii (1905-13), 239. P. Deffontaines, 'Sur la répartition géographique des voitures à deux roues et à quatre roues', *Travaux du I^{er} Congrès International de Folklore, Paris, 1937* (Tours, 1938), 119, offers puzzling evidence of an early modern reversion to two-wheeled carts in certain areas of France which had used four-wheeled wagons during the later Middle Ages.

² See p. 157.

³ L. Génicot, 'Sur les témoignages d'accroissement de la population en occident du XI^e au XIII^e siècle', *Cahiers d'histoire mondiale*, i (1953), 446-62; J. C. Russell, 'Late ancient and medieval population', *Transactions of the American Philosophical Society*, XLVIII. iii (1958), 113.

⁴ É. Perroy, *La Terre et les paysans en France au XII^{ème} et XIII^{ème} siècles* (Paris, 1953, mimeographed), 144-5, shows that by the 1280's, in France, some recently reclaimed land was proving unsuitable for agriculture, and was being abandoned. Evidently by that time assarting had reached the point of diminishing returns.

⁵ B. Huppertz, *Räume und Schichten bäuerlicher Kulturformen in Deutschland* (Bonn, 1939), 131-9. When H. Stoob, 'Minderstädte: Formen der Stadtentstehung im Spätmittelalter', *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte*, xlvi (1959), 22, says, of the myriad little cities which arose during the later Middle Ages, 'bürgerliches Leben wird hier zur Miniatur, ja Karikatur', he is looking at the phenomenon from the standpoint of urban man, not with the eyes of the rising peasant.

is it that, beginning in the eleventh century, so many of them were able to act upon their desires?

The answer seems to lie in the shift from ox to horse as the primary farm animal. The ox moved so slowly that peasants using oxen had to live close to their fields. With the employment of the horse both for ploughing and for hauling, the same amount of time spent going to and from the fields would enable the peasant to travel a much greater distance. The mathematical relation of the radius of a circle to its area governed the redistribution of settlement. Even a slight increase in the distance which it was convenient to travel from the village to the farthest field would greatly enlarge the total arable which could be exploited from that village. Thus extensive regions once scattered with tiny hamlets came to be cultivated wildernesses dominated by huge villages which remained economically agrarian, for the most part, but which in architecture and even in mode of life became astonishingly urban.

The phenomenon of 'balling' has thus far been ascertained only for parts of Germany. There is, however, some evidence of it from northern France¹ and England,² and doubtless it took place in other areas where it was technically feasible. Deep in the Middle Ages this 'urbanization' of the agricultural workers laid the foundation for the change in the focus of Occidental culture from country to city which has been so conspicuous in recent centuries. It gave the peasantry of northern Europe psychological preparation for that great shift and perhaps enabled them to build up attitudes and spiritual antibodies which reduced the social shock of subsequent developments.

In pondering the relation of horse to ox, we are faced by a curious set of facts. Over much of northern Europe, from Wales to Sweden, the dominance of the heavy plough was such that the arable land had come to be measured in eight sections correlated to its eight oxen,³ yet it was roughly in this same region—the drainage basins of the North Sea and the Baltic—that the horse eventually became the normal plough animal.⁴ What particular affinity developed

¹ É. Chantriot, *La Champagne: étude de géographie régionale* (Nancy, 1905), 247.

² M. W. Beresford and J. K. S. St. Joseph, *Medieval England: An Aerial Survey* (New York, 1958), 111-13.

³ R. Mielke, 'Das Pfluggespann', in *Festschrift Eduard Hahn* (Stuttgart, 1917), 194-7, 202.

⁴ E. Hahn, 'Das Pfluggespann', in *Festschrift für Marie-Andree Eysn* (Munich, 1928), 90; cf. the map of the area of horse-culture in France c. 1650 in R. Musset, *De l'élevage du cheval en France* (Paris, 1917), 137.

between the horse and the heavy plough? And if the modern harness was known in Europe by the year 800, why was there a delay of nearly three centuries in the wide use of the horse in agriculture? The answer is to be found in a new system of crop rotation which, when joined with the heavy plough and the draught-horse, completed the pattern of a new and vastly more productive system of northern agriculture.

