

IMPROVED DESIGN OF SMALL ENGINE-OPERATED
RICE THRESHER

by 1264

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INTRODUCTION

Grain at harvest time has a maximum potential of quality and quantity. Its handling and treatment during and after harvest should preserve that maximum potential. The present practices of threshing and separating, adopted in India, cause losses of grain higher than 25 per cent (11). Besides, men and animals used in producing a crop consume it as a fuel leaving nothing to exchange with the non-food producers (17). The wages of one man-day being 3 to 10 kgs of paddy is equal to the production of an agricultural laborer per day. Forty-three per cent of the food produced in India is rice (3.10 crore tons of rice out of 7.23 crore tons of total food grains) (15). Saving of the losses during the harvest and post-harvest operations of paddy alone may completely dispense with the import problem of food in the country.

Farmers in Andhra Pradesh State, India, grow two to three crops of paddy in a year (29) and have hardly three to four weeks time in between to attend to the crop operations as well as land preparations. Bullock power cost, Re. 0.865 per H.P. Hr. is high as compared to Re. 0.20 per H.P. Hr. (electrical) and Re. 0.50 per H.P. Hr. (tractor) (5). Labor wages are increasing by 6 to 7 per cent every year (29). Employment in factories and industries is also increasing by 4 per cent a year in Andhra Pradesh State (15). Besides, greater returns are received from the high yielding varieties and multiple cropping program recently introduced by the Government.

Compared to local varieties, two to three times greater force is required to separate the grain from high yielding varieties of paddy. These factors are inducing the farmers to grow more and more eager to take to mechanical appliances on the farm. Quick operations of threshing by mechanical means help to save grain losses, alleviate the problem of timely operations, and also make full use of the small amount of power, such as oil engines, gas engines, etc., already available with the farmers (15).

Though some successful work has been done in developing a thresher for wheat and small grains in India, no significant work has been done to develop a paddy thresher. Experience has also indicated that the conventional threshers are large and precision built requiring accurate adjustments. Besides being bulky and expensive they need special skills and experience for operation and maintenance, which is lacking today. Small pedal-operated threshers did not compare favorably with hand threshing (24,26). Improved designs of the existing animal operated olphad thresher for wheat proved to require more draft on animals besides being uneconomical (27). A medium-sized thresher operated by a 5 hp engine may, therefore, be of considerable use to the farmer.

OBJECTIVE

The object of this report is to prepare plans for an improved design of a rice thresher over the double-drum thresher already developed (2) at the Agricultural Research Institute,

A. P. Agricultural University, Rajendranagar, Hyderabad, India. It is intended to separate the ear heads from sheaves, grain from heads, chaff and other foreign materials from the grain, and elevate the clean grain to a suitable height for delivering into a sack. This would completely dispense with cattle power and relieve the actions of human muscles involved in the mechanics of present-day threshing by hand. Present methods involve holding a bundle of crop at butt-end by hand, beating the heads against an object, winnowing the mixture of grain and chaff, and then collecting the grain for sacking.

It is desired that the thresher mechanism and accessories not be complicated in order that it can be operated, maintained, and cared for by the skills at hand. Its construction must be sturdy and must be such that it can be transported easily in a bullock cart from place to place.

REVIEW OF LITERATURE

The conventional thresher of the West is designed to perform three essential operations, namely, threshing (detaching the grain from the sheaves), separating (separating the grain from straw), and cleaning the grain (cleaning from chaff, dust, foreign material, etc.). The early threshers were driven by two and four horses in the early stages, by steam engines, electrical power, and later by tractors. They were modified to handle a variety of crops. Threshing of grains has gone through much evolution during the past century, and yet the basic principles employed in threshing remained the same.

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without much significant changes except variations in designs to suit different conditions. The present-day combine embraces harvesting of the crop in the field in addition to performing the three essential operations of threshing. Most stationary threshers are large in size and the whole crop passes through them for processing. In contrast, the Japanese threshers are designed for compactness and in some of them only ear heads are fed for threshing without allowing the whole plant to go through the machine (23).

Present day threshers operate in the following manner:

Feeding of unthreshed grain with straw is done evenly and uniformly to the threshing cylinder with the help of a self-feeder (10).

Threshing in the conventional threshers is done either by impact or by impact and rubbing action. The threshing effect of the cylinder depends on the speed of the cylinder, the number of concaves, and the clearance between the concaves and the cylinder. Rasp bar type threshers which have corrugated bars to rub the grain over a corrugated concave do not break the straw to the same extent as the toothed cylinder (6,9,10).

Separation of Straw. Most of the grain (nearly 90%) passes through the grate placed directly below and back of the cylinder. The rest of the grain mixed with straw and chaff passes over the straw rack which is constantly agitated, stirred, etc., to cause the grain to drop through onto the grain pan. The long straw is moved to the rear and over the straw racks. From the grain pan, the grain is conveyed to the

shoe for cleaning, whereas the chaffer carries the unthreshed ears or heads into the tailings auger trough (6,9,10) for returning them back to the cylinder for re-threshing.

Grain Cleaning. The top sieve in the cleaning shoe removes the chaff and the bottom sieve the weed seeds and other small particles. The kernels pass over the lower sieve and reach the grain auger for elevating and delivering into sacks. While dropping between the sieves, blasts of air from a fan blows off the chaff, dust, etc. (6,9,10), and the grain which is elevated and delivered is ready for marketing.

Straw Stacking. Wind stackers have replaced the straw carriers with endless conveyors, either direct or swinging. Operation of the former costs less than the latter because of its adaptability and less labor requirements (9,10).

Research, Development and Testing

Lamp and Buchele (22) conducted experimental research for complete threshing (100% removal of the kernel from the glume) for five varieties of wheat, making use of centrifugal force. They investigated threshing properties under different kernel and moisture conditions. They found that wheat could be threshed at any mature kernel moisture (40% and below) without any crackage to kernels; a force of 0.3 lb. would thresh 98 per cent or more of the mature grain independent of the method of holding, and a force of 0.2 lb. would thresh 98 per cent of the grain under all typical harvesting conditions; the processes of threshing and separating could be integrated dispensing with

the need for special straw separating equipment; kernel germination may not be affected if threshed under proper conditions without applying high force; and a reduction of up to 50 per cent in threshing force occurred where the force was applied such that it bent the rachilla.

Lalor and Buchele (20,21) developed a threshing cone (constructed of perforated sheet metal and a rubber-coated angle bar rotor) to find out the possibilities of dispensing with the straw rack in the combine and increasing threshing and separation efficiency. The crop moves axially from the small end of the cone to the large end. A special device regulates the time which the crop is subjected to threshing and separating forces. The threshing efficiency was found to be above 99 per cent for all rotor speeds, ranging from 300 to 500 rpm. Clogging was a factor at low speeds of 300 to 350 rpm of the rotor. Separating efficiency of the threshing cone remained between 68 and 77 per cent without any improvement over that which is obtained in a conventional thresher. Further, as rotor speed increased, the separating efficiency was lowered.

Buchanan and Johnson (7) used a one-half inch perforated sheet metal horizontal cone, keeping the cone angle at 30° and maximum diameter of the cone at 33 inches, and conducted tests with wheat. Preliminary tests of the thresher indicated that air movement was a major factor which influenced crop motion and that the dwell time was too short to allow angular velocities approaching that of the cone. An inner cone of sheet metal with three-inch clearance from the outer cone and having

three rubber paddles all driven by a variable-speed drive was added. The threshing efficiency was then found to be more than 90 per cent for outer-cone speeds above 1050 rpm when run at 90 to 95 per cent inner-cone speed ratio. It appears that this high threshing efficiency is due to the rubbing effect of the paddles provided on the inner cone, which means that threshing would have been obtained mainly by forces other than centrifugal forces. Hamdy et al. (13) evaluated that when the crop is rotated in the inner cone, at the 90 per cent speed of the outer cone, it would have been subjected to a maximum centrifugal acceleration of 417 g's (0.035 lb. threshing force), and at this force threshing efficiency would have been less than 20 per cent according to Lamp and Buchele (22). Studies made by Hamdy et al. (13) neglecting air drag on the particle and assuming a constant coefficient of surface resistance, indicate that some vertical generalized rotors are theoretically capable of subjecting particles sliding inside them to centrifugal accelerations of the same order as that necessary to thresh wheat under typical harvesting conditions. However, technological problems, such as strength and vibration, arising from inherent unbalance in a continuous flow machine, would be very critical and could set a limit on the development of centrifugal threshers.

