INTERNATIONAL ENGINEERING CONGRESS,
GLASGOW, 1901.

SECTION III. (MECHANICAL),
ARRANGED BY
The Institution of Mechanical Engineers.

AGRICULTURAL MACHINERY IN THE CANADIAN PAVILION AT THE GLASGOW INTERNATIONAL EXHIBITION, 1901.

BY MR. G. HARWOOD FROST, B.A.Sc.,
SMITH'S FALLS, ONTARIO, CANADA.

Agriculture is the art of cultivating the ground and obtaining from it the products necessary for the support of animal life. It is the oldest occupation of which we have any record, being mentioned in the earliest parts of the Bible, where we are told of certain persons being tillers of the ground and others being shepherds. The herding of sheep was confined to the mountainous districts, where the natural growth of grass afforded plenty of pasturage, and tilling the soil was carried on in the well-watered valley districts, where the periodic overflowing of the rivers fertilized the land and forced an abundant crop with little manual labour after the ground had been prepared for seed and the seed sown. Hence the processes of agriculture originally employed were extremely simple, being confined to merely preparing the ground without any effort to stimulate its productiveness, and the plough was practically the only implement in use. To-day, by the use of mechanical appliances, the farmer prepares vast areas of land in a short time, sows the seed, stimulates the growth of the grain, and forces the maximum yield that the land is capable of; he opens up to cultivation barren wastes and unbroken tracks covered with coarse prairie grass; and he harvests the crop with a rapidity undreamed of even fifty years ago.

The process of agriculture may be divided into its several classes as follows:—

1. Preparing the ground for the seed by means of ploughs and harrows.
2. Sowing the seed—broadcast seeders and drills.
3. Cultivation and care of the growing crop—cultivators of various kinds, horse hoes, weeders, thistle cutters, &c.
4. Harvesting the crop—mowers, tedders, rakes and loaders for hay, self-binding harvesters and reapers for grain.
5. Preparing the crop for use—threshers and other machines.

In the Canadian Pavilion at the Glasgow International Exhibition, Canadian implements for the first four purposes are represented by the products of six factories, namely, the Massey-Harris Co., Toronto, the Frost and Wood Co., Smith's Falls, the Noxon Co., Ingersoll, David Maxwell and Sons, St. Mary's, all of which manufacture a large variety of implements, and the Verity Plow Co., and the Cockshutt Plow Co., both of Brantford, which are devoted exclusively to the production of ploughs.

The earliest implements used by the settlers in Canada were imported from Great Britain, but as the almost illimitable area of arable land in Canada became opened up to settlement, the demand for implements soon induced their manufacture at home. The rapid development of the West rewarded these early manufacturers with success, and the capacity of their factories was constantly increased until to-day Canada is the largest producing British Colony and, next to the United States, the largest producer of farming machinery in the world.

Ploughs.—The first demand was, naturally, for ploughs for breaking the land. The plough is the oldest and simplest of agricultural implements, being represented amongst the hieroglyphics on the ancient tombs of Egypt, dating back more than 4000 years, and as early as the year 1000 B.C., the plough was described by one of the Greek historians as consisting of a beam, a share, and handles. To-day it consists essentially of the same parts. Until the past century it was made of wood and its form had not undergone many changes, but now it is safe to say that no other instrument for use in agriculture or for any other purpose can boast of so many varieties of shape and construction as the plough. Its forms are numbered by thousands, every country and almost every locality having its own models and every condition of land being provided for. The varieties shown in the Exhibition are a selection of those made in Canada to suit the conditions of Great Britain, where the soil has been cultivated for generations and is free from many of the obstructions met with in the barren and unbroken wildernesses of Western Canada. They are constructed on the straight line principle and all local conditions have been met. A difference in the method of holding and turning the plough in this country, although very slight, has been provided for by the use of two adjustable supporting wheels attached to the beam and by an increase in the thickness of the heel of the landside, to prevent too rapid wear at this point. The mouldboards are made of soft centre or "syndicate" steel, which prevents brittleness, and permits of cleaning; the landsides and coulters are made of crucible steel, highly tempered; the beams of wrought iron and the handles of wood, making the plough much lighter than the English steel-handled ploughs, with, as has been proved by experience, equal strength, and greater ease of handling. The points are made of cast steel, chilled, and may be detached and replaced by new points as they wear.

Harrows.—After the ground has been broken and turned by the plough, it is pulverised and a level seed bed made by the use of a harrow. Of the harrow, there are shown several varieties:—the spring-tooth, the spike-tooth, and the disc, each having its particular merits and uses. Harrows are usually made in sections, which may be coupled together to allow two, three, or more sections to be used at a time. The framework of the spring-tooth harrow is made of one continuous bar of steel running entirely around each section, across which are several angle-shaped steel bars, and to these are attached, in different ways by different makers, a series of highly tempered steel teeth, about $\frac{1}{4}$ inch thick. The teeth are curved in such a way that they dig into the ground, tearing the clods of earth and levelling the furrows. The spike-tooth harrow is made in much the same manner, with the exception that it has solid steel teeth, in the form of pointed spikes, about one inch square, instead of spring teeth. In both these harrows there is a heavy coiled spring attached to an adjusting bar, to allow the teeth to yield when in contact with an unmovable obstruction, and also to give them a continuous vibration. By means of a lever operating the adjusting bar, the teeth may be set at various angles for working over different kinds of ground. The disc harrow is an implement extensively used in America, but only recently introduced into Great Britain. It is different from the others, being composed of a series of concave discs of highly tempered steel which cut the ground instead of tearing it. It will pulverise and level soil that is too hard for any other kind of harrow to properly handle. The discs are arranged in two sections of six, seven, or eight discs, which revolve on hardened steel ball-bearings. The sections are adjustable to any angle; in some makes by one lever which compels both sections to work at the same angle, in others, by two levers which allow either section to be set at an independent angle. The former has an advantage in ease of operation on perfectly level ground, and the latter has the advantage on rough and hilly land, while working equally well on level land. The depth of cutting can be regulated by the angle at which the sections are set, and in turning corners or working on hillsides the draught on the horses can be regulated in the same way. The sections are also flexible to allow either end to rise and pass over an obstruction. The discs are provided with scrapers arranged in sections, for keeping them clean, the scrapers of each section being independently locked on or off and shifted with the section of discs to which they belong. Each scraper works on an independent spring, and always fits tightly against the disc. The principal uses of this implement are cutting turf, and pulverising and levelling the ground after ploughing, but it is equally well adapted for breaking up the land after the corn crop has been taken off, which cannot be done with a toothed harrow. For this purpose the British farmer generally uses a rigid-tooth cultivator, while the Canadian farmer uses a disc harrow, which answers also for ordinary harrowing purposes.