III

The Three-field Rotation and Improved Nutrition

The three-field system of crop rotation has been called 'the greatest agricultural novelty of the Middle Ages in Western Europe'.¹ It bursts upon us in the late eighth century, the first secure indication of it being datable in 763;² the next comes in 783;³ the third, in 800.⁴ Thereafter the evidence of it is so frequent that those historians who hold the dogma that nothing in rural life can change quickly are required to believe that the three-field system is a much earlier invention⁵ which managed to elude the records.

But it would seem that Charlemagne himself thought of the new pattern of the agricultural year—which had been adopted on the imperial manors, if we may judge by the capitulary *De villis*⁶—as something so new and significant that he felt impelled, as has been mentioned, to rename the months in terms of it. In former times, the ploughing for the winter crop had been done in October or November, and the harvest had been reaped in June or July. But in Charlemagne's new nomenclature, June, when the fallow is ploughed,

¹ C. Parain in *Cambridge Economic History*, i (1941), 127.

² H. Wartmann, *Urkundenbuch der Abtei St. Gallen* (Zürich, 1863), i, 41, no. 39: 'et in primum ver aratro iurnalem unum et in mense Junio brachare alterum et in autumnio ipsum arare et seminare.'

³ O. Dobenecker, *Regesta historiae Thuringiae* (Jena, 1896), i, 15, no. 48: 'in tribus Hoheimis . . . in tribus Geochusis . . . in tribus Percubis.' A document of 771 in *Codex diplomaticus et variarum traditionum antiquissimi Monasterii Lauresheimensis* (Tegernsee, 1766), Part II, 312-13, no. 494, mentioning a 'mansum de terra araturia xxvii iurnales in tribus locis sitos', is often cited as one of the earliest evidences of the three-field system. But W. Fleischmann, *Caesar, Tacitus, Karl der Große und die deutsche Landwirtschaft* (Berlin, 1911), 53, n. 1, correctly points out that this codex records so many gifts of land located in 2, 4, 5, 6, &c., loci that the instance of 3 is ambiguous.

⁴ K. Lamprecht, *Deutsches Wirtschaftsleben im Mittelalter* (Leipzig, 1886); i, 545, n. 4.

⁵ e.g. K. Weller, 'Die Besiedlung des Alemannenlandes', *Württembergische Vierteljahrschrift für Landesgeschichte*, vii (1898), 340-1.

⁶ Haudricourt and Delamarre, *op. cit.* 46.

is the 'Ploughing Month', and August is the 'Harvest Month'.¹ Such was the emperor's propaganda for an agricultural novelty which he must have felt was of the first importance to his realm.

There was nothing comparable to three-field rotation in Roman times. Pliny² tells us that the people of Trier once sowed grain in March after their winter crop had been destroyed, but this is recounted as a most unusual episode, and there is no indication that it was repeated. Pliny, indeed, knows of summer crops to be sown in the spring, but the very listing of them—millet, panic, sesame, clary, winter-cress (all of which, he says, are winter crops in Greece and Asia, but not in Italy), lentils, chickpeas, alica (?)—as compared with his list of winter crops—wheat, spelt, barley, beans, turnips, and rape—shows how unimportant the spring planting was.³ He mentions that Virgil had recommended planting beans in the spring, as was done near Padua, but Pliny regards their sowing in the autumn as normal.⁴ Peas, on the other hand, in Italy and colder climates, are sown only in the spring.⁵ While both Pliny⁶ and the Roman agronomists⁷ were well aware that legumes enrich the soil, there apparently was no regular and customary system of alternating such crops with cereals.

Much more important anticipations of the triennial rotation are found in the far north. A Danish palaeobotanist has concluded, on the basis of pollen analysis, that the early agriculture of the Baltic region was confined to the spring planting, and that the autumn ploughing and planting was a fairly late medieval innovation in that area.⁸ Writing in the sixth century B.C., Hecataeus⁹ reports that in Britain two crops were harvested annually. Applebaum has noted¹⁰ that the chief grain of the northern Bronze Age was barley, which in northern climates has usually been a spring crop in the Middle Ages and more recent times; he suggests that the change of climate

¹ *Supra*, p. 56, n. 2.

