REMARKS ON THE AGRICULTURE OF ABERDEENSHIRE.

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No. VI.

DRAINAGE.

The soil of the greater proportion of Aberdeenshire being incumbent on granite, by the gradual disintegration of which it has been formed, is naturally of very inferior quality. The climate, too, is cold, humid, and exceedingly changeable; and hence it is obvious that the cultivation of wet, retentive lands, cannot, under any system of management, however skilful, be very advantageously prosecuted until relieved of superabundant moisture, by drainage. Being fully sensible of this, the proprietary and tenantry are now, generally speaking, zealously co-operating in all parts of the county, to carry that fundamental improvement into effect—a considerable share of the expense being defrayed by the former, as those most deeply interested in the permanent melioration of the soil. A great extent has been thorough-drained during the last ten years; but a vast deal yet remains to be done; indeed, it is probable that there are few counties (if any) in Scotland that stand so much in need of drainage as Aberdeenshire. In every district, and in all seasons, the injurious effects of redundant moisture upon the soil and crops are more or less apparent. Extensive tracts of arable land still remain in a wretched and unprofitable condition under the influence of superfluous moisture; and, although at present the produce of these, except in very favourable seasons, barely repays the expense of their cultivation (which is generally greatest where the soil is wettest and least productive), yet there is every reason to expect that when properly drained and adequately manured, the cost thereby incurred will be amply repaid.

The husbandry of Aberdeenshire has advanced at an astonishing pace during the last twenty years; and, efficient drainage being justly regarded as the primary step towards developing and increasing the productive capabilities of the soil, that fundamental improvement has been, for some time past, very extensively and vigorously carried on. In order to render my observations on this subject in some degree practically useful. I shall advert—First, to the different methods of draining usually practised in Aberdeenshire; secondly, to the expenses that have actually been incurred in executing the operation on different farms; and, thirdly, to the profits and other beneficial effects that have been found to accrue therefrom. Considering the immense importance of drainage, as conducive to the interests of all classes—landlords, farmers, and the community at large—and as the means of increasing simultaneously the productive powers of the soil and the salubrity of the climate, while affording useful employment to thousands of our labouring population, no apology is deemed necessary for entering somewhat minutely into detail in illustration of each of these heads.

Before proceeding to describe the Aberdeenshire methods of draining, it will be proper to premise a few observations respecting the causes of superabundant moisture, in order to enable the reader to judge of their propriety or impropriety. In a district so much diversified with hill and dale, it is to be expected that the over-wetness arises, in many instances, from water oozing up from beneath the surface in the form of springs, or flowing over the ground from a higher source. Accordingly, numerous springs do occur in all parts of the county, and, when not intercepted before reaching the surface, and conveyed away by a drain of sufficient depth, occasion swamps and morasses of greater or less extent, in proportion to the copiousness of the supply of water. In very many cases over-wetness in land arises from both springs and rain-water which is prevented from percolating downwards by a retentive soil or an impervious substratum; but in the great majority of instances, especially in the low-lying parts of the county, the latter is the sole or predominant cause. Throughout a very considerable portion of Aberdeenshire the active soil is incumbent on a ferruginous incrustation, or "moor-band pan" as it is commonly designated, which is quite impervious to water; and so indurated that the two-horse plough is altogether unable to penetrate it. In other parts of the county, as in the division of Buchan, the soil is of a more or less tenacious character—resting on a sub-stratum of tilly clay—a combination which likewise prevents the free descent of rain-water.

It is obvious, then, that thorough-draining or furrow-draining (as it is indiscriminately termed) and deep tillage are the only means of effectually relieving by far the greater proportion of the wet lands of Aberdeenshire of redundant moisture,

and of diminishing the expense, while increasing the profits of their cultivation. Accordingly, the method of draining which has been so prominently brought into public notice by Mr. Smith, and thence denominated the Deanston system, is now very generally practised throughout this county; with such modifications, however, as circumstances render expedient. It is, therefore, to the different modes of executing *thorough-draining* that I purpose adverting in this article; but it may be proper, in the first place, to make a few observations on the deep or transverse drains, which have been so generally superseded by those constructed according to the Deanston system.

In the "Agricultural Survey of Aberdeenshire" it is stated that Dr. Anderson had not only executed a number of drains on his farm at Monkshill, but that he had *publicly* recommended the *tapping* of wet ground before Mr. Elkington's practice was known. It also appears that the Elkington system was practised to a considerable extent shortly after that once popular method of draining was brought into public notice. Dr. Skene Keith mentions that many of the landed proprietors had employed Johnston, a disciple of Elkington, to survey not only their personal farms, but also those of several of their tenants, for the purpose of obtaining directions from him regarding the best method of removing the superabundant moisture which they had found from experience to be most prejudicial to their crops. As the over-wetness arose, in many instances, from water issuing to the surface, in consequence of meeting with some interruption in its subterranean course, the Elkington system was found highly beneficial. In those days it was deemed unnecessary to drain any except springy or spouty land; and it was seldom that the whole of a field was drained, but merely the spots which it was dangerous to allow the working cattle at any season to walk over. When a spouty patch was to be dried, a large drain or trench was formed of sufficient depth to reach the channel or bed along which the water filtered before encountering the obstruction which had forced it to the surface; and so directed as to intercept as many springs as possible. It was found that one drain skilfully placed, and of sufficient depth, frequently rendered a large tract of wet land perfectly dry and firm. Though not now practised to anything like the same extent as formerly, this method of draining is still adopted in most cases where the wetness proceeds from one or more springs, as in bogs and swamps. The drains are cut from five to seven, and occasionally nine feet in depth, and most generally filled with stones, to within two-and-a-half or two feet of the surface; but they are also not unfrequently left open in bogs, and other situations where the cartage of stones would be difficult, if not altogether impracticable, until the ground has acquired some degree of solidity after the removal of the water with which it was surcharged.

