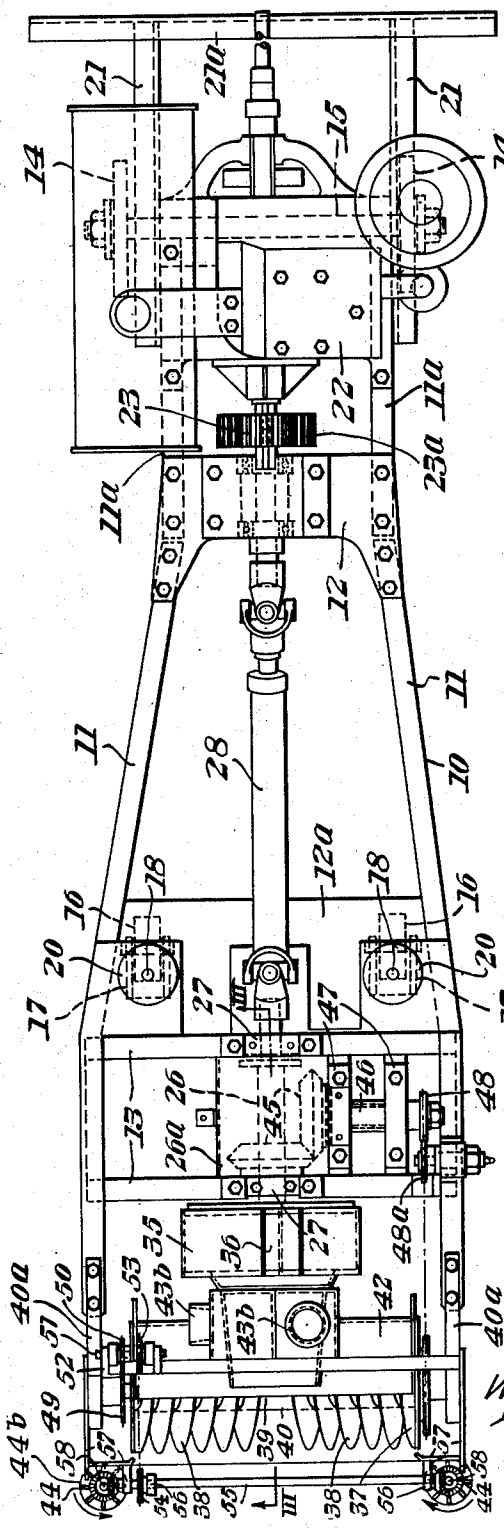
Oct. 23, 1945. W. M. VENABLE 2,387,422

SNOW-REMOVAL APPARATUS

Filed May 16, 1944 3 Sheets-Sheet 1

Fig. 1.



INVENTOR
William M. Venable
by his attorneys
Stellins, Blenko
& Webb

Oct. 23, 1945. W. M. VENABLE 2,387,422

SNOW-REMOVAL APPARATUS

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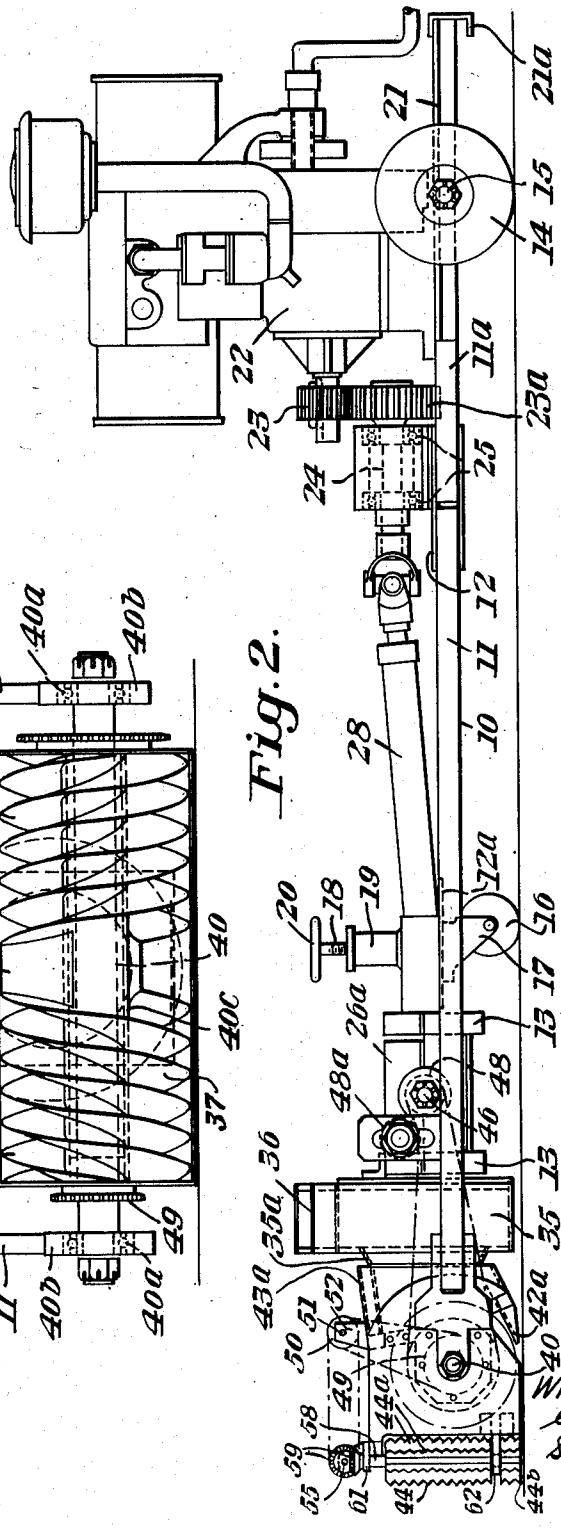


Fig. 2.