² *Naturalis historia*, xviii. 20, ed. C. Mayhoff (Leipzig, 1892), iii. 193.

³ xviii. 7, ed. cit. iii. 155.

⁴ xviii. 12, ed. cit. iii. 175.

⁵ xviii. 12, ed. cit. iii. 176.

⁶ xviii. 12, ed. cit. iii. 175.

⁷ F. Harrison, *Roman Farm Management: The Treatises of Cato and Varro* (New York, 1913), 41-42, 121-2.

⁸ V. M. Mikkelsen, 'A contribution to the history of vegetation in the Sub-Arctic period', in A. Steensberg, *Farms and Watermills in Denmark during Two Thousand Years* (Copenhagen, 1952), 302.

⁹ As preserved in Diodorus Siculus, ii. 47, ed. C. H. Oldfather (London, 1935), ii. 38.

¹⁰ S. Applebaum, 'The agriculture of the British Early Iron Age as exemplified at Figheldean Down', *Proceedings of the Prehistoric Society*, xx (1954), 104.

c. 500 B.C. may have led to concentration on winter plantings, but with vestigial spring plantings in certain areas.

It seems probable, then, that as the Carolingians marched their armies into barbarian Germany, as St. Boniface and his Benedictine legions replaced pagan shrines with cathedrals and cloisters, as Teuton and Latin began to fuse their talents in the building of a new European culture, at that same moment the Baltic-North Sea spring planting was married to the Mediterranean autumn planting to create a new agricultural system far more productive than either of its progenitors.

How did the three-field system work, as compared with the older Mediterranean two-field rotation?

Under the two-field plan about half the land was planted with winter grain while the other half was left fallow. The next year the two fields simply exchanged functions.

Under the three-field plan the arable was divided roughly into thirds. One section was planted in the autumn with winter wheat or rye. The following spring the second field was planted with oats, barley, peas, chickpeas, lentils, or broad beans. The third field was left fallow. The next year the first field was planted to summer crops; the second field was left fallow; the third field was put into winter grains.

		1st year		2nd year		3rd year		1st year
1st field	AUTUMN	-----	AUTUMN	AUTUMN	-----	AUTUMN	-----
2nd field			-----			
3rd field		-----			-----		

Winter planting = ----- Spring planting =

In the eighth, ninth, and tenth centuries there were only three ploughings for the entire three-year cycle: winter field in October or November; summer field in March, or whenever the ground was beginning to warm; fallow towards the end of June.¹ Thus in this earlier period a manor of 600 acres under the two-field system would plough 600 acres for 300 acres in crops, whereas the same 600 acres under the three-field system would have 400 acres under crops for the same ploughing, or an increase of one-third.

¹ G. Hanssen, *Agrarhistorische Abhandlungen* (Leipzig, 1880), i. 163.

But by the twelfth century at latest¹ it had been found profitable both in the two- and three-field systems to plough the fallow twice in order to keep down weeds and to improve fertility. This change increased the advantage of the triennial rotation even further. Peasants handling 600 acres under the two-field plan, and ploughing the fallow twice, would plough annually $300+600 = 900$ acres for 300 acres in crops. Managing 600 acres on the three-field system, again with double ploughing of the fallow, they would plough annually only $200+200+400 = 800$ acres for 400 acres in crops. In terms of 600 acres, the increase of production in adopting the new rotation would still be only one-third. But since the change involved 100 acres less of annual ploughing, 75 acres (ploughed as $25+25+50$) might be added without additional labour,² if such land could be secured by reclamation. The same peasants would thus be cultivating not 600 but 675 acres (450 in crops), and their production advantage over the two-field rotation would be 50 per cent. The spread of the triennial system thus gave a major impulse to assarting: forests fell; swamps were drained; dykes stole polders from the sea.