Strohman et al. (30) have developed a new technique for harvesting standing grain. Heads and a section of stalk immediately below are fed into the space between the cylinder and concave without severing the plant from the surface as the

machine is moved forward. The motion of the heads thus pulled down is opposed to that of the beaters and hence, removal of kernels starts at the base of the head. The threshed grain is deflected into two grain pans as the grain leaves the rotor. Baffles were provided to follow above the bent straw and prevent loss of grain. Three tests were conducted on rice which was reasonably erect and three on lodged rice. In the latter case, a pitch fork provided for simulating the action of pickup reel reduced the average feeder loss of 42 per cent to 1.9 per cent. The grain harvested by this machine did not experience cracks, hulling, and loss of germination quality, regardless of rotor speed. Best results were obtained with a rotor speed of 460 rpm for Northrose rice and 368 rpm for Nova rice. Negligible kernel damage, insignificant total losses, minimum straw damage and low power requirements are the features of the standing grain harvester. While threshing up to 10 bushels (600 lbs.) of rice per hour, less than one-fourth hp was found adequate to drive the rotor.

After evaluating machine and method efficiencies in combining wheat, Johnson (16) concluded that the higher the moisture content, the higher the cylinder losses, and the lower the shoe losses. Rack loss was lowest between 13 and 19 per cent of straw moisture, and the highest machine efficiency occurred between 15 and 20 per cent grain moisture. Combining was recommended at 20 per cent and below and not less than 15 per cent grain moisture in order to maintain higher test weight, germination, and storability. However, the effect of shatter

and cutter bar losses tended to shift the most desirable stage of harvest toward higher moisture contents from 17 to 22 per cent grain moisture. When moisture content was high, unthreshed grain, i.e., cylinder loss, was high in the cylinder for any one cylinder-concave clearance (Fig. 1). It might be possible to lower this loss to 1 per cent and below, either with high cylinder speed or with closer cylinder-concave clearance.

Chalmers and Billington (8) used a rasp bar drum 18 inches in diameter, with 24-inch width, and a concave with a lap of 152° of the drum and built a small thresher without the use of straw walkers. The 152° lap of the drum provided more threshing area than normal. The mixture of grain and chaff from the concave was deflected directly on to the sieve which is run at 240 oscillations per minute. In this machine, cleaning of grain other than removal of pieces of broken straw was not involved.

The effects of different cylinder speeds and moisture contents on visible and invisible damages as indicated by germination of the visibly-undamaged seed on wheat and peas were investigated by King and Riddols (19). The crop was harvested, brought to different moisture conditions in a special chamber, and then threshed with a combine harvester (header-harvester). Over the range of moisture contents from 12 to 26 per cent and cylinder speeds from 600 to 1,400 rpm, an increase of cylinder speed increased visible loss, loss in germination, and hence an increase in the wastage. At low

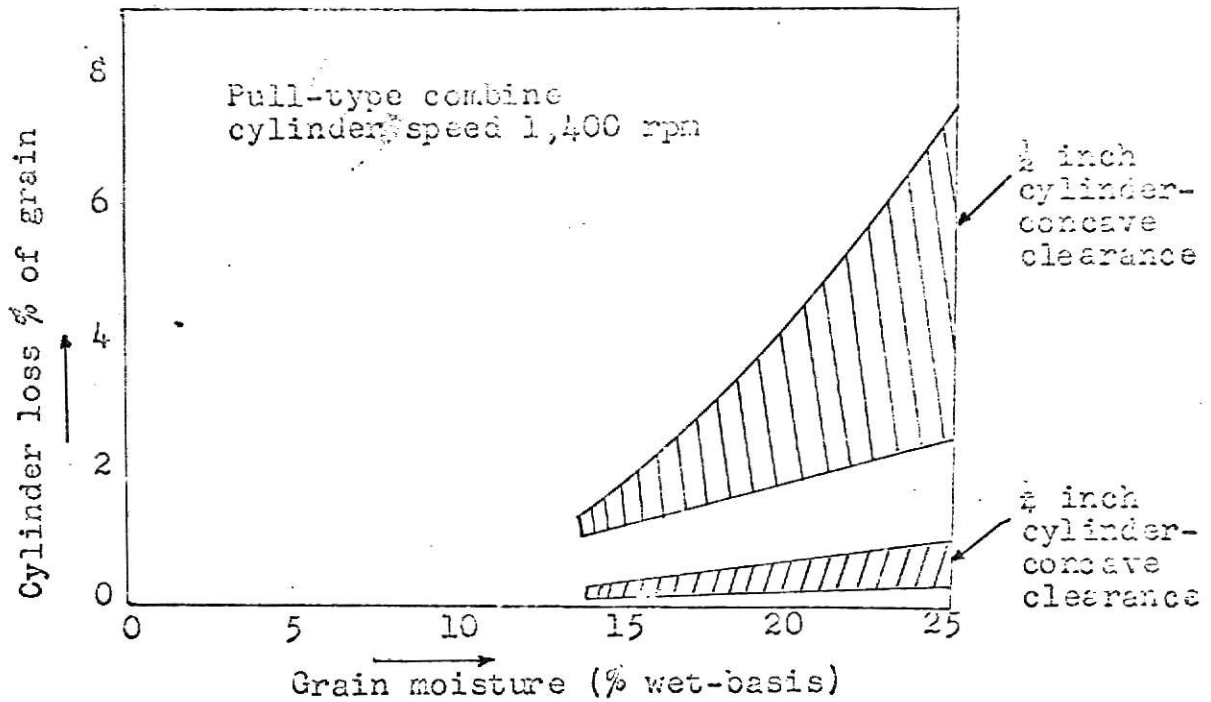


Fig. 1. Influence of grain-moisture content on cylinder loss during the grain maturation period (22).

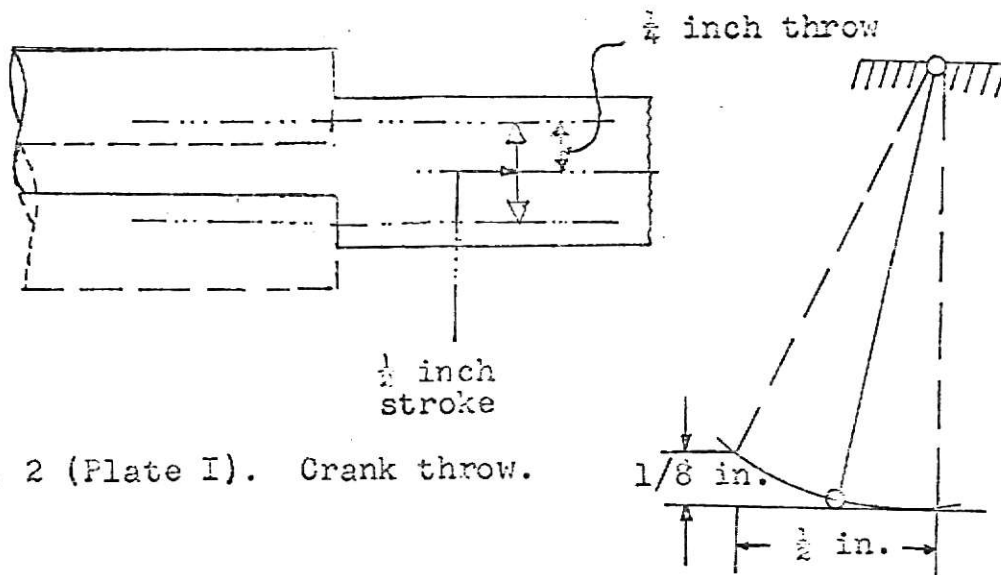


Fig. 2 (Plate I). Crank throw.

Fig. 3 (Plate II). Sieve travel.

($\frac{1}{2}$ in. horizontal and
 $\frac{1}{8}$ in. vertical travel)

moisture contents, wastage was lower. Above about 21 per cent moisture content, as cylinder speed increased, germination of visibly-undamaged seed decreased, increasing the wastage. Below about 16 per cent moisture content, visible damage and wastage tended to increase.

A survey of grain damage with reference to cylinder settings was conducted for wheat and barley by Arnold and Jones (3) during 1960 and 1961, by taking samples from combine-harvesters working on commercial holdings in England. The moisture content of the grain was determined immediately after threshing and the grain dried before subjecting them to sand and acid germination tests and assessing the broken grain percentage. The concave clearances measured on 44 machines varied from one-sixteenth to three-fourths inch. The moisture contents varied from 16.1 to 31.8 per cent in case of wheat and 12.3 to 21.9 per cent in case of barley, and cylinder peripheral speeds were from 4,335 to 6,447 fpm in case of the former and 4,350 to 6,594 fpm in case of the latter. Speeds were not varied to suit the moisture content. The moisture content of grain at time of threshing and the cylinder setting were found to be the most important factors that controlled the damage of seed.

