SERVICE TRAINING MANUAL

THEORY

Snowmobile Drive System

ARCTIC ENTERPRISES, INC.

THIEF RIVER FALLS, MINNESOTA

Foreword

The intent of this manual is to provide you, the service technician, with a detailed examination of the design, function, and operation of the drive system used on Arctic Cat snowmobiles. This information is provided to help you acquire a working knowledge of basic drive system theory and design as applied to snowmobiles. With this knowledge, you should be able to provide the quality service the customer expects and deserves.

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Theory of Operation

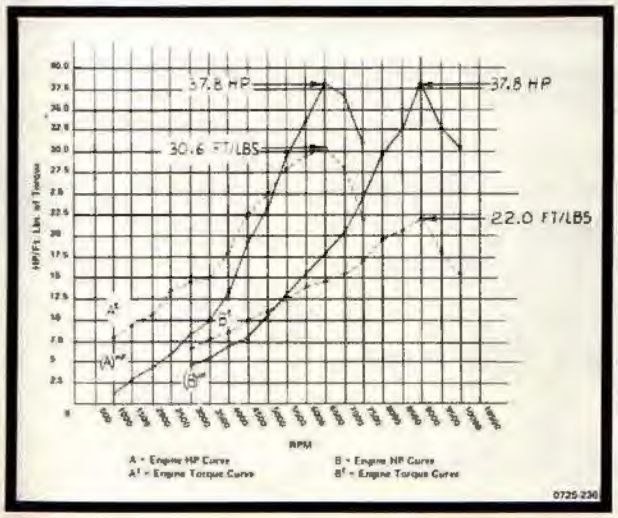
The drive system of a snowmobile is a major component in giving the operator maximum enjoyment and utility. To fully understand the important effect the drive system has on the performance of the Arctic Cat Snowmobile, each component and its function must be understood. In the sections that follow, elements of the driven clutch, drive clutch, drive belt and sprocket ratio will be examined. Knowing what influence the various elements have on the drive system will help you to better understand the operating characteristics of the "Arctic Cat System".

Matching the Drive System to the Engine

Snowmobile powerplants are generally highly tuned 2-cycle engines and usually have a narrow band of operation. Depending upon the type of track used and the design of undercarriage, different snow conditions produce different load resistances on the machine. In order to give the operator maximum enjoyment and performance, the drive system should perform satisfactorily by delivering maximum power to the track under all conditions and load demands.

Before a drive and driven clutch can be matched correctly to an engine, the torque curve of the engine must be known, Fig. 11.

Fig. 11



The two engines in the graph have the same amount of horsepower but at different rpm.

Engine A: 30.6 ft-lb at 6500 rpm = 38 hp
Engine B: 22.0 ft-lb at 9000 rpm = 38 hp

The graph shows how different the torque curve of two engines can be at the same maximum hp (See A & B curves).

Engine "B" develops much less torque but runs at a high rpm to produce the same hp.

Engine A is a family machine type engine. Engine B is a high performance racing engine. Before the clutches can be matched, the torque curves must be known. From the torque curve, engine "A" has maximum hp at 6500 rpm whereas engine "B" has peak output at 9000 rpm. If the drive system is matched correctly, the engine will run at the rpm where the most hp is developed. This is the point that the engine should run at full throttle in all conditions. If the engine runs at either above or below the point of maximum hp, the clutches are not using optimum output of the engine.

Example: (See Fig. 11) If the drive system on engine "B" was not matched correctly, and the engine ran at 10,000 rpm, what is the hp at the drive clutch? (Answer: The hp would drop from 38 hp down to 30.5 hp, a loss of almost 8 hp because the rpm of the engine was past its peak power point).

