THE SCIENCE SLEUTHS

Book 1

Adventures in Physics

by Randal Lee Gritzner

Illustrated by Taylor Randa Gritzner

CHAPTER 1

The Science in Dairy Farming

My name is Donny Karr, but they call me Grits. It's my favorite breakfast food. What can I say?

More importantly, I love Science, and so does my buddy Joe Grean. I'm pretty good at it, and Joe is a good assistant. He tries really hard to be smart, but Joe never did study enough to excel. He spends too much time playing baseball, basketball, fishing, and other frivolous stuff like that. We're both twelve years old, so perhaps that's understandable.

Joe and I live in the small town of Clearmont. To give you an idea of how small our town is, we have a population of 517. I actually live less than a mile outside of town, on a small farm. Joe lives in town. That might be part of why I learned to excel in Science. Farm life can teach a young fellow a bit about work ethic. City boys sometimes have an easier life. Feeding calves and cleaning their pens happens every day, for me. Joe's dad is a salesman, and all Joe has to do is mow the yard and take out the trash. It isn't much of a yard, either. Not like the two acres that I mow on the farm. Even Joe's trash duties are easier than mine. He puts the trash bags at the curb in a trash barrel. I burn the trash in a big hole Dad had dug out back behind our buildings. A neighbor dug that hole with his backhoe. It's one big hole!

I really do love living on the farm. The work is hard, but I love having space between our place and the neighbors. I also love the fact that Dad is his own boss. He's buying this farm, and he works hard to make a good life for his family. My friends at school are always telling stories about their dads having arguments with their boss.

My Dad is such a cool dad! He was in the U.S. Army back during the Persian Gulf War. When he was getting out of the Army, an officer asked him what his plans were after he got out. Dad told him that he planned to farm, and that officer told Dad, "You're smarter than that, Karr! You've got the brains to go to college and do anything you want to do!" That's when Dad told him, "Farming is what I want to do!" At one time, farming was considered as a job that any big, dumb, brute could do. Since then, farming has become big business. Dad was smart enough to simply get a jump on farming as a business! Besides, farming was deep in Dad's heart. His dad was a farmer, and his grandfather was a farmer.

I also have the world's greatest Mom. She was real pretty when she was younger, and she's still a good-looking woman, even at forty. Mom loves her family sincerely and takes incredibly good care of us. When I get sick, she becomes *SUPER NURSE*! I've also got some brothers and sisters, but they're not real interesting. Maybe I'll mention them later.

One more thing about my life that makes me the luckiest preteen on planet Earth, is the fact that all four of my grandparents live within one mile of my farm. They're all good

Christian people, and they love their grandchildren. Mom and Dad are also strong in their Christian faith. I probably don't say it enough, but they've led me to a strong Christian belief, and it's an important part of my life!

Enough about that! Let's get down to the good stuff, Science! A farm can be the best place to live if you love Science! Dad milks twenty-eight guernseys, and he has two pastures. Overnight, the cows stay in the small pasture. The small pasture is down a lane from the barn, near to the river. During the day, the cows stay in Dad's larger pasture. After the morning milking, we drive the cows through the small pasture and out the far end. From there, we take them across the gravel road, and into the large pasture. In the evening we bring the cows back to the barn for a second milking.

Some people might think that a farm isn't a good place to learn Science, but they're just plain wrong! Cows used to be milked by hand back in the old days, when Grandpa was a kid and before. Now we have fancy machines to do that. Dad has a big vacuum pump in the milk room, at the front end of our barn. That pump is connected to vacuum lines, and those lines run down both sides of the barn, in front of two rows of stanchions. The cows each stand in their own stanchion, which can be closed around their neck. This keeps them comfortably in a good position, just long enough for them to be milked.

Now most kids might get bored looking at a bunch of cows in a barn waiting to be milked. Joe and I like to analyze every aspect of the setup and figure out why things are done the way they've been done. Dad's milking operation appears to work well. Was this a big accident, or was there some Science involved in designing his milking setup? The Science Sleuths talked about it and decided to study the Science behind milking cows.

Joe and I started at the Clearmont Public Library. The School Library was closed for the summer, but the town library was also pretty good. I've heard Dad talk a lot about his vacuum pump, so we need to first understand what a vacuum pump is, and how it works. Joe found some good books about vacuum pumps. He did that using the online catalog. Joe does much of my foot work, allowing me more time to do the actual research. Our research usually turns into a good team effort.

