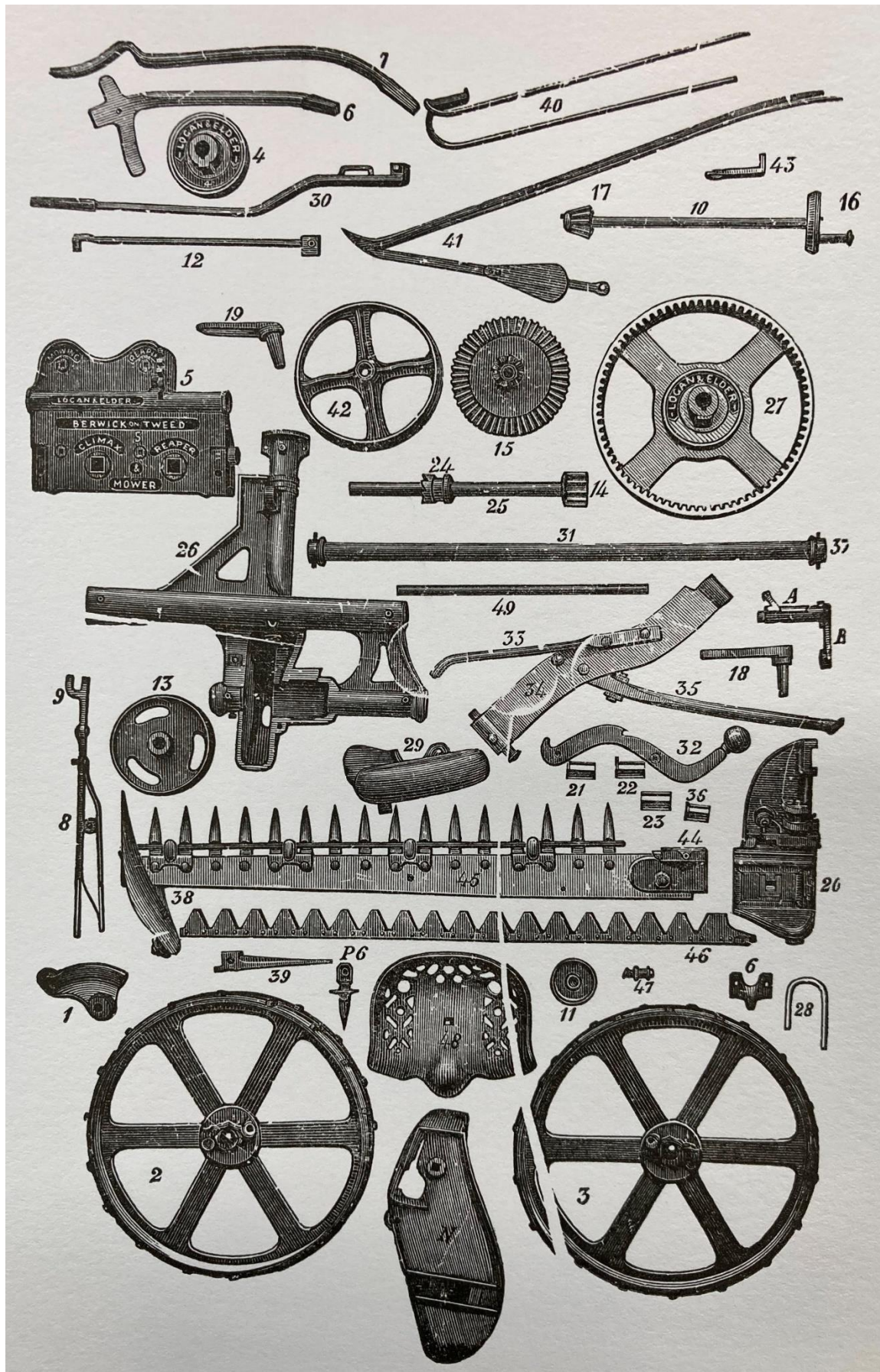


Croft scale equipment used to process grain

A historical perspective and a route to revival



[Spare parts print from
1901 WM Elder of Berwicks Catalogue]

*Behold her, single in the field,
Yon solitary Highland Lass!
Reaping and singing by herself;
Stop here, or gently pass!
Alone she cuts and binds the grain,
And sings a melancholy strain;
O listen! for the Vale profound
Is overflowing with the sound.*

*No Nightingale did ever chaunt
More welcome notes to weary bands
Of travellers in some shady haunt,
Among Arabian sands:
A voice so thrilling ne'er was heard
In spring-time from the Cuckoo-bird,
Breaking the silence of the seas
Among the farthest Hebrides.*

*Will no one tell me what she sings?—
Perhaps the plaintive numbers flow
For old, unhappy, far-off things,
And battles long ago:
Or is it some more humble lay,
Familiar matter of to-day?
Some natural sorrow, loss, or pain,
That has been, and may be again?*

*Whate'er the theme, the Maiden sang
As if her song could have no ending;
I saw her singing at her work,
And o'er the sickle bending;—
I listen'd, motionless and still;
And, as I mounted up the hill,
The music in my heart I bore,
Long after it was heard no more.*

The Solitary Reaper
William Wordsworth - 1770-1850

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1.Introduction to the Highland Grain Machinery research

The Gaia Foundation is an international charitable organisation with 35 years working alongside Earth's best custodians and defenders. Seed and food sovereignty for climate change resilience is a central pillar of Gaia's work. To achieve that work on our islands The Seed Sovereignty UK and Ireland Programme was formed within Gaia to support a biodiverse and ecologically sustainable seed system across Britain & Ireland.

Seed Sovereignty has been nurturing grain growing groups in particular in Scotland and Wales over the last three years, helping to encourage, co-ordinate, share knowledge, and break down barriers towards sustainable local grain economies. One of the core barriers identified within multiple growing networks has been **access to low cost small scale grain processing machinery**.

The barrier is one of both cost and scale. New grain processing equipment and facilities exist for large scale agricultural operations, but are simply too large scale for crofts and small farms. New small scale grain processing equipment does exist for trial and laboratory settings, but being a niche market it is prohibitively expensive and not fit for purpose.

And so perhaps unsurprisingly, many participants in the local growing networks have been turning to and rescuing small scale grain machinery from the past, cobbling together their own on croft and on farm machinery. This has helped in some parts of the process but not all. Neither is this solution sustainable longer term, as this industrial heritage, now largely resigned to the museum, degrades in field and barn.

But there are lessons to be learned from this historic equipment. And so this research, funded by the Gaia foundation, sought to tease out those lessons and answer the following question:-

“What were the historic crofting tools/equipment used to process grain at small scale?”

Here follows the result of that research – a comprehensive description of the grain machinery historically used at each stage of the grain process by a small scale crofter, along with sufficient technical details to facilitate maker innovation for the small grain growers of today.

2.Introduction to Am Fasgadh

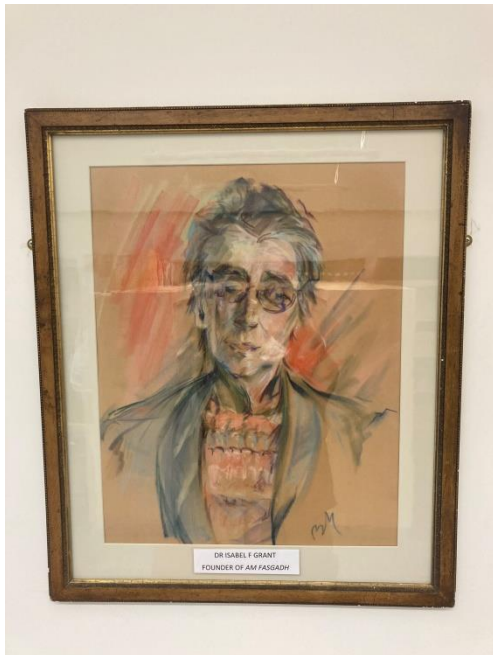


Figure 1 - Portrait of Dr Isabel Grant hanging in the Am Fasgadh library

Am Fasgadh at the Highland Folk Museum was chosen as the core venue to undertake the research, being a nationally recognised and unique collection with a strong Highland & Islands crofting focus.

Dr Isabel Grant (1887-1983) was a highlander, an author, a historian and a curator. “Affectionately known from childhood as Elsie” (Grant, 2007), Isabel Grant is best known as the pioneering force from which the Highland Folk Museum has grown.

The collection started life as a transient and makeshift exhibition of artefacts in Inverness town

hall in August & September of 1930. Thereafter it found a more permanent exhibition space when Isabel purchased a closed Free Church on the Isle of Iona in 1935. “It was here that the collection received the name Am Fasgadh (meaning ‘The Shelter’) – a place to keep and care for the sought and rescued relics of our vanishing past.” (Grant, 2007)

The Isle of Iona did not satisfy Grant – it had little room for expansion, and had restricted access for both acquired exhibits and visitors alike. An opportunity arose and Grant moved the collection to another shelter, in the form of an empty church at Laggan in Badenoch in 1938, in the dusk before the dark declaration of World War Two. It was amidst this period of conflict, in 1943, that Grant moved Am Fasgadh a final time to an old shooting lodge in Kingussie, a three acre site where the collection resided for some 40 more years.

In the 1980’s, the now Highland Council owned Highland Folk Museum acquired a larger 80 acre site in Newtonmore, and the collection was gradually transposed onto the site we visit today.



Figure 2 – Am Fasgadh – new purpose build museum store built 2003



Figure 3 – Am Fasgadh – inside ground floor of the preserved collection

In 2013, a new purpose build storage shed with the original 'Am Fasgadh' name, was completed and the Grant collection was finally moved in full from Kingussie. This facility now shelters over 10,000 items.

The current custodians of this nationally recognised and unique collection are curators Liz English and Rachel Chisolm, whom particular thanks go to for organising archive access whilst navigating the 2020 Covid-19 pandemic restrictions.

3.Context of Scottish Grain Growing

Crofting is land tenure found in Scotland, notably in the Highlands and Islands, which arose from the ashes of the Highland clearances. At the time of writing there are 21,186¹ crofts registered in Scotland, each croft being on average a 5 acre parcel of land often with a share in a larger common grazing.

Crofting typically is not a primary occupation, which is consistent with the small tenant farmer holder lifestyle it arose from – “The crofter’s non-agricultural employment – in fishing, weaving, tourism, forestry, construction, service industry, and so on – is usually of greater financial importance to him than his work on the land.” (Hunter, 1976)

Crofting land tenure requires that the land not be misused or neglected, which in practice means it is cultivated, maintained or put to another purposeful use by a crofter ordinarily resident on, or within 32km of their croft.

But one component of crofting use (“crofter’s corn” – encompassing any type of small scale grain production) has broadly died out in the crofting territories over the last century and a half. Crofter’s corn is now only routinely practiced at the township/community level on some of the islands – notably in Uist cultivating mixtures of small oats, Bere barley, and Hebridean rye principally for animal feed, and in Orkney cultivating Bere barley for human consumption.

But when did crofter’s corn die out? The library at am Fasgadh helps shed some light on this. Generally speaking, the further back you go, the more tantalising the accounts of small scale grain production in the Highlands and islands become. Mid- 20th century, agricultural practice is a shaded reflection of today – with the crofting counties having broadly turned away from grain. Post war agricultural advice was generally scathing of small grain in the West highlands (Darling, 1945). And whilst touring of the highlands and islands in the 1930’s, two Swedes recorded those crofters in the Outer Hebrides “cultivated corn more rarely for bread-baking, but for feeding the cattle. Meal was bought at the grocers”. (Fenton, et al., 2012)

Roll back to the Napier Commission set up in 1883 to ‘inquire into the condition of the crofters and cottars in the Highlands and Islands of Scotland from which the crofting commission was born, and you see the tipping point where croft grown grain started to recede .