Another kind of harrow, but only adaptable for use in light soil, is the chain harrow, made of a series of steel links.

Sowers, Plate 1.—The ground, being broken and level, is ready for the reception of the seed. The earliest method of sowing was to carry the seed in a receptacle, scattering it broadcast by the hand, and some fell on good ground and yielded a crop, while some fell on bad ground and was lost. In our day, however, the chances of thus losing seed are reduced to a minimum by mechanical devices. For different purposes, seed is sown in different ways—broadcast, and in rows, or drills. Machines for both methods are shown; the broadcast seeder by the Massey-Harris Co., and the drill by the Noxon Co. Such seeds as corn, peas, beans, barley and some others are, as a rule, sown in drills, while grass seed, clover, and sometimes corn, are sown broadcast. There are two varieties of drills—the hoe and the shoe. The seed is contained in a box, from which it passes to the ground through a series of tubes, at the bottom of which are the open hoes or shoes. The hoe-drill hoes a channel through the ground by means of diamond shaped points, the seed passes into this channel and is covered by the earth falling back on it. The shoe-drill has a row of steel runners with V-shaped bottoms which are curved upward at the points in a form resembling a shoe. These sharp bottomed shoes cut furrows through the earth into which the seed passes, and short drag chains attached to the rear of the shoes throw a loose covering over it. Grass seed may be sown from the drills by replacing the hoes with "scatterers," which, instead of digging into the ground, scatter the seed broadcast over it. In the regular broadcast seeders, the tubes are dispensed with altogether, the seed falling from the box, and spring cultivator teeth are attached which throw the covering over it. The feed-wheel which carries the seed from the box to the tubes consists of a solid cut-away cylinder of about three inches in length, Fig. 1, Plate 1. This is turned by a gearing driven by the road wheels, so when the machine is at rest, the feed is closed; it is also closed when the hoes or shoes are lifted from the ground, or there is a motion of backing the machine. On the rear of the seed box there is an indicator showing how much seed of different kinds should be sown to the acre—grain seed being given in pecks and grass seed in pounds, Fig. 2. By moving the pointer on this indicator to the figure showing the quantity it is desired to sow to the acre, the feed-wheel is shifted, enlarging or diminishing the size of the opening in the measuring channel to allow just the amount desired to pass through. Besides this there is a dial which registers the number of acres sown. The hoes are held in position by springs which allow them to pass over obstructions freely, and quickly return to their working positions. They are locked securely to the frame by clamps, without the use of bolts or pins, so that they may be easily removed and replaced by cultivator teeth. The depth at which they deposit the seed and the angle at which they cut the ground is regulated in some by spring pressure, in others by a mechanism similar to the reversing link of a locomotive; and they may be lifted out of the ground either all together by a lever, or independently by chains. Another lever is provided for shifting the hoes to a double-line, or zigzag position, to permit clods to pass between when working on rough lumpy ground that has not been sufficiently broken up by the harrow.

Cultivators.—The third process of agriculture—the care of the growing crop—is an important one, but the implements used for it are of the simplest variety. The ground must be kept clear of weeds and thistles, and it must be loosened up, especially while the crops are young, after it has become caked either by rain or by sun. For these purposes a variety of implements is used, such as horse-hoes, spring-tooth and rigid-tooth cultivators, weeders, hillers, etc., but all may be classed under the general head of Cultivators. The most extensively used, and the only variety shown in the Canadian Section, is the spring-tooth cultivator. The framework is of angle steel and strongly braced; the teeth, or tines, are S-shaped, and are made of spring steel, oil tempered; the points are of various shapes, and are reversible and interchangeable, permitting points for various purposes to be used on the same tines. The teeth are arranged in sections, similar to the sections of the harrows, which are supported by a shaft at the front, and the depth of cultivation is regulated by spring pressure on each of the sections. On the Massey-Harris cultivator this pressure is applied from the front, while on the Frost and Wood, the Noxon, and the Maxwell implements it is applied directly to the rear, above the teeth. One lever, assisted by a coiled spring, serves both to lift the teeth out of the ground and to force them in, according to the depth desired.

Most of the spring-tooth cultivators are arranged also for use as broadcast seeders, space being provided above the front of the sections for the seed-box.

Harvesters.—The process of harvesting the crop is the one that has brought out the greatest ingenuity of man in the development of farming machinery. Neither the preparing of a seed-bed, nor the sowing of the seed necessitated the application of machinery in the early days, and natural fertilisation saved further labour, but when the crop ripened, it had to be gathered before the weather ruined it, and prepared for use. This was done by means of sickles, threshing floors, flails, winnowing boards, and grinding mills, all of which are shown by paintings in the tombs of ancient Egypt. Egypt was one of the first countries in which agricultural practice was developed and animal power applied to the various processes. From Egypt the knowledge of agriculture spread to Greece, thence to Rome, and from Rome to the rest of Europe, and the first mechanical device for cutting grain by animal power was suggested by the Romans. Pliny describes a device in use by the Gauls, in the form of a cart with a comb-like bar in front, which stripped off the ears of wheat and delivered them into a box. After the lapse of eighteen centuries the principle of this machine has been re-invented, and is now in use in the headers which harvest the enormous crops of wheat of Canada, the United States, and other parts where only the grain is gathered, leaving the straw to be burned. The problem of developing the primitive sickle and scythe into the most useful and available machines for harvesting the grass and grain crop of the world has long engaged the attention of man, but it was not until comparatively recent times that the practical results showed any great efficiency. During the nineteenth century, however, the mower, the reaper, and the binder have come into existence, and have passed through many stages of shape and principles of construction and operation into their present state of perfection. These time and labour saving machines are now deemed indispensable by all who raise hay and grain, and their production has alone rendered possible the opening up to settlement and agricultural development of the prairie districts of America, Australia, Russia, Siberia, South America, and Africa, in all of which parts Canadian-made harvesting machinery is now in every-day use.