It turns out that a vacuum pump pulls air out of a sealed chamber, thus creating a vacuum inside that chamber. There are three ways to do that.

A positive displacement pump can do that. Rotary vane pumps, diaphragm pumps, liquid ring pumps, reciprocating piston pumps, screw pumps, and gear pumps are examples of positive displacement pumps.

A moment transfer pump is a second way to create a vacuum. These pumps accelerate air molecules from the vacuum side of the pump to the exhaust side. Moment transfer pumping is only possible below pressures of about 0.1 kPa (kilopascals). Matter flows differently at different pressures based on the laws of fluid dynamics. At normal atmospheric pressure and minimal vacuums, molecules push on nearby molecules in what is known as viscous flow.

The third way to create a vacuum is with a <u>regenerative pump</u>. These pumps use the vortex behavior of air. They are constructed using a hybrid concept of the centrifugal pump and turbopump. Several sets of perpendicular teeth are used on the rotor that circulates air molecules inside stationary hollow grooves like a multistage centrifugal pump.

Now comes the fun part! How can we figure out which of those three methods is used in Dad's milking system? Joe suggested that we simply ask Dad. I agreed, so we did just that.

Now Dad is an intelligent man, but he didn't know the answer to this question. He did, however, point us in a constructive direction to get that answer. He told us to look in a cabinet in the milk room of our barn. There we found the instruction manual that came with the milking system when Dad bought it. Of course, the manual was written to be used with multiple models of milking machines. We had to search the machine for its exact model number.

With that data, and a quick reference to the instruction manual, we finally had our answer. Not all milking machines use the same type of pump, but Dad's pump is a positive displacement pump. Different types of pump can be used, depending on several factors. One factor is the number of cows to be milked every day. Another factor is the cost of the machine. Buying a more inexpensive machine can have its benefits, but the machine can't be expected to last as many years as a more expensive machine.

The milking system has a milking side and a pulsator side. When the system is on, vacuum is created by a vacuum pump that removes air from the system. When the cows are not attached to the system, the vacuum will be the same on both sides. Once the cows are attached, milk and vacuum are present on the milking side only. That causes the vacuum to be lower on the milking side, as compared to the pulsator side. The pulsator side will not have milk, but only vacuum.

Pulsator speeds are usually 60 pulses per minute. Pulsator ratios vary from 50/50, to 60/40, or 70/30. The first number represents the amount of time the pulsator creates vacuum to open the liner and cause milk to flow. The second number is the amount of time it allows atmospheric pressure to collapse the liner and massage the cow's teat. Uniform pulsation milks all four teats at the same time. Alternate pulsation milks two teats at a time. Dual pulsators allow different teats to be milked at different ratios. The 70/30 ratio milks cows fastest, but the 50/50 ratio is gentler on the cow's teats. Farmers can make these adjustments to accommodate young cows, older cows, and cows with injured teats. This new information was absolutely fascinating to me! Dairy farmers use way more Science than I was ever aware of!

A big leather belt hangs around the cow's abdomen, with a bucket hanging below the cow, near her teats. There are four teat cups on each milk bucket. A teat cup contacts each teat on the cow's udder. Cleanliness of those teat cups is crucial, to avoid an infection called *mastitis*. A rubber liner inside each teat cup gets exposed to vacuum, the liner is

pulled open around the teat and milk begins to flow. Vacuum causes that flow. When exposed to air at normal atmospheric pressure, the liner collapses around the teat, and milk ceases to flow because it briefly experiences no vacuum. Those four teat cups are connected by a device called the claw, and the claw connects to the milk bucket.

This image is available at www.hambydairysupply.com/reconditioned-surge-bucket-milker-with-standard-bore-clear-silicone-inflations-new-pulsator/

Once the flow of milk from the cow's udder to the bucket was complete, the bucket needed to be carried to the milk room and dumped into the large bulk tank. The bulk tank was a large refrigeration unit.

Proper maintenance of the milking system is also very important. The milk buckets, claws, and teat cups need to be scrubbed thoroughly after each milking. This cleaning involves more than just hot water! Soap, acid, and germicide solutions are also used.