Fig. 4.

INVENTOR
William M. Venable
by his attorneys
Stebbins, Blanke
& Webb

Oct. 23, 1945. W. M. VENABLE 2,387,422

SNOW-REMOVAL APPARATUS

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Fig. 3.

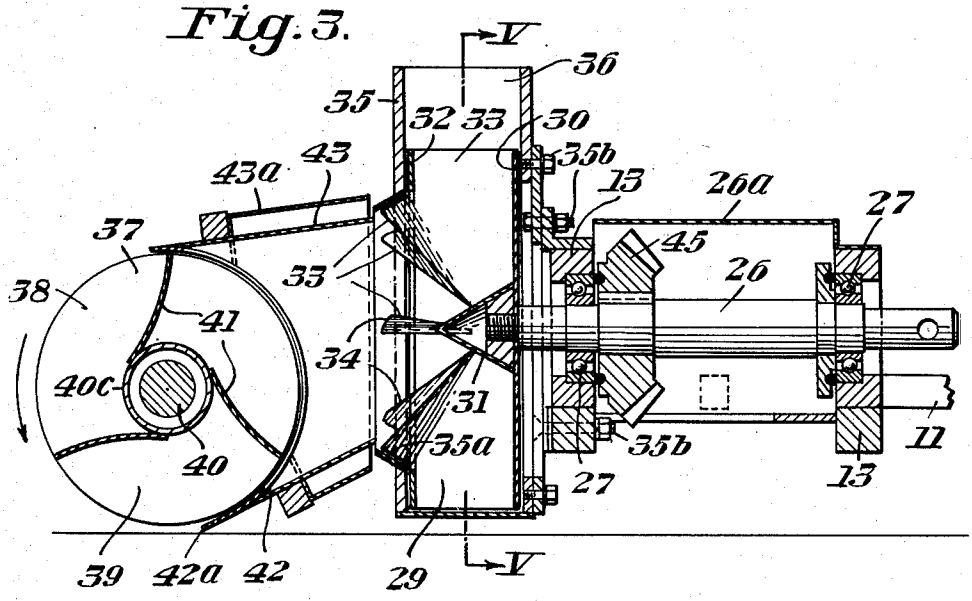
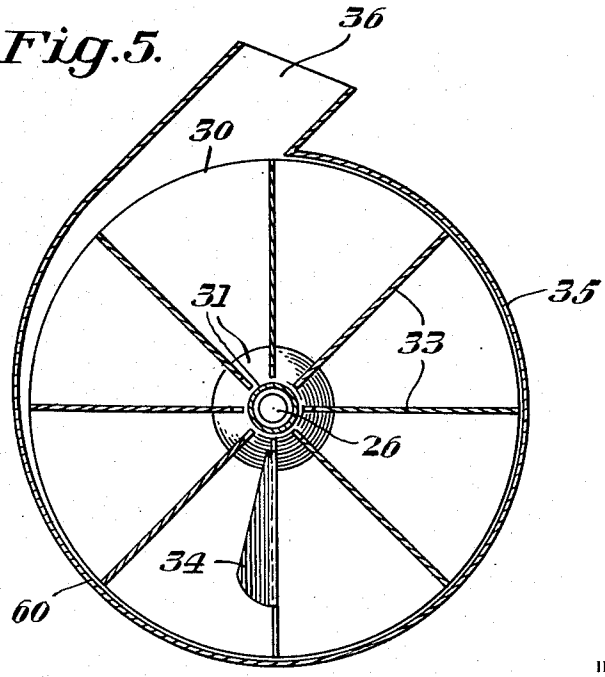


Fig. 5.



INVENTOR
William M. Venable
by his attorneys
Stebbins, Blenko & Webb

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UNITED STATES PATENT OFFICE

2,387,422

SNOW-REMOVAL APPARATUS

William Mayo Venable, Pittsburgh, Pa., assignor to Blaw-Knox Company, Pittsburgh, Pa., a corporation of New Jersey

Application May 16, 1944, Serial No. 535,826

7 Claims. (Cl. 37—43)

This invention relates to an improvement in snow-removal apparatus, and particularly to the type adapted to be pushed by a truck, tractor, or locomotive, and to throw snow to either side of the right of way, employing a rotary impeller (sometimes called a "fan") rotating in a vertical plane at right angles to the path of travel of the device, and means for feeding snow laterally across the front of the apparatus and into the impeller inlet.