Both mowers and binders are exhibited by the Massey-Harris Co., the Frost and Wood Co., the Noxon Co., and David Maxwell and Sons. While the principles of operation and the results obtained are the same in all, the mechanical methods of obtaining this result and the devices by which the different machines meet the varying conditions imposed upon them are different, and each firm claims superior advantages for its own construction, which it is not the purpose of this Paper to discuss.

For harvesting the hay crop, four machines are used. The grass is cut by the mower, turned for drying by the tedder, gathered by the rake, and loaded on the waggon by the loader. Rakes are shown by three firms, tedders by two, and the loaders by only one.

Mowers, Plate 2.—On the Mower a solid and heavy tubular cast-iron frame is used, as this secures a more perfect and permanent alignment of the running gear and shafting than a steel frame, which must be built up of several pieces bolted together. The wheels are of cast iron, 31 to 34 inches high, 3½ to 4 inches wide, and are provided with horizontal and vertical lugs on the rims to ensure good driving contact with the ground. The wheels communicate their forward motion to the shaft and the main gear-wheel through a ratchet and spring pawls on the inside of the hubs of both wheels, Fig. 3, Plate 2. From the main gear-wheel the motion is communicated to the cross-shaft by various arrangements of spur and bevel wheels and pinions, giving a rapid motion to the crank, and thence to the knife through the connecting-rod. The connecting-rod is long, and is in some machines made of wood, the variety used being well-seasoned second-growth hickory, and in others it is of wrought-iron or steel. It is attached to the knife-head and to the crank either by a ball and socket joint, Fig. 4, or by a hook and eye, Fig. 5. The speed given is in a ratio of from 55 to 62 vibrations of the knife to one revolution of the drive-wheels. A lower speed than this would not cut rapidly enough in heavy grass to prevent some of it blocking the action of the machine, and a higher speed would overheat the bearings. The cutting apparatus, consisting of the heavy steel cutter-bar, the fingers or guards, and the sectional knife, is attached to a hinged portion of the main frame, called the hanger, by large bearings, and is supported at each end by a shoe with either wheels or steel runners. It is made of different lengths to cut a swath of from 3½ to 6 feet wide, and the width of tread between the drive-wheels is proportionately wide—from 3½ to 5 feet—to give the machine stability. The knife is held tightly against the guard-plates by several clips, to make a close shear cut and to prevent short and soft grass from getting between the knife and the bar. After much use, the constant strain on the cutting apparatus has a tendency to make it sag backward and to throw the knife and the connecting-rod out of line, although every effort is made by the use of large and strong bearings to prevent its doing so, and if this were not remedied the knife would cut into the fingers and soon the entire apparatus would be ruined. A strong brace is therefore provided, connecting the hanger with the solid tubular part of the main frame, which can be adjusted to take up any wear, and keep the cutter-bar and the connecting-rod always in perfect alignment. The hanger connection must also allow the cutter-bar to accommodate itself automatically to the most uneven surface, so that it may float easily up and down over all irregularities of the ground without interfering with the action of the knife. Convenient to the operator on the seat there are several levers, Fig. 6, one for throwing the machine in and out of gear, one for tilting the cutter-bar to any angle to suit the nature of the ground or condition of crop, a foot lever for raising the bar from the ground, temporarily, while turning corners or passing an obstruction, leaving both hands free to handle the reins, and a hand lever for raising the bar higher and locking it in the raised position. A coiled spring assists the action of both of these raising levers. On the outer shoe of the cutter-bar is a track clearer, which deflects the grass sufficiently to leave a clear track for the inner wheel on the succeeding round of the machine. It works against a pressure spring that allows it to give freely before all obstructions. The horses draw the machine from below the pole, the draft being applied directly to the hanger, and the weight of the pole is counterbalanced by the driver on the seat, thus relieving all weight from the horses' necks, while drawing the machine.

Hay Tedder.—This implement is used for tossing and turning the grass for drying. It can turn as much grass in one day as ten people can by hand, and by its use a much better quality of hay is secured than by hand turning, for the reason that it permits the grass to be more quickly and uniformly dried, instead of being sun-scorched on the top by being left too long on the ground and imperfectly turned. It is strongly and lightly constructed and is drawn by one horse. The frame is of angle steel, well braced to give rigidity, the wheels are of channel steel and about four feet high. There are six four-pronged forks, mounted on a zigzag steel shaft at the rear of the machine, giving the forks three positions, and they are pivoted about one-third their length above this shaft. The shaft is operated directly from the centre by a chain, the power coming from the drive wheels through an internal spur gear near the centre of the main axle. By a lever the forks can be adjusted up and down while in motion, and the machine thrown in and out of gear. The forks are provided with springs which prevent breakage from striking obstructions.

Rake.—The horse rake is made to dump either automatically by means of a friction band or a spur wheel on the axle, thrown on by a foot lever, or by a hand lever assisted by a coiled spring. The teeth are made of a fine quality of crucible spring steel, tempered. By the use of this material the Canadian manufacturers can use light weight teeth of less than ½-inch diameter, while on all English makes the teeth are very heavy, being made of wrought steel and not tempered, of various shaped section, and about one inch thick. When the teeth are raised, the gathered hay is forced out by a line of clearing rods. The wheels and axles are of steel. The rakes are made of varying width from 7 to 10 feet, and the teeth are from 3 to 4 inches apart.

Loader.—The hay loader, Fig. 7, Plate 3, is a comparatively recent machine, but its use is being greatly extended every year. Its advantages are many, the principal being, perhaps, that by its use, hay is often secured when ready for the stack, that might otherwise be ruined by the weather. When the hay has been turned and thoroughly dried, it must be collected without loss of time, and the farmer often works far into the night rather than take the chances of losing his crop before morning. Further, the loading of the hay on the waggon is the most laboursome part of haymaking. With the loader it is possible for three men to place a ton of hay on the waggon in five minutes, while it would require the same men fully fifteen minutes to do the work by hand. The machine is attached to the rear of the waggon and operated by the same team that draws the load, adding but slightly to the draught. The driving power comes from the wheels through a ratchet and pawl in the hubs, which may be thrown on and off at will. These drive a cylindrical cage revolving on the axle and carrying six rows of curved teeth which pick up the hay and deposit it on an elevating screen whose driving roller is the revolving cylinder. It is then carried to the top of the loader whence it falls on the waggon, where it is put in position by hand labour. The angle of elevation is automatically adjusted as the height of the load on the waggon increases. An upright frame supports several long wood slats which rest on the ascending hay to prevent its being carried away by wind or falling over the sides.