As can be expected, the cows often get anxious to leave the barn after each milking. It's more pleasant to roam the cow yard, eating hay at will, than to stand in one position in the stanchion in the barn. Releasing the cows from their stanchions can often be a humorous example of animals regaining their freedom. Sometimes they even kick their heels in the air, as an expression of their pure delight!

Just watching Dad handle the cows has always been quite entertaining. Closely studying the Science involved is becoming more fun than I had expected. But one thing has still escaped me. How does that vacuum pump work?

Joe might not be the brightest brain in town, but he does come up with some clever ideas frequently. He suggested that we go back to the instruction manual that came with Dad's milking system. He beat me to that idea by a fraction of a second. Oh well! I've got to give the kid credit when credit is due!

We went back to the barn, investigated the cabinet, and got the instruction manual. The manual showed us that a diaphragm, or flexible membrane, is rapidly flexed by a rod riding on a cam. The cam is an egg-shaped wheel. Because the rotating cam is not quite circular, the rod goes up and down quickly. This causes air to come in one valve, the inlet, and out the other valve, the exhaust. The diaphragm and valves need to be replaced after about 10,000 hours of operation. Proper lubrication and other maintenance can maximize their lifetime. Good suction can be created reliably and economically.

Just when I thought our study of Science relating to Dad's dairy operation was complete, Joe asked another question. He then asked even another one. How could he keep coming up with such good questions before I did? Joe asked me how the refrigeration unit worked on Dad's milk tank, and then how the milk truck driver got the milk from the milk tank onto his truck. I couldn't answer either question! Here we go again!

First things first! We needed to find out how the refrigeration unit on the milk tank works. We looked at the milk tank in Dad's barn, hoping that its workings would be obvious. They weren't, so we went back to the cabinet in the milk room. We searched for the longest time, and eventually found another instruction manual. It was the manual for the bulk milk tank and its built-in refrigeration unit.

The manual explained the need for a highly efficient cooling system to keep the temperature very consistent. To maintain the high quality of raw milk, it must be cooled quickly to 40 degrees Fahrenheit. Milk comes out of the cow at about 100 degrees Fahrenheit. That's no small task. Milk tanks usually have a mixing paddle to accelerate the cooling process and mix the milk from multiple cows very uniformly.

Pipes are welded directly to the exterior of the milk tank. They carry refrigerant, a liquid which carries heat easily from one place to another. That is done by changing from liquid to gas, and back again to liquid. A layer of insulation covers those cooling lines, with an exterior metal shell over the insulation. This system must be turned off when the tank is empty, or the inside walls of the tank could freeze, and be damaged. When warm milk is put in, the tank is cooled rapidly. That requires very large refrigeration compressors and condenser radiators. Compressors move the refrigerant through the lines quickly. Radiators release the heat which has been removed from the milk into the air outside of the tank. This system uses large amounts of electricity and is therefore too expensive for many small dairy farms.

Joe's question about the removal of milk from the milk tank and putting it into the milk truck was easily answered. We asked Dad when the milk truck driver would show up. He knew exactly when to expect his next visit.

The milk truck driver's name was Leo. Leo is the father of a friend of mine from school. Her name is Nancy, and we're also in the same Sunday School class. Leo is a very good man!

Leo picked up our milk the very next day. He didn't have a lot of time to spare, but he still found time to answer our questions. He explained that his truck had a big vacuum pump, very similar to the one on my Dad's milking machine. That vacuum pump pulls air through a filter, a secondary shut-off valve, and a primary shut-off valve. That creates a vacuum in the tank of his truck. Those shut-off valves are protection devices to make sure the tank does not overfill. The shut-off valves are made of a rubber seat and a stainless-steel ball inside a cage. The filter keeps chunks of anything from passing through, because those chunks could damage small parts in the pump.

All this investigation and research made me ponder on several things that my parents and grandparents had instilled into me over the years. A truly educated person understands both science and art. Science is the understanding of our world, and how things work and interact. Art deals with the value of human interactions as perceived by the senses of sight, touch, hearing, and even smell. Religion seeks to understand the source, purpose, and meaning of everything. The domains of science, art, and religion are different, but they do overlap.

I've read about several world class scientists who believe strongly, that the more they study our world and its intricate beauty and organized structure, the more they believe in the creation of it all by God! They believe that our universe could not have resulted from anything less than an incredibly intelligent omnipotent God!