As superfluous moisture (in hilly lands in particular) often arises from both causes associated, namely, springs and (recent) rain-water; so both systems of draining, viz., the Elkington and the Deanston, are frequently combined with the greatest advantage. Although the latter popular method is beyond question the most applicable to the greater proportion of the wet arable land in this and other parts of the country, yet experience has fully proved that it cannot, in all cases, be practised with equal benefit or economy, and abundantly shown the impropriety of altogether abandoning the system of deep draining, as has been done in most districts throughout the kingdom. Drains cut to the usual depth of furrow-draining will always more or less mitigate the evil in the case of wetness proceeding from springs; but it is manifest that they cannot remove the cause, as they are too shallow to reach and intercept the current of water. Both remedies are, in reality, applicable to very different cases; and, consequently, neither of them can with propriety be substituted for the other, though both may be, and, indeed, have been practised in conjunction with the most beneficial results where both sources of wetness exist.

A kind of drain which was formerly much employed, and is still frequently constructed in particular cases, is made in the following manner:—A trench of about twenty-four inches in width at the top, from sixteen to nineteen inches at the bottom, and of such depth as the nature and texture of the subsoil and other circumstances may render necessary in order to obtain a secure foundation, on which the stones may firmly rest, is cut through the field to be drained in such a direction as is considered best calculated for carrying off the water. After the bottom of the drain has been made quite even, and all loose soil cleared out, two rows of medium-sized stones, set obliquely, and leaning to each other at the top, like the roofing of a house, are carefully laid for the passage of water. If the drain be narrow, and the stones employed are of a tolerable size, the whole of the water passes through between these two rows; but if the stones be small, and a large flow of water is expected, there are two, and sometimes three, rows of these couples, with a flat stone between every two rows, which, together, will void a considerable stream. A quantity of small stones collected off the fields is then thrown promiscuously above these, until the top of the drain is within sixteen or eighteen inches of the surface of the ground. The stones being rendered uniform on the top, are covered

either with heath or turf cut from the adjacent land, if the field is in grass; after which a sufficient quantity of the earth thrown out in excavating the drain, is returned, and the rest scattered over the ground. This description of drain is sometimes employed as a "leader" for receiving and conveying away water from smaller drains; and by using pretty large-sized stones for couples, a copious stream will be voided by a drain so constructed. It is also well adapted for conducting water from springs, is easily formed, and will continue in efficient operation for an indefinite period, provided proper care is taken in its construction.

As has been already observed, *thorough*-draining is that which is now most generally practised in Aberdeenshire; and in all parts of the county the operation is being extensively and vigorously carried on. All agriculturists are unanimous as regards the necessity and utility of drainage; but in reference to the manner in which particular parts of the process ought to be be executed, considerable diversity of opinion still prevails among practical men. The most proper depth of the drains with a due regard to economy, the most suitable size of stones for filling, and the manner of putting them in, are the chief points that now remain unsettled. In the following pages I shall endeavour to place before the readers of the "Farmer's Magazine" a brief account of the main features of the modes adopted by some of the most intelligent agriculturists in Aberdeenshire.

Every farmer being sensible of the immense utility of efficient drainage, not only as the basis of all subsequent improvements on the soil, but also in most instances the source of immediate and lasting remuneration, as well as the means of materially diminishing the expense of cultivating the land, while increasing its productive powers, one of the first particulars that engages the attention of a candidate for a vacant farm, in making his inspection of the grounds, is, the condition of the soil with respect to moisture. Should draining be considered necessary in any field or part of the farm (which it most generally is, to a greater or less extent), an arrangement between the proprietor and the offering tenant, specifying the allowance to be given to the latter for executing that improvement, is agreed to previous to the bargain being concluded and a formal lease drawn up.* In such cases the operation is, of course, begun immediately after entering into possession of the farm, and prosecuted with all possible expedition during the first five or six years thereafter, in order that the maximum advantage may be secured therefrom before the expiration of the lease.

Draining is carried on during every season of the year, and at all stages of the rotation; but the winter and early spring months are those in which the operation is most generally accomplished. Drains are occasionally executed while the land is in stubble, and also in some instances after the removal of the turnip-crop from the ground just previous to ploughing it up for the sowing of grain. It is, however, during the period in which a field is in grass, and immediately before breaking it up for oats, that most farmers in this quarter prefer to drain it, for the following, among other reasons; viz., that the stones employed in filling are then carted to the drains with less difficulty and labour to the horses, and less injury to the land; and that they can be broken and filled in more cleanly and expeditiously than when the ground is soft and loose on the surface; besides, when the field is in grass at the time of draining, suitable turf can very conveniently be obtained for covering the stones previous to putting in the earth.

Main-drains.—In beginning to drain a field or piece of land, the situation, direction, and dimensions of the main-drains or leaders first demand the careful consideration of the farmer. Their number and position are of course regulated in a great degree by the nature of the surface; and their dimensions are determined chiefly by the extent of land whence they are intended to receive water, the degree of wetness, and other obvious circumstances. They are invariably made several inches deeper than the small or parallel drains, for the purpose of affording the water a sufficient fall from the latter, and thereby preventing the accumulation of sediment at the junction of the drains with their leader, which, it is obvious, would soon render them partially inoperative. Main-drains, constructed in the manner to be presently described, are generally from three to three-and-a-half feet in depth, from fifteen to eighteen inches in width at the bottom, and a proportionate breadth at the top. The depth just mentioned is considered quite sufficient for main-drains, when the branch ones that fall into them are only from thirty to thirty-three inches deep; but, of course, the depth of the former must be increased in proportion to that of the latter. It is hardly necessary to state that the main drains are always opened before the cutting of the smaller ones that are to be led into them is commenced, but that the latter are generally filled in before the former, the propriety and object of which must be known to every reader. The following is the usual mode of constructing main-drains:—After the

* The different arrangements entered into by landlords and tenants in Aberdeenshire, for executing the operation of draining, have already been adverted to under the head "Connection between Landlord and Tenant," in the "Farmer's Magazine" for June last.

