Summers.
Paramagnetic and Diamagnetic Substances and the Effect of Temperature on them.

"PARAMAGNETIC AND DIAMAGNETIC SUBSTANCES AND THE EFFECT OF TEMPERATURE ON THEM."

In the latter part of the eighteenth century only a few substances, such as iron, nickle, and cobalt were thought to possess magnetic properties. Little by little, research work has gone on until now, it is believed that all substances are either attracted or repelled by a magnet. This attraction or repulsion in most substances, is extremely feeble. Those that are attracted, Faraday called paramagnetic, and those that are repelled, he called diamagnetic.

This diamagnetic property was first discovered by Brugmans in 1778. He noticed that bismuth put into a paper boat, floating on mercury, was repelled by both poles of the magnet and, if suspended by a thread between the poles of a strong magnet, it would set equatorially or at right angles to the magnetic lines. He explained this newly discovered phenomenon by assusming that mercury was transversely magnetic.

In 1802 Coulomb noticed that a magnet acted more or less on a number of bodies. He attributed this to small particles of iron in the substances, that were too small for even the chemist to take out. He mentions having suspended a piece of wood between the poles of a magnet and it set at right angles to the magnetic lines. He then suspended it between the wires of a galvanometer and it would swing parallel with the wires.

Saregy (1828), did some investigating along this line, and come to the conclusions that no body, except iron and substances

~~conclusion that no body, except iron, and substances~~ containing iron, possessed this quality. How he accounted for the action of bismuth, I do not know.

In this same year (1828), Lebaillif repeated Brugman's experiment on bismuth, and established the fact that both, bismuth and antimony were repelled by a magnet.

At this point, the subject seems to have been droped and nothing was done until it was rediscovered by Faraday in 1845. While he was experimenting with the rotation of a polarized ray of light, he accidentally noticed that a fragment from his heavy glass swung across the magnetic field and when closer to one pole than the other, it was repelled. He pushed his experiments in all possible directions, going into the subject more thoroughly than any before him. He experimented on almost every substance he could get. When Bancalari and Zantedeschi established the magnetic properties of the flame, Faraday repeated their experiments. He passed from the flame to gases and established their paramagnetic and diamagnetic properties. On account of his extensive research work along this line, he has been called the father of what he thought to be a new property of substances.

Professor Plücker of Bonn did a great deal of work along this line. His "Object was to investigate the influence of the fibrous constitution of plants upon their magnetic deportment." This led to his working out the effect of Crystalline structure upon their magnetic action. His investiagtions gave us these two laws;- first,"When any crystal, whatever with one optic axis, is brought between the poles of a magnet the axis is repelled by each of the poles; and if the crystal possesses two axes, each of these is repelled with the same force by the two poles;" second;-"The

forces which cause this repulsion is independent of the magnetism or diamagnetism of the mass of the crystals, and it decreases with the distance, more slowly than the magnetic influence exerted by the poles."

"G. Wiedemann had made elaborate investigations of chemical compounds with a view to connecting their magnetic properties with their chemical compounds."

Tyndall did a great deal of work along the line of diamagnetism and magne-crystalic action of substances. He worked in Marburg, Berlin and in the laboratory of the Royal Institution, spending in all six years on the subject. Prof. Knoblanch assisted him part of the time.

Various theories have been advanced as to the nature of diamagnetism. Faraday advances the theory that diamagnetic substances possess polarity the same in kind but opposite in direction from the magnetic substances. He founded his theory upon the character and direction of the force itsself, whatever the cause of the force might be. The direction of the current determined the polarity. Plücker, Reich, Weber, and Paggendorf believed in this theory.

Faraday finally abandoned the theory and in his own words he says, "I am obliged to say I can find no experimental evidence to support the hypothetical view of diamagnetic polarity either in my own experiments or in the repetition of those of Weber, Reich and others. I do not say that such a polarity does not exist." He appealed for farther investigation of the subject.

Others took the view that it was not a polar force but an unpolar force like that of gravity. The repulsionof a diamagnetic substance increased when the strength of the magnet increased.

Tyndall takes his type from soft iron and "Considers that anybody presenting the like or antithetical phenomena which such iron

would present under magnetic action is in a like or antithetical state of polarity."