¹ **Crofting Commission Annual Report & Accounts 2019/20**

https://www.crofting.scotland.gov.uk/userfiles/file/annual_report_and_accounts/LOW-RES-4398-CC-Annual-Report-2019-20-STATS.pdf

The commission did come across active grain growing in the islands, near Shetland. On Foula, crofter Robert Gear said “the best return on oats we can get in a good year is three or four fold. We don't grown any other crop but for bere” (Cameron, 1986). Further west the commission saw “a man grinding bere (a hardier courser kind of barley) in a simple water mill” (Cameron, 1986) in Upper Barvis, Lewis. The Outer Hebrides were though the exception - generally “In most places the amount of grain-growing was declining and as a result many corn mills were reported to be falling out of use in Skye and the Outer Isles, but querns (hand mills) were said to be still in use in houses in Lewis.” (Cameron, 1986)

Many a crofter during the Napier commission interviews lamented the reduction of local grain which in part seemed tied to a growing shift towards sheep and cattle production. John MacDonald, a factor of North Uist said “I remember when there was no meal sold except the produce of the country, but now they require to buy food from the south”....“grain is principally grown to provide fodder for cattle and horses, and they keep more cattle now”. (Cameron, 1986)

Angus Stewart, a Braes crofter said “the year before last we had a half a bushel over and above” and “all our earnings at the fishing we have to put into meal for the support of our families”. “We will always need a Joseph in the south to send us seed (corn)”. (Cameron, 1986)

Erasmus Doul of North Roe in Northmavine (Shetland) “grew enough corn to keep his family and animals about half the year” Besides oats a little bere.” He ground a little grain at home and the rest he put out to the mill, but not the local mill (off islands). But he “remembered little mills grinding in valleys in the hills where he said “the water came down and heaved it round”. (Cameron, 1986)

It is not until you get into the early 18th century, and the late 17th century that you see sustainable, commonplace grain growing on land in the Highlands and Islands. One of the best accounts comes from Isabel Grant's first published work (Grant, 1924) in which she delved into the account books of William Mackintosh of Balnespick, the head of one of the older Mackintosh families. He describes farming at Dunachton over a period 1769-1782, where year on year was grown a range of grain - white oats, small oats, bere barley, barley, rye and peas. The account books also give an interesting glimpse into the equipment used to process this grain - 2 sieves – 1/-each, 2 fans – 4d each, 3 riddles, 4d each, 6 sheaving hooks, 5d each and 2 corn forks, 2d each being all that was needed – all by hand, with an outlay of 6 shilling and 10 pence (or £29.17 in 2017).

The grain of this period was undoubtedly grown for human consumption. “Balnespick produced mainly for home consumption. No bread or wheaten flour ever seems to have been bought for the use of his family; and their allowance of 6 bolls of meal a head was the most important item in the farm servant’s wages.” (Grant, 1924). Growing and eating grain in the highlands and islands was indeed commonplace in the late 18th century and early 19th century. In Scotland during this same period grain was a staple food “Barley which had been ‘knockit’, that is rubbed and beaten free of its husks and left whole rather than ground, was used for barley broth” and “the Scottish ‘mashlam’, a mixture of peas, beans, bere or oats” and the bread derived from it was” still generally eaten by all classes until the end of the 18th Century. (Gauldie, 1981)

Roll forward to today and there is a growing number of crofters (new and old alike) on a path to reviving small scale grain production for human consumption at a croft scale. And although by provenance this research is ‘croft-centric’, it is applicable to other small farms and holdings outside of the crofting territories, encompassing the wider Gaia led grain growing networks which The Seed Sovereignty Programme has been cultivating.

This research is for them – it is for our shared reclaiming of our grain heritage.

4. An overview of stages in grain production

Although there is a myriad of processes leading both up to a sheath of grain (cultivation, sowing, husbandry and harvesting) and after (storing, moving, milling, rolling, cooking), this research has focussed on **the core grain processing equipment from a sheath of corn to clean grain**, which at this stage has been identified as the main equipment barrier to local grain growing networks.

Taking away the machinery for a moment, it is worth illustrating and describing the typical process steps of taking grain from a freshly cut sheath to a clean bag of naked grain.

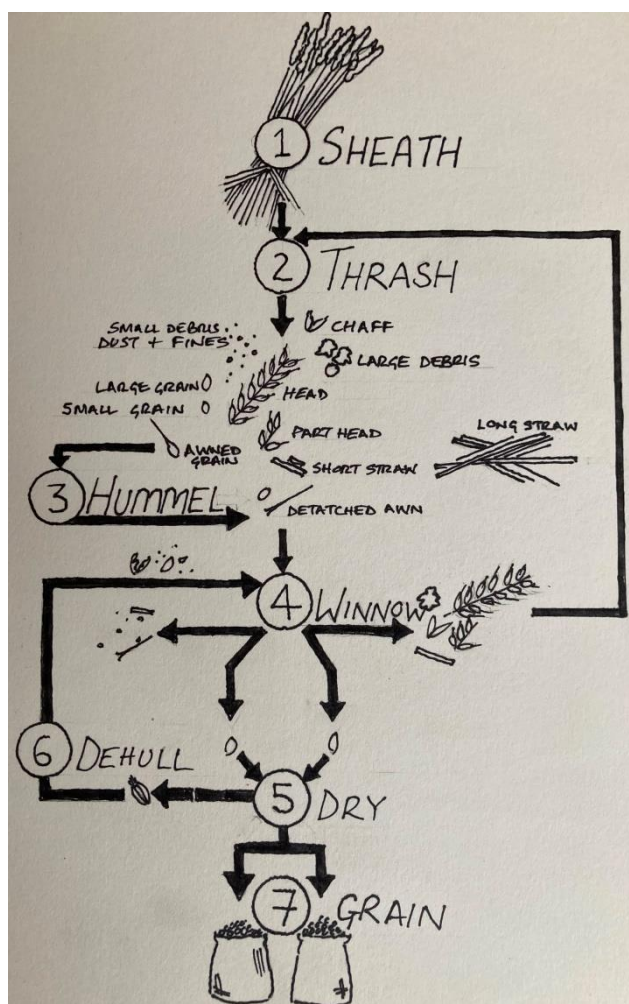


Figure 4 - Flow Diagram of Grain Processing

Our starting point (1) is a freshly cut sheath of corn, bound either with twine or a twisted rope of grain. The first stage is to knock the grain out of the ear, leaving us with a resulting assortment of smaller items with our grain amongst them (2). If our grain is bearded (i.e. with long awns), we may need to hummel at this stage to forcibly detach the awn from the grain (3). The resulting mixture then needs sorted into component parts, giving us both waste products and several grades of relatively clean grain (4). Depending on how we got to this point, we typically need to dry our grain at this point – for both storage and onward processing (5). Thereafter, if we have a hulled grain, now is the time to rub or knock the grain free from the husk (6). This resulting mixture

again needs to be sorted into component parts, (4) leaving us with naked grain (7).

The historical research has shown that in terms of equipment, this process has evolved from rudimentary hand tools over the last two centuries. We are going to explore now, how this equipment was evolved by looking at and reading about each stage in this process.

5. Processing by Hand

Processing grain by hand remains a remarkably accessible method for small scale grain growers to process small volumes of grain. It also serves a good foundation for thinking about the first principles of processing grain, and where machinery evolved to increase efficiency.

Threshing by hand

The most primitive version of initial separation that was utilised in times past was fire - "the primitive process of 'graddan' prepared the corn for grinding by what can only be described as a quick burning over a field fire." (Gauldie, 1981)

This rudimentary method of burning the grain from the ear was undoubtedly carried out in Scotland as recorded by Thomas Pennant, the curious traveller, when he wrote of grain preparation in the Island of Rum in the late 17th century "the corn is graddan'd or burnt out of the ear, instead of being thrashed; this is performed in two ways; first by cutting of the ears, and drying them in a kiln, then setting fire to them on a floor, and picking out the grains, by this operation rendered as black as coal. The other method is more expeditious, for the whole sheaf is burnt without the trouble of cutting off the ears; a most ruinous practise as it destroys both thatch and manure." (Pennant, 1772)

The more established method was to strike the head of the grain. One method for striking the grain was simply with a notched stick, known in Gaelic as *maide frasaigh* (stick for showering grain). The practice of using this stick was known in Gaelic as *frosadh* a 'choirce' (showering the oats).

The alternative method was to hold the sheath of the grain and lash or strike the whole sheath against a stationary object. This threshing by lashing often featured an inclined threshing frame, with cross pieces with iron nails, or by using a feature of many a barn - the 'gloy stone' - a protruding stone at waist height for lashing the sheath against.

The most established striking method for hand threshing was to use a Flail. Still widely used throughout the world, "the flail, *sùist*, consisting of three parts, a wooden handle, *lorg*, a souple, *buailtein*, of wood or rope, with which the sheaf was beaten, and the sail, *shùiste*, the thong of sheepskin or some other material that linked the hand staff and the souple."

(Fenton, 1980) These varied significantly in design depending on where you were located within Scotland.



Figure 5 - A selection of Scottish flails at am Fasgadh



Figure 6 - a distribution of Scottish flail types in different areas

Working the flail was often done in gangs of threshers, on a threshing floor in a dedicated building. “Threshing done in two stages, firstly ‘cathadh’, was in the barn”. (Fenton, et al., 2012). In the traditional barn design, there was a winnowing hole ‘toll fhasgnaidh’. “During threshing it could be opened along with the door at the front of the house, so that a breeze blowing through the passage helped clear away the chaff from winnowing and disperse the dust created by threshing in an enclosed area.” (Fenton, et al., 2012) “Threshers did not receive a money wage, but a proportion of the grain they threshed. This was called the **lot** usually a 25th of the task or piece of work he did “i.e. a piece worker”. (Fenton, et al., 2012)

“There’s a little story about the flail used many years ago on the farms. In the days of the flail the farmer would pick up a handful of corn or a tet of corn, as they ca’d it, and shake it tae see if it was clean threshed. If it rustled, reestled or tremilt, it was not cleanly threshed and the men we’re classed as bein weak. The saying goes like this:-

Tremlin straes maks kickin owsen
Kickin owsen maks barkit land
Barlkit land maks peer corn
An peer corn maks thin pottage

*Thin pottake maks wyke men
And wyke men maks tremlin straes² “*

Hummerling

If the grain is bearded with awns (such as bere barley), it was common after threshing to hummel the grain with a hummerler, to forcibly remove the awns.

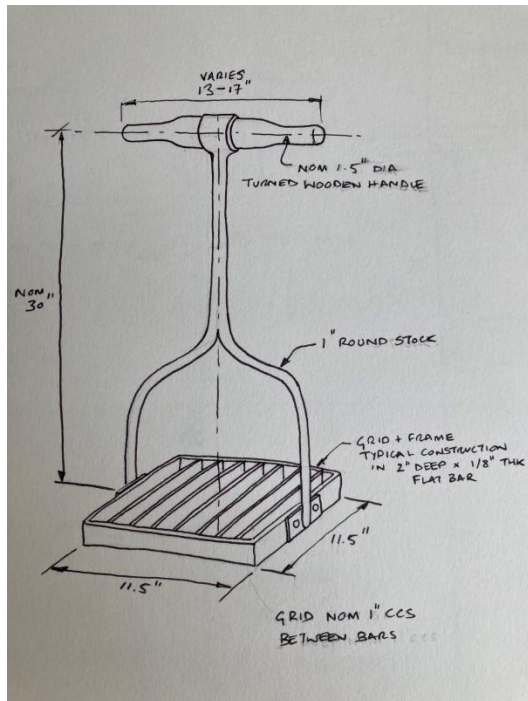


Figure 7 - A sketch of a barley hummerler



Figure 8 - A photo of a barley hummerler

“A tool of similar appearance was the ‘barley hummerler’. This had a greater number of blades, which might be parallel or arranged to cross. This was pounded on the barley to remove the long spines or ‘awns’. A roller type, which gave the same action was used and later threshing machines incorporated hummerlers to deal with Barley awns.” (Blandford, 1976)

² Transcript of Audio recording from Charles Reid, Buchan/Epson by Hamish Henderson and James Porter, October 1972.

Winnowing by Hand

Before machinery was available, grain was cleaned or dressed following the flail, by being passed through a series of hand shook riddles, often with a breeze between doors or atop a small hill.

There was a multitude of examples of these riddles at am Fasgadh. They were mostly constructed of a bent hoop of laminated wood, with a sewn skin of leather of varying design. In the case of the perforated holes, they were burned into the leather with a hot awl.