cutting and filling of the whole of the smaller drains are completed, and it has been observed that a sufficient and uniform fall is secured for the water both into and from the main drain, a low wall is built with flat stones at each side of the bottom of the latter; openings being, of course, left at the proper places for the parallel drains to enter. Their height is commonly nine inches, the distance apart about seven inches; and they are surmounted by strong flag-stones or "covers;" any interstices between which are carefully filled up with small stones to prevent the entrance of earthy matters. There is thus formed a conduit or "eye" as it is here designated, of seven inches in width by nine in height, which is capable of voiding a considerable body of water. When the subsoil is composed of sand, or is in any degree soft, the bottom of the main-drain is generally paved with round stones, previous to the formation of the little side walls of the conduit, with the view of insuring the permanency of the work. Indeed, many intelligent agriculturists are of opinion that whatever may be the texture of the subsoil, the bottom of all mains should be so paved, as however firm and secure it may be at the time, there is some reason to apprehend that the continual abrasion of the water would eventually undermine the sides or otherwise endanger the safety of the drain. No doubt the cost is thereby increased; but, in the opinion of many skilful drainers, it is an exceedingly false economy to construct main-drains in an imperfect or insecure manner, for the sake of saving a trifle of the expense. Efficiency and durability are the great points to be aimed at in their formation; and the judicious farmer will not hesitate to incur a little additional expense, in order to secure these desirable qualities; especially when aided, as he always should be, by his landlord. There are various other sorts of main-drains besides that just described; but, as neither of them is so much approved of as it, it is deemed unnecessary to occupy valuable space with any further remarks on this part of our subject.

Common drains.—The parallel or common drains are invariably made in the direction of the greatest ascent or slope of the ground, except where it is considered the declivity is so great that the velocity acquired by the water in descending would be likely to produce an injurious effect; in which case it is supposed by some to be necessary to direct them with a slight inclination across the slope, in order to diminish the force of the current of water in the drain. But it is, perhaps, needless to observe that such situations rarely stand in need of thorough-draining, at least not in such a degree as the low, and almost flat grounds, which it is the farmer's first care to relieve of redundant moisture.

The *intervals* at which the drains are placed in the field vary from seventeen to thirty feet, according to the texture of the soil and subsoil. In the division of Buchan, which contains a greater proportion of clay than any other part of the county, it is, in many cases, found necessary, for effecting complete and efficient drainage, to have them so close to each other as seventeen or eighteen feet. When the ridges are seventeen feet in width, it is the common practice to form a drain in each of the inter-furrows. In the other divisions of the county, however, the soil is not in general of a very adhesive character, and drains from twenty to thirty feet apart are found quite adequate to effect the object in view. They are often, but not invariably, made in the furrows; the proper direction and distance asunder being objects of greater importance.

Dimensions.—The dimensions of furrow-drains are in a great degree regulated by the kind of material intended to be employed in filling, and also by the manner of forming the channel for the passage of water. Stones are almost exclusively used for this purpose throughout Aberdeenshire; and there are two methods of putting them into the drains. Many farmers, agreeably to the Deanston plan, break the stones to a small size, like those used in repairing the public roads; and put them promiscuously in to a certain depth. Several others, however, are of opinion that each drain should be furnished with an "eye" or open conduit in the bottom, similar to, but of smaller dimensions than, that of the main-drains already described. Each of these modes of filling, and the cases in which the last-mentioned one becomes preferable to the other, shall be adverted to in a subsequent part of this paper. When it is intended to form an "eye" or opening in the bottom of the drain of three inches in width by four in height, which are the usual dimensions, the drain requires to be about eighteen inches wide at the top, and twelve at the bottom; but when broken stones are to be used, without a conduit in the bottom, the drains are formed so narrow as barely to afford room for the labourers to work with freedom. In this case the width at the top is generally fifteen inches, and that of the bottom five.

Much difference of opinion exists among farmers in regard to the most proper depth of drains. There seems, however, to be a general and an increasing disposition to practise somewhat deeper draining than has hitherto been considered necessary or advisable. The usual depth of furrow-drains at present is thirty-two inches; until very recently a depth of thirty inches was the most common and the most generally approved of in Aberdeenshire; but the opinion is fast gaining

ground among intelligent agriculturists that by cutting the drains from six to twelve inches deeper their efficiency in drying the soil would be very materially augmented; and that, therefore, the distance between them may be proportionably increased. When the subsoil plough is intended to be afterwards used, the minimum depth to which stone drains are cut is thirty-two inches below the surface of the ground. Both these important operations, viz., draining and subsoiling, are deemed by many experienced farmers in this district to be necessary accompaniments to each other; for, when either is left undone, the maximum advantage cannot be derived from the accomplishment of the other.*

Cutting.—The situation, direction, and dimensions of the drains having been determined on, their formation is next proceeded with, beginning, as already mentioned, with the opening of the leaders. It is very customary for farmers to enter into an agreement with one or more skilful workmen, called *contractors*, for executing the cutting and filling of the drains at a stipulated rate of wages per hundred yards; and this is found to be a convenient and useful practice, as one or two men are thus rendered responsible for the work of the others. But as the filling-in, especially when stones are the material employed, is justly regarded as the part of the process that demands the greatest care and attention in its performance, many farmers contract only for the opening or *casting* of the drains, preferring to have the remainder of the work accomplished by the regular or constantly employed farm-servants, or by labourers hired and paid by the day. These, having no interest in hurrying over the operation, and being under the immediate superintendence of the farmer or his steward, are more likely to execute it in a perfect and substantial manner than men engaged at piece-work. Regular specifications, stating the dimensions of the drains and other particulars, are drawn up for the guidance of the contractor, who is usually bound to complete the operation within a limited period, and engages workmen accordingly.

It is considered unnecessary to occupy space by describing at any length the manner of opening the drains, as there can be but little peculiarity in the mode of performing this part of the process. I shall, therefore, merely remark that the farmers, in general, are particularly solicitous that the drains, besides being of the specified dimensions, shall be straight and even along the bottom, that a sufficient and uniform fall be secured for the water, and that the sides be regularly and similarly sloped. Previous to the filling-in being commenced, or the contractor being paid for the cutting, all the drains are individually inspected by the farmer or his steward, in order to be satisfied that all parts of the work have been correctly executed, agreeably to the previous arrangement. Most of the landlords (all of whom in Aberdeenshire defray a considerable proportion of the expense of draining) have a man specially for the purpose of examining the drains in course of formation on their respective estates, and seeing that they are constructed in a correct and substantial manner. It is, perhaps, needless to observe in this place that in every case the opening of the drains is commenced at the lower, and the filling at the higher level, in order that any water which may happen to be present, may thus be permitted to escape, which not only insures a dry footing for the labourers, but also serves to indicate any defects in the work already accomplished.