M. Bequerel's differential theory seems to me to be the most reasonable of all the theories that have been advanced. He says that diamagnetism may be only a relative term and the reason that some substances point equatorially is the same as that for a piece of light wood floating on water while a piece of lead sinks, there are more gravity lines running through the lead per unit of volume than there are through the same volume of water so the lead is pulled down or sinks into the water. There are more gravity lines through the water per unit volume than through the wood so the water is pulled down and the wood floats. If we had a liquid with a less number of gravity lines running through it per unit voulume than through the wood, the liquid would give way and the wood would sink as the lead did.

So it is with paramagnetic and diamagnetic substances. If the substance tried will admit more magnetic lines of force through it than the surrounding medium, it is magnetic with reference to the medium that surrounds it. If the surrounding medium admits more lines of force than the substance, it is diamagnetic with reference to the medium. Air is considered as the standard medium and is taken as zero. All substances that are attracted by the magnet, when in a medium of air, are called paramagnetic, and all substances that are repelled are called diamagnetic.

He bases his conclusions on the following results which he obtained. The repulsion of a bar of bismuth, sulphur, wax, etc. increases as the square of exciting current, and the attraction of a bar of iron, nickel, coablt, etc. increases with the square of the

current. Thus following the same law except that one is a negative force while the other is a posative force. Tyndall proved this same law but by a different method. Becquerel also proved that some substances point axially when in a meduim of air and equatorially when in some other medium. Faraday also shows us that the strength of a solution makes a difference in its ~~the~~ magnetic properties

From these results it is easy to come to M. Becquerel's conclusion, that this is not a new property of substances, as Faraday thought, but that substances possess the magnetic property in different degrees of strength. This property forms one great series from iron, the most paramagnetic, to bismuth the most diamagnetic.

Diamagnetic substances have been found to be far more numerous than paramagnetic substances, but their effects are more feeble. Iron, the strongest paramagnetic substance, is said to be from thirteen to eighteen million times more paramagnetic than bismuth, the strongest diamagnetic substance, is diamagnetic. A magnetic substance of either class differs from a magnet in that they have no poles, and that a paramagnetic substance is attracted by either pole and a diamagnetic substance is repelled by either pole. Magnets and magnetic substances attract each other but magnetic substances alone have no attraction for each other. The unmagnetised magnetic substance is attracted at all parts equally and at the same time, ~~wh~~ while magnetism is unequally distributed. Faraday says, "By diamagnetic, I mean a body through which lines of magnetic force are passing and which does not by their action assume the usual magnetic state of iron or loadstone."

It is to Faraday that we are indebted for most of our knowledge along this line. Those before him had proved this power of paramagnetic and diamagnetic substances far more active than scientists

thought, but their experiments were isolated and limited in number. So it was left to Faraday to establish the fact that this property belonged to all substances.

For successful research work along this line, Faraday tells us that our "Apparatus must have great power and be under perfect control." As Tyndall puts it, "The forces to be investigated are so weak, and action so complex that the extreme of delicacy had to be combined with the maximum of power." The electro magnet is the best as its strenght is the greatest and its power can be altered or suddenly stopped at any time. Faraday in his researches, used a number of magnets, but the one he used most was "The Royal Institute Magnet." It is horseshoe shaped and formed from the link ~~and~~ of a great chain cable; the magnet and coil together weighing 272 pounds.

Faraday invents two terms which I will use; from pole to Pole or parallel with the lines of force, he calls the "axial direction," and perpendicular to the axial direction or across the magnetic lines of force, he calls the "equatorial direction."

Faraday showed that there was a force in crystals wholly distinct from paramagnetism and diamagnetism and that attraction and repulsion had nothing to do with that phenomenon but concludes that the phenomenon ~~was~~ presented by crystals is due to the interaction of the magnetic force and the forces which build the crystals. It is not polar because there is no attraction or repulsion. The crystal turns round without attraction or repulsion. It is distinct from magnetic and diamagnetic forces and Faraday calls it Magne-Crystalic action.