The new plan of rotation, then, had several advantages. First, as has just been said, it increased the area which a peasant could cultivate by one-eighth and it pushed up his productivity by one-half. Second, the new plan distributed the labour of ploughing, sowing, and harvesting more evenly over the year, and thus increased efficiency. Third, it much reduced the chance of famine by diversifying crops and subjecting them to different conditions of germination, growth, and harvest. But fourth, and perhaps most important, the spring planting, which was the essence of the new rotation, greatly stepped up the production of certain crops which had particular significance.

Oats had entered Europe in prehistoric times from Asia Minor, probably as a weed accompanying wheat, but the Romans had not developed it.³ Oats is the best possible food for horses.⁴ The ox is

¹ M. Bloch, *Caractères*, 25; K. Lamprecht, *op. cit.* i. 558.

² On Walter of Henley's unnecessarily intricate calculations to discover that one-eighth more area could be handled under the new system, cf. *Cambridge Economic History*, i. 129. It is significant that this passage is omitted from one of the Henley MSS.: cf. E. Power, 'On the need for a new edition of Walter of Henley', *Transactions of the Royal Historical Society*, xvii (1934), 101-16.

³ D. R. Sampson, 'On the origin of oats', *Harvard University Botanical Museum Leaflets*, xvi (1954), 295-8; F. A. Cofman, '*Avena sativa* L. probably of Asiatic origin', *Agronomy Journal*, xlvii (1955), 281; F. Schwanitz, *Die Entstehung der Kulturpflanzen* (Berlin, 1957), 122.

⁴ They are not a modern fad with horses: W. Dugdale, *Baronage of England* (London,

a grass-burning engine; the horse is a much more efficient oats-burning engine. The peasants of southern Europe had no choice between ox and horse as plough-beast because their biennial rotation did not give them a sufficient surplus of grain to keep many horses.¹ As a result of their rotational system, since oats was one of the major spring crops, the northern peasantry had both the quantity and quality of surplus food needed for horses.² By the end of the Middle Ages there appears to be a clear correlation between the triennial rotation and the use of the horse in agriculture.

It may be that the 300-year delay between the arrival of the modern harness and the widespread use of the horse for non-military purposes can be explained by the practical difficulties of switching a village from the biennial to the triennial rotation. We know of a few cases in which it took place,³ but unless an entirely new third field could be assarted,⁴ or unless by sheer accident individual holdings were so arranged that what had been two could now be cut into three without drastic reallocation of strips, such a change must have run into the opposition of vested rights.

Arrangements of this sort are much more easily effected when new land is being settled, or when devastated areas are being repopulated after a time of chaos. The later ninth and early tenth centuries were an age of dismay. The parts of northern Europe which were not overrun by the Hungarian horsemen were put to the torch by Viking raiders. Only after the Northmen were domesticated at the mouth of

1675), i. 183-4, cites an agreement of 1317-18 providing regularly 'hay and oats for four horses . . . hay and oats for eight horses'.

¹ A survey made in 1338 of 123 estates of the priory of the Hospitalers at Saint Gilles, near the mouths of the Rhone, shows that all but three were using oxen for ploughing, despite the fact that twenty-four of these properties, because of favourable circumstances, had been able to develop rhythms of cultivation more intensive than the two-year rotation; cf. G. Duby, 'Techniques et rendements agricoles dans les Alpes du Sud en 1338', *Annales du Midi*, lxx (1958), 404, 407. In 1422 an effort was made to use horses to operate Brunelleschi's great hoist erected to help build the dome of the cathedral at Florence, but power from horses proved at least 50 per cent. more expensive than from oxen; cf. F. D. Prager, 'Brunelleschi's inventions', *Osiris*, ix (1950), 516, n. 146.

² J. Boussard, 'La vie en Anjou au XI^e et XII^e siècles', *Moyen âge*, lvi (1950), 57, 67, says that oats are first mentioned in Anjou in 1129, and that during the second half of the twelfth century oats and wheat tended to replace barley and rye as the basic crops. Since Anjou lies on the border between the horse and the ox areas, the triennial and the biennial areas, and the open-field and the enclosure areas, it would be very interesting to know the exact local relationships and changes involved in this shift of crops.