Should the land about to be drained be in grass at the time, the work is usually begun by stretching a line in the proper direction, and marking off with a spade the breadth of the drain at the top. The surface sods are then dug out, and placed on one side; and in some instances they are cut with care, in order that they may subsequently be available for covering the stones before returning the earth. The tools employed in draining are two different sizes of spades, a pickaxe, a footpick, and a narrow shovel or scoop for throwing out the loose earth from the bottom of the drain. The footpick or "tramp-pick," as it is likewise termed, is a most effective instrument for breaking up the indurated subsoil, through which the spade alone could not easily be made to penetrate; as, also, for loosening any stones that may be met with.

Filling.—It has been already mentioned that stones are the material almost exclusively employed throughout Aberdeenshire for filling drains; and there are but few parts of the county in which they are not obtainable in abundance for that purpose. Within the last few years tiles have been used to a limited extent. There is a tile manufactory in operation in the vicinity of Aberdeen, another in the parish of Forgue, and one in the division of Buchan; but, probably, the largest works of this kind in the county are those lately erected in the district of Byne. where drain-tiles, fourteen inches in length, are now sold at the rate of twenty-eight shillings per thousand. The usual price at the other tile-

* Any farmer engaged in draining may readily and fully convince himself, should he be sceptical of the advantage of deep over shallow drains, by getting one cut some six or eight inches deeper than the rest, and observing, after the first heavy rain, or previous to its occurrence, if the ground happens to be very wet at the time, which draws the largest quantity of water.

ries is, I believe, thirty shillings per thousand. In the neighbourhood of the slate quarries at Foudland the broken or refuse slates are very usefully employed as *soles* on which to rest the tiles. In many parts of Aberdeenshire, however, drain-tiles are almost entirely unknown, though there can be no doubt but that the establishment of a number of tileries in the district of Buchan, where there exists abundance of clay suitable for the purpose, would be of immense benefit to the farmers in that locality, as tiles at a moderate price would, in many instances, be considerably cheaper than stones, on account of their greater portability, and the greater degree of expedition with which the work can be accomplished by their use. The labour attending the quarrying, cartage, breaking, and filling-in of so heavy a material as stones renders them more expensive than tiles at the above-mentioned prices, except when the latter have to be carted a considerable distance; besides, the tile and sole are considered by many to constitute a more effective and durable drain, and will draw off the surplus water after a heavy fall of rain, sooner than that filled with stones.

The stones employed in draining are procured from two sources, viz., the surface of the ground, and the quarry. The small round stones annually gathered off the grass-fields, as well as those brought to the surface by the action of the tillage implements while preparing the land for green crops, are carted into heaps in convenient situations, with the intention of being subsequently employed (if necessary) in draining. The fields in most parts of the county contain a great number of such stones, and they are considered to be peculiarly well adapted for draining; they also constitute an economic material, since it is necessary or proper at all events, to collect and remove them off the ground; and they require little breaking preparatory to being put into the drains.

Not a few farmers, it is confessed, are still very sceptical of the propriety or advantage of filling drains with stones broken to nearly the size of road *metal*, even in situations where the practice might, in all probability, be adopted with safety and success. It is difficult to determine to what extent this is to be ascribed to prejudice; but, certainly, the objection to the use of small stones, thrown in promiscuously without forming a conduit in the bottom, is well founded in particular cases, and cannot be altogether attributed to the lingering attachment to ancient usage, which most farmers are so fond of manifesting in their practice. The greater proportion of the land that stands most in need of drainage in this county abounds with ferruginous matter, here denominated *iron ore*. The indurated stratum occurring in many places between the soil and subsoil, and known by the name of *moor-band pan*, to which I have already alluded as being, from its impervious character, one of the main causes of over-wetness, is a ferruginous deposit, consisting chiefly, I believe, of oxide of iron in chemical combination with certain organic acids. Now, wherever the oxide or peroxide of iron exists in any considerable quantity in the soil, it is considered injudicious by the majority of the Aberdeenshire farmers to drain with broken stones put in after the Deanston fashion, though they are almost unanimously of opinion that this method is the best that could be adopted in the draining of land containing only a due proportion of iron. In the former case the water impregnated with the ferruginous matter, in making its way through the stones, leaves an ochery deposit, that, sooner or later, renders the drains wholly useless, by obstructing the passage of the water. In several instances drains filled with broken stones have had to be re-opened, in consequence of becoming choked up, when the deposit alluded to was discovered, and at once accounted for the progress of the water having been impeded. This substance chiefly accumulates at the junction of the branch and main drains, and is always seen at their outfall.

The only effectual method, then, of thorough-draining with stones land thus abounding with salts of iron is to furnish each drain with a securely formed "eye" or open conduit in the bottom, which affords a channel for the free passage of water, and is not very liable to be rendered inoperative by the accumulation of deposit. This is more especially necessary in the case of ground having but little fall or inclination. But when the soil contains no undue proportion of ferruginous matter, it is admitted by all, that drains filled with the proper quantity of small-sized stones are equally, if not more, efficacious and durable, than those furnished with "eyes." It will be proper to describe briefly both methods of filling, and, first, when broken stones are employed without any conduit in the bottom.

Some difference of opinion still exists among farmers in reference to the most proper size of stones for thorough-draining. Many consider that it would be imprudent to reduce the stones to a smaller size than four-and-a-half or four inches in diameter, from an apprehension that the water would not make its way with sufficient celerity through those of less dimensions. Others, however, break them so as to pass freely through a ring three-and-a-half inches in diameter, and there are not a few who prefer them so small that the largest in the heaps may pass through a three-inch ring. The propriety of using stones of a small

size is every year becoming more and more generally recognised in practice; and, as the size is diminished, the quantity put into the drain is also lessened. On one estate, the proprietor of which defrays the whole of the expense of draining, except the carriage of the material used for filling, the drains were, in 1844, filled with fifteen inches in depth of stones, broken so as to pass through a ring *four* inches in diameter; in 1845, all that were made were filled with twelve inches in depth of *three*-inch stones; and the regulation since the beginning of the current year is, that only nine inches in depth of stones, broken so small as to pass freely through a *two-and-a-half*-inch ring, shall be used. The drains, it may be proper to mention, are thirty-two inches in depth, fourteen inches in width at the top, and five at the bottom. I may here observe that Mr. Smith considers four or five inches of broken stones to be quite sufficient.