The coarser riddles typically had $\frac{1}{4}$ " holes, the finer riddle had $\frac{1}{8}$ " holes, often in an ornate pattern. Finally there was the ancient wecht – with no holes.

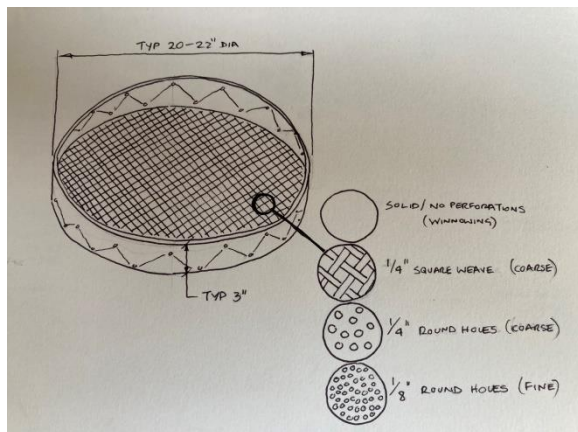


Figure 9 - A sketch of winnowing riddles and wechts at am Fasgadh



Figure 10 - A selection of winnowing riddles

*"Some useth to winnow, some useth to fan,
Some useth to cast it as clean as they can.
For seed go and cast it; for malting now so,
But get out the cockle and then let it go." (Tusser, 1573)*

Dehulling by Hand

It was recorded that dehulling could be done by hand (or foot!) – when the Napier commission came across this on their inquiry tour in the late 18th century “she was grinding off the beards and hulls of barley with her naked feed, to make broth, a common thing’. (Cameron, 1986)

It was also recorded that both hummelling and dehulling could be conducted by forceful application of the flail – “originally grain was “hummelled” or de-husked with the flail on a special wooden threshing floor - the baram or barrow - to struck heavily.” (Fenton, 1980)

But the most common method when it came to de-hulling husked grains by hand was the knocking block or knocking stone. This could be made from wood or stone. The examples at Am Fasgadh are all stone, with surviving wooden versions being “a great rarity”. The mallet was typically of wood. The block was called in Gaelic “*An Cnap Eorna*”, the Barley block, and often for shortness the *Cnap*, or *Cnotag*. The mallet was called *An teangaidh*, the tongue.



Figure 11 - An example of both knocking stone and stick



Figure 12 - another example of a knocking stone

The general principle was “some barley was put into a dish and damped with water. It was rubbed with the hand, and when so far cleaned and moistened it was put into the block and beaten with the mallet. The operator, usually a women, was seated, and carried on the process very methodically – first giving a stroke downwards upon the barley, and then a lighter stroke on the side of the block to shake off any grains that might have adhered to the mallet. So on she went, with a sort of musical rhythm, often with the accompaniment of song,

till the grain was loosend from the husk. The next step was to re-winnow the grain, which was done with a fan (an *dallanach*). The barley was then put into a dish with warm water, and carefully worked about with the hand, till it was perfectly smooth and white. It was then fit for use, and was called “Cnots”, pronounced “Grots. Perhaps this may be the origin of the English word “groats”. (Forsyth, 1900)

Another description of the use of the knocking block came from am Fasgadh’s founder “To shell the barley it was brownd before the fire and then put in a hollowed stone, the Cnotag (or Eornachan) in some of the Islands, water was added and it was stirred with a stick (the Maide Cnotaig) till the kernals were freed from the husks. The Maide Cnotaig has appeared in many tales, for instance, a witch is said to have flown on one from Moidart to Lochaber.” (Grant, 1961)

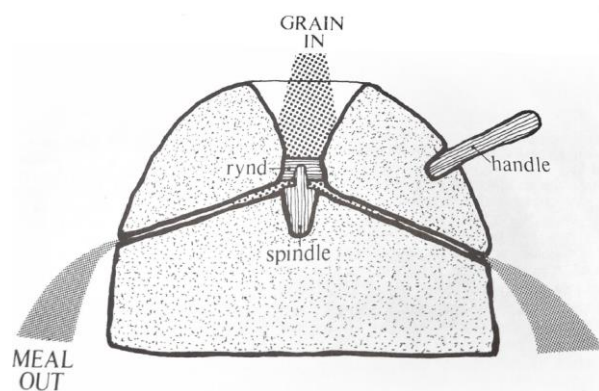


Figure 13 - Cross Section of a Hand Quern



Figure 14 - Example Hand Quern at am Fasgadh

There was little literary evidence to support this, but it would seem likely that some grain was dehulled with the ubiquitous hand quern, it being well suited to the process. And as we will see later, the rotary mill the querns developed into were definitely utilised for the purpose of Dehulling.

“The principle of the quern held throughout the development of milling with stones: a stationary lower stone, or *bedstone*, and an upper, or *runner*, stone which was turned above it, while grain was fed through a central hole, the *eye*, in the top stone. The grain was ground between the faces of the stones, which were later grooved or dressed, to give a better cutting action, and the ground meal was distributed to the edge of the stones for collection.

Three wooden parts were essential: the *rynd*, the spindle and the handle. The rynd bridged the eye of the runner stone and enables it to be hung on the top of the spindle. The spindle projected from the centre of the bedstone, was at first fixed to carry the runner stone a little

above the bedstone, but later the elevation of the spindle could be altered to allow regulation for the gap between the stones.” (Watts, 2008) It is likely this control would have allowed crofters of old to utilise the hand quern for the purpose of friction dehulling.

Drying by Hand

Drying small batches of grain by hand was a common practice in the highlands and islands. “In the moist climate of Scotland, grain must be dried before it is ground, otherwise the kernels will not granulate easily. This was especially true of oats. Drying was less necessary for the harder grains of bere or barley.” (Fenton, 1976) For small batches this was performed in either an iron pot at the hearth, or in within a net *tarran* hung over the fire. “Aigar meal was prepared from grain dried very slowly in a pot over a fire before being ground in a quern. (Gauldie, 1981). This is likewise described by Am Fasgadh’s founder “the grain was heated in an iron pot above the fire and turned with a stick to heat more evenly before being ground. The purpose was to harden the grain. The quern consisted of two round stones set on a firm table with a strong handle fixed in the upper stone. When the handle was turned the meal fell to the clean table.” (Grant, 1961)

Later it was commonplace for a crofter to have a dedicated corn drying kiln, and many a blackhouse would have featured a round corn kiln at one end. There is a recreated kiln barn at am Fasgadh, which is well documented.³

³ Paper by Bob Powell – **A Scottish Highland Corn Drying Kiln-barn Recreated**

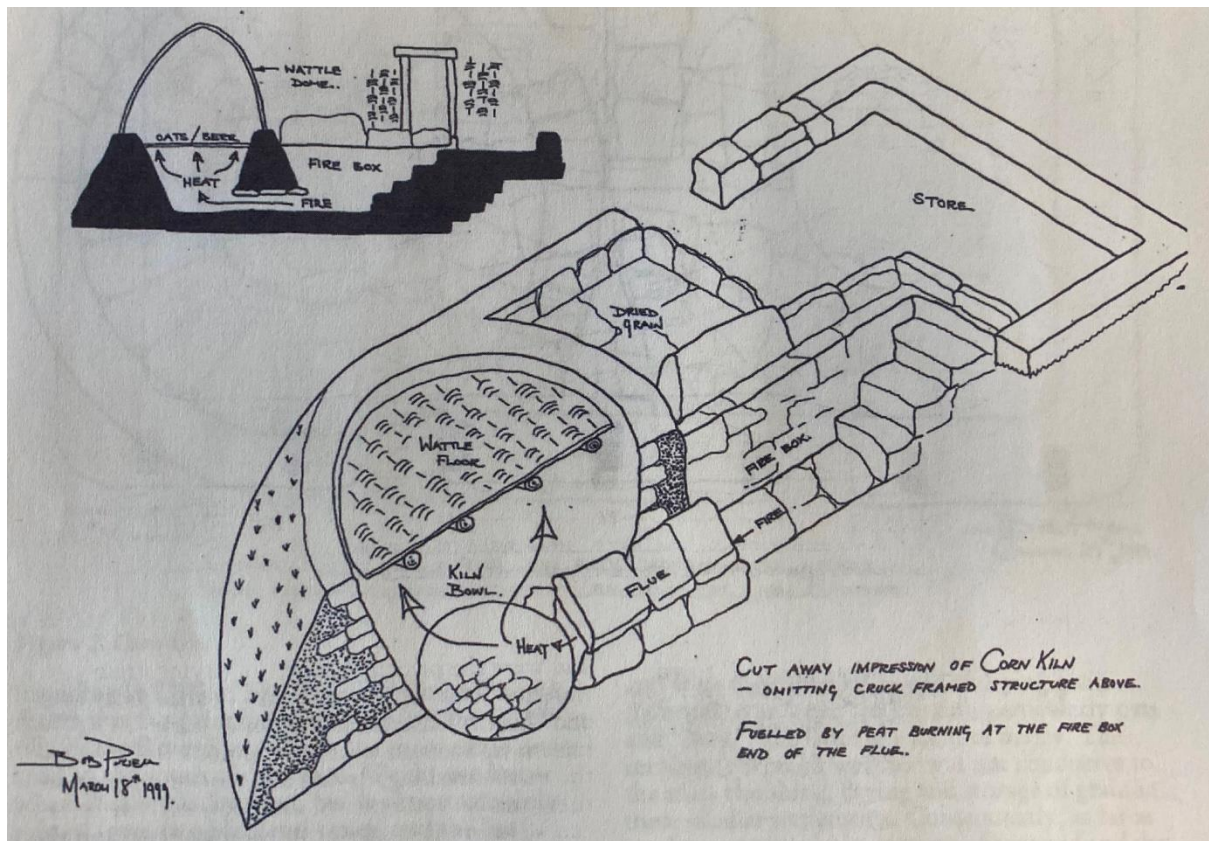


Figure 15 - Cutaway sketch of a Corn Kiln - Credit Bob Powell, Working Horse & Farming Historian Kingussie

In the corn kiln, the main structure revolved around a circular drying floor originally of timber ribs with straw mats, on which the grain was laid, and fired via an adjacent firebox. It was “also common for “a ‘toll-càthaidh’ (chaff hole), to admit wind to clean the corn.” (Fenton, et al., 2012). The grain in the kiln was laid at a depth of 6”, for 5 to 6 hours, turned at regular intervals.

6.Processing by Machine

Thrashing Machine



Figure 16 - Two thrasher examples at Am Fasgadh

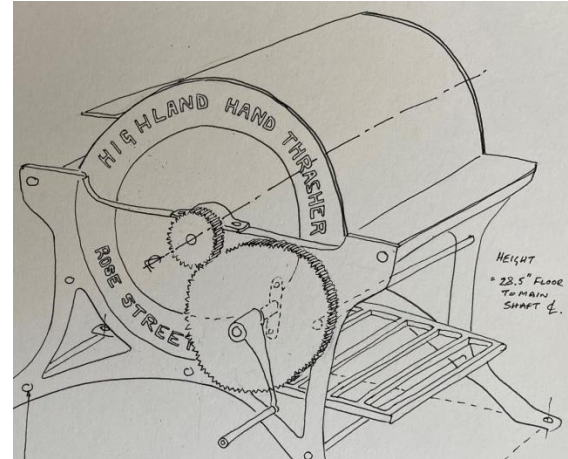


Figure 17 - Author sketch of the Highland Hand Thrasher

The Highland folk museum has two examples in the collection of small hand operated thrashers – the “Tiny” thrashing machine, made by C W Murray & Co Engineers, Banff Foundry Scotland – and the Highland hand thrasher, made by the Rose Street Foundry, Inverness Scotland. Formed of a number of cast iron castings secured with studs, the thrasher is operated by a hand crank which rotates a large 12” gear on a stub shaft. This is geared up 1:4 via a 3” spur gear which rotates the main 7/8” shaft in oil lubricated bushes. On this shaft a cast six spoke wheel is spun. On each spoke is an oak paddle secured with 2 no 3/8” bolts. Each oak paddle is installed with 8 no 1/2” pegs, inclined backwards (back rake) at nominally 30°. These rotating pegs interface with a fixed peg board installed on a concave plate. Sheaves of grain are inserted into the thrashing chamber, and due to the rotation are thrashed between the moveable and stationary pegs. Grain falls directly down, through straw sieves, whereas long straw is fed onwards out the rear of the thrasher. It was noted that these tiny thrashers were specifically designed for small individual crofts.