³ See p. 158.

⁴ As occurred before 1220 at one village in Yorkshire; cf. T. A. M. Bishop, 'Assarting and the growth of the open fields', *Economic History Review*, vi (1935), 19.

the Seine and in the Danelaw, and after the Magyar might had been crushed on the Lechfeld, did the second wave of invasions—more destructive than the Teutonic incursions which had toppled Rome—come to an end. At once the reconstruction began, and in the north it seems likely that the new agricultural communities would be eager to organize themselves according to the superior new technology of crop rotation.¹ This in turn would gradually supply the oats which permitted the building up of the stock of horses. In terms of such a sequence, it is not surprising that the farm-horse began to come into much more general use in the eleventh century.

The question of the spread of the three-field system from its point of origin in the Frankish area between the Seine and the Rhine has not been studied systematically. Like the answers to so many other fundamental questions in agricultural history, it must await far more careful local documentary and field investigation than has thus far been accomplished.² Even in Germany, where more such research has been done than elsewhere, no one can yet be more definite than to say that its diffusion took several centuries after its start shortly before 800.³ Hungary is puzzling: one abbey seems to have three fields on its estates in 1086; then there is no mention of a triennial rotation until 1355.⁴ In the thirteenth century it appears among the southern Slavs,⁵ in Poland,⁶ and in southern Sweden.⁷ On the other side of Europe it seems not to have reached England until the twelfth

¹ A large proportion of the communities in the area of summer rains which could not redivide their lands, so as to exploit the new system to the full, compromised: their lands remained divided into two fields, but half of each year's arable was planted in the autumn, half in the spring. While obviously less productive than the perfected system, this plan would have many of its advantages, and was perhaps particularly suited to regions with relatively poor soil which would become depleted with the more intensive rotation; cf. Gray, *op. cit.* 71; C. S. and C. S. Orwin, *The Open Fields* (Oxford, 1938), 49.

² See p. 158.

³ H. Mortensen, 'Zur deutschen Wüstungsforschung', *Göttingische gelehrte Anzeigen*, ccvi (1944), 210.

⁴ M. Belényesy, 'Angaben über die Verbreitung der Zwei- und Dreifeldwirtschaft im mittelalterlichen Ungarn', *Acta ethnographica Academiae Scientiarum Hungaricae*, v (1956), 185.

⁵ J. K. Jireček, *Geschichte der Serben* (Gotha, 1918), ii, 54; J. Sakazov, *Bulgarische Wirtschaftsgeschichte* (Berlin, 1929), 105.

⁶ D. Warriner, 'Some controversial issues in the history of agrarian Europe', *Slavic and East European Review*, xxxii (1953), 105; S. Chmielewski, 'Notes on farm tools and implements in early Polish agriculture', *Kwartalnik historii kultury materialnej*, iii (1955), 282.

⁷ *Zeitschrift für Agrargeschichte und Agrarsoziologie*, v (1957), 206, citing D. Hannerberg, 'Byamål', *Kungl. Humanistiska Vetenskaps Samsfundets i Lund, Årsberättelse* (1954-5), 19-62.

century,¹ whence it was probably taken to Ireland towards the end of the same century by Anglo-Norman colonists.²

We have seen how greatly the new supply of oats made available by the three-field system increased the numbers and prowess of horses. But people likewise were shaped by the new food resources.

In addition to oats and barley, the spring planting was habitually composed of legumes. We have already noted that the Romans knew peas, chickpeas, lentils, and broad beans, and that they were aware that legumes help the soil. But the Mediterranean emphasis on the autumn planting appears to have been so strong that even in the northern area of summer rains these crops were not grown by the Romans in great quantity, in proportion to cereals. At last, however, beginning in the late eighth century, legumes as field-crops came to play a vast and integral part in the new triennial rotation. Indeed, their role in its success has not been sufficiently emphasized; the nitrogen-fixing properties of these plants were fundamental to the maintenance of fertility under the more rigorous cultivation.