Grain Harvesting.—For harvesting grain only two operations are necessary—the cutting, and the tying of the bundles. There are two machines for cutting grain—the reaper and the self-binding harvester, or binder, as it is more generally called. The reaper simply cuts the grain, delivering it in gavels, which must afterwards be tied by hand. Of the reaper there are two varieties—the manual delivery and the automatic self-delivery. The binder both cuts the grain and ties it in sheaves. In the early days, when machines were first produced to take the labour of tying off the hands of the farmer, wire was used, but this had many disadvantages and gave much trouble to users. Experiment finally produced the twine-binding harvester of to-day, which ranks high, not only as a great time and labour saving machine, but as one of the greatest inventions of the nineteenth century.

Binders, Figs. 8, 9 *and* 10, *Plate* 3.—This is essentially a place-changing machine; it cuts the grain, binds it in compact sheaves and delivers the sheaves, but it in no way alters the form or condition of the grain itself. To do this there are six distinct operations, namely, reeling, cutting, elevating, packing, tying and discharging. The mechanism for each of the first four operations forms a complete machine in itself which can be worked independently, and those in which adjustment is necessary for varying conditions, are separately controlled by the operator, while the last two operations are worked together. The reel holds the grain against the knife until it is cut, then lays it on the moving platform canvas which carries it to the foot of the elevators. Here it is carried upward between two canvases to the top and on to the slanting binder-deck under which the packers work. It is then packed tightly against the binding cord until the required size of bundle is obtained, when a trip is pressed releasing a catch, which, in turn, throws the tying mechanism into gear. The needle arm rises through the deck, carrying the twine which completes the circle of the sheaf, a quick knot is tied, the twine cut, the needle quickly returns to its position below the deck, and the bundle is discharged on the ground or on a carrier at the will of the operator.

The entire mechanism is driven from a high and broad-rimmed steel wheel whose motion is communicated to the main gear shaft through a large sprocket-wheel and a powerful endless chain, Fig. 8. On this shaft is located the arrangement for throwing the machine in and out of gear, controlled by a lever within convenient reach of the driver when on his seat. From the main gear shaft the motion is communicated throughout the machine by means of chain and spur-wheel gearing. The main weight of the machine is supported by the driving-wheel, and the lesser weight by a steel grain-wheel at the outer end of the platform. At each end of the platform there is a divider extending about two feet in front of the knife. The outside divider separates the grain to be cut from the standing grain, supports it above the grain wheel, and lays it evenly on the platform. It is set at a slight outward angle to gather in a sufficient quantity beyond the end of the platform to provide a clear track for the grain wheel.

The crank-shaft is driven directly from the main gear shaft by a bevel wheel and pinion. This drives the knife through a wooden connecting-rod as on the mower. At the rear end of the crank-shaft is the sprocket-wheel for driving the long main-chain which passes over several wheels, driving directly the platform canvas, the lower elevator canvas, and the packers, also a shaft or roller which drives the upper elevator canvas through a chain or wheel gearing at the front. This elevator must be driven from the front as it is narrower than the lower to allow the heads of long grain to pass up clear of the canvases. The lower elevator is driven from its top roller and this in turn drives, through two or three pinions, a free roller, inserted in the space between the top of the elevators and the binder-deck to carry the grain across this space without danger of its falling through on to the main wheel. Each canvas is driven from one large roller, the other rollers being smaller and free running. The rollers are of wood with steel spindles inserted at the ends; they are pinned through in two or three places in different directions to avoid possibility of splitting, and they revolve in close-fitting malleable collars which prevent grain becoming twisted about the ends and blocking the action of the machine. The canvas aprons are provided with cross slats at intervals to hold the grain straight and prevent it from slipping.

A difference in the method of driving the upper elevator canvas in two of the machines may be explained here. In the Massey-Harris it is driven from the top, making the side next the grain the tight side, and in the Frost and Wood from the bottom, making this the loose side. At first sight this might appear to have different effects upon the grain, but the construction of other parts counterbalances this difference and makes the result the same. On the machine, Fig. 9, a third roller is introduced into the elevator to make the upper ply of the canvas run at an angle, leaving a considerable space between the two plies. The slope of the elevator not being very steep, a tight grip on the grain is not necessary in dealing with ordinary crops. The grain is carried up on the tight side of the lower elevator canvas, and is simply held in place by the loose ply of the upper canvas. But when the crop is extra heavy, the larger amount of grain deflects this loose ply upwards to get more space, thereby making the tighter grip that is necessary for the extra weight. On Fig. 10, on the other hand, the slope is steep and a tighter grip is necessary, which is obtained by driving the canvas so that the grain side is the tighter. To provide for extra heavy grain, the upper elevator is made to float, that is, the supports of the rear end are set in slots in a fixed frame, allowing the entire elevator to yield with the pressure of the larger quantity of grain. The purpose of these devices is to give the machines capacity for handling the heaviest crops without becoming choked.

From the front of one of the driving-rollers the reel is operated by a gearing so constructed that it allows great freedom of reel adjustment. On the Massey-Harris, the Noxon and the Maxwell binders this is accomplished by a bevel wheel and pinion, with bearings on the reel frame, the power being communicated from below through a square shaft which slides through the pinion as the reel is shifted. On the Frost and Wood the power is obtained from the top through a square shaft fitted with a sliding sleeve, and with universal joints at both ends, and the driving mechanism of the reel is operated through two chains, one for each of the two sections of the reel, which are independently adjustable. A vibratory motion is also communicated through one of the rollers to a reciprocating butter, which evens the butts of the grain and brings it down on the binder deck to within reach of the packers. There are two or three rapidly and continuously moving packers which force the grain tightly against the twine and a compress hook, until the proper amount for the size of bundle desired has been packed, when the pressure on a trip throws the binding mechanism in gear, it being driven from the packer shaft, generally by a chain, but in some by a bevel gearing, and in others by a combination of chain and spur gearing. All three of these methods are illustrated on the binders in the Canadian Exhibit.