Work Done in India

Adopting the principles of Japanese threshers, paddy threshers were developed at the Agricultural Implements and Power Development Center, Allahabad Agricultural Institute,

India. Four prototypes were built one after another with modifications and improvements as necessary. The final one (fourth one) was comparatively successful. Only the heads are presented for threshing by the cylinder without letting the entire crop pass through (25). At the same institute experiments were conducted on wheat with a rotary head thresher equipped with oscillating screen and aspirator for cleaning the grain with promising results (25).

A semi-automatic Japanese power thresher (Model ATA 45) was tested at the Department of Agricultural Engineering, I.I.T., Kharagpur, India, and the effects of cylinder speed on output, output per unit cost, etc., were evaluated by Sri Arya and Sri Trivedi (31). The cylinder concave clearance and blower setting were kept constant during the threshing operation. An increase in cylinder speed increased the recovery of grains per unit time up to 650 rpm and then decreased very abruptly with a further increase in speed. Similarly, the output of paddy per unit cost increased up to 650 rpm of cylinder speed and beyond that speed it dropped. In the case of grain loss, the lowest (2.64%) occurred at 550 rpm of speed. It was higher both below and above 550 rpm. Visible grain damage, however, increased with an increase in speed. Table 1 shows the results of these tests.

Friends' Thresher, developed for wheat by "Friends Own Foundry," Ludhiana, India (23), does not only threshing and cleaning of grain but also delivers acceptable quality of "bhusa" (broken straw). Threshing is done by revolving hammers

Table 1. Effect of cylinder speed on the output of paddy, output of paddy/unit cost, grain loss and grain damage (31).

Cylinder rpm.	Output kgs/hr.	Output/Unit cost kgs/re.	Total grain loss per cent	Visible grain damage per cent
365	24	24.60	3.84	----
440	30	-----	3.33	0.23
550	48	47.00	2.64	0.32
590	53	52.75	-----	-----
600	55	-----	-----	1.20
650	63	60.50	3.32	4.70
950	51	6.70	-----	23.05

Table 2. Effect of cylinder speed on the output of different varieties of paddy (2).

Cylinder rpm.	Variety of paddy (Output - kgs/hr.)		
	HR35*	HR19**	MTU15**
250	200	49	82
300	215	96	102
350	224	112	114
400	246	114	116
450	179	82	102

*Four men were employed to operate a 5 hp thresher.

**Two men were employed to operate a pedal thresher.

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inside a housing with grates at the bottom. Aspiration fans are used to suck up the broken straw and chaff. Screens are used to clean the grain which is delivered for sack. The threshing machine requires high power of 20 to 25 hp to run and has low output. An experimental threshing machine ("Fenzo" threshing machine) using the principles of conventional separating and cleaning, and indigenous parts for construction was developed at Budhni, India, by F. C. Fenton and H. Jones for wheat threshing (23). Threshing machines with twin cylinders operating at different speeds are being developed at present. Partial threshing is done at low speed in the first cylinder and complete threshing at a higher speed in the second cylinder. Less damage to grain and better separation at the grates result from using twin threshing machines for wheat (23).

Experiments conducted to develop a double-drum threshing machine at the Agril. Res. Institute, A.P.A.U., India (2), indicated that as the speed of the cylinder increased, the output increased up to certain speed and then declined with further increase of speed. Maximum recovery, irrespective of the variety of paddy used (HR35, HR19, and MTU15), was obtained in the speed range of 350 to 400 rpm of the cylinder as shown in Table on Page 13.

Methods of Threshing

Threshing of small grain can be accomplished by one of the three methods: mechanical methods such as rubbing or stripping; impact or impulsive acceleration received when the grain is threshed by a threshing machine.

head strikes a cylinder bar; and by centrifugal threshing, i.e., subjecting the ear head to non-impulse acceleration or suddenly accelerating the ear head by centrifugal force. The centrifugal threshing of grain using a cone is still in the experimental stages (7,13,20,21,22) whereas the mechanical and impact methods are universally adopted.

SELECTION OF THRESHER

Unlike wheat, paddy ear heads are composed of rachillas (side-heads) with grain all over. The grain cover or shell is relatively brittle and should not be cracked or shelled at the time of threshing in order to maintain grain quality for seed purpose as well as for storage, marketing, and consumption. The straw of local varieties of paddy, HR35, HR19, CC2, etc., is soft and hard to break but easy to bend. The length of ear heads varies from 0.8 to 1.0 ft. and that of straw from 4.80 to 5.50 ft., including ear heads. Passing the whole crop through the machine requires more power, more mechanisms, and more capital to possess the thresher. The power available is limited (5 hp engines). The general yields in rice growing areas vary from 1,500 to 2,500 lbs. of grain per acre. Local situations and experiences are such, as already pointed out in the introduction of this report, that a medium-sized thresher operated by a small engine would go a long way to help the economy of the farmers.

Mechanical methods of freeing grain are less severe. This is a necessary requisite for paddy grain. Therefore, choppers

with slicer-knives for cutting the sheaves on the feed platform, a rasp-bar cylinder rasp-bar concave mechanism for threshing the heads, a single fan to provide necessary air blast, a crank and connecting rod for imparting reciprocating motion to two sieves for separating the grain from chaff, dirt, weeds, etc., and a grain elevator to deliver the grain at a convenient height for sacking are the main features of the thresher selected for design in this report.

In predominantly rice-growing areas of India, 100 man-hours of work are required for threshing one hectare of paddy harvest. This requires five men for beating, three men for winnowing and cleaning using natural wind, and two men for sacking, etc., working for ten hours a day. It is desired to develop a stationary thresher requiring not more than 5 hp, with which three men can thresh three hectares in an eight-hour day.

DESCRIPTION OF THRESHER

The machine provides for threshing ear heads and recovering grain, separated from chaff, pieces of straw, etc. Second dressing and grading of the grain is not attempted. The head portion only is chopped off and fed into the threshing cylinder dispensing with the need for straw racks. Three men are required to operate the machine, two for feeding the bundles and one for sacking grain. The length of the cylinder is 30 inches and the width of the separating mechanism is 30 inches; hence, the size of the thresher is 30 x 30 inches. The threshing

capacity is estimated to be between 20 and 40 lbs. of grain/min.

The unit consists of a feed platform with a chopper on each side, a threshing mechanism, two sieves with a crank drive, a fan, and a grain elevator as shown on Plates I and II. Power is provided by a 5 hp diesel, kerosene or gasoline engine with a V-belt drive to the cylinder shaft. Power to operate the choppers, fan, sieve-crank, and cup elevator is taken off the cylinder shaft. The sheave diameters, shown on Plate I, are such that the fan will operate at 333 rpm, the sieve crank shaft at 300 rpm, and the choppers at 200 rpm when the cylinder is operated at 400 rpm. The elevator receives power through an intermediate set of V-sheaves and operates at 100 rpm. Other sheave diameters can be used to change component speeds for variable conditions. The grain is delivered to the side of the machine about 4.25 ft. above the ground level for sacking.

The stationary feed platform is about 34 inches above the ground level. The operators hold the butt ends of the bundles as they are fed into the chopper knives from either side of the platform. Once the ear heads are severed from the butt portion of the stem they fall by gravity into the threshing cylinder. The chopper guards encircle all except the front portion where the bundles are fed in to help prevent operator injury.