The other common type of thrasher was of wooden construction, operated by pedal or hand.

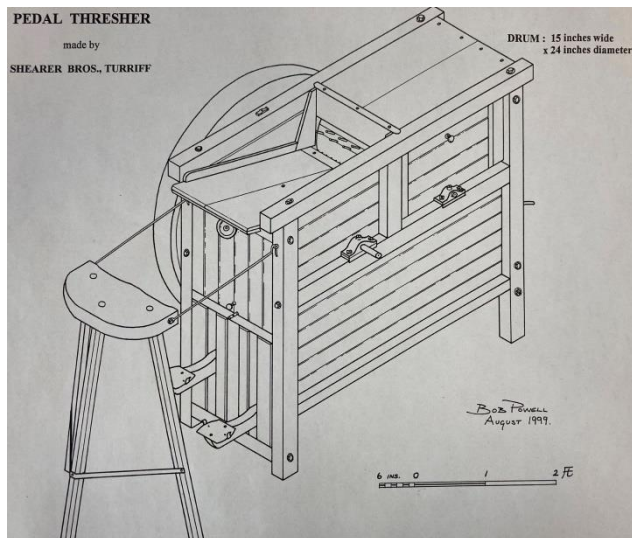


Figure 18 - Illustration of Shearer Bros Pedal Thrasher
– Credit Bob Powell, Working Horse & Farming Historian Kingussie

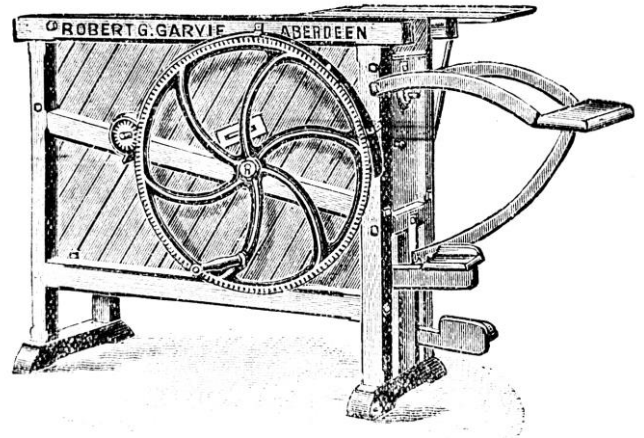


Figure 19 - Illustration of Robert G Garvie pedal Thrasher

A more detailed technical sketch of a thrashing machine is available in the appendices.

Winnowing Machine

Grain when it comes from the thrasher needs to be cleaned or dressed. That is, the grain has to be separated from the chaff or husk; from material smaller than the grain, such as dust and small grass seeds; and from larger unwanted material, such as bits of straw.



Figure 20 - Six examples of winnowing machines at Am Fasgadh

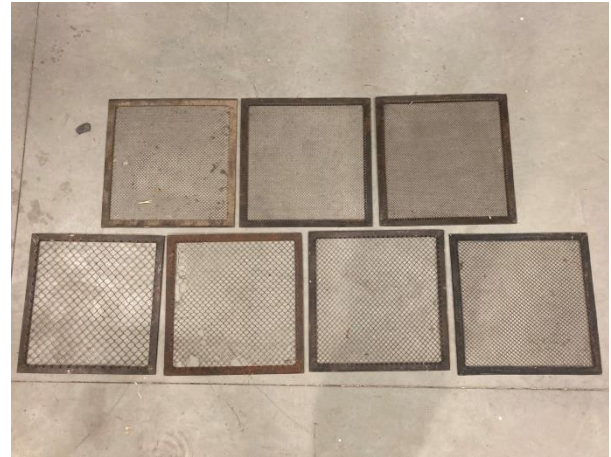


Figure 21 - The seven grades of coarse riddle typically supplied alongside each winnowing machine

The winnowing machines held at Am Fasgadh are all broadly of the same design and size. They are broadly wooden cabinet construction, with cast iron shafts and fittings at strategic points. Power is via a hand crank, which is geared and translated to provide power to the fan shaft and riddle crank.

The thrashed grain mixture enters the machine via a 27" square grain hopper at the top. The mixture is delivered by gravity to the riddle frame via an adjustable hopper gate. The riddle frame holds two flat horizontal coarse screens, and a third inclined fine screen, and is shaken by a riddle crank with typically four settings varying the throw of the crank. The riddle frame has a central pivot point at the front, and swings on a pair of adjustable chains at the rear. The riddles themselves are removable, with a set of 7 screens typically supplied by the original manufacturer. The grain mixture passes through over all three screens in the riddle frame, whilst at each drop being winnowed by the air flow from a large paddle fan. The air blast from this fan is adjustable by a set of sliding nostril boards on each side. The small light chaff and dust exits the rear of the machine, whereas heavier waste and grain is delivered to chutes which exit from either side of the machine, adjusted by means of a removable ramp board. The end result – a bag of tailings (waste), a bag of seconds (small grain) and a bag of firsts (large grain).

A more detailed technical sketch of a winnowing machine is available in the appendices.

Threshing Machine

A threshing machine combines the functions of the aforementioned thrasher and winnowing machine. It both knocks the head of the grain via a rotating peg drum, and winnows the resulting debris. Typically fed from the top, the grain first entered the thrashing drum, normally revolving at 1000-1100rpm. The pegs drums gradually evolved into corrugated beaters, set against a diminishing concave grid. "When threshing cereals the usual distance between drum and concave is 1" at the start, $\frac{1}{2}$ " at the hinge, $\frac{1}{4}$ " at the end." (Culpin, 1938). After the thrashing drum, an additional mechanism was used to deal with the straw, either a cranked set of straw 'walkers' or a rotating straw rake. Thereafter it followed a similar process to the winnowing machine. There were multiple examples of threshers within the am Fasgadh collection, ranging from small static barn threshers to large mobile threshers typically transported between farms and crofts for threshing.

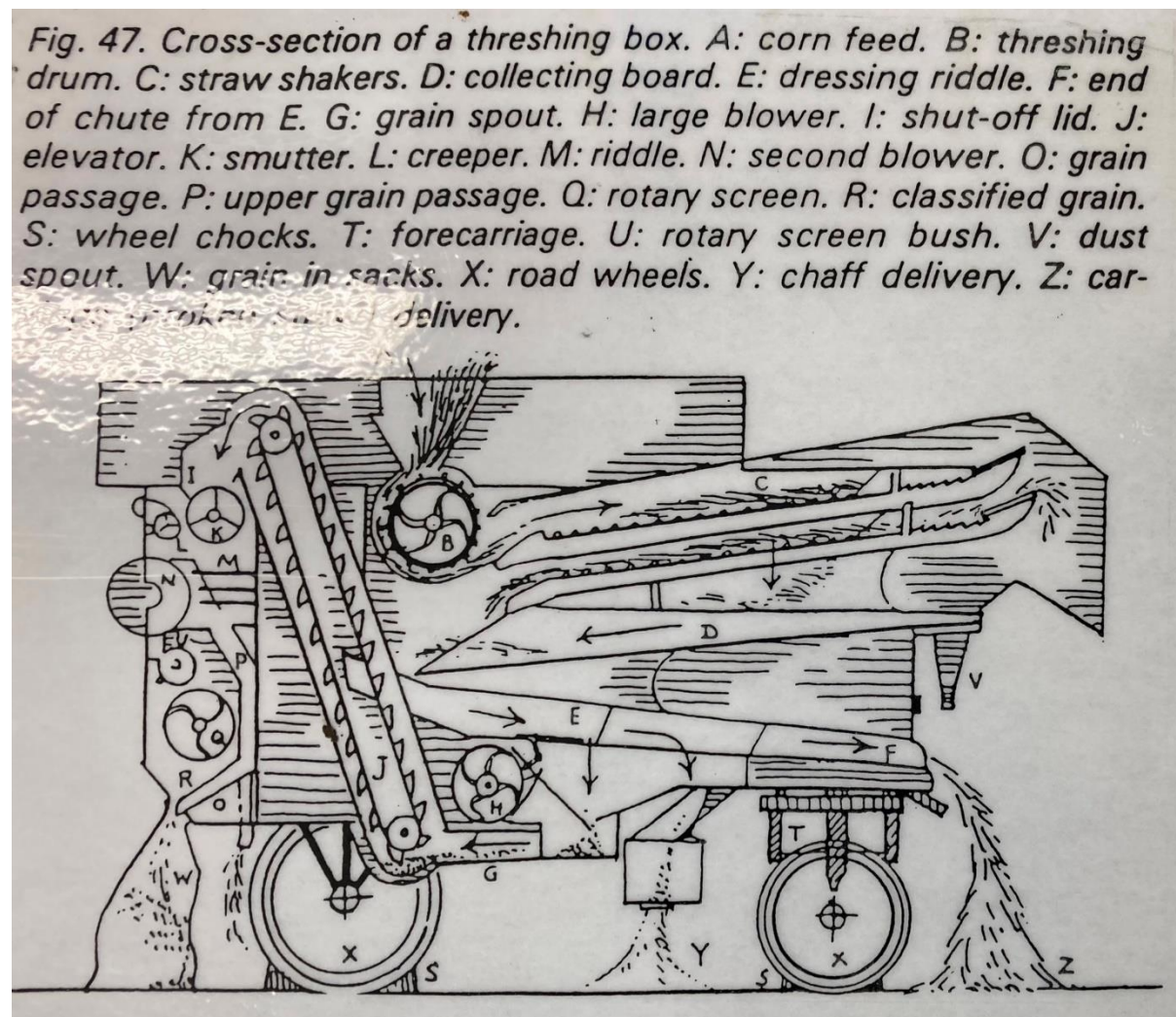


Figure 22 - Cross section through a mobile thresher

Threshers were available with a number of add-on items following the winnowing process. An awner and chobber assembly, also known as a rotary hummerler - consisting of a shaft carrying a number of knives and bars, rotating at about 700 rpm inside a stationary iron drum or wire cage. The purpose was to break up chobs (pieces of unthreshed ears) and remove the awns from certain grains such as bere barley.

A huller apparatus was also available to dehull certain grains such as oats, typically mounted on top of the thresher. The huller itself consisted of a cylindrical cage of steel wires, inside which a drum rotates at high speed. The seed was rubbed through the wire mesh and the heads and chaff pass through an opening at the bottom before a subsequent winnowing operation sorted empty hulls and chaff from the grain.

Finally it was common for a rotary cleaner to be added to the thresher, of which the next section describes.

Rotary Cleaner

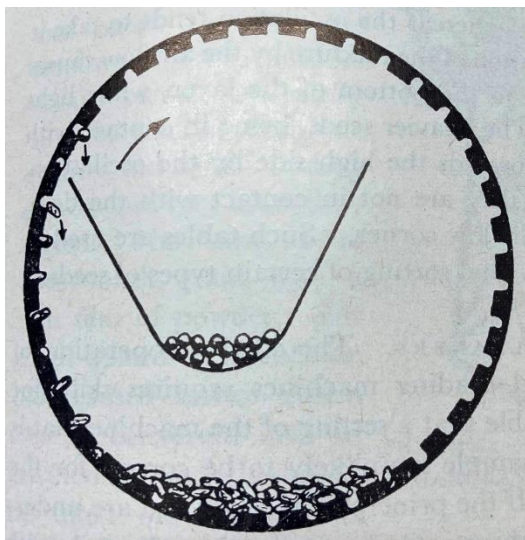


Figure 23 - The principle of an indented drum rotary cleaner (Culpin, 1938)

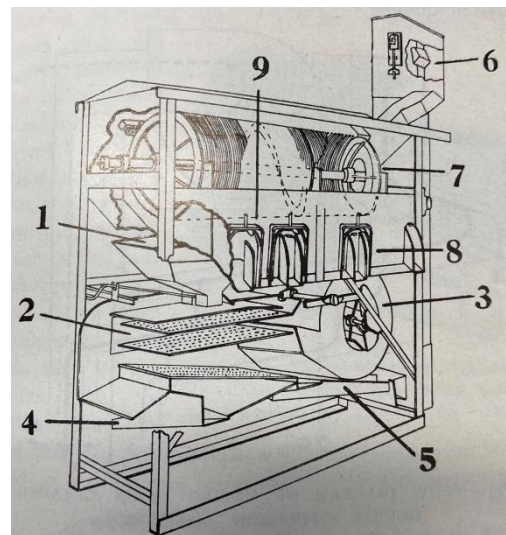


Figure 24 - A combined winnower and rotary grader (Culpin, 1938)

There were no physical examples of rotary cleaners or graders within the Am Fasgadh collection, but there was reference to them in machinery catalogues such as by Rainforth, who produced quite separately from their winnowing machines a "rotary corn screen".