Selecting the Engagement Speed from the Torque Curve

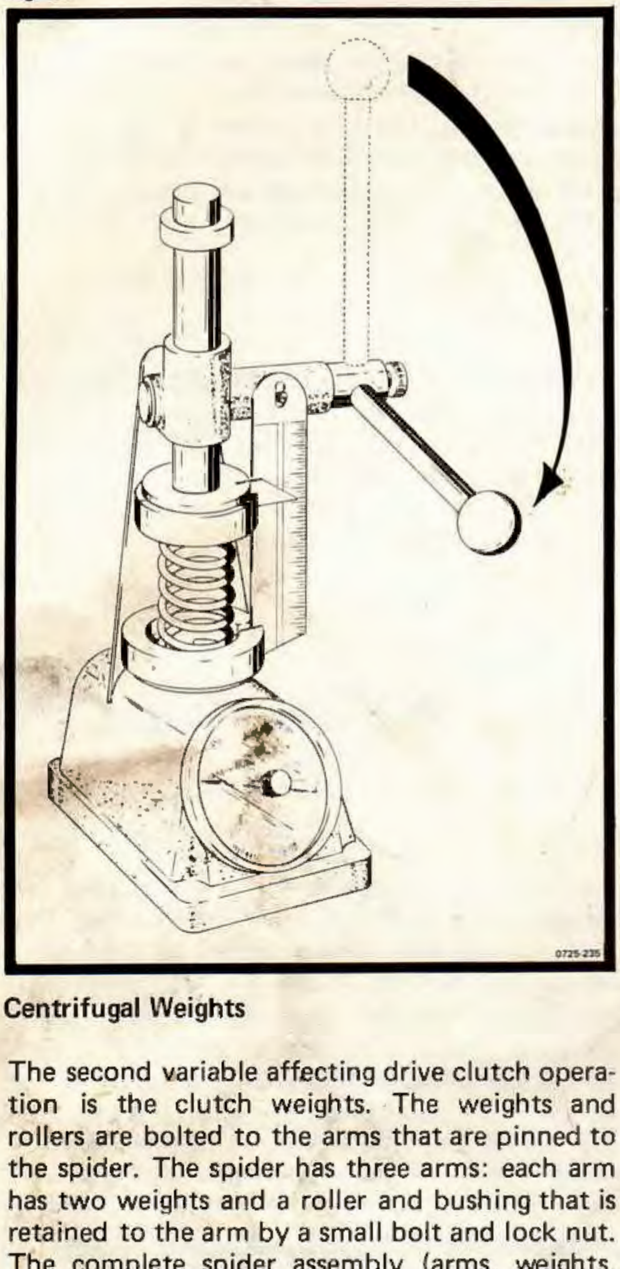
The desired drive clutch engagement speed is where the engine puts out enough horsepower to move the snowmobile from a stop without hesitation or a "flat spot". From the torque curve of the engine, the point at which the engine will not hesitate on engagement can be calculated.

In the introduction, we said the driven clutch was used to multiply engine torque needed by the track to pull the snowmobile. The low end clutch ratio is 3.79:1. The drive clutch must turn 3.79 revolutions before the driven clutch can turn 1. Therefore, the amount of engine torque is increased 3.79 times when transmitted to the driven clutch at engagement. The sprocket ratio that the machine is using also multiplies the torque. If the gear ratio is 19:39, the sprocket ratio is 2.05:1. The torque through the sprockets will be 2.05 times greater.

Example: From past testing we know that 110 ft-lb of torque is needed at the track to move the snowmobile from a stop without hesitation.

Question: At what engine rpm do we have 110 ft-lb of torque? (See Fig. 11 at torque curve).

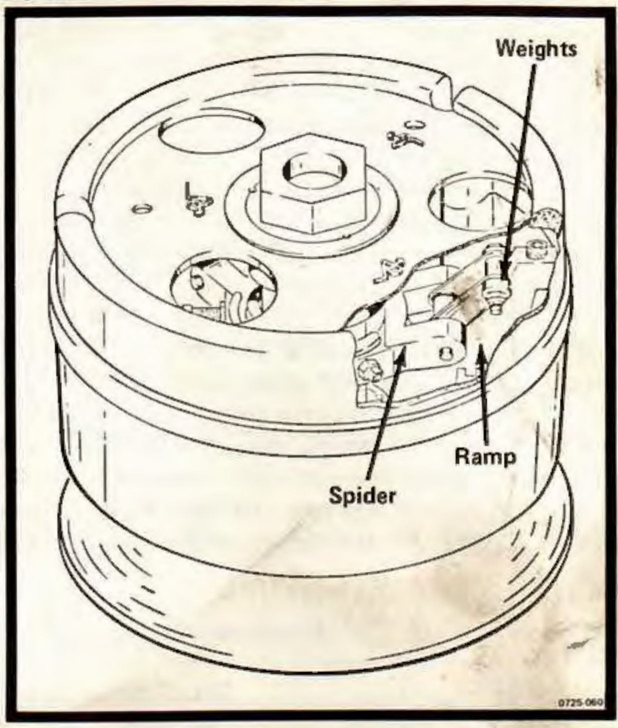
Fig. 14



Centrifugal Weights

The second variable affecting drive clutch operation is the clutch weights. The weights and rollers are bolted to the arms that are pinned to the spider. The spider has three arms: each arm has two weights and a roller and bushing that is retained to the arm by a small bolt and lock nut. The complete spider assembly (arms, weights, and rollers) is fastened to the stationary sheave shaft by three set screws and a split ring.