Apparatus of this general character is not broadly new, an early example being shown in Figures 8 and 9 of Patent 1,413,007, issued to Harry D. Curtis, April 18, 1922. Another early example is described in Patent 1,587,449, issued June 1, 1926, to Dan Wandsheer, to which original designs there have been numerous improvements. At the present time there are in practical use several designs of snow-removal machines embodying the essential features of Curtis and Wandsheer with other features. In general, the efficiency of such machines measured by the percentage of power delivered to the machine which is converted into useful work in actually discharging snow, is low, and the capacity of the machines relative to their size is small. The primary object of this invention is to increase the efficiency of such machines so that a more effective throw can be obtained with an engine of a given size, and a greater capacity for a machine of given size and weight.

Snow-removal machines of this general type are at present used chiefly in clearing snow from streets and highways. They either throw snow sideways off the paved road into vacant land on either side, or if there is no adjoining vacant land, they are equipped with chutes by means of which the snow is thrown into trucks, to be hauled away. The width of highways seldom exceeds 60 feet, and only a moderate length of throw is required for work of this kind. The capacity of the machine need not exceed that of the hauling facilities provided by available trucks. For the removal of snow from the runways of airports, however, the conditions are more severe. These runways may be two or three hundred feet wide, and the maximum practicable length of throw is desired. In order to keep an airport open, moreover, the removal of snow must be accomplished very rapidly, in case of a quick, heavy snowfall.

This invention is intended to provide a machine especially suitable for airport work, though not necessarily limited thereto, and particularly a machine so constructed that it may be operated at a higher speed of travel and will have greater capacity than has been practicable hitherto, with a greater length of throw and with less scattering effect. A further object is to reduce the difficulties encountered in handling with one machine snow of different degrees of compactness and moisture content. There is great variation in the character of snow at the time of its removal, its condition then depending on many variable factors, such as (*a*) the character of the snow at the time of snowfall (if the ground and the weather are cold, the snow does not pack seriously even when windrowed by push plows); (*b*) the weather after the snowfall until the time of removal; and (*c*) the amount of rehandling, thawing, and freezing that has taken place before the snow is removed. Because of these variable conditions, the density of snow to be handled may vary from as little as 10 pounds to as much as 40 pounds per cubic foot, and its consistency from dust to slush or loose, porous ice.

The invention may be fully understood from the following detailed description which refers to the accompanying drawings representing the actual construction of a working embodiment powered by a gasoline engine, which was actually built and operated in throwing snow. While the proportions of a commercial machine may vary from those shown in the drawings, the latter represent a form of the invention which proved successful under test.

In the drawings,

Figure 1 is a plan view of the machine in outline;

Figure 2 is a side elevation;

Figure 3 is a longitudinal section through the machine on line III—III of Figure 1;

Figure 4 is a front elevation with some parts omitted; and

Figure 5 is a transverse section through the thrower impeller taken along the plane of line V—V of Figure 4.

Referring to the drawings, a frame 10 on which the entire device is secured, comprises longitudinal members 11 and 11*a*, connecting plates 12 and 12*a* and cross members 13. The rear of this frame is supported upon wheels 14 journaled on an axle 15 secured to the frame. The front portion is supported upon casters 16. The casters permit the front end of the machine to swing in any direction for steering purposes. They are journaled in brackets 17 which are vertically adjustable by means of jack screws 18 threaded in nuts carried in housings 19 and having handwheels 20. Thus the front end of the machine

may be adjusted to the desired elevation by turning the handwheels. Any other means for adjusting the height of the casters may be employed, e. g., hydraulic cylinders and pistons which can be operated rapidly and conveniently by valves placed at a distance. The adjustment of the casters as to height may be made sufficient to elevate the snow-handling equipment to any desired height above the road when the machine is being transported to working location but is not operating to remove the snow.

In the machine shown in the drawings, the casters **16** are located behind the snow-throwing mechanism for reasons of convenience and the availability of space. In a large machine, the sizes of the operating parts, especially the impeller with reference to the width of the car, are relatively smaller, and the casters may therefore be placed further forward than shown in the drawings. The apparatus may be pushed forward by any convenient propulsion means, such as a motor truck. Suitable means such as longitudinal extension members **21** and a cross member **21***a* are provided for connection to the truck. An engine **22** mounted near the rear end of the frame **10** supplies power for throwing snow. Certain features of the apparatus covered by the foregoing description are more fully described and claimed in my copending application, Serial No. 535,827, filed May 16, 1944, for Snow-removal apparatus. A pinion **23** secured to the engine shaft meshes with a gear **23***a* on a shaft **24** for transmitting power to the thrower mechanism. The ratio of these gears may be chosen to give the desired speed of rotation to the impeller. The shaft **24** is journaled in bearings **25** mounted on the upper plate **12**. Any suitable bearings may be employed, but I have shown two standard antifriction ball bearings. The shaft **24** drives a shaft **26** journaled in bearings **27**, through a propeller shaft **28** including telescoping shaft members, two universal couplings and terminal sleeves. The shaft **26** and bearings **27** are disposed in a housing **26***a* carried on the cross members **13**.