“The *rotary cleaner* was commonplace in mills during the 19th century; it consisted of a single grade of wire mesh formed around a circular or polygonal drum into which cord was fed to be forced against the mesh by rotating brushes or beaters. Similar machines, in which the cylindrical sieves are usually vertical rather than horizontal or inclined is the *smutter* a form of grain scourer used to remove spores of smut, a fungus typically found in wheat.” (Watts, 2008)

Rotary cleaners were improved during the 19th century “with the use of cockle *cylinders* or *trieurs*. The *trieur* was developed in France.” (Watts, 2008)

Culpin describes both the principle of indented drums (see Figure 21) and the operation of a combined winnower and rotary grader (see Figure 22). This would appear to be a general upgrade available to the winnowing machines shown previously, whereby upon grain leaving the final riddle, it is lifted by a grain bucket elevator to a series of indented rotary drums, before exiting bagging chutes.

The advantage of indented drum cleaners over the riddle or sieve is their ability to sort based on shape (typically length) as well as size. Typically there would be several passes as the grain is rotated down the inclined rotating drums, with one or more drums lifting out unwanted material, and one or more drums lifting out desired grains.

That said operation of these rotary cleaners, which applies alike to much of the machine equipment here researched, suggests that “the efficient operation of complicated cleaning and grading machines requires skill, for grain samples are so variable that a setting of the machine that is suitable for a particular sample is unlikely to be correct for the next sample dealt with.” (Culpin, 1938)

The object of using a cleaning machine is to separate from the grain all chaff, straw, weed seeds, broken and inferior seeds, dust and other rubbish. The process commonly employed on farm machines is as follows:-

- a) Screening over a sieve with large holes to remove stalks, stones, and other large roughage.
 - b) Separation by air blast, either with a simple winnowing device or by aspiration.
 - c) Use of nests of sieves or rotary screens to separate grain according to its width.
 - d) Use of pockets (e.g. indented cylinders) to separate grain according to length.
- (Culpin, 1938)

Combined Harvester

The natural progression of grain harvesting machinery led to the advent of the combined or combine harvester, often now known simple as a combine. The name derives from the combined cutting and binding of the harvesting reaper binder, with the thrashing and winnowing of the static barn thresher.



Figure 25 - Massey-Fergusson Type 780 combine harvester

There were no physical examples of combines within the Am Fasgadh collection, although there was reference to early combines in the various machinery catalogues and manuals. The mid-20th century was the conceptual time of the combine, and to begin with the scale of the combine equipment was well suited to the croft scale holding, although at pace it outgrew its small scale beginning.

To begin with the combine harvester was detachable from the tractor. In the UK, the manufacturer of the ubiquitous grey Ferguson tractor produced a 'wrap around'

combine, in the 1950's as shown in Figure 27. And the other notable offering available

to the crofter at that time was the more widespread JF MS90, and later the JF MS105 as shown in Figure 26. Less available in the UK during this period was the tractor drawn all crop range of combine harvesters from Allis Chalmers in the US.

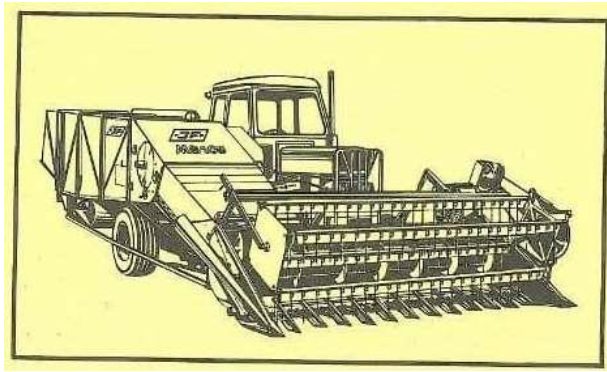


Figure 26 - Catalogue Diagram of the JF MS90 / MS105 wrap around combine harvester

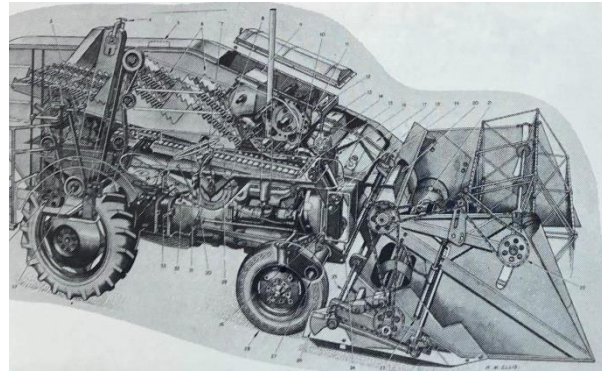


Figure 27 - Catalogue Diagram of the Grey Ferguson wrap around combine harvester

Drying at the Mill

There were no physical examples of machine drying at am Fasgadh, not being of sufficient antiquity, but with the advent of the combine, where grain was typically harvested wetter, machine drying on croft became commonplace. “Most farmers... have a drier capable of dealing with a large amount of wet grain...It is necessary to reduce this to about 14% before safe storage is possible.” (Culpin, 1938)



Figure 28 - Example Lister Petrol driven grain drying fan on South Uist

The remainder of grain drying undoubtedly occurred off croft, with most if not all mills having a kiln. “At the end of the 18th century was the greatly improved kiln situated within the mill. Oats has always required careful drying to make it millable.” “In fact most mills in upland areas had kilns (to deal with oats) whereas lowland wheat grinding mills did not.” (Gauldie, 1981)

Drying of the grain immediately before shelling on the mill was commonplace, and indeed appeared essential. “Kilns had two main functions: to lower the moisture content of any grain to between 12 and 18 per cent for milling, and to lower the moisture content of oats to such a point that the husks became brittle and could be readily shelled or split off, an important stage in the production of oatmeal.” (Watts, 2008)

As with the croft based corn kilns described previously, “It is first bedded with oats spread over a pre-heated floor. The fire must have been lit some hours previously (rise early). After spreading the oats need constantly watched and turned with a long handled shovel to turn over the hot piles of grain. Coarser oats needed longer drying. Modern oats could not endure for as long, and needed shorter drying. If the oats remained too long over the fire the meal

made from them would be darker in appearance. Oats fired with husks is said to give the resulting meal a sweeter taste. Fuel could be peat, left over sids or husks from threshing, anthracite.” (Gauldie, 1981)

Dehulling at the Mill

There was little to no reference of standalone dehulling machines in the am Fasgadh archives, other than attachments to threshers. Most references to de-hulling were at the mill. Initially this was on small ungeared horizontal paddle mills. These mills were generally not much larger than the humble hand querns, with a small vertical shaft to a ~540mm diameter⁴ bed and runner stone. The gap was set with a wedge, which allowed adjustment of the runner stone setting. Grains such as oats were then cracked between the two mill stones, set large enough to de-husk the grains without crushing them.

Dehulling did however present a problem to crofters of old. A first person account by Alex Mackay of this on a small croft based mill states “the shelling of oats was never well executed – not more than two thirds of the grain was shelled.” “If the shelling was not all that could be wished for, it was made up in “pronn” – that is, sid for sowans, a healthy dish, and, when properly cooked a palatable one. The portion of oats meant for “grouts” had to be put through the mill two or three times”⁵

Dehulling continued at the mill as they turned to geared designs. “Where only one pair of stones was available, the oats were first shelled, that is the husks were rubbed off by grinding with the stones set well apart...the shelled oats and husks were separated by fanning, and the husks saved...the husks....were once consumed as sowans, which was procured by steeping the husks in water for a week or two so that the fine, floury part of the meal from the inner husk, known as sids, remained as sediment to be strained off, boiled and supped with a horn spoon. After shelling, the oats - at this stage called groats - were returned to the stones which, now set closer, ground them into meal.” “When using more than one set of stones “one pair of stones without grooving was then maintained as a suitable set for shelling”. (Gauldie, 1981)

⁴ Measurement from Hellumylan (Upper Mil) Faeroes

⁵ The Celtic Magazine; The Horizontal Mill at Kirtomy, Farr, Sutherland. Vol 9

7. Hacking Small Scale Grain Machinery

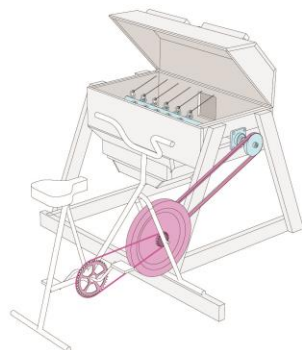
The table below summarises the answer to the original curiosity “what were the historic crofting tools/equipment used to process grain at small scale?”

Cutting & Binding	Heuk & Scythe	Reaper	Reaper Binder	Separate Combine Harvester	Self propelled Combine Harvester
	Twist tied		Twine tied		
	Field Stook Drying				
Thrash	Hand flail	Thrasher	Thresher		
Winnow	Winnowing Seives & Wechts	Winnower			
Hummel	Hand hummerler		Rotary hummerler		
Dry	On croft kiln		At mill kiln	Grain dryer	
Dehull	Knocking Stone	Rotary ungeared Mill	Geared offsite mill		

Figure 29 – Progression of historic crofting tools/equipment used to process grain at a small scale

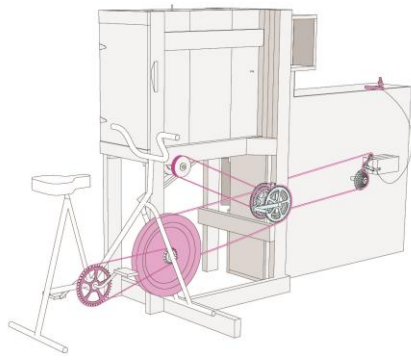
I think at this stage it is useful to step back from the historical past, and look around at modern day adaption (or hacks) of small scale grain machinery. The machinery barrier is not new, nor is it a croft specific issue, with people historically hacking small scale grain machinery. The most co-ordinated example is probably to be found via the online Farmhack platform. Farmhack is a worldwide community of farmers that build and modify farming tools, which have open source plans available distributed under a Creative Commons License.

Currently they have three well developed grain machines on their platform, as follows:-

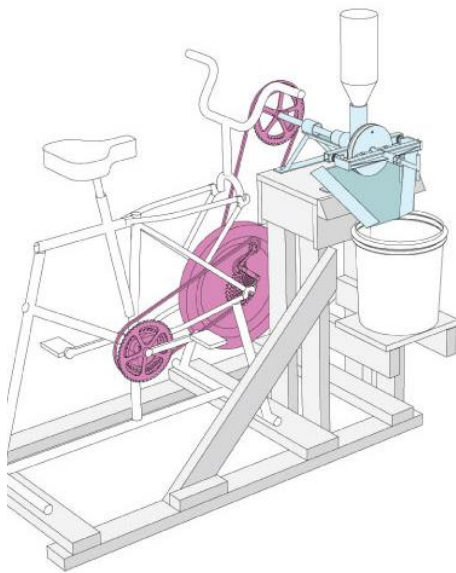


Bicycle powered thrasher⁶ - This piece of equipment is a simple chain/flail beater design similar in scale to the historical hand threshers, and claiming to thresh up to 0.45kg per minute.