In my experimenting I used ~~Ruhmkorff's~~ Faraday's Apparatus, which consisted of two very powerful electro magnets. These two magnets

are fastened together by means of two L shaped pieces of soft iron that slide horizontally in a groove, made in a stout iron bar. In this way the poles can be adjusted at any convenient distance apart and fastened in position by means of two large clamping screws. The axes of the two coils are on a horizantal line. The coils are connected in series and both wound in the same direction, making opposite poles come together. This brings the magnetic lines of force very strongly across the field between them. There are two sets of pole pieces; one set tapers off to a rounded or blunted cone, the other tapers uniformly but is cut squarely off where the diameter is about one centimeter. There are places chipped out, in the sides of the latter, for setting a watch-glass for testing liquids. These pole pieces have threads cut on the other end of them and are fitted into the magnets as a bolt into a tap. The object of these pole pieces is to make the magnetic field very intense just where we want to use it. I suspended the substance, to be tested with a fine silk fiber, so as to leave it as free to the influence of the magnetic field as possible.

I tested the magnetic properties of all the varieties of dried fruit, barks, wood, and pith, that I could get and found them to be diamagnetic. I also found the following substances diamagnetic; leather, sealing-wax, sulphur, dried beef, rosin bismuth, antimony, lead, zinc, silver, selenium and tin.

I found iron, nickel, cobalt, cadmium, potassium bicromate, sodium bicromate, alum,platinum magnesium, copper-sulphate, copper, aluminum, and aluminum bronze to be paramagnetic.

I cut the pieces of wood I used with a steel knife. On testing them some of them showed to be p ramagnetic. After scraping them

carefully with a copper strip, I found them to be diamagnetic. Enough iron had been rubbed from the knif blade to over balance their diamagnetic properties.

I found some pieces of dried apricots and peaches that showed to be paramagnetic. Sometimes in the same half of a peach, I would find both paramagnetic and diamagnetic properties. I soaked some of the paramagnetic pieces in warm water and then dried them again. I found them all changed to the diamagnetic, except one large piece. I resoaked it and dried it as before and found it to be diamagnetic. The peaches, before drying, had probably been cut with a steel knife. The acids in the peaches and apricots retaining enough of the knife to make them magnetic.

THE FLAME.

In my first experiment with the flame, I used a sperm candle with a current from fifteen cells. The flame flattened out equatorially but the lines of force were not strong enough to split it into. In the center of the flame, where the lines were strongest there was a dark spot surrounded by the luminous flame. The shape of the flame varied as it was moved to different positions. If the top of the flame be put in the strongest part of the field, it would smoke. It was evident that this was caused by the lines of force and not by the cooling effect of the poles, for it would burn very nicely when there was no current. On breaking the circuit the flame jumped back to its normal position very suddenly but on making the circuit the change was more gradual. When I placed the candle a little to one side of the central magnetic force, the flame was very noticeably repelled to the one side as if a steady and uniform breeze was blowing it. It straightened up immediately on breaking the circuit. By using twenty cells and bringing the candle up from below the top of the flame seemed to be cut squarely off but as I raised the candle it began to hollow out as though it was coming up around a solid body. On raising the candle still more the lines of force would drive the sides of the flame downward and melt the sides of the candle, showing the flame to be strongly diamagnetic.

I tried the flame from ether, and the soft carbon flame from the Bunsen burner and found that they were affected in the same way.

The flame from the burner was not so strongly diamagnetic as that from the candle and ether. The oxidizing flame of the Bunsen burner was very little affected by the lines of force. This I think was partly due to the magnetic properties of the oxygen.

LIQUIDS.

I tried to get the magnetic properties of liquids by putting them into a watchglass and noticing tha action of the magnetic field upon them. If diamagnetic there would be an upheavel of the liquids and a lengthing in the equatorial direction. If paramagnetic the liquid would be drawn out in the axial direction. My magnetic field was not strong enough to get good results. I could not tell that it made any change with water, ether, amonia, acids or oils. I could see some movement with the alcohl, but not enough to establish very much. I then took a small watch-glass and suspended it between the poles with a fine silk fiber. The watchglass being round, the magnetic field had no tendency to turn it in either direction. Then by arranging a few drops of the liquid, to be tested, across the glass, and making the circuit, the lines of force would turn the glass around until the liquid set in an equatorial or axial direction according as it was diamagnetic or paramagnetic. By this method I found the following liquids to be diamagnetic; carbon bisulphide, mercury, water, kerosene, alcohol, gasoline, linseed oil, amonia-water, ether, sulphuric acid, hydrochloric acid, and olive oil. Turpentine showed very weak paramagnetic properties. This was probably caused by some impurities in it.

METALS.