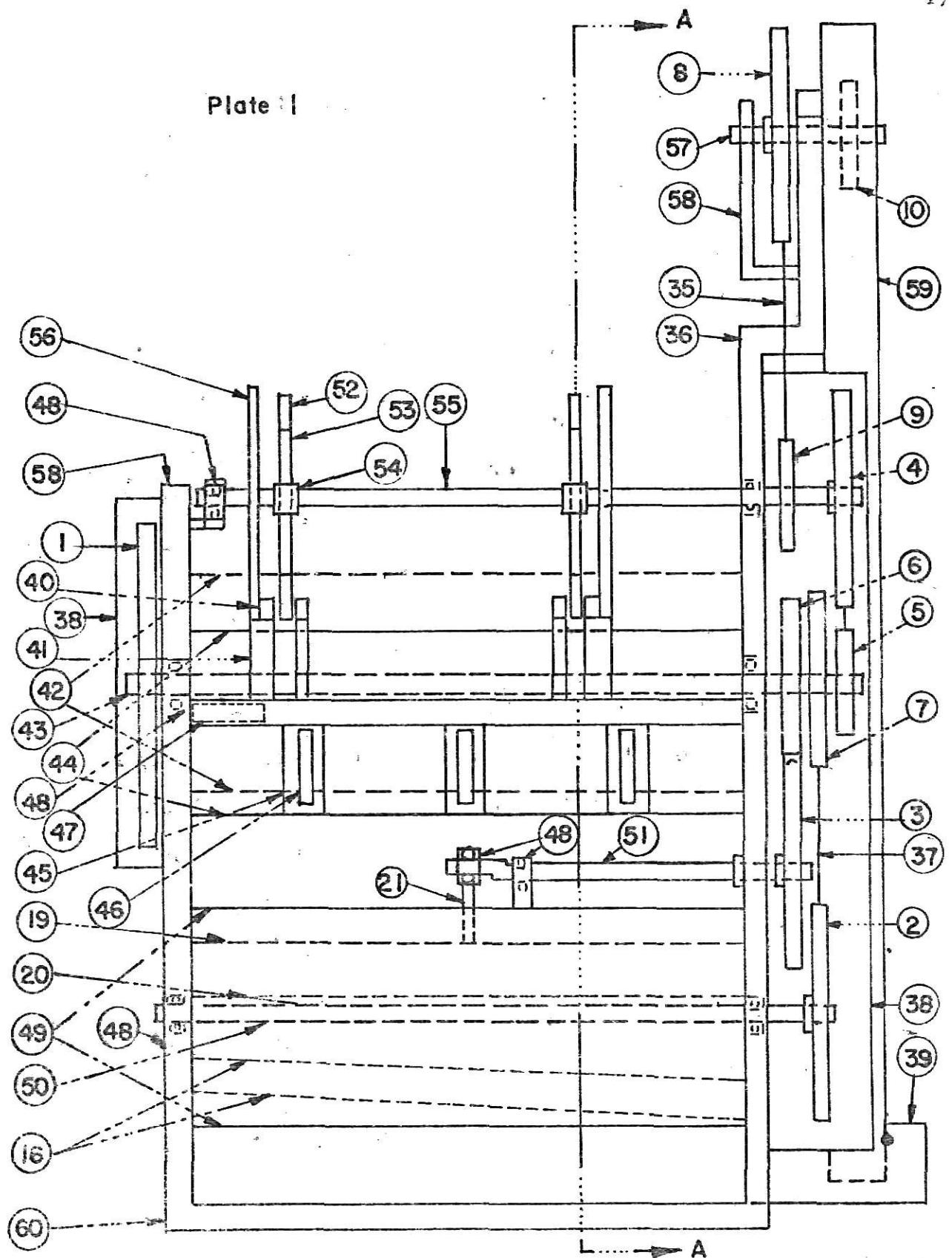
The ear heads are threshed by a rasp bar type cylinder. The cylinder is 12 inches in diameter and 30 inches long. It has six rasp bars and is mounted on a one-inch mild steel shaft. The ear heads are threshed between the cylinder and rasp type concave bars. The bottom portion of the concave is slotted for

EXPLANATION OF PLATE I

Front End View of the 5 hp Threshing Machine

- | | |
|---|----------------------------------|
| 1 - Cylinder sheave driven by a 5 hp engine | 41 - Shear plate bracket |
| 2 - Fan driven sheave | 42 - Threshing cylinder |
| 3 - Crank driven sheave | 43 - Cylinder shaft |
| 4 - Chopper driven sheave | 44 - Concave body |
| 5 - Driver sheave for chopper | 45 - Iron plate |
| 6 - Driver sheave for crank-shaft | 46 - Slot in item 45 |
| 7 - Driver sheave for fan | 47 - Spirit level on front frame |
| 8 - Head sprocket sheave | 48 - Ball bearing |
| 9 - Driver sheave for head sprocket | 49 - Fan housing |
| 10 - Head sprocket wheel | 50 - Fan shaft |
| 16 - Semicircular trough or spout | 51 - Sieve crank shaft |
| 19 - Top sieve | 52 - Slicer knives |
| 20 - Bottom sieve | 53 - Chopper plate |
| 21 - Connecting rod | 54 - Bushing |
| 35 - Cross V-belt drive | 55 - Chopper shaft |
| 36 - A Z-bracket | 56 - Chopper guard plate |
| 37 - Direct V-belt drive | 57 - Head sprocket shaft |
| 38 - Expanded metal shield | 58 - Angle iron L-bracket |
| 39 - Elevator boot | 59 - Elevator housing |
| 40 - Shear plate | 60 - Front angle iron frame |

Plate II



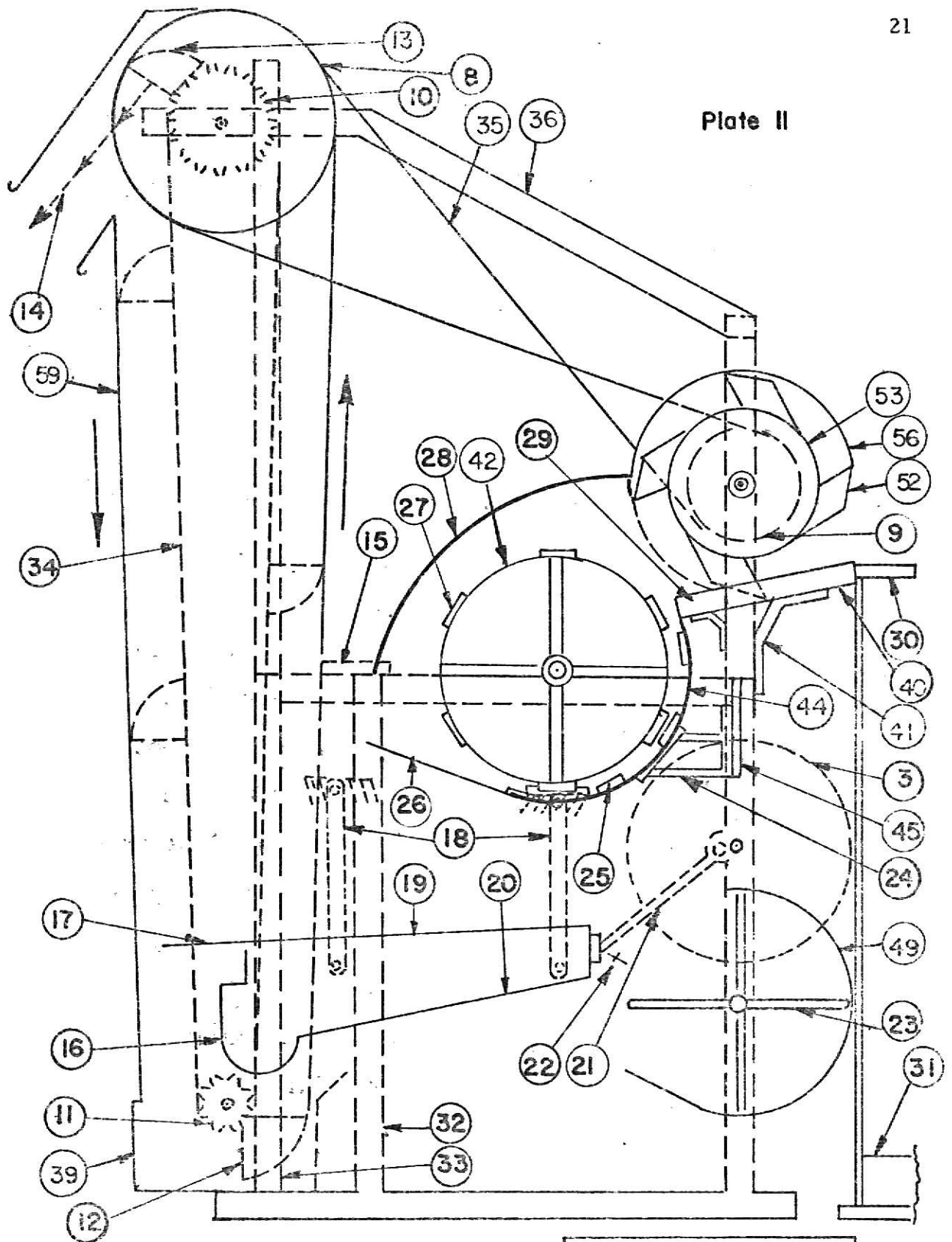
Front end view
 5 HP threshing machine
 Design: G. Ramana Reddi
 Drawn: G. Ramana Reddi
 Date: September 25, 1969.