⁶ <https://farmhack.org/tools/bicycle-powered-thresher>



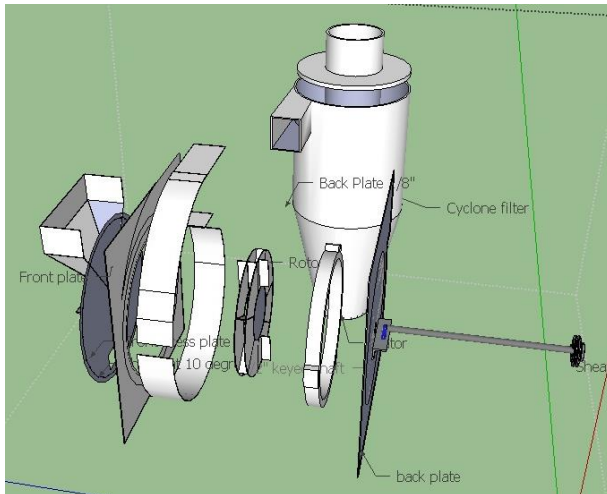
Bicycle powered fanning mill⁷ – This piece of equipment is a similar version to the hand cranked winnowing machines historically available, but designed for a bike drive train. The open source plans are of a slightly smaller size than the historical versions found in am Fasgadh, claiming to clean up to 4.5kg per minute.



Bicycle powered dehuller/flour mill⁸ – This piece of equipment is a horizontal shaft, bike drive train version of the small stone mills we found reference to being used for dehulling, by having a larger gap and rubbing hulled grain between two discs.

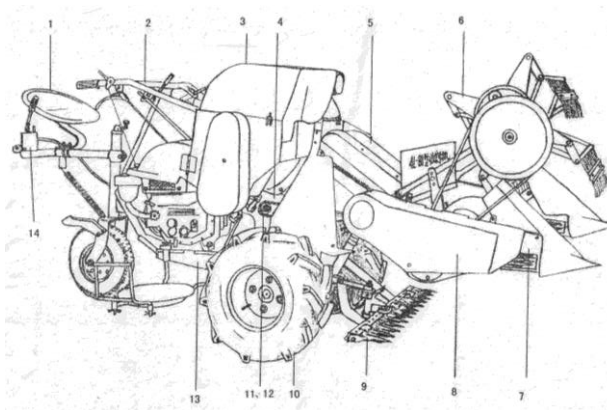
The Farmhack also has two less well developed grain machine projects on their platform, as follows:-

⁷ <https://farmhack.org/tools/bicycle-powered-fanning-mill>
⁸ <https://farmhack.org/tools/bicycle-powered-thresher>



Impact/Abrasion Dehuller⁹

A reverse engineered grass seed scarifier, this impact/abrasion dehuller impels the grain against a hard surface whilst scarifying the seed, causing the hull to release.



Small Axial Flow Combine Harvester¹⁰

A reverse engineered small axial flow combine harvester, suitable for a two wheel drive tractor.


The original funders behind the three bicycle powered grain processing equipment being shared on the Farmhack platform, was the US Sustainable Agriculture Research & Education (SARE)¹¹.

In addition to funding the above, SARE have two other pertinent pieces of grain machinery at different development stages:-

⁹ <https://farmhack.org/tools/oat-and-grain-dehuller>

¹⁰ <https://farmhack.org/tools/small-axial-flow-combine-harvester>

¹¹ https://projects.sare.org/sare_project/one16-277/

	<p>A Farmer Built Spelt Impact Dehuller¹²</p> <p>A well-developed impact dehuller specifically designed for spelt.</p>
<p>A Farmer Built Pearling Machine¹³</p> <p>A small farm-scale pearling machine is currently in development with a project end date of 28/02/2021. A pearling machine typically will remove both the husk and the outer bran of a grain. The pearling machine under development will have a theoretical throughput of 450kg of grain per hour.</p>	

8.A route to revival

This is the first stage of a three stage project. Stage 1 was this historical research at am Fasgadh, looking at what were the historic crofting tools/equipment used to process grain at small scale?

We did not find everything we sought, notably the unicorn to the questions of a small scale croft dehuller. But we found a lot of interesting material. There is considerable flexibility in these old machines – the adjustability inherent in various design features, and the simple construction which lent itself to being flat packed and exported around the world. Many of these early grain processing machines are still in use, and that is due in part to their simple low cost construction, their scale, and the ease with which they were transported.

¹² https://projects.sare.org/sare_project/fne11-731/
¹³ https://projects.sare.org/sare_project/fne19-945/

Stage 2 of this three stage project will be **selection** - a community led selection process at an event early 2021– asking the specific question what do the grain growing groups nurtured by Gaia want to develop further?

Of the historical pieces there are four contenders:-

- a. **A Thrasher machine**
- b. **A Winnowing machine**
- c. **A Threshing Machine**
- d. **A combined Winnowing & Rotary Cleaner**

As part of the selection dialogue, broader questions will be asked such as, whether the project should pivot to further develop one of the Farmhack projects already started? What equipment do we want commonplace again on croft and small farm alike? What is our final aim?

Stage 3 and the last stage of this project will be to **prototype** a selected piece of grain processing equipment and test on samples of real grain grown in 2021.

9. Appendices

- Technical Sketch of Thrashing Machine at Am Fasgadh
- Technical Sketch of Winnowing Machine at Am Fasgadh
- Technical Sketch of Thrashing Machine at Am Fasgadh © G.J.Douglas 1987
- Technical Sketch of Thrashing Machine at Lunna, Shetland © G.J.Douglas 1987

Ye Olde Units of grain



A boll of grain – the old scots word for a measure of meal or grain (~140lbs /63.5kg)

A firloft or bushel of grain – (~35lbs / 16kg) – 4 firlofts = 1 boll

A peck of grain – (~8.75lbs / 4kg) – 4 pecks = 1 firloft

Gaelic Grain Glossary (Dwelly, 1988)

Buailtein - the part of a flail that threshes the corn

Càthadh – chaff, winnowing, riddling, sifting

Coirce - oats

Cnap – thump, strike, beat, knock, wrap, also **An Cnap Eorna** - the Barley thump

Cnot – to unhusk corn

Cnotag – block of stone or wood, hollowed out for unhusking corn.

Cruithneachd - wheat

Dallan – winnowing fan

Dallanach – large Winnowing Fan

Dallanachd – winnowing with a large fan.

Eòrna - barley

Fasgnach – a corn fan, a winnowing fan, also known as **beantag**

Fasgnadh – winnowing, cleansing of grain out of doors.

Froiseain – a grain of seed

Lorg – a wooden handle of a flail

Maide Frasiadh – a stick used for separating the ears of corn from the sheaves.

Pronn – the coarsest part of oatmeal with the seeds left in sifting; ground oats for sowens – also **Pronn Coirce** – pronn means to pound, mash or bruise.

Seagal – Rye

Sail shùiste – the thong part of a flail, often of sheepskin, which attaches the staff to the buailtein.

Sùist - the flail; to thresh, beat or thump.

Sùistear – a thresher, one who threshes.

Sùisteachadh – threshing with a flail

Tarran – Frame of net or straw to hold grain over a slow fire for drying.

Toll-càthaidh - a chaff hole

Toll fhasgnaidh - a winnowing hole

Teanga – tongue or **An teangaidh** the tongue (the wooden stick used with the cnotag).

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3"x2"x11.5" OAK BLOCK PADDLES
BOLTED TO WHEEL WITH
2 NO 3/8" COUNTERSUNK
SQUARE HEAD BOLTS.

8 NO 1/2" PEGS SCREWED
INTO OAK PADDLES
PROTRUDING 1 1/2" AND
RAKED BACK 30 deg

4-6" HIGH
x 12" WIDE

SHEATH ENTRY

6 SPOKE CAST IRON
WHEEL KEYED TO
7/8" SHAFT AND
RETAINED WITH
GRUB SCREW.

1/2" PLATE CONCAVE
WITH 6 ROWS OF 4 PEGS (1/2" DIA)
PROTRUDING 1 1/2", PATTERNED TO
INTERFACE MALE/FEMALE WITH
ROTATING PEGS.

3/8" HOLES DRILLED EQUISPACED
BETWEEN PEGS

27 TOOTH 3" SPUR GEAR
ON MAIN 7/8" SHAFT
(KEYED + GRUB SCREW)

GRAIN EXIT

WHEEL
CCW

4:1 GEAR
RATIO

CRANK
CW.

24" DIAMETER (PEG FACE)

21" DIAMETER (PADDLE FACE)