The invention claimed herein comprises more particularly snow handling and throwing elements now to be described and the mechanism necessary for operating them by power delivered by a suitable engine which may be either that shown at **22** in the drawings or another engine located elsewhere and having appropriate connection for operating said elements.

As best shown in Figure 3, the shaft **26** has an impeller **29** mounted on the forward end thereof. The impeller includes a disc **30** having a conical hub **31** adapted to receive the end of the shaft **26**, a ring **32** parallel to and forwardly of the disc, and radial blades **33** extending between the disc and ring. The forward edges of the blades extend beyond the plane of the ring **32** and are curved as at **34**, as shown in Figure 5, as will be described hereafter. The impeller is enclosed in a casing **35** having an outlet **36** to be described more fully hereafter, and supported on the housing **26***a* by bolts **35***b*. The casing has an inlet **35***a* receiving the forward edges of the impeller blades, the impeller being open on the forward side within the ring **32**.

Snow is thrown into the inlet **35***a* by an auxiliary rotor **37** which consists of paired right- and left-hand conveyor flights **38** mounted on a long hub or tube **40***c*, in turn supported by the shaft **40**. The two members of each pair of flights are joined together in the middle either directly or by a narrow closure member **41**, so that snow fed laterally will be arrested in lateral motion because of junction of the flights, and acquire rotary motion by which it is thrown, not pushed, into the inlet **35***a* at substantially the full width thereof. The shaft **40** is journaled in bearings **40***a* in brackets **40***b* secured to the frame members **11**, and the intermediate portion of the shaft is enclosed in a tube **40***c*. The relative speeds of the impeller **29** and rotor **37** and the construction of these members are coordinated in such a manner as to bring about this result and to overcome the difficulties that are ordinarily encountered in machines of this general type in causing the material to enter the impeller in sufficient quantities to develop the capacity thereof and to achieve the highest efficiency of which the impeller is capable.

As shown in Figure 3, a casing **42** extends around the rear side of the rotor **37** except at the inlet **35***a*. The construction of the rotor **37** and the casing **42** will be described hereafter under the caption "Feeder rotor." Intermediate the feeder rotor and the thrower rotor is a tubular neck **43**. This neck will be described in detail under the caption "Neck extending to impeller inlet."

As will be more fully shown hereafter, the relationship of the parts **29** to **43** is essential to the attainment of the higher capacity and efficiency which are the principal objects of this invention. It is necessary, however, for the machine to be pushed forward and, to attain this object, it is necessary for the snow to be removed from a space sufficiently wide to permit the passage of the machine and proper steering thereof. With machines of this general character there is usually difficulty in keeping the snow from packing and bulldozing at the sides of the machine where it must cut a swath. This is particularly difficult if the machine is to be moved forward at a high rate of speed. To overcome this difficulty, side cutters **44** arranged with their axes substantially vertical are preferably provided, but there are conditions in which snowplows of this type may be operated which will not necessarily require these side cutters, and although they are shown in these drawings and sufficient description will be included under the caption "Side cutters" to show how they function, they are also disclosed and claimed in the copending application referred to, in which such cutters will serve the same function as in this device and an additional function as well.

The rotor **37** and the side cutters **44** may conveniently be driven by the same engine which drives the impeller **29**. It is not essential to the invention that the same motor be used to drive all of these parts, but it is essential to the invention that the speeds of rotation of the various rotating members be correlated so that they cooperate to produce the desired results. This correlation of the speeds will be described under the caption "Coordination of speeds of operation."

While the particular method of driving these parts so that the speeds will be coordinated may be varied, the drawings show a simple means for coordinating these speeds by means of mechanical drives. These include bevel gears **45** by which a shaft **46** suitably journaled in bearings **47** on members **13** is caused to rotate in a horizontal plane at right angles to the shaft **26**. Secured to the shaft **46** is a sprocket wheel **48** which

through a suitable chain and sprocket drives shaft **40** of the feeder rotor **37**. An adjustable idler **48***a* is provided to take up the slack in the chain. To drive the vertical side cutters **44**, a sprocket wheel **49** is mounted near the opposite end of the shaft **40** of the rotor **37** and is connected by a chain to a sprocket wheel **50** on a shaft **51** journaled in bearing brackets **52**, at an elevation above the casing **42**. A sprocket wheel **53** drives a sprocket **54** on a horizontal shaft **55** journaled in bearings **56**. The bearings **56** are carried on plates **57** secured to brackets **40***a*. The vertical cutters **44** have radial blades **44***a* secured to shafts **58**. These shafts are driven by the shaft **55** through bevel gears **59**, and are journaled in bearings described hereafter.

It will be observed from the brief general description just given that by properly selecting the sizes of the sprocket wheels, the desired relationships of rotational speeds of different members may be secured, within reasonable limits. The drawings do not indicate the precise relationships of the speeds to be selected, since this matter is more fully discussed hereinafter. Neither are the particular arrangements of sprocket chains and wheels to be considered essential, since in order to attain the proper speeds in a large machine it may be desirable to use other methods of driving in order to get the most suitable and compact assembly for a machine of a given size and in order to make it convenient to properly protect the parts. In a commercial machine the moving parts will ordinarily be cased, although casing is not essential to the invention and is not shown in these drawings, in order to avoid undue complexity in description.