Knotters.—These are different in detail in all the binders shown on Plate 4, but each consists essentially of a disc keyed to the knotter shaft working the movable parts either by cams or spur teeth, a notched disc or ring to hold the twine, a gripper or hook, a knife, and a stripping hook to remove the knot from the gripper when tied. One end of the twine is always held by the twine-holder tightly wedged between it and a short sleeve, and as the needle returns to its place, the twine is drawn through the eye from the twine can, and against this the grain is packed. When the knotting mechanism is set in operation the curved needle-arm rises, completing the circle around the bundle and carrying the twine beyond the holder, lays it across the top of the gripper and into one of the notches on the holder. There are now two strands across the tying hook, which is given one quick revolution by the teeth on the disc, and in doing so a roller working along a cam has raised and closed the top of the gripper, tightly gripping the double strand and holding it while the twine is cut, and as the stripping hook removes the loop from the gripper, the ends are held and are drawn through the loop, thus completing the knot. The delivery arms attached to the revolving shaft now discharge the bundle and the needle returns to its place. While the bundle is being bound and delivered the grain brought up by the elevators is held back by the long curved needle-arm to prevent its becoming mixed with the knotter, and to permit of a clean separation of the bundles.

The bundles, or sheaves, may be delivered on to the ground or a sheaf carrier. The carrier is attached to the frame and is operated by a foot lever under control of the driver. It will carry as many as six sheaves, which are laid down at one place, thus saving much labour in gathering and stacking.

On all the binders, with the exception of the Frost and Wood, Fig. 13, the knotter driving shaft is in the centre of the driving-wheel. On this, however, an eccentric lever wheel is used. When the bundle is being compressed and tied the chain draws on the long spokes, and when being delivered, it draws on the short spokes. The object of this arrangement is to obtain a greater power for compression, making a tight bundle, and for tying, thus making a more uniform draught by relieving the horses of the sudden and intermittent strains caused by the binding operation, and to give a quicker delivery of the bundle and return of the needle.

Adjustments.—A number of parts are capable of adjustment to meet the varying conditions of crops, land and weather, nearly all the adjustments being made by levers within convenient reach of the operator, and while the machine is in motion. The reel has a wide range of adjustment up and down, forward and back, by means of a hand and a foot lever, to enable it to pick up long, short, or tangled grain, and lay it evenly against the knife and on the platform canvas. It is balanced by a spring, making it easy to operate and permitting it to pass an obstruction without breakage. The tilt of the machine is regulated by another lever, to provide for cutting within an inch of the ground which is necessary when the grain is much beaten down. To ensure the twine being tied about the centre of the bundle, whether the grain is long or short, the entire packing and binding mechanism may be shifted, the square packer-driving shaft sliding through the centre of the driving sprocket. Other adjustments, not made from the driver's seat, are, regulating the size of the bundle for damp or dry grain, done by altering the position of the compress hook regulating the tightness of the twine about the sheaf; and raising and lowering the entire machine, by a crank and worm-gear working a spur pinion along an enclosed rack.

Local conditions are all provided for. The three conditions which are so different from those of Canada as to require special construction are, the value of the straw, the dampness of the climate, and the narrow gates in common use. The value of straw requires that the machine be made with an entirely open rear to allow any length of grain to be handled, while in America the rear of the machine is closed, and the height is regulated by the raise and lower gear to cut a length of straw that will easily pass up the elevators within the space between the closed ends. The Canadian grain is, as a rule, dry, but in Great Britain it is so damp that it soon soaks the platform canvas, causing it to shrink, and when it dries again, the canvas expands. In order, therefore, to keep it always tight, springs are provided in the platform, which contract when the canvas shrinks and force the rollers outward again when it dries, thus keeping it always just tight enough to work perfectly. In Western Canada there are no gates at all, and in Eastern Canada the gates are wide, but in Great Britain the gates are too narrow to allow the projecting points of the dividers to pass through easily when the machine is mounted sideways on the transport truck. To provide for this the dividers are made to fold, reducing the width of the machine by about two feet.

Bearings.—The application of roller and ball bearings to agricultural machinery, Plate 5, has resulted in so reducing the draught that two light horses can now easily draw machines formerly requiring three or four horses, and at the same time they have materially lengthened the life of the machines by reducing friction on the wearing parts. In all the Canadian mowers and binders shown in the exhibit, roller and ball bearings are used. The proper application of these bearings has been a problem that has taken years of experimenting to solve. At first they were used on the binder only for the bearings of the main driving-wheel, then they were put in a small grain-wheel and the main gear-shaft, and latterly they have been applied to the crank-shaft and to the bearings of the apron rollers. After a certain amount of experience it has been found that on the crank-shaft they can be applied only at the gear end. At the connecting-rod end, the constant jarring caused by the rapid vibratory motion of the knife renders them impracticable, as the strongest cage is soon shaken to pieces, so at this place a renewable brass wearing bushing is used. Their use on the apron rollers has not proved a success, as the extremely small cages and rollers necessitated soon become clogged with oil and dust, so in a majority of the machines self-aligning metal bearings are used. The roller bearings are made of hardened steel rollers of $\frac{3}{8}$ to $\frac{5}{8}$-inch diameter, so set in a malleable iron cage that they are free to turn with little or no friction on the ends of the cage, and at the same time will not come out of place when the cage is removed for cleaning.

On the mower, rollers are used for the bearings of the drive-wheels and the intermediate gearing, and renewable brass bushings on the cross-shaft.

Ball bearings are used to take up the end thrust on shafts due to the bevel gear. On some of the machines provision is also made for taking up the wear in the bevel wheels, thus keeping them always in perfect mesh, and allowing the machine to work as evenly after years of use as when new.

The use of steel for the framework and platform of the binder is now universal. Formerly the platform was made of wood, some of the braces of wood, and some of iron, giving the machine a heavy and cumbersome appearance. With the reduced price of steel caused by the erection of a number of steel works in Canada, its use has been largely extended by all manufacturers. Now the platform is made of sheet steel rolled perfectly level, and braced beneath by diagonal and cross braces of angle steel. This gives the platform extra strength and rigidity combined with lightness. The main frame of the machine, the braces and shafting are all of steel; the sprocket wheels and the working parts on which there is not much strain are of malleable iron, and the bearings of the main gear-shaft are of cast iron, as is also the frame of the binding mechanism attachment, to keep the shafting in permanent alignment.