EXPLANATION OF PLATE II

A Cross Section of the 5 hp Threshing Machine (Sectional View on A-A of Plate I)

- | | |
|-------------------------------------|----------------------------------|
| 3 - Crank driven sheave | 27 - Cylinder rasp bar |
| 8 - Head sprocket sheave | 28 - Cylinder cover |
| 9 - Driver sheave for head sprocket | 29 - Feed plate |
| 10 - Head sprocket wheel | 30 - Feed platform |
| 11 - Elevator bottom sprocket wheel | 31 - Bench for operator to stand |
| 12 - Cup filled with grain | 32 - Left side frame |
| 13 - Cup emptying grain | 33 - Right side frame |
| 14 - Fall of grain (into a sack) | 34 - Elevator drive chain |
| 15 - Spirit level on the side frame | 36 - A Z-bracket |
| 16 - Semicircular trough or spout | 39 - Elevator boot |
| 17 - Fingers | 40 - Shear plate |
| 18 - Sieve hangers | 41 - Shear plate bracket |
| 19 - Top sieve | 42 - Threshing cylinder |
| 20 - Bottom sieve | 44 - Concave body |
| 21 - Connecting rod | 45 - Iron plate |
| 22 - Fan deflector | 49 - Fan housing |
| 23 - Fan blade with its arm | 52 - Slicer knives |
| 24 - F-bracket | 53 - Chopper plate |
| 25 - Concave bar | 56 - Chopper guard plate |
| 26 - Grate | 59 - Elevator housing |

Plate II



Section on A-A of Plate I
 5 HP threshing machine.
 Design : G. Ramana Reddi
 Drawn : G. Ramana Reddi
 Date : September 25, 1969.

grain to fall through. Additional separation is accomplished by the one-fourth inch steel rod grate which extends from the rear of the concave. The rods of the grate are spaced one-half inch apart. They are hinged at the concave end. The outer end can be raised or lowered to adjust for different conditions.

The threshed mixture is deflected from the concave to the top of the sieve. The top sieve has $15/64$ inch round holes. The threshed grain with the chaff is subjected to the air blast from the fan as it falls from the grate and the lighter material is blown off to the rear end of the top sieve. Any unthreshed heads are shaken off the end of the top sieve where they can be gathered by hand and put back through the cylinder. Grain which falls through the top sieve onto the bottom sieve moves to the lower end where it falls into a sloping trough that delivers it to the cup elevator. The bottom sieve has $1/16$ inch round holes which remove small particles of cracked grain, small weed seeds, etc. The two sieves are vibrated as an integral unit by the sieve crank shaft. Some air is directed upward through the top sieve to help removal of light material.

The cup elevator has 10 cups each with a capacity of approximately one-fourth pound of grain. The cups are spaced at 12-inch intervals and are fitted to a one-inch pitch chain. When the elevator is operated with a lineal velocity of 313 ft. per minute, which corresponds to the drive sprocket speed of 100 rpm, it has a capacity of 40 lbs. per minute.

All moving parts such as sheaves, belts, shafts, etc., are suitably protected by an expanded metal shield to avoid danger to the operators. No controls to stop or operate any particular part or separate assembly are necessary in the thresher. Every mechanism operates together as a unit and is started or stopped by controlling the power unit only. Two spirit levels, one on the top of the front frame and another on the right side frame, are fitted to facilitate levelling and correct setting of the machine in both directions when installed.

DESIGN OF THE THRESHER

The feed platform is made of wood. It is about 30 inches by 21 inches in size, and is mounted on six foldable legs. It is flush with the free end of the shear plate and hooks on to the top of the front frame. A sloping metal sheet sits in between the inner shear plates. Ear heads severed by the choppers fall over this sheet and roll on to the feed plate by gravity as shown by Plate II.

The feed plate is made of steel sheet. It is hooked to the U-brackets at its upper end and on its lower end it is rivetted to the upper end of the concave as shown by Plates II and V. It extends across the entire width of the cylinder.

The shear plates are made of steel. They are fixed to the U-brackets and slope towards the cylinder as shown on Plates I and II.

The chopper is made of steel plate with four knives on its periphery. Two sets of knives are rivetted to the chopper.

plates and the choppers are keyed to a three-fourths inch shaft as shown on Plate III. They are spaced 16 inches apart. The knives are made of cutter steel and are rivetted to the chopper plate. They sever the heads as they are fed in between the shear plates and the knives. The knives extend all the way through the shear plates. The shaft is mounted on three-fourths inch ball bearings. The two ball bearings are fixed to the front frame as shown on Plate I. The knife guards which are made of steel plate are fixed on the outside to protect the operator from the danger of rotating knives.

The threshing cylinder is made up of six rasp bars which are bolted on to the cylinder frame as shown on Plate IV. The cylinder frame consists of three steel rings. Single row one-inch ball bearings, one on each end of the cylinder shaft, support the cylinder. A slot is also provided for the bearing mounts to permit adjustment of cylinder concave clearance. The cylinder cover is made of steel plate as shown on Plate II. It is hooked on its lower end to the top of the rear frame and on its upper end to the Z and L brackets. Hinges are provided at its mid point so that inspection of the cylinder housing can be done from either side.

The concave is made of steel plate. It encircles the threshing cylinder with an arc of 150° . This provides more threshing area than normal. The concave is supported by three F-brackets as shown on Plate V. The two arms of the F-bracket are welded to the outer body of the concave and on its opposite side it is bolted to an iron plate. The iron plate is welded

EXPLANATION OF PLATE III

Details of Chopper Assembly

Fig. 1. End view of chopper assembly.

Fig. 2. A longitudinal section on B-B of Fig. 1 above.

- 40 - Shear plate
- 41 - Shear plate bracket
- 52 - Slicer knives
- 53 - Chopper plate
- 54 - Chopper plate bushing
- 55 - Chopper shaft
- 56 - Chopper guard
- 60 - Front frame
- 61 - Taper key
- 62 - Rivets

Plate III

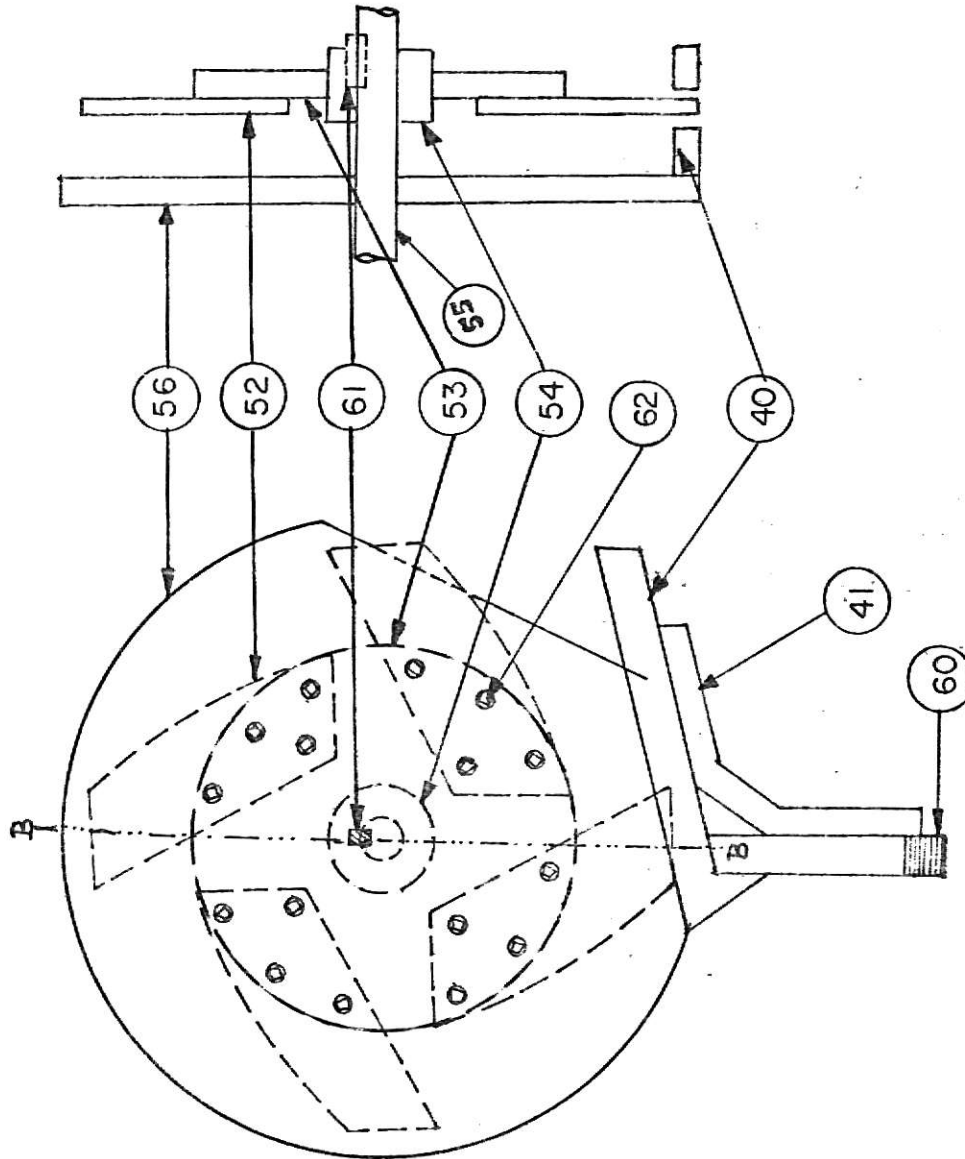


Fig. 1. End view

Fig. 2. A longitudinal section
on B - B of Fig. 1.