Impeller and rotor casing

Cold snow consists of solid particles or fragments of ice. If the snowfall occurs during a time when the atmospheric temperature and the ground temperature are well below freezing, these particles remain small and are readily blown about like dust. If the snow remains in this finely divided state until it is handled by an impeller, the snow may be so mixed with air while passing through the impeller as to be handled almost like a fluid. But if sufficient time elapses between the snowfall and the handling, the snowflakes adhere to one another forming a porous, semi-solid mass, which must be broken up before it can be successfully thrown. If such snow is very cold, it may easily be broken up into fragments; but if it is warm enough to contain considerable moisture, it tends when handled to pack into larger masses or snowballs which must be kept from agglomerating into bodies too large to pass through the impeller.

The larger masses, fragments of packed snow or porous ice, do not behave in the impeller as semi-fluid, but maintain the character of solid fragments, more or less compacted during the process of passing through the impeller. The distance to which a solid particle can be thrown through quiet air depends entirely upon its size, mass and shape, and the velocity imparted to it by the thrower. In order to throw to as uniform a distance as possible, the velocities of all particles leaving the thrower should be as uniform as possible. The maximum peripheral velocity of the impeller is the maximum tangential velocity with which any particle or agglomeration of particles may be thrown. Particles or agglomerations which leave the impeller without attaining this peripheral velocity cannot be thrown as far as those that do.

As will be seen in the drawings, the impeller **29** comprises a disc **30** rigidly connected to the drive shaft **26** so as to revolve in a substantially vertical plane, to which disc are secured several radial thrower blades **33**. Eight such blades are shown although the number is optional. These blades diverge outwardly from the axis, so that snow entering between them, moving radially outward as the rotor turns, is not compressed by its outward motion, but because of centrifugal force tends to compress against the inner rim of the casing which restrains outward motion. If there were no outlet to the casing and the latter were cylindrical, the snow would pack tightly against the casing and slide thereon, as a flywheel of ice, as the rotor turns. In order that there may be a discharge there must be an opening, and the snow must be accelerated radially relative to the rotor as it moves outward toward the discharge opening **36**. To facilitate this radial acceleration, the casing employed in this invention is of cylindrical form for only a portion of its periphery, as shown in Figure 5.

As will be noted from Figure 5, the periphery of the disc **30** is circular and the extremities of the impeller blades **33** extend to the periphery thereof. The portion of the casing **35** adjacent one side of the outlet **36** diverges from the circular form at about the point indicated at **60** to increase the clearance between the impeller blades **33** and the casing as the outlet is approached. The purpose of this is to allow radial acceleration of the snow as the outlet is approached, and not to bring the casing outlet on a straight line tangential to the cylindrical section as is usual in most throwers of this general type which do not allow a gradual radial acceleration as it approaches the outlet. By this expedient, a larger volume of snow may be discharged than if this gradual divergence of the casing from the rotor were not permitted. This results not only in making it possible to accelerate a larger portion of the snow to the full peripheral speed of the end of the blades **33**, but also to increase the capacity of the thrower impeller as less snow is carried around past the outlet **36**. Although this may appear to the casual observer to be a very minor change from existing practice, it is found that the resulting increase in capacity and efficiency is quite pronounced.

The snow to be thrown must enter the thrower impeller as well as leave it. One great difficulty hitherto encountered in devices of this general character has been difficulty in causing the snow to enter the impeller at a sufficiently high rate to charge it to capacity. To obviate this difficulty it has been the practice to make the inlet very large, almost as large, in fact, as the outer casing diameter, thus leaving little space for radial acceleration. This expedient resulted in lowering the efficiency of the impeller and is accordingly not incorporated in my invention. As shown in the drawings, particularly Figure 4, the diameter of the circular opening **35***a* into the casing **35** is materially less than the diameter of the latter. The snow is thrown, not pushed, into this opening by the feeder rotor **37** turning at a high rate of speed. Figure 4 also shows that the forward edges of the thrower blades **33** are curved in such a manner as to assist the entry of the snow instead of to retard it or splatter it by direct impact with the faces of the blades. The

curvature of the forward edges of the blades is so correlated with the speed of rotation of the impeller and the speed at which the snow is cast into the opening by the feeder rotor that neither the forward nor the back side of the curved blades impacts the snow at the point of entry to any appreciable extent. After the snow has entered, the tendency of the blades is to carry it further in and also to prevent any excess from being pushed forward out of the impeller into the space in front thereof.

The blades **33** present sharp cutting edges to the incoming snow, and besides preventing the escape forward into the space in front if there is an excess, they also chop up any heavy lumps of snow which may reach the inlet, so as to prevent the clogging of the impeller by snowballs or aggregations too large to be handled. This also increases the efficiency of the impeller.

As further shown in the drawings, the casing **35** for the thrower rotor is open at the back except for a small distance which is necessary to fully enclose the disc **30**, leaving the back of the disc free, and thus preventing any tendency to clog between the support of the blades **33** and the casing at the rear thereof. Furthermore, the inlet **35***a* which encloses the curved portion **34** of the impeller blades is frusto-conical, resulting in a more gradual radial acceleration of the snow from the inlet to the outlet. This conical inlet may be made Venturi-shaped with advantage.