Fig. 15



The function of the weights is to provide an outward force against the spring while the rollers roll on the three ramps. When the engine is idling (less than clutch engagement rpm), the outward force is not enough to overcome the outward pressure of the spring. However, as engine rpm increases and predetermined clutch engagement speed is reached, the weights are thrown outward by centrifugal force caused by increased engine rpm. Since the outward movement of the weights overcomes the pressure of the spring, the moveable sheave pushes the drive belt against the stationary sheave. Power is then transmitted from the drive clutch through the remainder of the drive system.

The weights in the drive clutch affect the engine rpm throughout the complete shift pattern. Arctic makes available weights ranging from one gram to over 18 grams, Fig. 16. By increasing the weight, the centrifugal force is greater and the drive clutch will "shift up" quicker. Conversely, by putting on lighter weights, the force becomes less and the drive clutch takes longer to completely "shift up".

Fig. 16

WEIGHT CHART

	Part No.	Gram Weight	Outside Diameter	Thickness (inch)	Color Code
Light	0146-227	1.00	.400	.250	Aluminum
	0146-225	1.50	.463	.250	Aluminum
	0146-226	2.00	.521	.250	Aluminum
	0146-159	2.50	.377	.250	White
	0146-108	3.05	.406	.250	Yellow
	0146-175	3.73	.437	.250	Red
	0146-135	4.48	.471	.250	Black
	0146-176	4.68	.500	.228	Green
	0146-107	4.96	.491	.250	White
	0146-279	5.46	.511	.250	Black
	0146-106	5.96	.530	.250	Red
	0146-278	6.48	.549	.250	Black
	0146-123	6.99	.568	.250	Yellow
	0146-105	7.86	.598	.250	Black
	0146-286	8.80	.629	.250	Red
	0146-136	9.28	.644	.250	Green
	0146-104	9.75	.665	.250	White
	0146-166	10.60	.684	.250	Red
	0146-307	11.30	.703	.250	Yellow
	0146-314	12.00	.723	.250	Black
Heavy	0146-308	18.00	.873	.250	Green

The clutch weights also have a slight effect on engagement speed. A heavy weight slightly decreases the drive clutch engagement speed and produces lower engine rpm throughout the shift pattern. By contrast, a light weight slightly increases engagement speed and produces higher engine rpm throughout the shift pattern. Fig. 16.

What Happens When the Clutch Weight are too Heavy or too Light for the Machine Being Clutched?

From before, we know that each engine has an rpm where maximum horsepower is developed. For example: If engine A (see page 7) has maximum horsepower at 6500 rpm, it should run 6500 rpm at full throttle. If the clutch weights were too heavy, the clutches would "shift up" too fast pulling the engine rpm below 6500. Thus, maximum hp would not be delivered from the engine, causing a loss in speed and performance. If the clutch weights were too light, the clutches would not "shift up" to the 1:1 ratio and engine rpm would be over 6500. With too light a weight, the rpm would run over the point of maximum power, causing a loss in speed and performance.

NOTE: When the proper weights are used in the drive clutch, the engine will run at the rpm where maximum hp is delivered. The clutches will shift from low ratio (engagement) to high ratio (top speed) at the fastest rate they can without going either above or below the point of maximum power.

Ramps

The third variable affecting drive clutch operation is the clutch ramp. Drive clutch ramps made by Arctic Cat are carefully designed to provide the proper shift pattern for a specific engine. The total shift pattern of the drive clutch is affected by the clutch ramps. The ramps are designed so clutch engagement is smooth, and the total shift pattern is responsive to various loads.

The design of the ramp is dependant upon the torque curve of the engine. A low rpm, family type engine does not use the same ramp profile as a high rpm, racing engine. The ramp is designed so the shift pattern is within the peak torque curve (rpm) of the engine. Arctic has a number of different ramp profiles that were designed to meet widely varied engines. Ramps were designed to meet the needs of 20 hp engines at 5500 maximum rpm all the way to 100 hp engines running at 9000 rpm.