Details of chopper assembly
5 HP threshing machine
Design: G. Ramana Reddi
Drawn: G. Ramana Reddi
Date: September 25-1969

EXPLANATION OF PLATE IV

Details of Cylinder Assembly

Fig. 1. Cylinder with shaft mounted on the frame.

Fig. 2. A cross section of the cylinder wheel (Section on C-C of Fig. 1 above).

Fig. 3. Cylinder teeth.

27 - Cylinder rasp bar

42 - Threshing cylinder

43 - Cylinder shaft

63 - Top frame

64 - Slot on the face of the side frame

65 - Countersunk bolt with a nut and lock washer

66 - Cylinder frame

67 - Cylinder teeth

68 - Rim of the cylinder frame

69 - Spoke of the cylinder frame

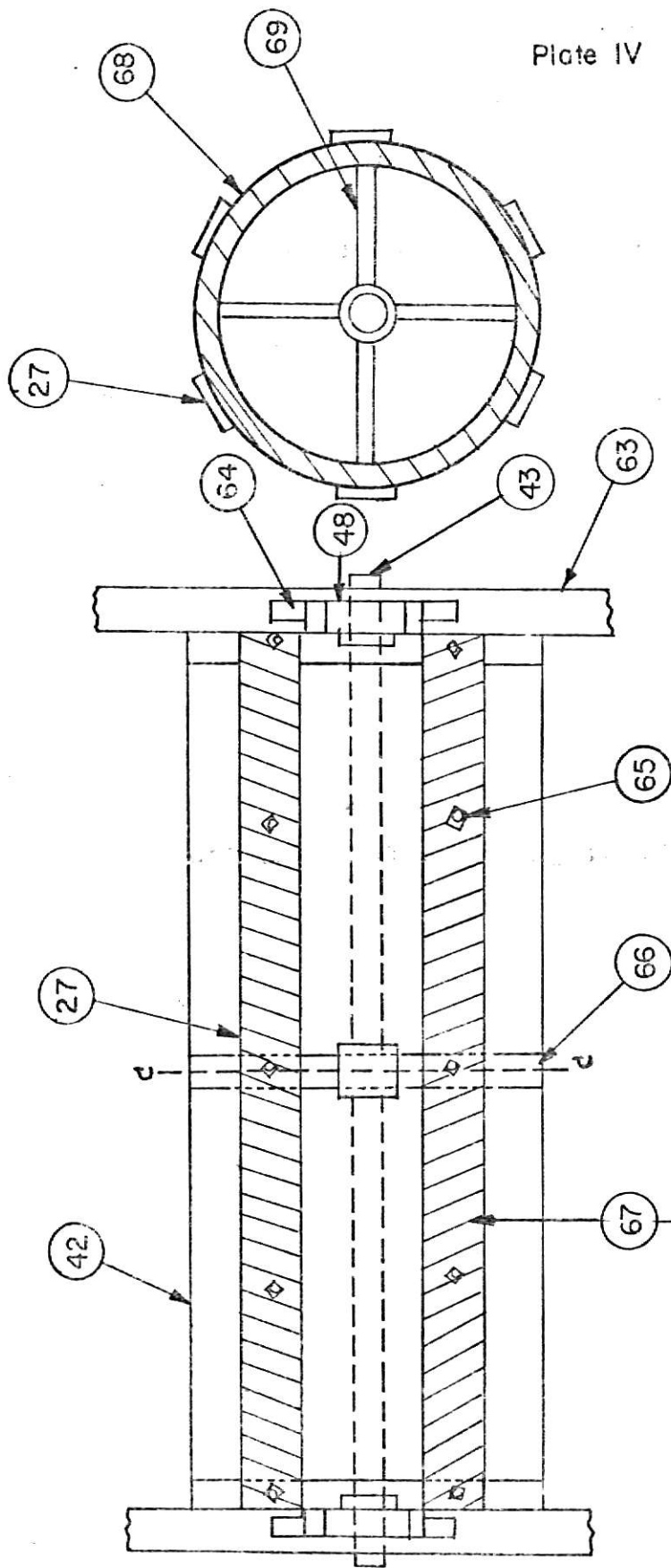


Fig. 1. Cylinder assembly.

Fig. 2. Cross section of
the cylinder.
(section on C-C of Fig. 1.)



Fig. 3. Cylinder teeth.

Details of cylinder assembly
5 HP threshing machine
Design: G. Ramana Reddi
Drawn: G. Ramana Reddi
Date: September 25, 1969.

EXPLANATION OF PLATE V

Details of Concave Assembly

Fig. 1. Plan view of concave with feed plate and grate.

Fig. 2. A cross section of concave with its supporting bracket, feed plate, and grate (Section on D-D of Fig. 1 above).