The stones are most generally laid down in cart-loads at proper intervals along the sides of the drains, either prior to the cutting being commenced, or while it is being performed. It is found advantageous, particularly during winter, to have the stones on the spot previous to cutting the drains, as it is desirable to fill them in immediately after being opened, in order to guard against the falling-in of any portion of the sides, which not unfrequently happens during wet weather, or after frost, and occasions much additional labour. Many farmers prefer, however, to get the stones broken at the quarry in large heaps, or *bens*, whence they are carted to the drains when required; and this is unquestionably the more judicious practice. The small stones that have, from time to time, been gathered off the fields are commonly broken to the required size at the heaps into which they had at first been formed. In both these cases the broken stones are carted to the drains as required, and shovelled into them from the carts, care being taken not to break down any of the soil from the sides, or to allow any earthy matters to get in among the stones.

The foregoing is the usual mode of filling drains with broken stones; but latterly some farmers have, with great advantage, been using an apparatus for the double purpose of expediting the operation, and of freeing the stones from all earthy matters. This consists of two separate articles, viz., a screen or "harp," as it is designated, and a strong wooden box called a "crib." The screen is formed of a number of strong iron rods attached to a frame of the same material; and the distance between the rods is such as to prevent any of the stones passing through while being freed from all *débris* and particles of earth. It is generally made four feet in length, two-and-a-half feet in width at one end, and twenty-six inches at the other. The wider end is furnished with two hooks, by means of which it is readily attached to the hinder part of each cart on arriving at the drain to be filled, while the other extremity is supported about a foot above the ground by a low wheel, on which the instrument runs when the cart to which it is affixed is moved. The purpose of the wooden box or crib is to receive the stones from the laden carts after passing over the intervening screen, and to deposit them in the drain. It is three feet in length, one foot in height, and six inches in width at the bottom—all inside measurements. It therefore contains rather more stones than are usually put into the same length of drain; but the precise quantity intended to be used can of course be regulated by placing a mark on the inside of the crib. The bottom is attached on one side by means of strong hinges, and on the other by a spring which is readily opened by drawing a little upwards an iron rod on the outside of the box. It is commonly formed of board three-quarter inch thick, strongly clasped with iron hoops rivetted to the wood, and is furnished with handles like a barrow. The price of the screen and box is about twenty-six shillings; and the manner of using them is as follows:—When a cart arrives with broken stones at the side of the drain about to be filled, the screen is attached to its hinder end, and the box is placed at the proper position at the lower end of the screen. The stones are then hauled or shovelled out of the cart, and, in descending the screen, are freed from all *debris* and earthy matters before reaching the box beneath, which, when sufficiently full, is emptied by two men. They stand with their legs on both sides of the drain, holding the box in the proper position between them; and, by drawing the iron rod in connection with the spring, the bottom gives way at one side with a smart jerk, on which the contents fall into the drain without carrying scarcely a particle of earth from the sides. In order to proceed with the greatest dispatch, two boxes and four men (besides the carter) are necessary; one party to be filling while the other are emptying. In this case the cart stands midway between two adjoining drains, both of which are filled simultaneously, and the cart is emptied of its contents without its position being altered. By the use of the very simple, cheap, and efficient contrivance, which I have thus rather tediously described, the filling-in of drains with broken stones is accomplished not only with much greater expedition than in the ordinary way, but in a more secure and perfect manner.

The stones, after being made uniform on the surface, which is very easily effected when the mode of filling just described is adopted, are covered with

turf of about two inches in thickness, cut from the contiguous surface if the field is in grass at the time. Sometimes the first or top sods are reserved for this purpose. Heath, straw, and similar matters are also occasionally used when the land is in stubble or tillage. The covering of the stones with turf is a part of the process on which much attention is bestowed, as considerable damage may ensue to the drain from having it imperfectly performed.

In the construction of the other description of drain—namely, that furnished with an "eye," or square conduit—much care and attention must also be exercised. The eye is formed in nearly the same manner as the conduit of main-drains already described; stones of suitable size are placed at both sides of the bottom, upon which others are laid across the drain, thus forming an opening, the ordinary dimensions of which are three inches in width by four in height. In order to render this a substantial mode of draining, the side stones—or "cheeks," as they are designated—must be all of the same height, and be firmly laid upon the bottom, as the subsequent displacement of any of them would obstruct the passage of the water. The labourers accustomed to construct this kind of drain perform the work in a secure and expeditious manner. After the eye has been formed in the bottom of the drain, five or six inches in depth of broken stones are commonly, but not always, placed above the covers, and these are again covered with turf, straw, or other suitable material.

Not a few of the farmers still adhere to the old practice, when returning the earth thrown out in excavating the drain, of placing the loose surface soil next the covered stones, and keeping the more tenacious subsoil near the top. This is done with the view of facilitating the descent of rain-water into the drains; but many intelligent drainers are now opposed to the practice, and deny its propriety, as they deem it essential to the efficiency and durability of the drains to guard against the direct entrance of water from the top. It is considered preferable to force all the water to find its way into the drains by percolation through the subsoil; for, if permitted to enter through the loose earth above the stones, it must necessarily carry along with it a greater or less quantity of the soil, which will be deposited in the drain. The most approved practice, therefore, and that which is becoming general, is, after the stones or other materials used for filling have been properly covered with turf, to have a portion of the most tenacious of the subsoil well trampled with the feet, or beaten down with a wooden instrument adapted for the purpose. This consolidated stratum is commonly two inches in thickness. The remainder of the earth is then put in, sometimes with the plough, but generally by the spade; and a few turns of the harrows complete the process.