Reaper.—On farms where the crop is not of sufficient acreage to warrant the purchase of a binder, the reaper is used. The self-delivery reaper has a gearing driven from the main wheel, which operates four or five rake-arms over a quadrant-shaped platform. These lay the grain against the knife, carry it across the platform, and deliver it in even-sized gavels, ready for tying by hand. The adjustment of the rake-arms will allow every rake to deliver, as is done when the crop is heavy, or only the second, third, fourth or fifth, according to the crop, or all the rakes can be thrown out of gear.

The manual delivery reaper is a combination of the ordinary mower and a reaping attachment. This attachment consists of a tilting platform, pivoted to a cutter-bar, and the necessary guards, extension dividers, supporting wheels for the inside and outside shoes, and an extra seat for the second operator, who lays the grain against the knife by a long-handled rake, and tilts the platform with his foot to allow the cut grain to pass off it.

In all varieties of farm machinery the manufacturer must have his machine—Firstly, strong enough and of sufficient capacity to successfully handle the most difficult conditions to be met with in the class of work for which it is intended; Secondly, as light as possible without imparing its strength and of the lightest possible draught; Thirdly, simple in construction and easy in operation. Agricultural implements are not, as a rule, operated by expert mechanical men, so there must be no complicated mechanisms, and all adjusting levers must be easily worked and convenient to the driver.

Fourthly, reasonable in cost. Although the best of material must be used in the construction, the fitting of the parts, the running of all gears, and the adjustments must be perfect, and the methods of construction must be of such a nature as to produce the machinery at a price within the reach of the farmers of all countries.

Canadian manufacturers have met these and other requisites by the use in their factories of the most ingenious labour-saving machinery, much of which is made for agricultural implement works alone, and by systems of shop practice that concentrate and specialise the different classes of work, with the result that they are able to place their goods on the markets of the world at a reasonable price, and with the certain knowledge that the machine in every part, as well as in its entirety, is perfect, that as soon as the several pieces, in which it is shipped from the factory, are put together, it will work, and successfully meet all reasonable conditions, and the many abuses, that are imposed upon it.

CANADIAN AGRICULTURAL MACHINERY.

Sowers.

Fig. 1. *Hoe Drill.*

Detail of Feed from Seed-box into the Tubes.

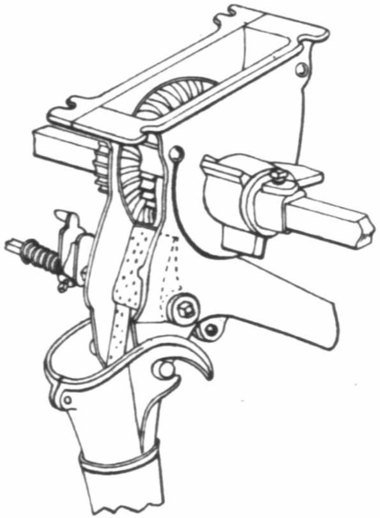


Fig. 2. *Arrangement for Regulating the Flow of Seed, and Dial for Indicating Number of Acres Sown.*

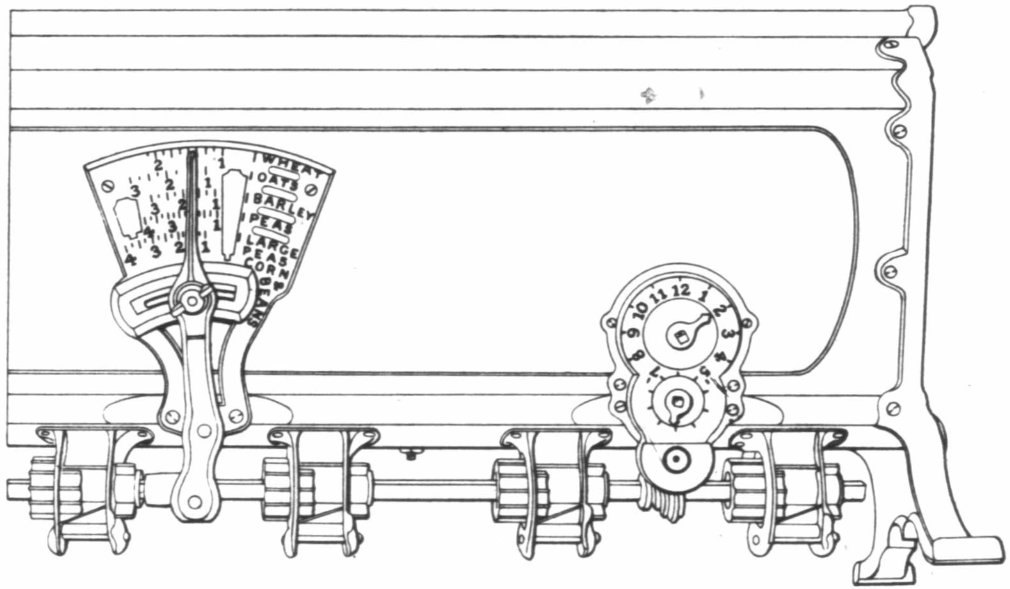


Plate 1.

Plate 2.

CANADIAN AGRICULTURAL MACHINERY.

Fig. 2

CANADIAN AGRICULTURAL MACHINERY.

Mowers.

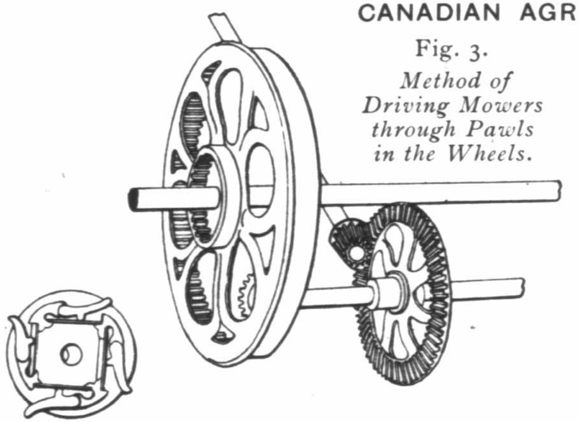


Fig. 3.
Method of Driving Mowers through Pawls in the Wheels.