24 - F-bracket

25 - Concave bar

26 - Grate

29 - Feed plate

44 - Concave body

45 - Iron plate

46 - Slot in item 45

60 - Front frame

70 - Concave teeth

71 - Slotted bottom portion of concave

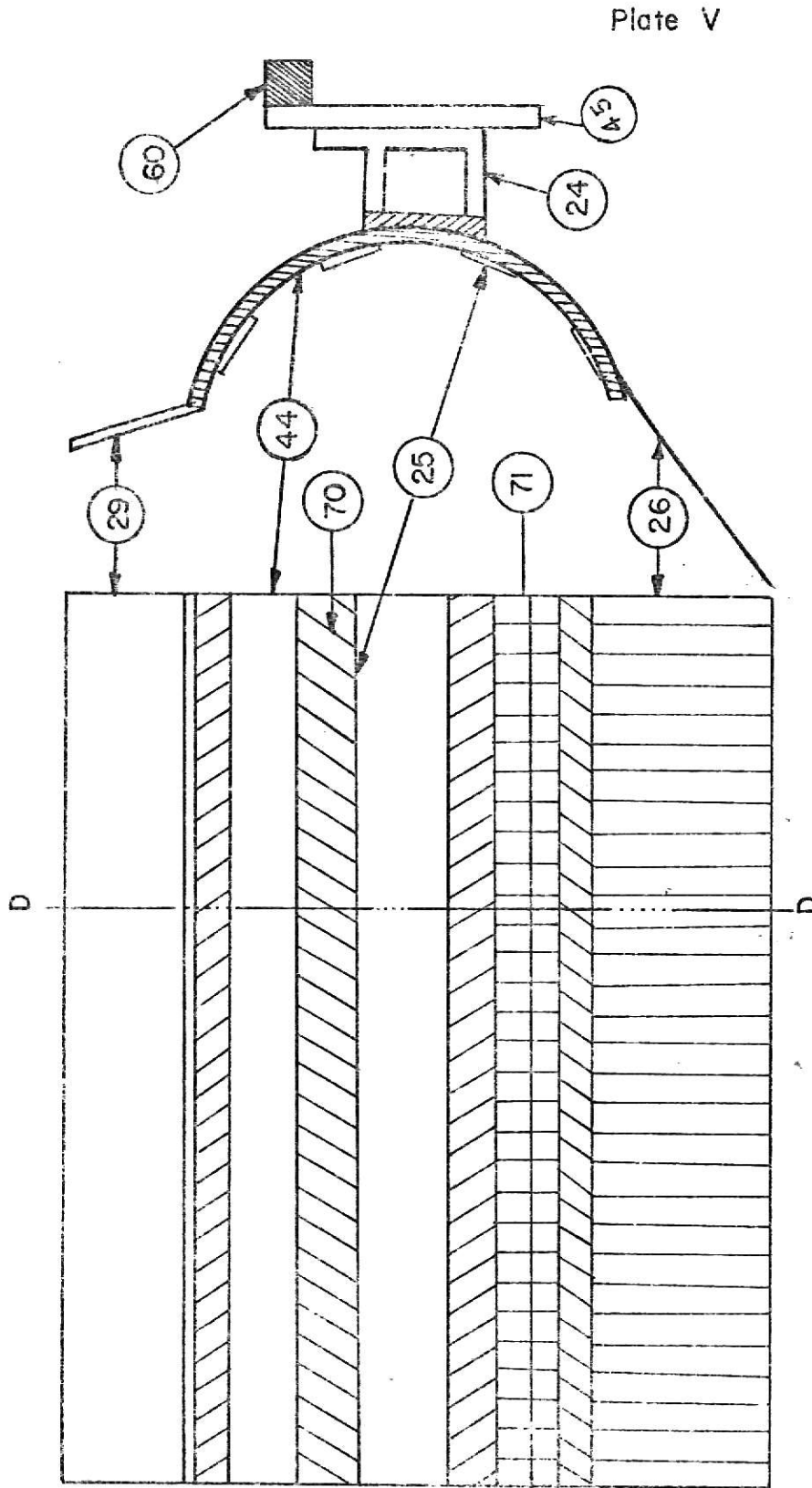


Fig. 2. Section on D-D
of Fig. 1.

Details of Concave assembly
5 HP threshing machine
Design: G. Ramana Reddi
Drawn: G. Ramana Reddi
Date: September 25, 1969.

Fig. 1. Plan view.

to the top of the front frame and is provided with a slot on it. By loosening the bolts of the F-bracket the concave can be moved up and down as a unit for additional adjustment of cylinder-concave clearance. Four concave bars are used. The teeth are set staggered on alternate bars to ensure effective threshing.

Sieves. The physical properties of paddy vary according to the moisture content and variety. With the average length of long grain as 0.3870 inch and its average width as 0.1038 inch, the geometric mean comes to $13/64$ inch (32). The seed has to pass through the top sieve. Since some of the varieties grown in India are longer and wider than the above (18), a $15/64$ inch size sieve with round holes is used for the top sieve. The lowest value of thickness for long grain is 0.0750 inch, i.e., $1.20/16$ inch (32). Since the seed should not pass through the lower sieve, a $1/16$ inch size sieve with round holes is selected. The two sieves are commercially available. The two sieves are vibrated as a unit by the sieve crank shaft as shown in Fig. 2 and Plate II.

The sieve crank shaft is three-fourths inch in diameter and is designed to rotate with a stroke of one-half inch from the axis of its rotation as shown in Fig. 2, page 10. The crank shaft is mounted on three-fourths inch ball bearings. One of the two ball bearings is fixed on the top of the fan housing as shown on Plate I, and the other is fixed to the frame. Another ball bearing connects the crank shaft to one end of the connecting rod. The other end of the connecting rod

is fixed to a bracket which holds the two sieves together as shown on Plate II. This imparts reciprocating motion to the sieves.

The sieves are supported by four hangers which are made of steel plate. Two hangers are fixed at their top ends to the right side of the frame and the other two to the left side of the frame. Their lower ends are freely mounted on the sieves as shown on Plate II. Therefore, the sieves move in a horizontal as well as a vertical direction as shown in Fig. 3 on page 10.

The coefficient of friction of the rough rice on galvanized plain iron sheet varies from 0.402 to 0.449 (1). As such a slope of 1 in 2 is needed for the semicircular spout which is fitted to the bottom end of the lower sieve to ensure free flow of grain from the spout into the elevator boot. Since this is not possible, the spout is fixed to the lower sieve and oscillated along with it. A slope of 1 in 15 given to the spout ensures complete flow of grain into the boot.

A blade type fan, 12 inches in diameter, fitted with straight blades is located about 11 inches above ground level as shown on Plate II. It extends across the entire width of the machine. The air stream is directed against the underside of the top sieve and through the grate to blow off the chaff, pieces of straw, etc., which are lighter than grain. Lineal velocity of the air is designed to be a maximum of 1,050 ft/min, taking into account the terminal velocity of paddy (14,18).

EXPLANATION OF PLATE VI

Details of Fan Assembly and its Accessories

Fig. 1. Plan view of fan assembly with side valves assembly.

Fig. 2. Side valve assembly.

Fig. 3. Deflector assembly.

Fig. 4. End view of deflector control lever.

48 - Ball bearing

50 - Fan shaft

72 - Fan blade arm

73 - Fan blade

74 - Deflector blade

75 - Side valve

76 - One-fourth inch rod connecting the two side valves

77 - Control lever for side valves

78 - Control lever for deflector

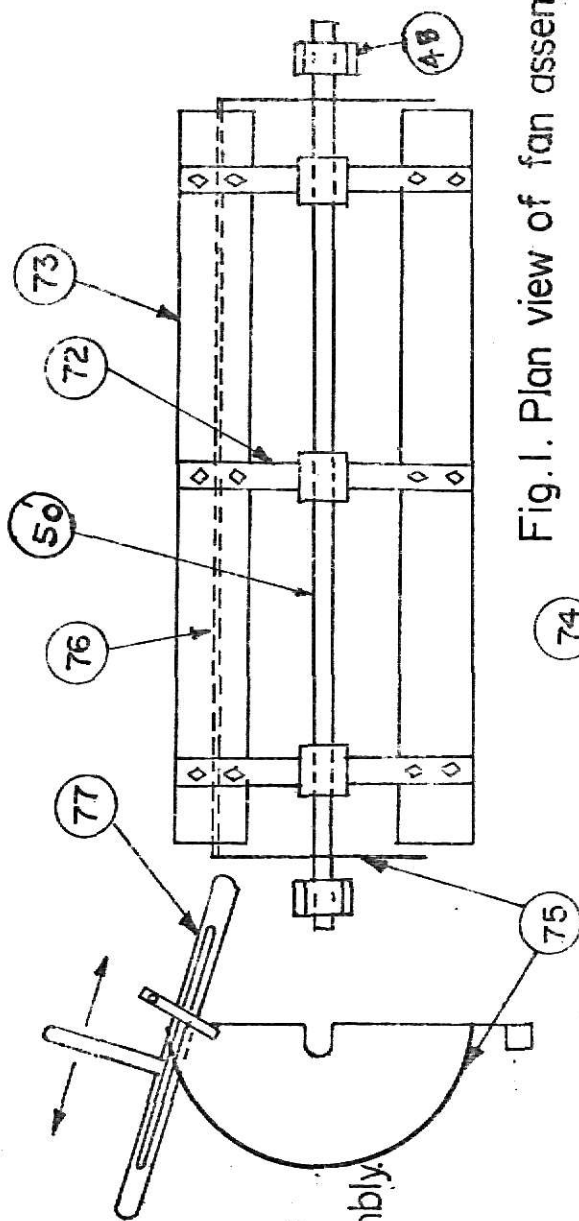


Fig. 1. Plan view of fan assembly.

Fig. 2. Side view of side valve assembly.

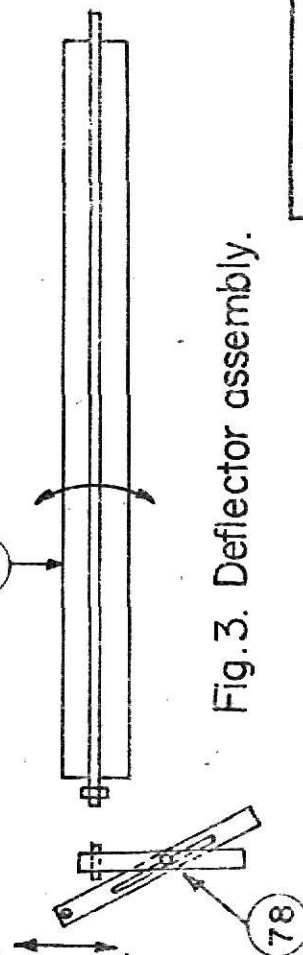
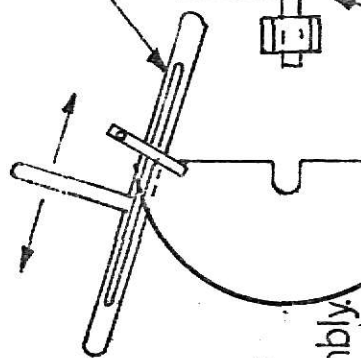


Fig. 3. Deflector assembly.