Although granite—an excellent material for draining—is obtainable in abundance in most parts of this county, yet there are some places where a sufficiency of stones cannot be procured for the purpose without incurring heavy expense in carting; and in these, recourse must be had to the most eligible and convenient substitute. It has already been mentioned that tiles are used to some extent in the vicinity of Aberdeen, and a few other localities, but that in most parts of the county they are scarcely known. A sort of drain-tile introduced a few years ago by Lord James Hay, of Seaton, near Aberdeen, was employed by many farmers for some time, but has fallen in estimation. The ingredients of which the *concrete* tile, as it is called, is composed, are good lime, sharp sand, and gravel, combined in the following proportions, viz., one bushel of lime-shells, two and a half bushels of sand, and four bushels of gravel, which will yield eight bushels of the composition (allowing half a bushel for the swelling of the lime by the application of water), and will make 120 tiles of one foot in length.

In reclaiming some boggy lands in the district of Buchan, several drains were formed with sods cut from the surface, and which have continued in efficient operation during a period of thirty years. By this means, and at a comparatively trifling expense, several hundred acres of peat moss have been completely and effectually dried, and, by liming and judicious tillage, have been brought into profitable cultivation. Sod or turf drains are resorted to with advantage in many quarters.

In other parts of the county, where stones are scarce and wood is obtainable at a cheap rate, the latter substance has been economically and advantageously employed in the formation of drains. The wood used for this purpose consists of the thinnings of plantations, *i. e.* the small trees commonly converted into paling. Larch is preferable, on account of its greater durability; but Scotch fir being the cheapest and most abundant kind in this quarter, is generally used. The drains to be filled with wood are usually thirty-two inches in depth, eighteen inches wide at the top, and about six inches at the bottom. It is essential to the efficiency and durability of wooden drains, that the sides be formed with a proper and regular slope from top to bottom. The small trees—or "spars," as they are designated—are prepared for being put into the drain, in the following manner: A portion of the butt or thick end of each is sawn off for placing transversely in the drain, about six inches above the bottom; the breadth of the drain at this

part may be assumed at nine inches, in which case the length of the cross-bars will require to be about fifteen inches, so as to have three inches resting on each side. They are generally about four inches in diameter, and are placed in the drains at intervals of four feet apart; they are forced firmly into their proper position by a few blows of a heavy mallet, the workman taking care that they are all in the same plane or level. Any earth loosened from the sides in striking down the bars is, of course, thrown out as the work is proceeded with. After the butt-ends of the trees (which are divested of their branches in the wood) are severed, and placed transversely in the drains in the manner just described, the remainder of them are laid longitudinally above the bars, three being commonly placed side by side, and covered with the branches and twigs, or with turf, heath, &c., previous to putting in the earth cast out in opening the drains. It is obvious that this method of draining can be adopted with advantage only in situations where timber is convenient and cheap, and when the subsoil is sufficiently cohesive to afford a proper support to the transverse bars of wood; hence it is inadmissible in the case of boggy lands. The putting in of the wood is accomplished in a very expeditious manner: two persons saw off the butts, and another places them in their proper position in the drain, after which the longitudinal spars are laid on as closely as possible, with the top and butt-ends alternately in the same direction, so as to make them fit the better. There is thus formed beneath the wood a channel for the passage of water, of about six inches in width and the same in depth.

The cost of this mode of draining obviously depends much on the price of the wood employed. In most parts of this county the spars used for the purpose are obtainable at from 1s. to 1s. 6d. per dozen; and it requires four dozen, averaging twenty feet in length, to do a hundred yards of drain. Drains thus constructed have been known to last for a very long period; on one farm the writer has been assured that drains formed of wood in the manner just described have been in perfect operation for more than thirty years.

Coarse gravel is sometimes employed with much advantage in filling drains in bogs and swampy situations, where stones would sink into the soft and yielding bottom. A friend of the writer's drained several acres of mossy or spongy land, about six years ago, with coarse gravel, carted during frosty weather from a river in the neighbourhood; and the drains so filled are still in efficient operation. They were formed of considerable width, and filled nearly to the surface with the gravel; and the field in question was thereby rendered perfectly dry, and capable of being tilled in the same manner as the rest of the farm. The cost was very trifling. This material, when it can be conveniently procured, may also be used in draining short pieces of wet land at the bottom of fields; but it is unfit for a long length of drain, or where any considerable current of water is expected.

Expenses and Profits—As already stated, the operation of draining is executed almost exclusively by a class of labourers called "contractors," who are paid at a certain rate per hundred yards, and are obliged to engage as many assistants as may be necessary for completing the work within a specified period. It is seldom that any of the regular farm servants are employed in cutting drains. The expense incurred in thorough draining a field or piece of land must, it is almost needless to observe, vary, in a greater or less degree, with the texture of the soil and subsoil, the dimensions and distance apart of the drains, the rate of wages common in the locality at the time, and other obvious circumstances. The usual cost, however, of cutting furrow drains in this county is from five to six shillings per hundred yards—*i. e.* from 3½d. to 4d. per imperial rod or pole of 5½ yards—according to the depth; and when the contractor engages to break the stones, and put them and the earth into the drains, he usually gets from 10s. 6d. to 13s. per hundred yards (18·18 rods). The different items of the cost may be stated as follow, per hundred yards:—

	s.	d.		s.	d.
Cutting	5	0	to	6	0
Breaking stones.....	3	0	to	4	0
Filling in ditto	2	0	to	2	3
Putting in the earth	0	6	to	0	9
	10	6	to	13	0

Main-drains or leaders, such as those described in a preceding page, commonly cost from 19s. to 22s. per hundred yards, or from 1s. to 1s. 2⅔d. per rod, for the cutting and entire construction. The foregoing rates are, of course, exclusive of carriage, which, in most cases, forms a considerable item of the expense; the quarrying of the stones, when necessary, also costs a pretty good sum per acre. There are 726 yards, or 132 rods, of drains in the statute acre, when the distance between them is 20 feet; but, as the cost of draining, per acre, depends so much on the size of the field, the length of main-drains required, and the distance stones may have to be carted, I consider that the most satisfactory mode of illustrating this part of my subject will be to introduce here a few statements of expenses that have actually been incurred in thorough draining in Aberdeenshire. It is presumed that many of the readers of an agricultural periodical are more or less engaged in draining, and that such authentic accounts of the expense incurred by

other farmers in executing that fundamental improvement, cannot fail to be acceptable.