3/8" PEG TO COVER OPERATING GAP
0.05" SHEET STEEL COVER

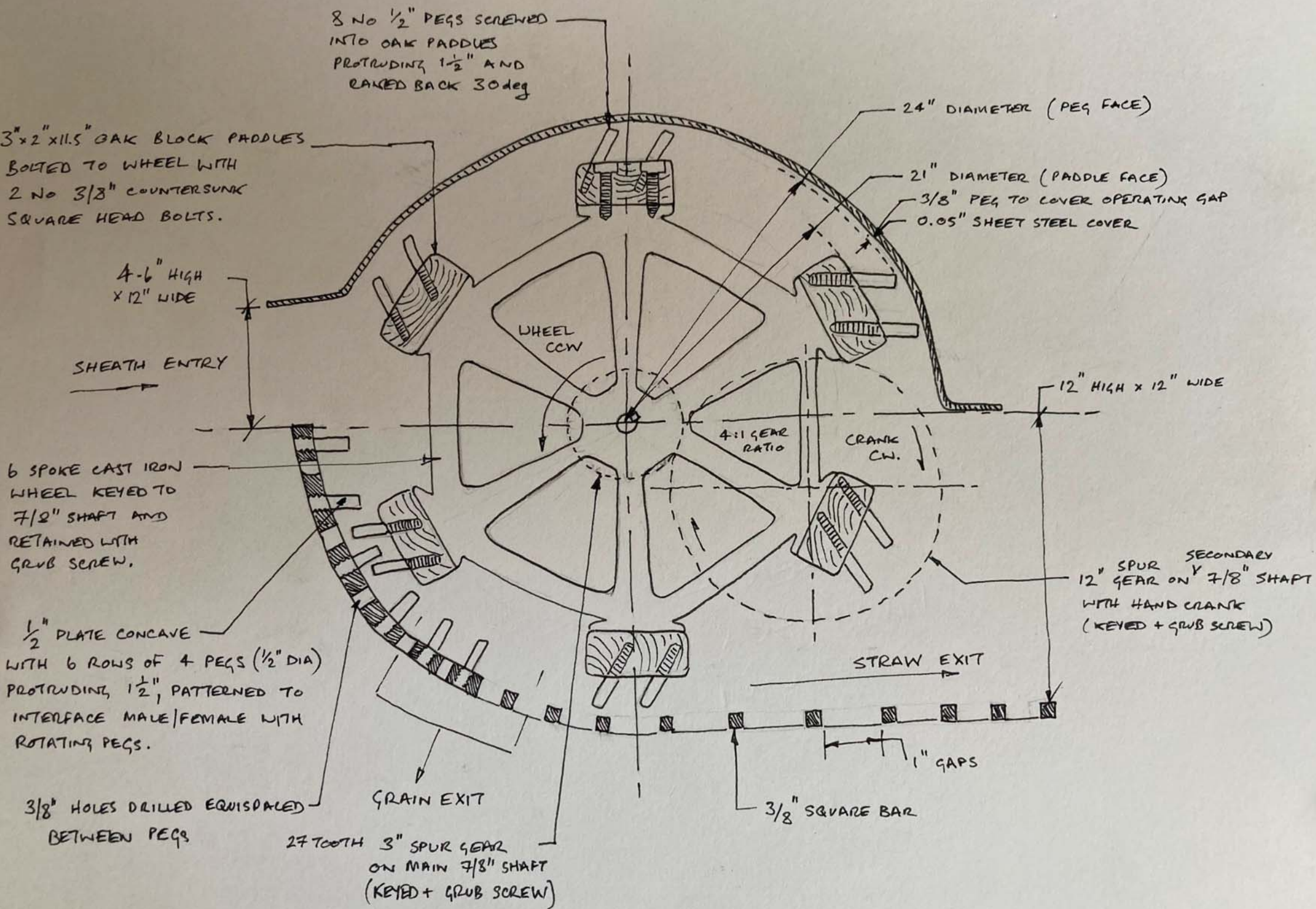
12" HIGH x 12" WIDE

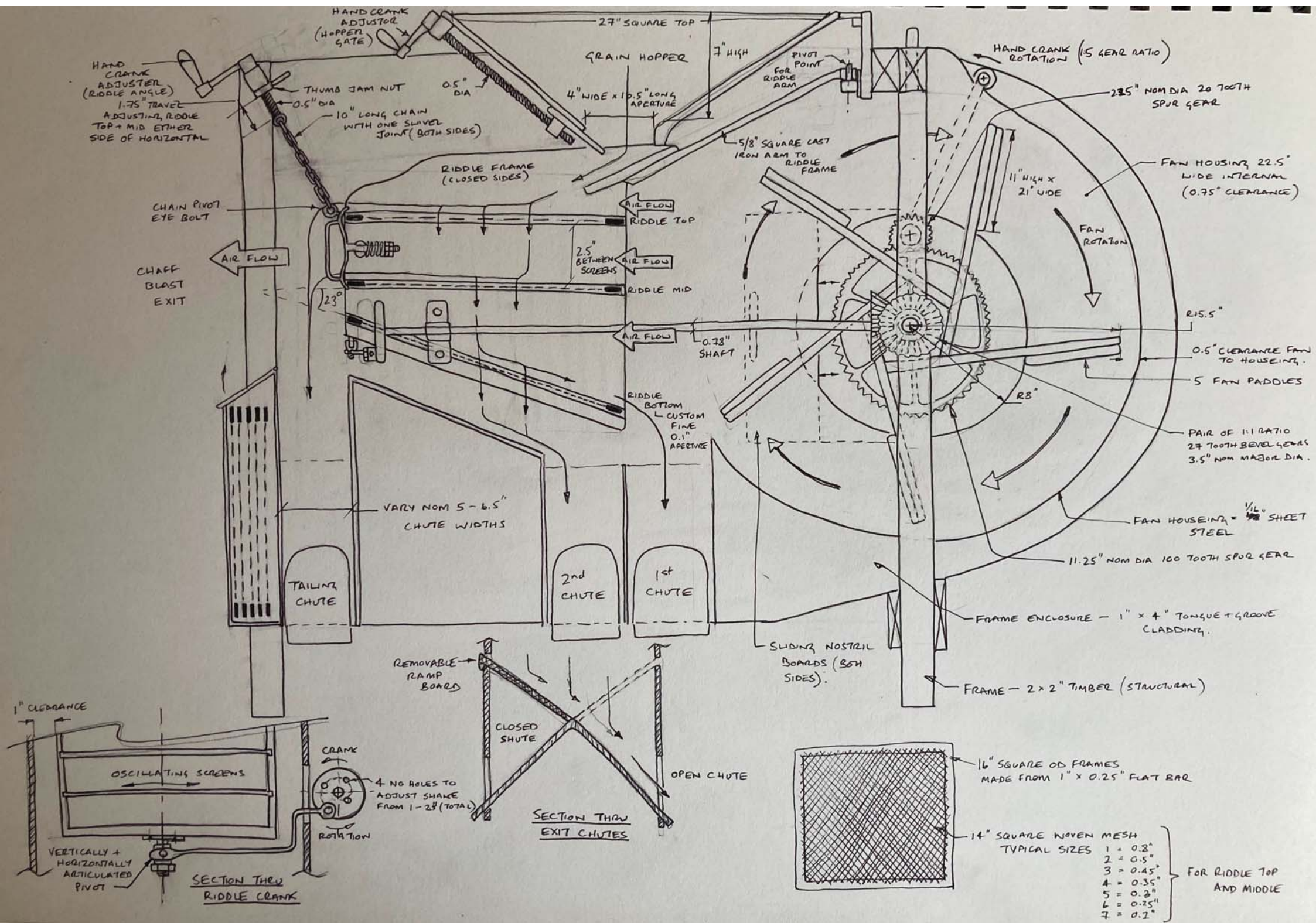
12" SPUR SECONDARY
GEAR ON 7/8" SHAFT
WITH HAND CRANK
(KEYED + GRUB SCREW)

STRAW EXIT

1" GAPS

3/8" SQUARE BAR

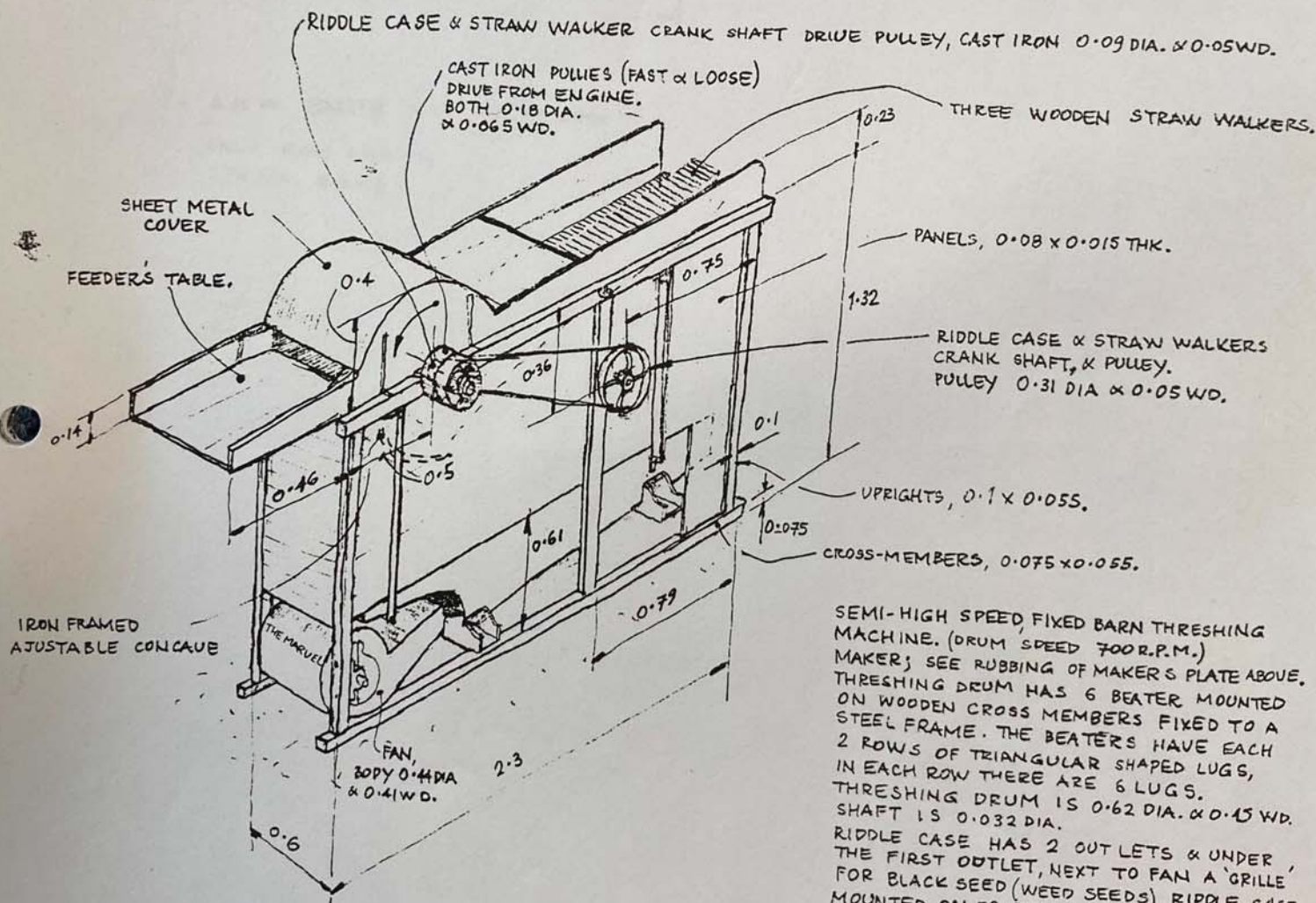
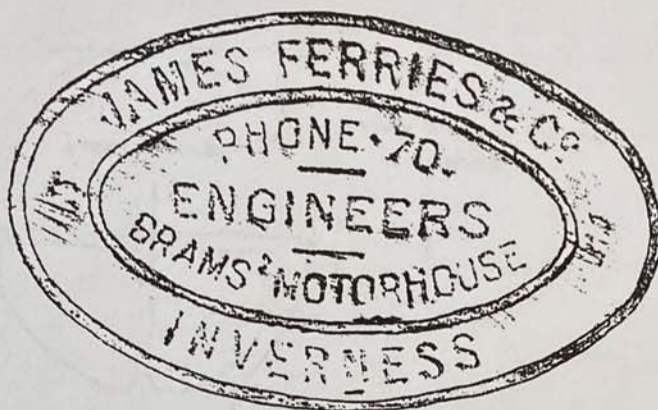




- DIMENSIONS m -
- NOT TO SCALE -

THRESHING MACHINE,
HIGHLAND FOLK MUSEUM,
KINGUSSIE, INVERNESS-SHIRE
NH760006.
G.J. DOUGLAS 18.3.1987.
R.C.A.U.M.S

MAKERS NAME PLATE.

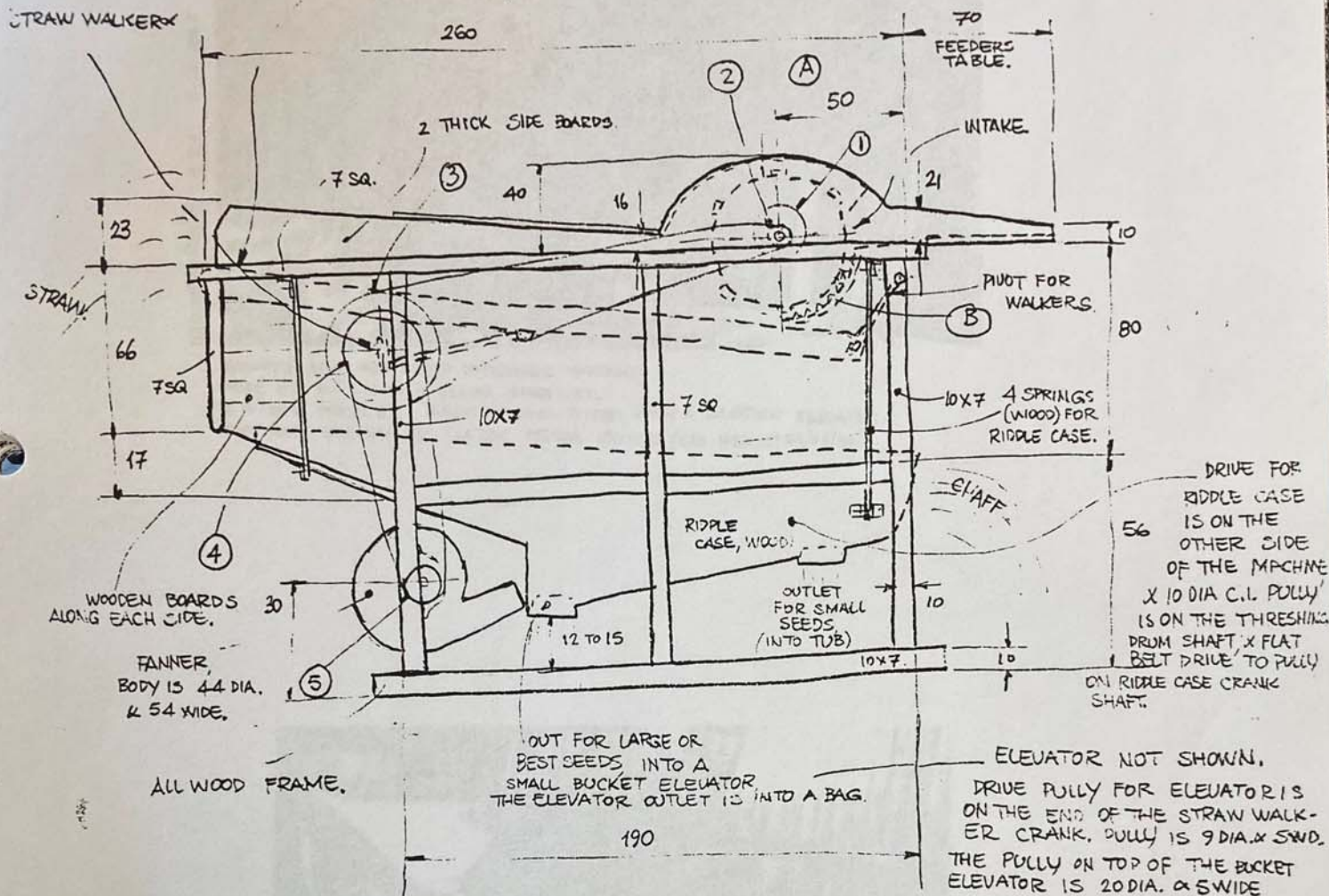


SEMI-HIGH SPEED FIXED BARN THRESHING MACHINE. (DRUM SPEED 700 R.P.M.)
MAKER; SEE RUBBING OF MAKERS PLATE ABOVE.
THRESHING DRUM HAS 6 BEATERS MOUNTED ON WOODEN CROSS MEMBERS FIXED TO A STEEL FRAME. THE BEATERS HAVE EACH 2 ROWS OF TRIANGULAR SHAPED LUGS, IN EACH ROW THERE ARE 6 LUGS.
THRESHING DRUM IS 0.62 DIA. x 0.45 WD. SHAFT IS 0.032 DIA.
RIDDLE CASE HAS 2 OUT LETS & UNDER, THE FIRST OUTLET, NEXT TO FAN A 'GRILLE' FOR BLACK SEED (WEED SEEDS) RIDDLE CASE MOUNTED ON FOUR WOODEN SPRINGS.
ALL WOOD FRAME WITH WOODEN SIDES.