How Drive Clutch Ramps are Designed

When the rpm of the engine increases, the clutch weights provide an outward force against the spring, while the rollers roll on the three ramps. The design of the ramp becomes critical from the point of engagement through the complete shift pattern. The total travel distance of the rollers on the ramps for the complete shift is approximately 1 inch. A snowmobile will go from engagement, through the midrange, and on to a top speed of 80 mph, all on this one inch of ramp profile.

NOTE: Because of this short roller travel distance through the complete shift pattern of the drive clutch, a thorough understanding of the relationship between ramp profile and shift characteristics is necessary before any changes are made.

Drive Clutch Engagement Speed

From Fig. 17, the point at which the roller contacts the ramp when the clutch is in neutral is the engagement point. From the discussion on the spring, we know the engagement speed can be changed by either increasing or decreasing the spring rate. The engagement speed can also be changed by the ramp profile. The degree of the angle of the ramp will increase or decrease the engagement speed.

Fig. 17

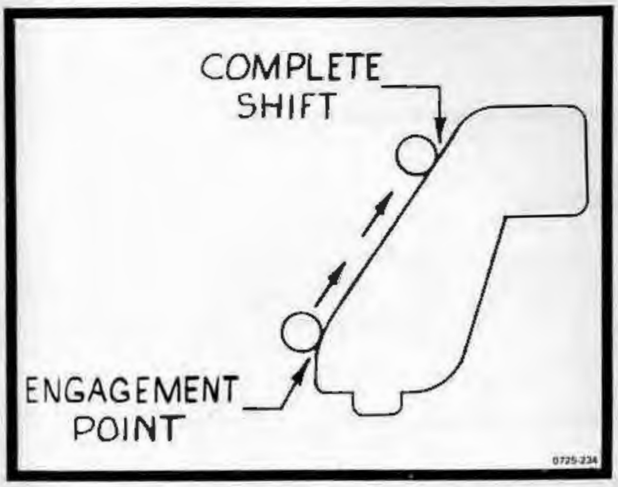
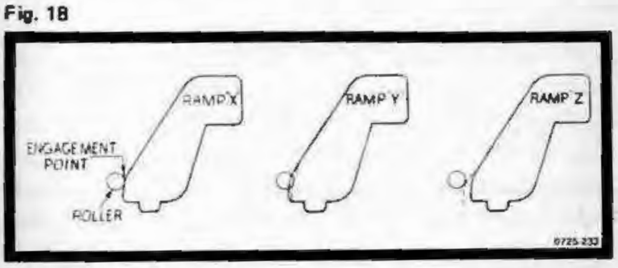


Fig. 18 shows how the engagement rpm can be changed by different ramp profiles.

Fig. 18

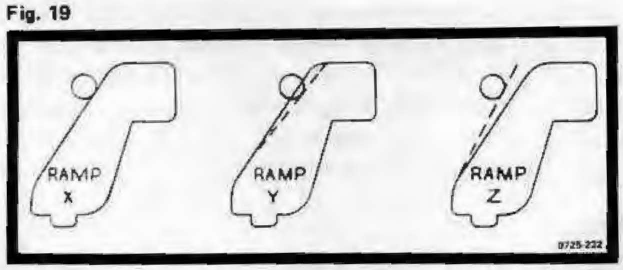


Example: (See Fig. 18) Ramp "X" has an engagement of 3500 rpm. On ramp "Y", the profile has been changed so that the angle at the point of engagement is steeper. Thus, the engagement on ramp "Y" would be more than 3500 rpm. On ramp "Z", the profile has been changed so that the angle is less than ramp "X", causing the engagement speed to be less than 3500.

Ramp Profile Affect on Full Throttle Engine RPM

Fig. 19 shows three different ramp profiles and the position of the roller when the clutch has completed the shift pattern. The ramp profile is a major factor in determining the characteristics of the shift pattern.

Fig. 19



Ramp X: For an example of ramp profile affect on engine rpm, we will say ramp X when fully shifted will run the engine at 6500.

Ramp Y: This ramp is cut back (less angle) at the top and will run the engine at below 6500 rpm.