Malthus was no dietician: he assumed that population is dictated by the available food supply. The matter is much more complex. Food is not food unless it forms a balanced ration, the chief element in which is a relation between carbohydrates and proteins. A diet overloaded with carbohydrates quickly becomes as bad as starvation, and is, in fact, amino-starvation. A society may theoretically be able to produce great amounts of carbohydrates which it has no practical reason to produce until it finds an increased supply of proteins. Anything affecting the quantity of proteins available will quickly be felt in terms of population.³

Under the three-field rotation the autumn planting was largely carbohydrates, but the spring planting held a large amount of vegetable proteins. That by the end of the eleventh century these latter loomed as large as the cereals is indicated by Ordericus Vitalis's lament over the fearful drought which struck Normandy and France in the summer of 1094, searing 'the grain and pulse (*segetes et legumina*)'.⁴ The normal picture of the summer fields is seen in the old English game song:

¹ G. Duby, 'La Révolution agricole médiévale', *Revue de géographie de Lyon*, xxix (1954), 362.

² J. Otway-Ruthven, 'The organization of Anglo-Irish agriculture in the Middle Ages', *Journal of the Royal Society of Antiquaries of Ireland*, lxxxi (1951), 9.

³ Cf. R. Linton, 'Crops, soils and culture in America', in *The Maya and their Neighbors* (New York, 1940), 36.

⁴ Ed. A. Le Prevost (Paris, 1845), 461; cf. 463.

Do you, do I, does anyone know,
How oats, peas, beans and barley grow?

And in the thirteenth century St. Albertus Magnus tells us how the eel leaves rivers for the fields where he will find peas or chickpeas sown.¹ Cato's slaves had been fed cereals, but no beans,² and Pliny had praised pulse above grain as food.³ A Carolingian sacramentary provided a *Benedictio favae*:⁴ now the prayers were answered.

Our recently acquired knowledge of nutrition, then, provides us with new insight into the dynamics of the later Middle Ages. While the legumes available to medieval Europe did not in themselves supply a complete series of the biologically necessary amino-acids, by a happy coincidence the smaller quantities of proteins found in the common grains were the perfect dietary supplement to those present in legumes, and particularly in field peas.⁵ It was not merely the new quantity of food produced by improved agricultural methods, but the new type of food supply⁶ which goes far towards explaining, for northern Europe at least,⁷ the startling expansion of population, the growth and multiplication of cities, the rise in industrial production, the outreach of commerce, and the new exuberance of spirits which enlivened that age. In the full sense of the vernacular, the Middle Ages, from the tenth century onward, were full of beans.⁸

IV

The Northward Shift of Europe's Focus

In 1937 there appeared posthumously the masterpiece of the Belgian historian Henri Pirenne, *Mahomet et Charlemagne*.⁹ Since then it has

¹ 'Nonnumquam [anguilla] etiam de aqua egreditur ad agrum in quo pisa vel cicer seminatur', *De animalibus*, Lib. XXIV, cap. 8, ed. H. Stadler (Münster i. W., 1920).

² N. Jasny, 'The daily bread of the ancient Greeks and Romans', *Osiris*, ix (1950), 228.

³ 'Fortiora contra hiemes frumenta, legumina in cibo', *Naturalis historia*, xviii. 7, ed. C. Mayhoff, iii. 159.

⁴ *The Gregorian Sacramentary under Charles the Great*, ed. H. A. Wilson (London, 1915), 221.

⁵ E. Woods, W. M. Beeson, and D. W. Bolin, 'Field peas (*pisum sativum*) as a source of protein for growth', *Journal of Nutrition*, xxvi (1943), 327-35; J. S. Lester and W. J. Darby, *Nutrition and diet*, 6th edn. (Philadelphia, 1952), 193. For detailed analysis of the protein content of legumes and grains, cf. M. L. Orr and B. K. Watt, *Amino Acid Content of Foods* (U.S. Department of Agriculture, Home Economics Bureau Research Department, report 4) (Washington, 1957) 16-21, 24-33, 54-59.