DRUM SPEED; 700 RPM.
FAN SPEED; 630 RPM. ?
RIDDLE CASE &
STRAW WALKER
CRANK; 203 RPM.

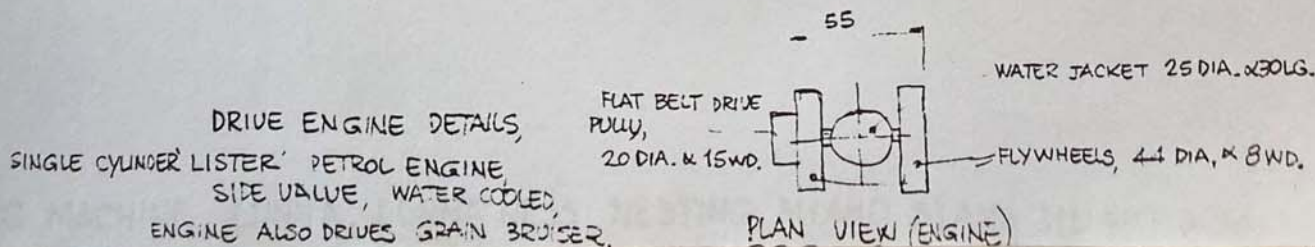
MADE BY:- W^M LESLIE,
MILLWRIGHTS,
KINELLAR, ABERDEENSHIRE.
(MADE IN 1950'S)
IN USE UNTIL 1982.
INSIDE WIDTH OF MACHINE

3 STRAW WALKER, WOOD,

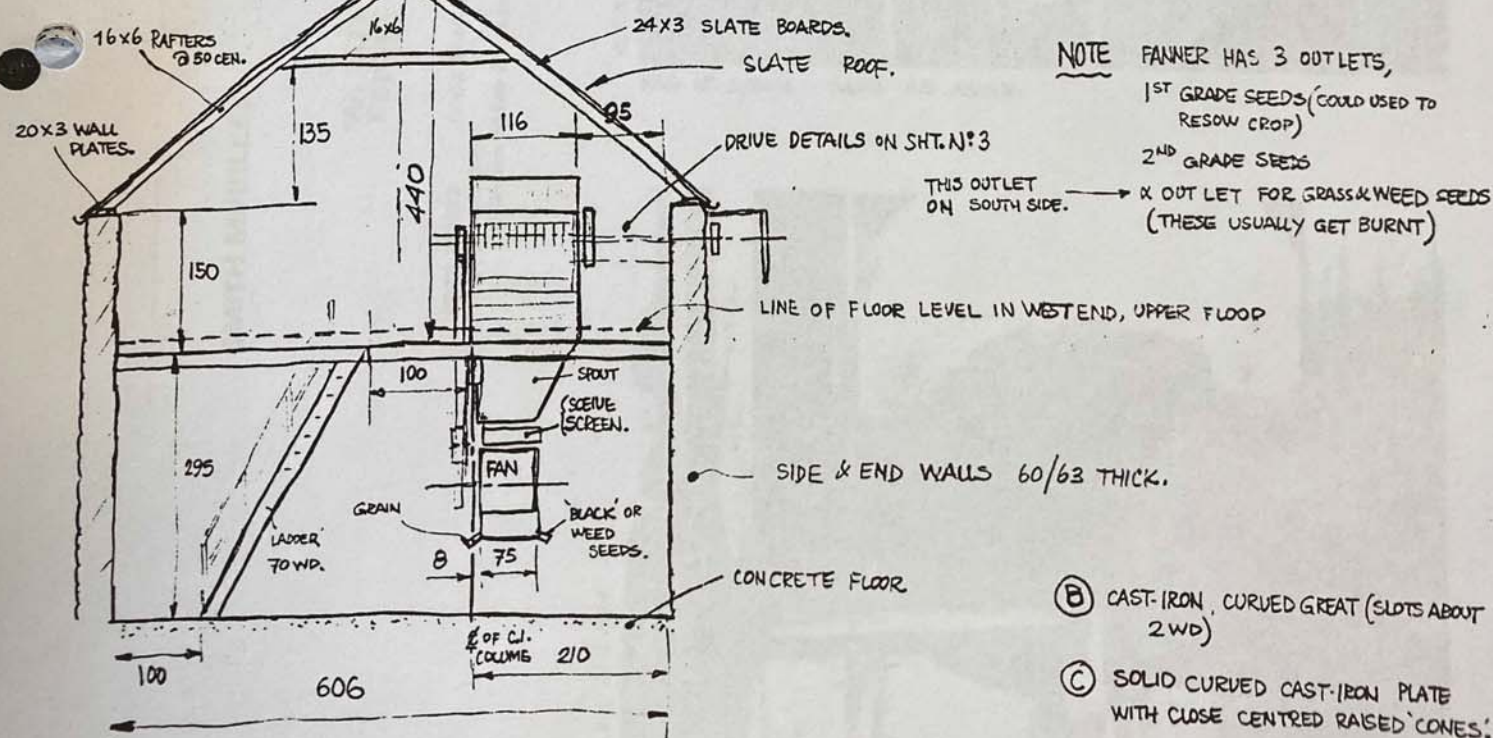
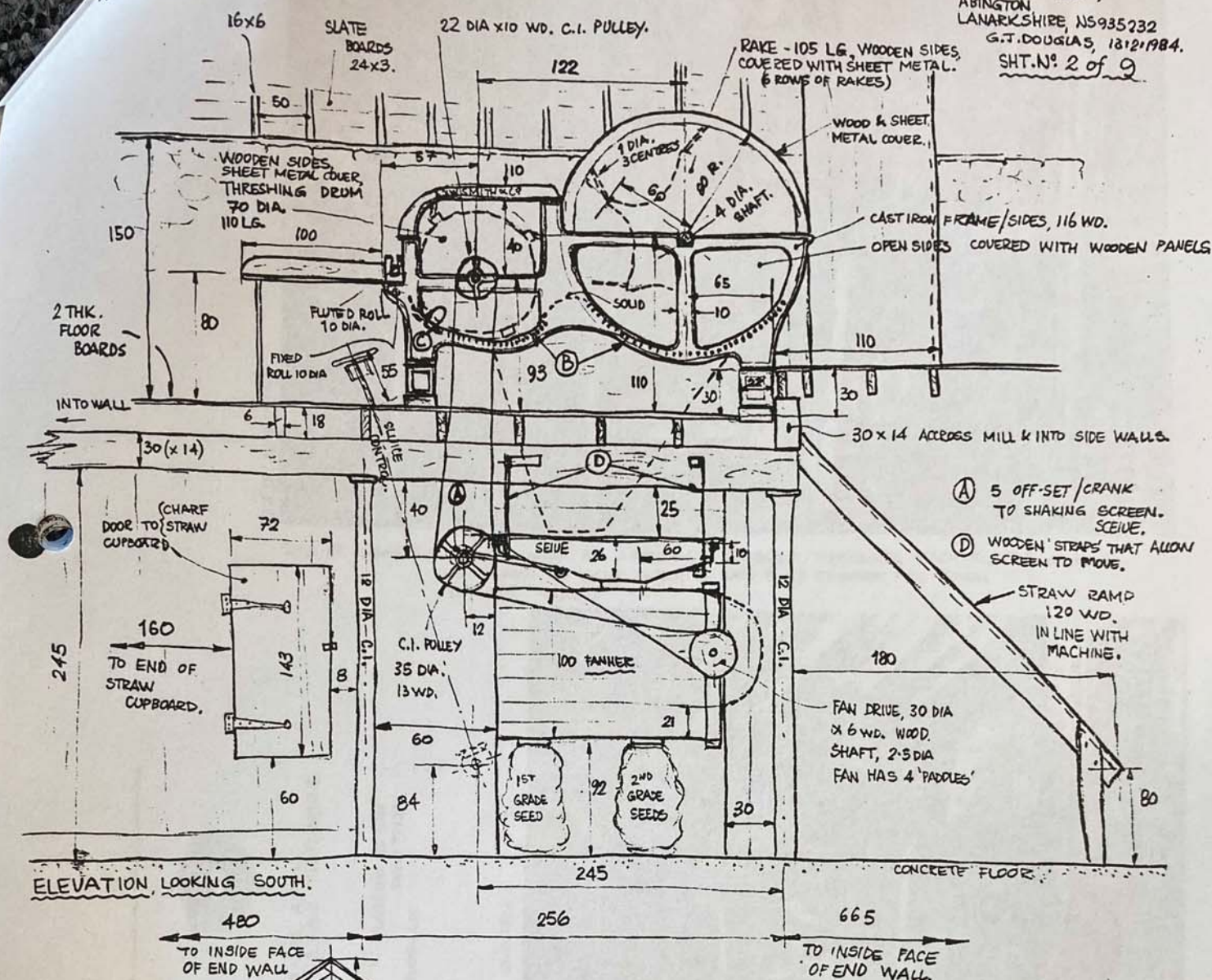


- ITEM -

- (A) THRESHING DRUM. 60 DIA (OVER-ALL) AND 53 WIDE, THRESHING DRUM SHAFT RUNS IN BALL BEARING PLUMBER BLOCKS.
FITTED WITH 6 BEATERS, EACH BEATER IS A C.I. PLATE WHICH HAS 2 ROWS OF TRIANGULAR LUGS, THE PLATES ARE FITTED TO THE WOOD & IRON FRAME OF THE DRUM.
 - (B) THRESHING PLATE, 3 CROSS-MEMBERS WITH PLATES SIMILAR TO THE ONES ON THE THRESHING DRUM.
- (1) DRIVE PULLEY, (DRIVE FROM A STATIONARY ENGINE, USING FLAT BELTS)
2 PULLEYS, C.I., ONE 'FAST', ONE 'LOOSE'. BOTH 17 DIA & 8 WIDE, EACH WITH 4 ARMS, SHAFT 3.5 DIA.
 - (2) DRIVE TO STRAW WALKER & RIDDLE CASE, CRANK SHAFT,
FLAT PULLEY, C.I., 10 DIA, & 5 WIDE.
 - (3) FLAT PULLEY - C.I., 35 DIA. & 5 WIDE, 4 ARMS.
 - (4) FLAT PULLEY - (DRIVE FOR FANNER) C.I., 30 DIA. & 5 WIDE, 4 ARMS.
 - (5) FLAT PULLEY (FANNER PULLEY) SOLID C.I., 9 DIA & 5 WIDE.



THRESHING & SAW MILL,
SOUTHWOOD FARM,
ABINGTON
LANARKSHIRE, NS935232
G.T. DOUGLAS, 18/2/1984.
SHT. N° 2 of 9



SECTION AT END OF THRESHING MACHINE,
(LOOKING ESE)

SEE ALSO PLAN VIEW ON SHT. N° 3