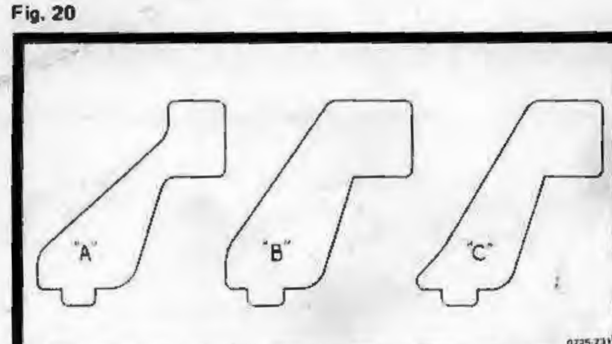
Ramp Z: This ramp is not cut back as far as ramp X (steeper angle) and will run the engine at more than 6500 rpm.

NOTE: The only change made in the example was the ramp. The spring and weights were not changed.

Different Ramp Designs for Different Type Engines

Fig. 20 shows three ramps that were designed to match the torque and horsepower curves of very different type engines.

Fig. 20



Ramp A: This ramp was made for an engine that develops maximum horsepower at low rpm (approximately 6000). A ramp that has less angle (cut back) will shift the clutches faster and pull the rpm of the engine down. This type of ramp would not work on a high rpm race engine.

Ramp B: This ramp was made for a high rpm race engine. A race type engine has very little torque at low rpm and needs a high engagement speed. On B the ramp angle at engagement is steep and will cause high engagement. The ramp profile after engagement continues has a steep angle and will run the engine at a high rpm.

Ramp C: This ramp was especially designed for a high rpm engine that would engage at low rpm. A low engagement speed was cut into the ramp. After engagement the profile becomes much steeper (much the same as ramp B) and will cause the engine to run high rpm.

The ramp profile becomes more critical on a very high performance race engine where the peak torque curve may be a few hundred rpm. The ramp profiles are cut to match the torque curve of each engine. A very small change in the ramp can mean a great difference in the horsepower transmitted to the track.

In conclusion, the Arctic drive clutch has three variables that are matched to each different snowmobile and engine size. In the clutch, the spring, weights and ramp profile, together have an effect on the performance of the machine. As produced, the Arctic Cat Snowmobile is "clutched" for average customer usage. However, by understanding these clutching variables, the Arctic drive clutch can be customized to suit almost any condition or owner request.

Drive Clutch Maintenance

Lubrication

The Arctic drive clutch uses "Duralon" bearing material. This material DOES NOT have to be lubricated.

NOTE: NO LUBRICATION SHOULD BE APPLIED TO THE DRIVE CLUTCH.

Cleaning

When cleaning the drive clutch, use cleaning solvent and dry with compressed air. DO NOT use steel wool or a wire brush to clean "Duralon" bearings.

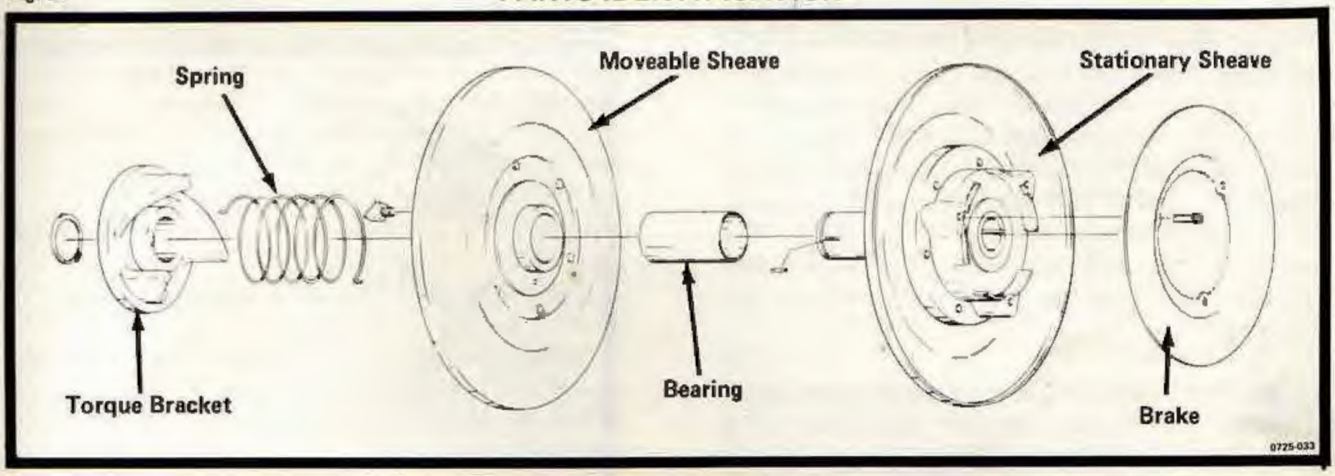
Inspect and Measure Bearing for Wear

The allowable bearing wear or clearance between the hex shaft and bearing is covered in detail in Section V, Drive System, in the 1975 Panther Service Manual.