I found zinc to be very slightly diamagnetic. It was strongly and suddenly repelled when the circuit was made and attracted when it was broken. I think this was due to induced currents in the zinc. It had no effect when the zinc set exactly axially or equatorially. I heated the zinc to the fusing point but could not tell that it made any difference in its diamagnetic properties.

A piece of pure tin showed diamagnetic properties. Another piece, which was supposed to be pure, showed paramagnetic properties. This was probably due to some slight impurities in the tin. I heated the latter piece to fusion. It seemed to lose part of its paramagnetic properties. The effect of induced currents was strong when cold but weak when heated.

I heated silver, lead and aluminum to their fusion points, but could not tell any difference in their magnetic properties.

Aluminum was strongly repelled at the instant the circuit was made, but was quickly attracted and showed strong paramagnetic properties.

Silver was repelled when the circuit was made and attracted when broken. It come to rest equatorially or was diamagnetic.

Lead was diamagnetic. It did not seem to be acted on by induced currents, at all. It would stop swinging with a vibratory movement and not suddenly as some of the metals.

Red sealing wax was diamagnetic. Its diamagnetic properties seemed to get stronger as it was heated.

I took a small piece of copper, cut from the ordinary electric copper wire, sandpapered it very carefully and then suspended it between the magnetic poles. It showed to have very slight para-

magnetic properties at the temperature of the room but, on heating, it became diamagnetic. I tried a piece of copper cut from an other wire. It gave me the same results as the first one. This paramagnetic property might have been caused by slight traces of iron mixed with the copper. When the copper was heated and the small particles of iron raised to such a temperature as to lose most of their paramagnetic properties, the diamagnetic property of the copper was left dominant and the copper turned to the equatorial direction.

In another experiment with some copper plates, I noticed that induced currents, caused by making and breaking the circuit, had less effect when the copper was at a high temperature than when it was at a low temperature. This I think is due to the fact that copper has a greater electrical resistance at a high temperature than it has at a low temperature. This cuts off part of the induced current.

One of the difficulties in testing the magnetic properties of copper, is the tendency of the induced currents, to stop it and hold it just where it is when the circuit is made. This is best shown in a copper cube. If the cube is suspended between the poles and caused to rotate so as to cut the lines of force at right angles to its rotation, it will be suddenly stopped to a dead rest when the circuit is made. The tendency of the induced current is to draw the cube just in the opposite direction from which it is rotating. This holds the cube in the position in which it is stopped.

There is a reaction in the opposite direction when the circuit is broken. This reaction is best shown by suspending a silver coin between the poles. If the circuit is made while the coin is rotating the coin will be suddenly stopped. It usually stops at an angle to the axial and equatorial lines, but can be made to stop exactly on

either of them. On breaking the circuit the coin was sometimes caused to rotate several times. The direction and amount of rotation depended on the position the coin was in when the circuit was broken. Each side of the coin was repelled by the pole nearest to it; the greatest amount of repulsion being given it when it was stopped at an angle of about forty degrees to the axial line. If it was stopped exactly on either the axial or equatorial lines, it was not revolved at all when the circuit was broken. In these positions, the lines of force have balanced effects on the whole coin.

I took one of the magnets off the apparatus, set it in an upright position and suspended the copper cube above the pole and directly over its center. In this position the magnetic field had no effect on the rotation of the copper cube. If I added a pendulum or vibratory movement to the rotary motion of the cube, the rotary motion would be stopped when the circuit was made.

I then suspended the cube near the edge of the magnet and set it rotating. When the circuit was made the rotation of the cube was checked. I placed the cube in various positions but its rotation would be checked except in a small space on a lime with the care of the magnet. This space seemed to widen as I drew the cube up from the magnet, making the non-active space funnel shaped. This action of the cube is explained by bearing in mind that at the center of the pole, the axis of rotation of the copper cube was parallel with the lines of force, so very few of the lines were cut. What few were cut caused the induced current to flow around the cube in the opposite direction from what it would if they were cut at right angles to the axis of rotation; so they did not cause any check on the

rotation of the copper cube. If I moved the cube to one side where the lines of force struck it at an angle, they would cause some induced currents around the axis of rotation of the cube, thus have a tendency to stop it. In this way the direction of the lines of force for the whole magnetic field might traced out.

In experimenting with iron, nickel, and cobalt, I used a current from twenty strong cells. This gave me a very strong magnetic feild. In my first experiment with iron, I set my magnetic poles eighteen centimeters apart.