Fig. 4. End view of deflector control lever.

Details of fan assembly
 5 HP threshing machine
 Design: G. Ramana Reddi
 Drawn: G. Ramana Reddi
 Date: September 25, 1969.

The lineal velocity of the air is kept far below the terminal velocity of the grain. However, the terminal velocity of paddy depends upon its physical properties, which in turn depend upon moisture content and variety. To accommodate these variables, the fan is provided with two side valves and one deflector which control the position, distribution, and velocity of air (Plate VI). The air blast thus controlled also determines whether the chaff is properly removed or not.

The grain elevator is designed for maximum capacity of the thresher as explained below.

Maximum capacity of the thresher = 40 lbs./min. (or)
2,400 lbs./hr.

Elevator head sprocket diameter (O.D.) = 5.950 inches.

Elevator small sprocket diameter (O.D.) = 3.014 inches.

Maximum permissible speed of head sprocket, $N = 54.19 \sqrt{\frac{1}{r}}$,
where r = the radius of head sprocket, ft. (14)

and N = speed of head sprocket, rpm

$$N = 54.19 \sqrt{\frac{1}{\frac{5.95}{2 \times 12}}} \text{ rpm} = 111 \text{ rpm.}$$

Distance between the centers of head and small sprockets
= 53.50 inches.

Length of chain = $53\frac{1}{2} + 53\frac{1}{2} + \frac{(5.95 + 3.014)}{2} = 121.0$ inches.

Cup Size:

Radius of curve: 3"

Projection: 3"

Length: 2"

Angle of Arc: 81°

$$\begin{aligned}
 \text{Volume of cup} &= \left(\frac{1}{2} \times R^2 \times \theta \times \frac{2}{12}\right) \text{ cu. ft.} \\
 &= \frac{1}{2} \times \frac{3}{12} \times \frac{3}{12} \times \left(81 \times \frac{\pi}{180}\right) \times \frac{2}{12} \\
 &= 0.00733 \text{ cu. ft.}
 \end{aligned}$$

Bulk density of paddy grain = 36 lbs./cu. ft. (14).

$$\begin{aligned}
 \text{Weight of grain in one cup} &= 0.00733 \times 36 \\
 &= 0.264 \text{ lbs.}
 \end{aligned}$$

Spacing between two cups is usually two to three times greater than the projected length. However, only one cup per foot length is provided, and the total number of cups is 10. As the speed of the head sprocket is 100 rpm (or) 156 ft. per minute, the capacity of the elevator is $156 \times 1 \times 0.264 = 41.20$ lbs./minute or 2,472 lbs./hour. The cups may not be filled to their full capacity every time. Therefore, a speed of 100 rpm is selected for the head sprocket and the elevator is designed for maximum capacity of the thresher.

A chain drive is provided in the elevator. One inch pitch R.C. 80 type of sprockets and chain manufactured by the Link Belt Company, U.S.A., are selected for the drive. The elevator is detachable from the machine for carrying it separately.

V-Belt Drive. Belt drives are employed extensively in farm machinery applications in which exact speed ratios need not be maintained. Belt slippage is usually from 1 to 2 per cent. Power transmission efficiencies range from 97 to 99 per cent. Belts cushion shock loads, do not require lubrication, are quiet working, and can be operated up to a lineal velocity of 5,000 fpm (4,12,28). Simple direct drive single groove

sheaves are adopted in the design. The belt specifications closely follow H.C. type of agricultural V-belts which are standardized by the ASAE (See Appendix A, ASAE Standard, adopted June, 1950).

The frame, brackets, hinges, and supports are all made of steel. The size of standard angle iron used for constructing them varies from $1\frac{1}{2}$ inch x $1\frac{1}{2}$ inch x $\frac{3}{16}$ inch to 1 inch x $\frac{3}{4}$ inch x $\frac{1}{8}$ inch. Bearings are all standard single row ball bearings selected to take the respective loads. They are pre-greased and are held by standard bolts, nuts, and spring washers. Metallic bushings (plain bearings) are keyed to the shafts.

General specifications of the thresher are as follows:

Size:	30 x 30 inches
Capacity:	40 lbs./min. (maximum)
Cylinder speed:	350 - 500 rpm
Height:	4 ft. (excluding elevator)
Length:	2.5 ft.
Width:	2 ft. (excluding feed platform)
Number of men required to operate:	3

SUMMARY AND CONCLUSIONS

A double drum spike tooth thresher was developed at the Agricultural Research Institute, Andhra Pradesh Agricultural University, Hyderabad, India, for operation by four men. It was run by a 5 hp kerosene engine. Only ear heads were fed

into the drums, by hand, for threshing paddy by the drums. Winnowing and sacking were done separately by hand. Threshing efficiency was maximum when the speed range of the threshing drum was from 350 to 400 rpm, irrespective of the variety of paddy (Table 2, page 13). The maximum capacity was 550 lbs./hr.

Schematic drawings are prepared for an improved design over the above thresher. A single rasp bar cylinder, which is relatively less vigorous, replaces the spike tooth double drum. Ear heads are severed from the stem by rotating knives and are fed into the cylinder by gravity for threshing between the cylinder and the concave. A grate, two sieves, and a fan are used for separation and cleaning. The sieves are vibrated by a sieve crank shaft. An elevator lifts the grain from the foot of the thresher and delivers it into a sack at a convenient height. Three men are required to operate the thresher. It is also run by a 5 hp engine. The maximum capacity expected is 2,400 lbs. of grain/hour. The size of the thresher is 30 x 30 inches. The dimensions are $2\frac{1}{2}$ ft. x 2 ft. x 4 ft., excluding the feed platform and the elevator which are detachable. It is sturdily built with all steel parts and is transportable in a bullock cart.

The arduous tasks of beating the ear heads against an object by hand, gathering the mixture of grain and chaff and winnowing it by hand, and collecting and delivering the clean grain into a sack by hand are all carried out in the thresher. Besides, timely operations can be attended to by the farmer on his farm.

A prototype needs to be built and tested for modifications if any are required. As only ear heads are presented for threshing in the cylinder, power requirement is low.

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IMPROVED DESIGN OF SMALL ENGINE-OPERATED
RICE THRESHER

by

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B. E. (Mechanical Engineering), Madras University,
Madras, India, 1952

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agricultural Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1970

The Andhra Pradesh State in India is known as the "Rice Granary" of India. Farmers grow two to three crops of paddy per year. Programs for raising high yielding varieties and multiple crops, recently introduced by the Government, yield higher returns to the farmer but involve them in carrying out the farm operations the year around. Primitive methods of threshing and winnowing by hand, which cause considerable delay and loss, are still employed.

Considerable work has been done for developing wheat threshers in India, but no significant work has been done for developing rice threshers in spite of the fact that 43 per cent of the food produced is rice. Limited skills and capital available prohibit the use of the large conventional threshers of the West. Use of small pedal-threshers of the East did not compare with handwork. Farmers already possess small engines of 5 to 6 hp for the purposes of lifting water, hulling rice, crushing sugar cane, etc.

The capacity of the double drum thresher developed in the Andhra Pradesh Agricultural University was low. Also, four men for operation and additional labor for cleaning and winnowing were required. A small engine-powered thresher for rice which is portable in a bullock-drawn cart would not involve investment of much capital and would save a great amount of labor, enabling the farmer to attend to timely farm operations.

A 5 hp threshing machine is designed and plans are prepared. The thresher has a single rasp bar cylinder. Ear heads are severed by rotating knives and fed into the cylinder by gravity.

They are threshed in between the cylinder and concave. Separation and cleaning is accomplished by the grate, sieves, and air from a fan. The sieves are vibrated by a sieve crank shaft. The clean grain slides on the top of the bottom sieve and falls in the semicircular trough fixed at the bottom end of the lower sieve. The semicircular trough is also vibrated and it slopes into the elevator boot. Elevator cups collect the grain from the boot and deliver at a height of about 4.25 ft. above ground level to the side of the machine for sacking.

General specifications of the 5 hp threshing machine are as follows:

Size - - - - -	30 x 30 inches
Maximum capacity - - - -	2,400 lbs./hr.
Height - - - - -	4 ft. (excluding elevator)
Width - - - - -	2 ft. (excluding feed platform)
Length - - - - -	2½ ft.
Cylinder speed - - - - -	350 to 550 rpm
Number of men required to operate - - - - -	3