Driven Clutch Basics

Fig. 21

PARTS IDENTIFICATION



Operation

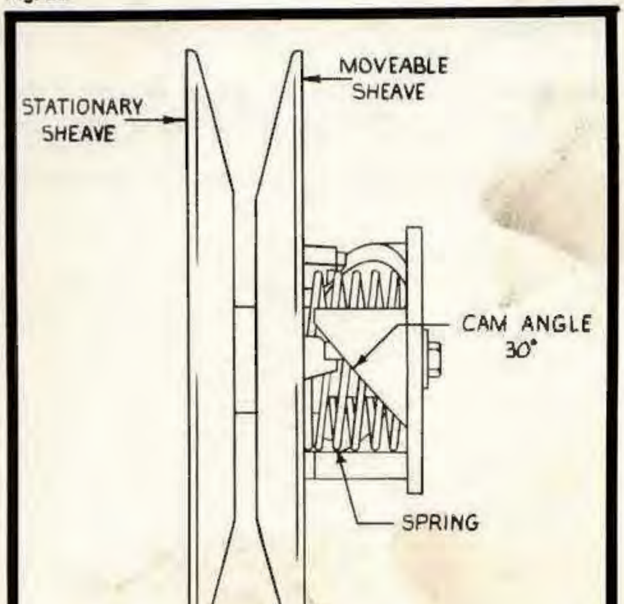
The second major component in the drive system is the driven clutch. The driven clutch unit, connected to the drive clutch by the drive belt, is connected to the drive shaft and track of the machine through the chain case and drive chain. The driven clutch's job is to sense the load on the machine and keep enough tension on the drive belt to keep it from flipping. The driven clutch is a very important element in the drive system, and, unless it is doing its proper job, the machine will not perform up to its capabilities.

The Arctic driven clutch is the only element in the drive system that is torque sensing. The driven clutch, unlike the drive clutch, can tell if the load on the track is only a light load or if it may be in two feet of snow. Because the driven clutch can sense the load, its job is to analyze how much torque it is receiving from the engine then compare this torque to how much resistance it receives from the track and ground. Once this information has been analyzed, the driven clutch shifts to the highest possible ratio, under the conditions, to obtain maximum speed and power.

When the load (resistance) on the driven clutch is increased and is greater than the torque delivered from the engine, the driven clutch becomes dominant and overrides the engine clutch. The driven clutch will "down shift" into a ratio that will supply the amount of torque needed for the increased load. Because the driven clutch can sense the load and shifts into the proper ratio the engine rpm will remain at the peak output. If the driven clutch did not "down shift", the clutches would stay in too high a ratio and the engine would run at rpm below maximum power.

The Arctic driven clutch has two variables that effect the proper shift pattern in the driven unit: spring tension along with the angle of the cam.

Fig. 22



Spring

The spring tension on the driven clutch determines the rpm that the engine will run at during the shift pattern. The Arctic driven clutch is made so that the spring tension can be adjusted. If the rpm of the engine is over the peak of the power curve, the spring tension can be decreased. This will allow the driven clutch to shift into a higher ratio, with the same amount of load on the track. This will pull the rpm of the engine down. Conversely, when the driven clutch is shifting into a higher ratio than the engine has power to pull, the rpm of the engine will go below the peak of the power curve. By increasing the spring tension on the driven clutch, the clutch will not shift up under the same load but will stay in a lower ratio. This will increase the engine rpm.