The casing **35** as a whole is preferably so supported that it may be rotated to bring the discharge outlet into different positions to discharge to either side of the roadway or directly upward if desired. Means permitting such adjustment are known and a detailed disclosure is therefore unnecessary. In the illustrated embodiment, bolts **35***b* may be removed to permit this angular adjustment of the casing.

Feeder rotor and casing

The feeder rotor indicated generally at **37** is disposed ahead of the impeller **29**. It is designed not merely to grind frozen snow and convey it to the space immediately in front of the inlet **35***a* but actually to cast, not push, it thereinto, making it possible to charge the impeller fully with snow that has not been unduly compacted at the inlet, and with a relatively smaller opening than customary in machines of this general type. The position of the feeder rotor is clearly shown in Figures 1 through 4. It is driven in the direction of the arrow in Figure 4, i. e., so the forward side moves downwardly.

The casing **42** for the feeder rotor **37** is shown in section in Figure 3. In general it is approximately a half cylinder and extends from end to end of the rotor around the rear side, as shown in plan in Figure 2. The bottom edge of this casing is provided with a cutting edge **42***a* of sufficient strength to act as a shovel in the snow which it will engage in use. The casing only has sufficient clearance from the flights and blades of the feeder rotor to permit free turning, and the cutting edge **42***a* is very nearly at the same level as the bottom edges of the flights **38** so that normally the flights, not the edge, cut the hard bottom snow.

The middle portion of this casing opens into the neck **43** communicating with the inlet **35***a* whereby the snow engaged by the rotor **37** is cast into the opening **35***a* by the feeder rotor **37**, the neck serving to confine the snow and direct it toward the center of the impeller. The neck **43** and casing **42** are substantially tangential at their bottoms.

As shown in the Figure 3, the helical flights **38** are of opposite pitch and merge into the closure plates **41**, the construction being such that when the rotor is turned in the direction indicated, snow engaged by the flights will be conveyed toward the middle of the rotor. Corresponding right- and left-hand conveyor screws are paired and merge at their adjacent ends into one of the closure plates **41**.

The closure plates **41** provide sufficient clear space in the middle of the rotor **37** to permit the discharge of large fragments and obstacles that may be picked up in the operation of the machine which could not be discharged readily if the space between the flights **38** were brought directly together. As shown in Figure 4, the closure plates are also curved so that any snow that may lodge in the rotor close to the middle thereof, as far down as the tube **40***c* will readily slide outward with gradually increasing acceleration when approaching the opening into the neck **43**. The feeder rotor has certain features in common with that disclosed and claimed in the copending application referred to above.

As will be seen in Figure 1, the opening into the neck is considerably wider than the closure plates **41** at their outer ends so that snow is not merely cast in chunks through the opening but is cast practically continuously from all that part of the rotor which is opposite the opening. Figure 3 shows a rotor with three sets of helical flights on each end and three radial blades therebetween. It will be noted that snow will thus be thrown into the neck in a practically continuous stream, one set of conveyor flights and their associated closure plates continuing to discharge snow through the neck until the flights associated with the next closure plates begin to discharge. The snow is not thrown merely by the closure plates, but practically all of the snow which is enclosed between the flights and is opposite the neck opening is thrown continuously into the latter. This is a feature which is entirely new and greatly adds to the efficiency of the device as a whole.

It will further be noted that the discharge into the neck is not limited to a relatively small angle, the construction being such that, unless the machine be pushed forward so fast as to receive a great excess of snow, all of the snow gathered by the rotor will be cast into the neck. If there is an excess and the height of the snow in front of the machine be not too great, the surplus will be cast forward but the neck will not be clogged with excess discharge. The device is thus practically free from the danger of clogging unless it be forced into a deep bank of snow at a rate greater than that at which it is possible to remove the snow with the power available.

Neck extending to impeller inlet

The importance of the neck **43** between the casing **35** and the casing **42** will be clear from the foregoing. The neck encloses the space between the casings, the general arrangement being clearly shown in Figure 3. The following features should be noted particularly.

The bottom of the neck merges into the casing **42** in a substantially tangential direction so that the throw of material from the latter begins to take place at the very bottom thereof and meets with no obstruction in the neck itself. In actual

operation it is found that by this arrangement snow is thrown through practically the entire area of the circular opening into the casing **35** at a speed approximating the peripheral speed of the rotor **37**, although not with entirely uniform distribution. As will further be seen upon examination of Figure 1, the neck is narrower where it joins the casing **42** than where it enters the casing **35**. There is thus no tendency of the snow to pack at any place in the neck, although the neck confines the snow and insures that all of it that is cast rearwardly by the feeder rotor enters the impeller. A transverse section through the neck where it adjoins the impeller casing is substantially circular; a section where it joins the feeder rotor casing is substantially rectangular. There is, of course, sufficient clearance between the rear end of the neck and the impeller to permit the free rotation of the latter and the angular adjustment of the casing **35** but this clearance is made as small as practicable.