⁶ See p. 158.

⁷ See p. 159.

⁸ L. White, jr., &c., 'Symposium on the tenth century', *Medievalia et humanistica*, ix (1955), 3-29.

⁹ (Paris, 1937); English tr. by B. Miall (New York, 1939).

dominated discussion of the economic history of the Mediterranean from the fifth through the tenth centuries. According to Pirenne, the Western Roman world did not 'fall': it slowly disintegrated. Until c. 700 the essential unity of the Mediterranean was preserved, despite political chaos. Levantine traders continued to do business as far west as the Merovingian kingdom, and indeed this commerce may have remained as active as in earlier and happier times. But the upsurge of Islam in the seventh century tore apart the seamless robe of the Middle Sea. Commercial connexions with the East were severed, and the conquest of Visigothic Spain by the Muslims in the eighth century left the Frankish king as the only considerable power in what was left of the Latin West. Cut off from the great currents of the continuing life of the Mediterranean, the Frankish realm turned inward upon itself and became the nucleus of a new kind of civilization. The Islamic smashing of Mediterranean cultural and commercial unity was, according to Pirenne, 'the most essential event of European history that had occurred since the Punic Wars. It was the end of the classic tradition. It was the beginning of the Middle Ages. . . . Without Mohammed, Charlemagne would have been inconceivable.'¹

No other historical work of our century has provoked such an outburst of research, mostly in opposition. His critics have now destroyed Pirenne's thesis in the greatest detail.² Mediterranean commerce suffered a long and steady decline; the Islamic conquest did not close the Mediterranean to the meagre trade still existing between the Orient and the West; economic historians can draw no sharp line between Merovingian and Carolingian times as regards contacts with the East.

But this controversy has been misleading. Pirenne's explanations have been cut to bits, but what he was trying to explain has not yet been clarified by other means. The observable fact from which he started was a shift of the focus of Europe, in Carolingian times, from south to north, from the classic lands of the Mediterranean to the great plains drained by the Loire, the Seine, the Rhine, the Elbe, the Upper Danube, and the Thames. The lands of the olive and vine remained vigorous and creative, but who can doubt that, save for

¹ English tr., 164, 234.

² The most extensive recent discussion is R. Latouche, *Les Origines de l'économie occidentale (IV^e-XI^e siècle)* (Paris, 1956). For something briefer, see A. Riising, 'The fate of Henri Pirenne's thesis on the consequences of the Islamic expansion', *Classica et medievalia*, xiii (1952), 87-130.

brief periods, the core of European culture has been north of the Alps and the Loire from the ninth century to our own day? If Pirenne's answer has been refuted, his question remains.

A more durable solution of the historical problem of the change of the gravitational centre of Europe from south to north is to be found in the agricultural revolution of the early Middle Ages. By the early ninth century all the major interlocking elements of this revolution had been developed: the heavy plough, the open fields, the modern harness, the triennial rotation—everything except the nailed horse-shoe, which appears a hundred years later. To be sure, the transition to the three-field system made such an assault on existing peasant properties that its diffusion beyond the Frankish heartland was slow; but Charlemagne's renaming of the months indicates how large the new agricultural cycle loomed in his thinking. We may assume safely that its increased productivity was a major stimulus to the north even in his day.

The agricultural revolution of the early Middle Ages was limited to the northern plains where the heavy plough was appropriate to the rich soils, where the summer rains permitted a large spring planting, and where the oats of the summer crop supported the horses to pull the heavy plough. It was on those plains that the distinctive features both of the late medieval and of the modern worlds developed. The increased returns from the labour of the northern peasant raised his standard of living and consequently his ability to buy manufactured goods. It provided surplus food which, from the tenth century on, permitted rapid urbanization. In the new cities there arose a class of skilled artisans and merchants, the burghers who speedily got control of their communities and created a novel and characteristic way of life, democratic capitalism. And in this new environment germinated the dominant feature of the modern world: power technology.