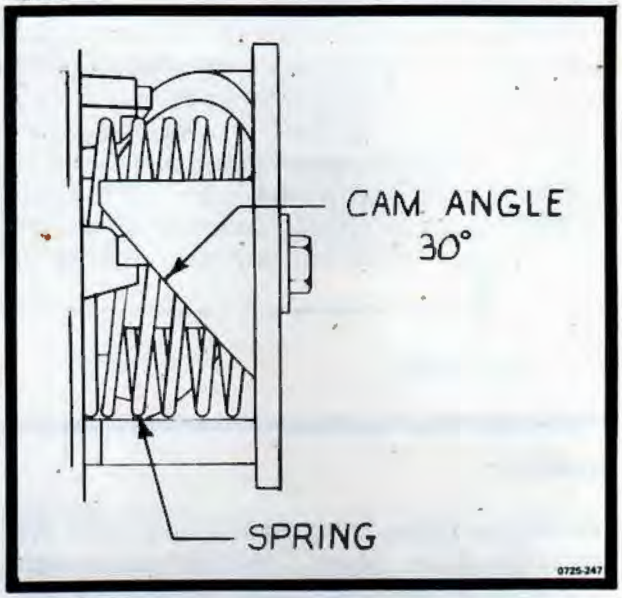
NOTE: Increasing driven clutch spring tension will increase engine rpm. Decreasing spring tension will decrease rpm.

By varying the amount of spring tension, the driven clutch can be matched to the drive system under vastly different load conditions. When the track has a very light load, like riding on a lake with little snow cover, the spring tension may be relaxed. For very heavy snow conditions, the spring tension may have to be increased to maintain the correct rpm. By having a driven clutch spring that can be easily adjusted, the engine rpm can be varied a few hundred higher or lower.

Cam Angle

The second variable in the driven clutch is the cam angle, Fig. 23. This angle, along with the spring tension, controls how easily the driven clutch will shift up. If the spring tension remains the same and the cam angle is changed to a steeper angle, the clutch will shift to a higher ratio under the same load. This will lower the rpm of the engine. The reverse is true when going to a cam with less angle. The rpm of the engine will increase.

Fig. 23



NOTE: A 30° cam angle will run more engine rpm and up shift slower than a 45 cam.

This variable is only adjusted at the factory and can not be changed by the customer. Much dyno and field running has been done with cam angles of varying degrees. The cam angle that is used on the Arctic driven clutch has been proven to be the most responsive to a wide range of snow conditions.

Drive Belt Basics

The drive belt plays an important part in drive system performance. The belt dimensions and construction are the two variables that influence the performance of the drive system. Drive belts have been vastly improved in the last few years. With the tremendous increase in horsepower, drive belts have been developed that far exceed original estimates of possible power ratings for a single belt drive system.

Drive Belt Dimensions

The drive belt dimensions are very closely calibrated when the drive system is matched to the machines at the factory. The two dimensions that are important to the performance of the machine are the O.C. (outside circumference) of the belt and width. Both of these dimensions will influence the shifting characteristics of the clutches.

Drive Belts Not Within Specification

If the drive belt is longer than specifications allow, the performance will not be up to standard. The drive clutches will not have the full shift ratio. With a long drive belt, the low end ratio may be 2.75:1 instead of 3.79:1 as it should be. This will cause a bog on engagement and poor acceleration. Also, the top ratio may only be about 1.5:1. This will cause a loss in top speed.

A drive belt that is worn thin will have the same affect as one that is too long. New drive belt width, measured across the outer edge, is 1-1/4 in. The belt has exceeded the minimum wear limit when it measures less than 1-1/16 in. The drive belt should then be replaced.

A belt that is shorter than specifications will cause a loss in performance. The clutches will have a different shift pattern because they are in different ratios than conditions for which they were originally matched.

Drive Belt Construction

The drive belt construction has an influence on the way the clutches will shift and on the amount of power that will be transmitted through the system. ONLY ARCTIC DRIVE BELTS SHOULD BE USED. A different brand of belt may not have the same construction, causing more friction when the belt is wedged between the sheaves. This will cause a loss in efficiency.

■ **NOTE: A stiff belt causes more hp loss to the track. As a belt warms up, it gets more flexible and transmits power with less loss.**

Wear Characteristics

Normal Belt Life: In general, there is no specific time or mileage at which the drive belt suddenly wears out or fails. With proper maintenance and proper customer operation of the machine, a drive belt can last a full season.

If the drive belt fails after a very short time, there is some sort of malfunction in drive system.

■ **NOTE: If abnormal belt failures occur, the Drive System, "Belt Trouble Shooting" section of the 1975 Panther Service Manual should be used to diagnose the problem.**