It may further be remarked that, although the primary function of the impeller and rotor is to throw snow and, when the device is operating at the desired capacity, almost all of the power is expanded in gathering and throwing snow with, of course, the incidental losses due to friction, the apparatus also operates as a fan and a considerable amount of air passes with the snow through the rotor and impeller. In this regard the impeller which operates at a very much higher peripheral speed than the feeder rotor, creates a very much stronger draft of air and there is on this account little or no tendency for snow to escape through the joint between the neck and the casing **35** because air is being induced at that point.

Although the neck is made of such shape that the snow does not tend to pack therein, it sometimes happens that wet or water-logged snow has to be handled when the temperature has fallen after a snowfall or after the windrowing of snow that had been partially melted, the snow then being encrusted with a thin layer of ice on the surface but being very wet beneath although the atmospheric temperature is very much below freezing. When such a condition exists, there is a tendency for the snow to freeze to any cold surface with which it is brought into contact, forming a layer of ice on such surfaces, and this circumstance frequently renders it difficult for rotary snowplows to cast wet snow such as "snowball" snow, or "slush," through discharge chutes owing to the gradual clogging up of the chutes by ice forming against their inner surfaces because of the temperature, not of the snow itself, but of the atmosphere outside. This obstruction can be avoided by maintaining the metallic surfaces engaged by the snow at a temperature above the freezing point. For this purpose and also to protect the neck itself from extreme cold, the neck has an air jacket **43***a*. An inlet **43***b* is provided for introducing the exhaust of the engine **22** into this jacket when necessary, although the piping from the engine to the jacket is omitted from the drawings, for the sake of clarity. Whether or not the space enclosed by the jacket is artificially heated, the mere enclosure thereof so as to prevent rapid cooling of the neck is beneficial, as is also the addition of a layer of thermal insulation such as asbestos or mineral wood surrounding the neck. The speeds of rotation of the rotor and impeller are sufficiently high to make it unnecessary to take special steps to protect them against freezing of material by surface contact.

Side cutters

Machines of this general character, when used in municipal and highway work, usually operate to cast snow which has previously been windrowed by other types of machines, although when there has been an unusually deep fall of snow or heavy drifts, they also are used to make an initial cut through the snow. It is desirable, therefore, for these machines to be able to cut into banks of snow that may be relatively high on one side and low, or of practically no height, on the other. Under such conditions the obstruction caused by the bank of snow, particularly if it be high on one side only, renders it difficult to push the machine forward and steer it properly. If the bank be high, it is also desirable that the cut should be a little wider than the truck which pushes the machine in order to provide room for properly steering the truck. The difficulty of cutting a path of proper width is a formidable one under some circumstances that are almost sure to occur on highways at some time during the season when snow must be removed. Furthermore, the difficulty of cutting a high bank of snow merely by the pushing of the device into it by the power of a truck behind it very seriously limits the speed at which the device may be operated. This, with other limitations, quite often means that a machine is limited to a speed of two or three miles per hour and thus is worked at much less than its maximum capacity owing to the difficulty of bank cutting.

To obviate this difficulty, side cutters are provided as has already been mentioned, as shown in general at **44**. These side cutters are claimed in the copending application and sufficient description is included here only for the purpose of explaining how their speed is coordinated with the speed of the other elements of the apparatus. The shafts **58** on which the side cutters are carried, are journaled in bearings **61** and **62**. The bearings are mounted on the plates **57**. The shafts have horizontal cutter discs **44***b* at their lower ends. The bottom bearings **62** are not placed beneath the cutter but above the lower end thereof, so that the cutter proper operates close to the roadway with no supporting mechanism beneath it. The snow is thus cut as closely to the pavement as practicable. It should also be noted that the direction of rotation of these cutters as shown by arrows in Figure 1, is such as to cast the snow into the space in front of the feeder rotor.

Coordination of speeds of operation

It is a particular object of this invention to provide a machine that will not be limited to a speed of two or three miles per hour in effective operation and which will not require that the snow be deep, either by previous wind rowing or otherwise, before the machine can be operated, but which can be moved forward at any speed at which it is safe to operate the truck, provided the amount of snow in front of it is not so great as to necessitate slowing down.

It will be observed that various features of the machine are designed to secure this ability to operate at a high speed. The elevation of the front end may be adjusted by means of the casters **16** to that height which is found most desirable. For operating on a level paved runway, the casters may be set so that the edge **42***a* of casing **42** merely clears the runway. It is found in practice with

a machine of this character having a large rotor in front, that the rotor actually cuts a path, after it breaks the encrusted snow, a little below the bottom of the rotor 37 itself, so that although the casing may be an inch or so above the pavement the machine practically cuts the snow down to the pavement level, providing it does not encounter some obstruction which it cannot cut. It is important in such a machine also that the wheels of the truck pushing the machine forward should have good engagement with the pavement, and, therefore, that the cut made by the plow should be of slightly greater width than the gauge of the truck wheels and leave but very little snow beneath those wheels which would tend to cause them to slip. It is important for these reasons that not only the arrangement of the rotor but the arrangement of the side cutters combine to effect cleaning of a path which will give the truck pushing the device the best opportunity to discharge its function.