I shall give, first, a statement of the cost of thorough draining, with broken stones, a field of twelve imperial acres, which has been kindly furnished me by a friend who has drained very extensively during the last ten years. In Aberdeenshire draining is executed at a certain rate per hundred yards; but in the following statements I have reduced the figures so as to show the cost per English rod, which will probably be more generally understood. It is proper to mention that the soil of the field in question, before being drained and subsoil ploughed, was of a very variable description, from light spongy peat to retentive clay. The substratum was mostly of an indurated character, but in some parts it was so soft as to render it necessary to place thin pieces of wood along the bottom, in order to prevent the sinking of the stones. The draining was commenced in the spring of 1834, the field being then in oat stubble. The small or parallel drains, of which there are 1,512 rods in the field, are 21 feet asunder, 32 inches in depth, 16 inches in width at the top, and 5 inches at the bottom. There are 61 rods of main-drains, which are 3½ feet in depth and 2 feet 3 inches wide at the bottom, previous to the construction of the conduit. The breadth at top varied according to the nature of the soil and subsoil. The "eye," or opening of the leaders, is 9 inches in height, the same in breadth, and is formed in the usual manner, with broken stones above the covers to within 18 inches of the surface of the ground. The bottom of the main-drains was paved with round stones previous to the formation of the little side walls of the conduit, this having been rendered essential in many parts of the field by the spongy character of the subsoil. The drains were all cut by contract, at the rate of 3½d. per rod for the small drains; a separate agreement was entered into for constructing the leaders, which were opened and formed in the manner described for 4d. per yard. The cost of this part of the work, therefore, stands thus:—

	£	s.	d.
To cutting 1,512 rods of small drains, at 3½d. per rod.....	22	1	0
To cutting and forming 61 rods of main-drains, at 1s. 10d. per rod	5	11	10
Whole cost of cutting, &c..	27	12	10

The greater proportion of the stones employed in filling were collected at different periods off the grass and other fields, and were formed into a large heap in a convenient situation, where they were broken so small as to pass through a ring of three inches in diameter. This was done at the rate of 3½d. per ton, the stones not requiring much breaking. The quantity requisite for the drainage of the field was 660 tons, exclusive of those taken up in digging and those that had to be quarried for the construction of the main-drains. The expense of breaking the stones may therefore be stated as follows:—

	£	s.	d.
To breaking 660 tons stones, at 3½d. per ton	9	12	0
To breaking stones thrown out in digging drains	1	12	0
To 73½ days of a man breaking stones, at 1s. 8d. per day.....	6	2	6
Total cost of breaking stones..	£17	6	6

As has already been observed, the stones were broken in a large heap or "bin," whence they were carted to the drains so soon as the opening was completed, and shovelled out of the carts into the drains, to the depth of 12 inches. The stones having been made level on the top, were carefully covered with turf brought from an adjoining pasture field; and in putting in the earth, a portion of the stiffest of the subsoil was beaten firmly down upon the turf. There are thus in each drain 12 inches of broken stone, surmounted by 2 inches of turf, 2 inches of consolidated clay, and 16 inches of soil. The cost of the various operations now referred to has been estimated as follows:—

	£	s.	d.
To 22 days of a man and a pair of horses carting stones to small drains, at 9s. 6d. per day.....	10	9	0
To 66 days of a man filling stones into carts, and afterwards putting them into the drains, at 1s. 8d. per day.....	5	10	0
To 12 days of a man and a horse carting broken stones and covers to main-drains, at 6s. per day ..	3	12	0
To 18 days of a man filling ditto, at 1s. 8d. per day.....	1	10	0
To 20 days of a man cutting turf, and placing it above the stones, at 1s. 8d. per day	1	13	4
To 3 days of a man and a horse carting turf for drains, at 6s. per day.....	0	18	0
To 4½ days of a man and a pair of horses ploughing in the earth over the stones.....	2	2	9
Total cost of filling..	£25	15	1

The entire cost of draining the field will, perhaps, be rendered clearer by the following recapitulation:—

	£	s.	d.
Cutting of small and main-drains, including the filling of the latter	27	12	10
Breaking stones	17	6	6
Carting and filling stones and turf, putting in the earth, &c.....	25	15	1
Total cost of draining 12 acres..	£70	14	5
Cost per statute acre.....	£5	17	10 ¼

This is certainly a high sum for the drainage alone, and doubtless the work might have been accomplished somewhat cheaper; but if the expense has been high, the operation has been most substantially executed, and we shall presently see how beneficial have been its effects. Economy is by all means to be studied in the performance of every agricultural operation, and especially in executing so costly a one as draining; but it is certainly a most mistaken economy to construct drains in a slight, hurried, and necessarily imperfect manner. All the drains not having been completed until the spring was far advanced, it was determined to subject the field to a course of summer fallowing, chiefly with the view of extirpating the weeds with which the ground was infested. I shall advert merely to the subsoil ploughing, this operation being so intimately connected with draining. The subsoil plough (Smith's, of Deanston) required four horses to work it, and was preceded by a common plough, drawn by two horses, both instruments penetrating to the depth of fifteen inches beneath the surface, or as far as could be done without endangering the drains. A woman followed the subsoil-plough with twigs, to mark the situation of the stones encountered by that implement, which were so abundant that three men were kept actively employed in taking them out of the ground during the fourteen days occupied in accomplishing the subsoil ploughing. The following is the account of expenses attending the process:—

To fourteen days of a man and a pair of horses, at 9s. 6d. per day	£6	13	0
To fourteen days of two men and two pair of horses, at 1*l.* per day..	14	0	0
To forty-two days of a man taking out stones, at 1s. 8d. per day....	3	10	0
To fourteen days of a woman marking stones, at 10d. per day.....	0	11	8
To wear and tear of subsoil plough, estimated on an average at 1s. per day.....	0	14	0
Total cost of subsoil-ploughing field.	£25	8	8
Cost per acre.....	£2	2	4⅔

Consequently the entire expense of draining and subsoil ploughing this twelve-acre field has amounted to no less a sum than 96*l.* 3s. 1d., or 8*l.* 0s. 3$\frac{1}{12}$d. per acre.