Two leading methods of attaching the Connecting-rod to the Knife.

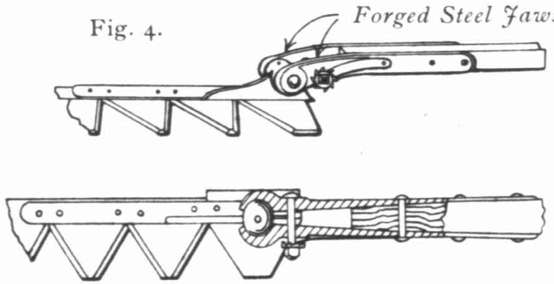


Fig. 4.

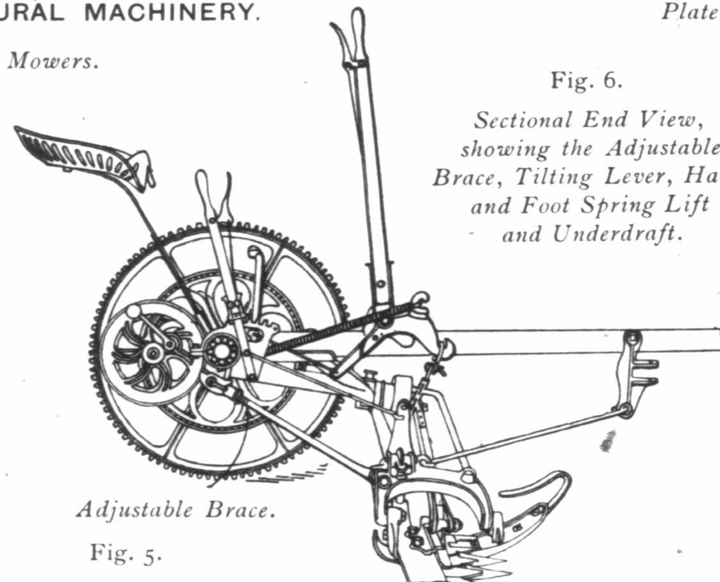
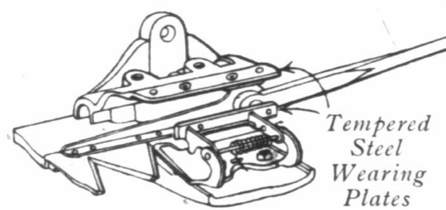


Fig. 6.
Sectional End View, showing the Adjustable Brace, Tilting Lever, Hand and Foot Spring Lift and Underdraft.

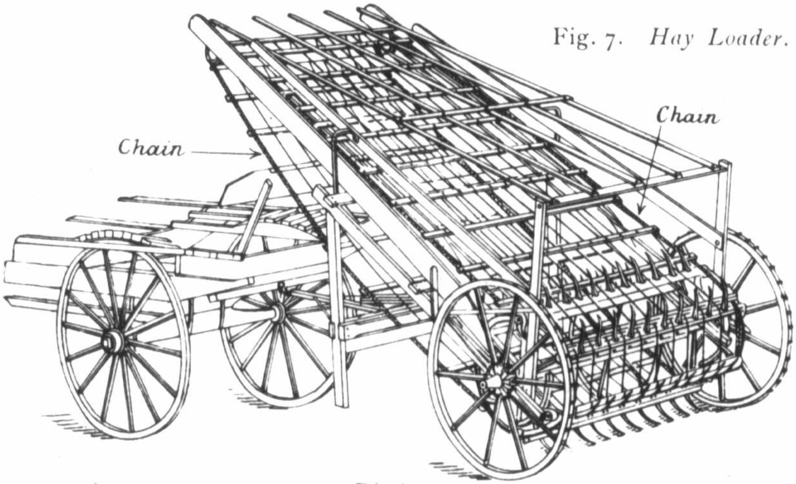


Adjustable Brace.
Fig. 5.

Fi
L
fro
a

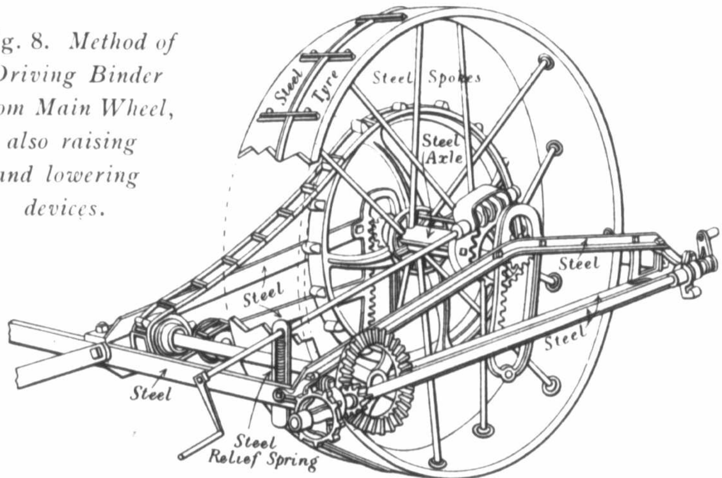
Platfor

Fig. 7. *Hay Loader.*



Binders.

Fig. 8. *Method of Driving Binder from Main Wheel, also raising and lowering devices.*



Arrangement for Elevating Heavy and Tangled Grain.

Allowing for expansion of space between elevators with a constant tight hold on the grain.

Fig. 9.

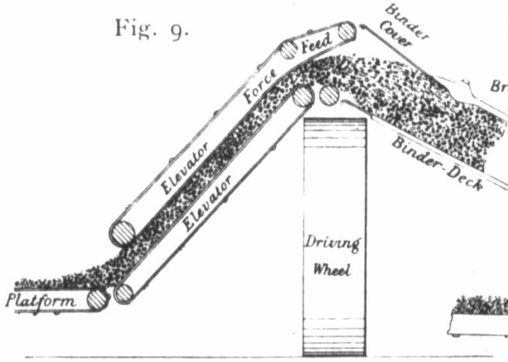
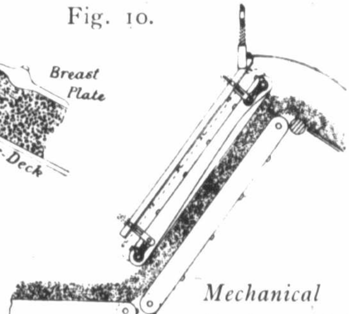


Fig. 10.