Since disposal of the snow is accomplished by the impeller it should be operated at the speed calculated to produce the desired length of throw. In practical machines this fixes the peripheral speed of the impeller. The function of the feeder rotor is to convey the snow into the impeller so as to keep the latter fully charged and also to cut up the snow if it be encrusted or frozen so that it enters the impeller in fragments small enough to be handled, and of such a character as to preclude packing during the process of throwing. To meet these conditions, I have found that the peripheral speed of the feeder rotor ought to be of the order of one-third that of the impeller. In practice, this means that if the machine be designed with an impeller capable of a maximum height of vertical throw of 81 ft., the feeder rotor alone should have a speed that would give a maximum throw of about 9 ft. if the throw were directed vertically. This is a very different thing from merely pushing the snow to the front of the impeller opening. These figures are not fixed, the ratio of these speeds depending on the size of the machine to be built; but in every case the peripheral speed of the feeder rotor must be made sufficient to actually cast the snow at a sufficient rate of speed into the impeller opening.

The peripheral speed of the side cutters should be somewhat lower since their function is to cast the snow from the sides to the space in front of the feeder rotor. At the same time the speed of the side cutters must be sufficient to dispose of all of the snow they will encounter when the truck is moved forward at the desired speed of operation and this means that their speed cannot be reduced to very much less than one-half the peripheral speed of the feeder rotor.

It will be apparent from the foregoing that my invention provides snow-removal apparatus having numerous advantages over devices known previously. The screw conveyors effectively gather snow from in front of the apparatus, moving it rapidly from both ends towards the middle where it is discharged forcibly by the thrower rotor through the neck and into the inlet of the impeller. The latter is capable of discharging the snow at a considerable distance and in substantial volume, thereby effecting rapid disposal of the snow collected.

The apparatus is of simple construction and is entirely self-contained. It may easily be attached to a conventional motor truck and its operation does not require any special skill.

Although I have disclosed herein but a preferred embodiment of the apparatus, it will be understood that the invention may take forms other than that shown, changes in the design and arrangement of the parts being comprehended within the scope of the appended claims.

I claim:

1. In a snow-removal apparatus, the combination with a traveling frame having a rotary impeller mounted thereon with its axis in line with the path traveled by the frame, and a casing for said impeller having a peripheral discharge outlet and a front inlet surrounding the axis thereof, a feeder rotor mounted on said frame with its axis at right angles to that of the impeller, and groups of helical flights of opposite pitch spaced apart on the rotor and effective to feed snow from both ends thereof toward the middle, corresponding flights of each group merging at the middle in a closure member substantially parallel to the axis of the feeder rotor and having a center outlet much narrower than the front inlet of the impeller.

2. In a snow-removal apparatus, the combination with a wheeled car adapted to travel along a roadway or the like, and a centrifugal thrower mounted on said car and adapted to discharge snow laterally therefrom, of a screw conveyor extending across the front of said car having spaced paired helical flights adapted to move snow from the ends thereof toward the middle, said paired flights being joined to form closures at the middle of said conveyor, a casing around the rear side of the conveyor and a tubular neck extending rearwardly from said casing to said thrower, the neck and casing being substantially tangential at their bottoms.

3. In a snow-removal apparatus, a traveling frame having a centrifugal thrower thereon adapted to discharge to one side of the path traveled by the frame, said thrower including an impeller rotating within a casing having a peripheral discharge port, said impeller comprising a disc at its rear side, a ring spaced from but coaxial with the disc and blades extending between the disc and ring and generally radially from their axis, the wall of the casing adjacent said ring having a circular inlet flange projecting therefrom tapering to a diameter materially less than the inner diameter of said ring.

4. In a snow-removal apparatus, a traveling frame having a centrifugal thrower thereon adapted to discharge to one side of the path traveled by the frame, said thrower including an impeller rotating within a casing having a peripheral discharge port, said impeller comprising a disc at its rear side, a flat ring spaced from but coaxial with and parallel to the disc, and blades extending between the disc and ring and generally radially from their axis, the forward edges of the blades extending through said ring and being curved.

5. In a snow-removal apparatus, the combination with a wheeled car adapted to travel along a roadway or the like, a rotary impeller adapted to discharge snow to one side, a feeder rotor disposed across the front of the car having conveyor screws adapted to move snow from both ends toward the middle, a casing enclosing said impeller, a casing extending around the rear side of said rotor, and a tubular neck connecting said casings, said neck including a bottom portion substantially tangent to the bottom of said casing.

6. In a snow-removal apparatus, the combination with a wheeled car adapted to travel along a roadway or the like, a rotary impeller adapted to

discharge snow to one side, a feeder rotor disposed across the front of the car having conveyor screws adapted to move snow from both ends toward the middle, a casing enclosing said impeller having an inlet in the forward side thereof, a casing extending around the rear side of said rotor, and a tubular neck extending rearwardly from said rotor casing to said inlet, said neck including a bottom portion substantially tangent to the bottom of said casing.

7. The apparatus defined by claim 6 characterized by said neck being so dimensioned and disposed relative to said inlet as to permit the induction of air along with the snow passing into the impeller.

WILLIAM MAYO VENABLE.