After undergoing the usual course of tillage in summer fallowing, the land got a top-dressing of lime, and street-dung from Aberdeen, and was sown with wheat in the autumn of 1834. It is worthy of remark that this was the first time wheat was ever attempted to be grown in the field in question. The utility of draining cannot be better illustrated than by a comparison of the crops raised in this field prior and subsequent to the execution of that improvement. Subjoined is a statement of the actual produce and value of the crops from 1829 to 1833, inclusive.—

1829, turnips, a miserable crop, barely worth 2*l.* per acre	£24	0	0
1830, oats, 31 qrs. 7 bush. (2 qrs. 5½ bush. per acre) at 25s. per qr.	39	16	10½
1831, first year's grass, (depastured), valued at 27s. 6d. per acre	16	10	0
1832, second year's grass, (depastured), valued at 1*l.* per acre	12	0	0
1833, oats, 24 qrs. 7 bush. (2 qrs. 0$\frac{7}{8}$ bush. per acre) at 35s. per qr..	43	10	7½
Value of crops on twelve acres for the five years preceding the drainage	£135	17	6

The following are the returns of the crops from 1835 to 1839, inclusive:—

1835, wheat, 49 qrs. 1 bush. (4 qrs. 0¾ bush. per acre) at 50s. per qr...	£122	16	3
1836, first year's grass, (depastured), valued at 47s. 6d. per acre	28	10	0
1837, second year's grass, (depastured), valued at 32s. per acre....	19	4	0
1838, oats, 57 qrs. 1 bush. (4 qrs. 6$\frac{1}{12}$ bush. per acre) at 25s. per qr.	71	8	1½
1839, turnips, valued at 5*l.* 13s. per acre	67	16	0
Value of the crops for the five years succeeding the drainage	£309	14	4½
Value of the crops for the five years preceding the drainage.....	135	17	6
Increase in value of produce of twelve acres, in six years.....	£173	16	10½
Cost of draining and subsoil ploughing.....	96	3	1
Gain in course of six years	£77	13	9½

One year's rent and the expense of the fallowing and manuring should, perhaps, be deducted from this sum; but still it will be seen that the cost of draining and subsoil-ploughing the field referred to has been soon and most amply repaid.

The foregoing interesting facts have been furnished the writer by an intelligent agriculturist, on the accuracy of whose statements he can place perfect reliance. Several other important advantages, besides that illustrated above, have also accrued from the drainage; not the least pleasing of which is, that while the productiveness of the soil has been greatly increased, the expense of cultivating it has been considerably diminished.

I have received from several farmers in different parts of the county interesting statements of the expense incurred in, and the profits arising from, draining, which I intended to give in detail; but

my observations having already, I fear, extended to greater length than will be agreeable, I shall introduce only a few of the more important facts.

A farmer who had put down in 1844 1,761 yards, or one mile, of main drains, and 14,895 yards, or 8·46 miles of small drains, at a cost (for cutting and filling) of from 16s. to 22s. for the former, and from 10s. to 13s. for the latter, per hundred yards, exclusive of carriages, and in 1845 nearly the same extent, states that the improvement in the land consequent on its drainage has been both immediate and very marked. The crops of every description, and more particularly turnips, have been considerably augmented in quantity and improved in quality, while the ground may now be ploughed or otherwise tilled in all states of the weather, except during hard frost. The value of the grass has also been greatly enhanced, the pasturage being more abundant and the herbage more nutritious. He is of opinion that the cost of thorough drainage is in most cases repaid in five or six years.

Mr. James Porter, the intelligent overseer of Logie-Elphinstone, the home farm of Sir Robert D. H. Elphinstone, Bart., made an experiment last year with a view to ascertain the influence of draining on the first crop. The soil is naturally very poor, being a thin yellowish clay, resting on a subsoil of hard gravel and clay. The whole of the field, except half an acre, was thorough-drained with broken stones in the autumn of 1844 at a cost of 4*l.* per acre exclusive of carriages. For the purpose of comparison, another half acre was measured off adjoining the undrained portion. The field was sown with Kildrummy oats on the 26th March, 1845, and the crop was reaped between the 14th and 21st of September. The following is a tabular statement of the result:—

Plots.	Marketable Oats on the half acre.	Weight per bushel.	Second quality of Oats on the half acre.	Weight per bushel.	Shillocks or inferior grain.	Whole produce of the half acre, exclusive of shillocks.	Weight of Straw.
	qr. b. pk.	lbs.	qr. b. pk.	lbs.	lbs.	qrs. b. pks.	cwts. qr.
1. Drained	2 2 0	41	0 3 3	38	89	2 5 3	15 1
2. Undrained ..	1 5 1	39½	0 2 1	37¼	69	1 7 2	12 0
Increase per half acre	0 4 3		0 1 2		20	0 6 1	3 1

It thus appears that even on the first crop after draining there was an increase of above one quarter and a half of grain, and 6½ cwts. of straw per acre, the value of which goes far to repay the expense of the operation.

Mr. Walker, Wester-Fintray, has drained extensively for some years past. All his drains are provided with open conduits, or "eyes," as the land abounds with ferruginous matter, and the cost varies from 4*l.* to 6*l.* 5s. per acre, according to circumstances. The most beneficial results have accrued from drainage on both his farms; one of the fields which was recently drained was last year in turnips, and the produce was valued at 6*l.* per imperial acre. When the same field was previously under this crop it was barely worth 3*l.* per acre.

In the low-lying parts of Aberdeenshire the expense of draining is not unfrequently repaid by the increased produce of the first three crops grown after the operation has been executed; but in general it is not expected to be fully returned until two courses of crops have been raised. There are some soils so naturally sterile as not entirely to repay the cost of thorough draining during the currency of a nineteen years' lease, if the increase of produce be alone taken into consideration; but several other advantages are also derivable from efficient drainage, to which, however, it is unnecessary to advert in this place.

ON THE RATIONALE OF CERTAIN MANURES EMPLOYED IN AGRICULTURE.

BY PROFESSOR DAUBENY, OF OXFORD.*

It might be deemed an act of presumption in one like myself, whose claim to address such a meeting as the present on subjects connected with agriculture arises merely from some acquaintance with the principles of scientific chemistry, to present to the practical farmer any method of culture at variance with his actual experience. The application of science to the details of husbandry is, indeed, too

* Read at the Chemical Section of the British Association, on Friday, September 11, 1846.