Mechanical Engineers 1901.

Fig

Fi

CANADIAN AGRICULTURAL MACHINERY. *Plate 4.*

Knotting Mechanisms.

Fig. 11. *Massey-Harris.*

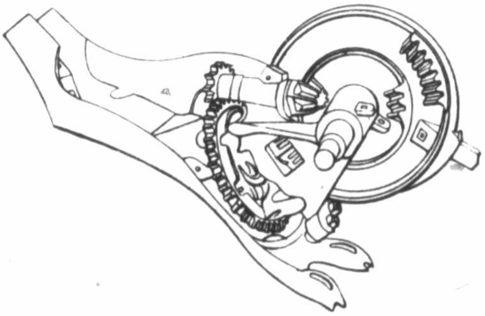


Fig. 12. *Frost and Wood.*

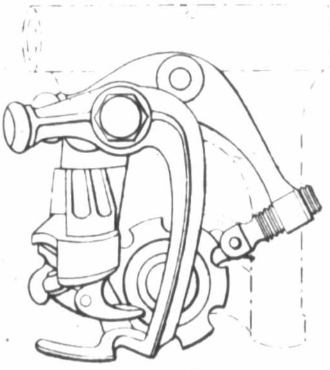


Fig. 13. *Frost and Wood.*

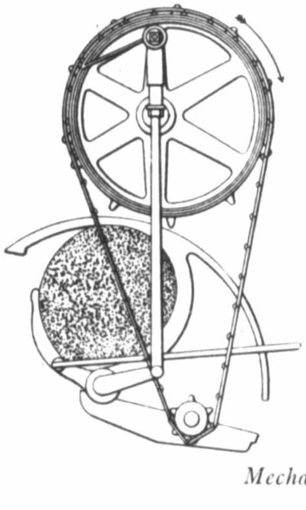
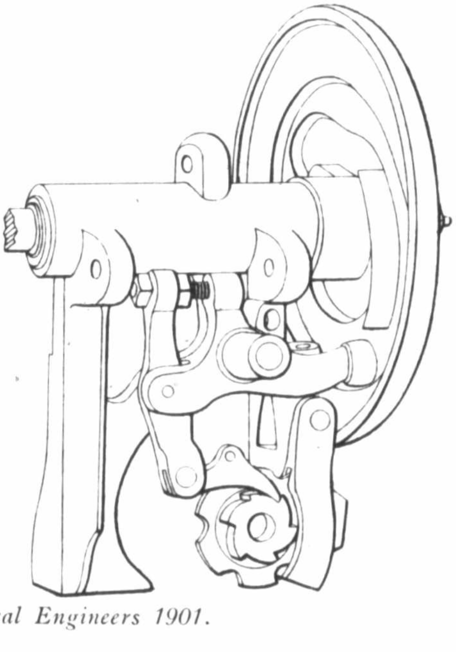


Fig. 14. *Maxwell.*



A

CANADIAN AGRICULTURAL MACHINERY. *Plate 5.*

Application of Roller and Ball Bearings in various Machines.

Fig. 15. *Mower.*

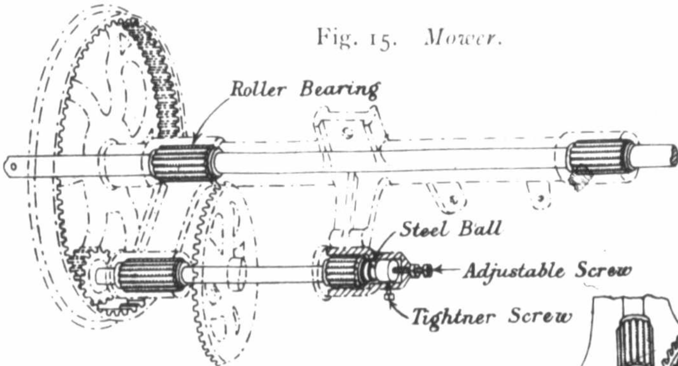


Fig. 16. *Mower.*

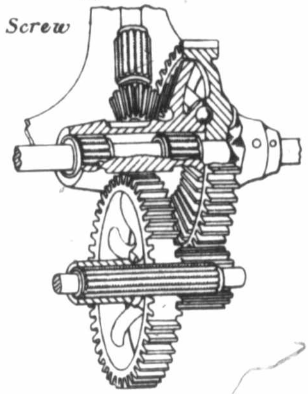


Fig. 17. *Binder.*

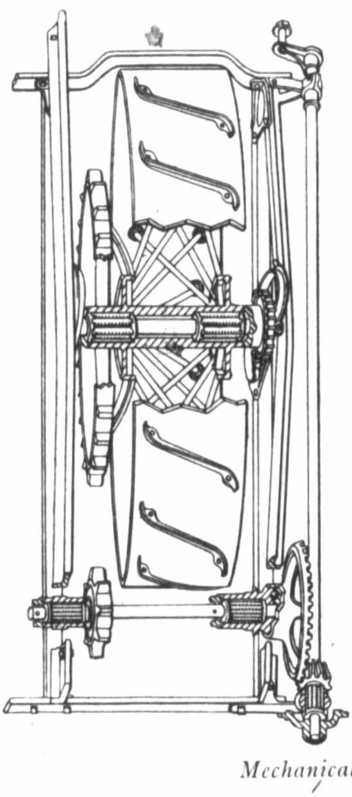
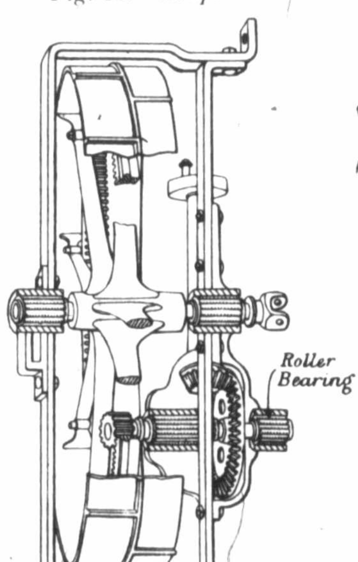


Fig. 18. *Reaper.*



Mechanical Engineers 1901.