I then took a small piece of a file, at the temperature of the room, and suspended it between the poles of the magnet by a short copper wire; which was attached to a long fiber suspended from a gaspipe. The wire was to protect the fiber from the burning. By means of a delicate balance, I found that it took a force of sixteen ounces to beeak the fragment of the file from the pole of the magnet. I heated the file witha Bunsen flame to about 800° C. At this temperature the file seemed to be neutral to the poles of the magnet; but, as it cooled, it recovered its paramagnetic properties very rapidly just before it passed to a dull red glow of heat. After it had passed this stage of rapid recovery of its paramagnetic property, which was at a dull red heat, it seemed to take the same force, sixteen ounces, to pull the file from the poles as when it was at the temperature of the room. I set my poles four centimeters apart and it took twenty two ounces to pull ths same piece of file from the poles. I heated the file before and found that it was feebly drawn to the poles when put close to them.

I tried the same experiments with a piece of wire nail, that I tried with the file. When the poles were eighteen centimeters

apart, it took a force of twenty ounces to pull the nail from the poles. When the nail was heated to a white glow with the Bunsen flame, there was only a slight attraction for the nail and that only when it was brought close to the pole. When the poles were four centimeters apart, it took a force of twenty-eight ounces to pull the nail from the poles. If heated to a bright glow with the Bunsen flame, the force was very weak but much stronger than before. It would feebly cling to the poles when brought very near them. When the nail was at the temperature of the room, it was attracted much more strongly to the magnet without a current than with a current when the nail was heated.

With poles eighteen centimeters apart, it took a force of twenty-eight pounds to pull a tap from the poles. I heated the tap to a temperature just below a dull red heat and a s far as I ~~could be~~ was able to measure, it still took twenty-eight pounds to pull the tap from the magnet. If there was any change in the force at all, it was very slight.

A Piece of cast iron was attracted with a force of eighteen ounces when the poles were eighteen centimeters apart but on raising the temperature to a bright glow, it lost nearly all this force. When the poles were four centimeters apart, it was more strongly drawn to them. The cast iron seemed to hold its paramagnetic properties just a little better than the steel and soft iron. It recovered its normal paramagnetic property at a dull red heat, just as soft iron and steel recovered theirs.

In every experiment with iron, it seemed to lose its paramagnetic property at a higher temperature than it regained it when cooling. This was probably due to the following causes; in heating the iron

the outside surface came to a glow before the inner part, making it appear to be at a higher temperature than it really was; in cooling the outside surface cooled faster than the inner, making it appear at a less temperature than it really was; in heating, it took some energy to disarrange the molecules and in cooling it took some energy to rearrange them.

With nickel, it took a force of four ounces to pull it from the magnet when the poles were eighteen centimeters apart. I heated the nickel with the Bunsen flame. The lines of force seemed to have no effect on it, except when put very near the pole it would turn in an axial direction. By placing the poles four centimeters apart, it took a force of six ounces to pull the nickel from the pole. On heating, it would turn axially anywhere between the poles; but the force was not strong enough to draw the nickel to them. As with the iron, the nickel when cold, was attracted more by the magnet without the current than with the current when heated. The nickel recovered its paramagnetic property very slowly, until it cooled to a temperature several degrees below a red heat; but at this point it recovered it very rapidly until it reached a state in which its paramagnetic property was as strong as at the temperature of the room.

It took forty eight ounces to pull a small cube of cabalt from the poles when they were eighteen centimeters apart. I heated the cube with the Bunsen flame to a good red heat. It still took forty eight ounces to pull the cube from the poles. I then heated it with the blowpipe. This burned the wires off so that I could not measure the force of attraction but appearently, it was drawn to the pole with as much energy as when cold.

Platinun was paramagnetic at the temperature of the room. It lost its paramagnetic property and became diamagnetic at a good red

heat. The change from magnetic to diamagnetic was made very rapidly when it had once begun to lose its paramagnetic property.

Magnesium was strong enough paramagnetic at the temperature of the room to cling to the poles. I heated it very slowly so as to keep it from burning as long as possible. It seemed not to lose any of its paramagnetic properties until just before it was hot enough to take fire. Then it suddenly lost most of this property.

Bismuth was strongly diamagnetic and slways stopped with a vibratory movement. One thing I noticed was that there was no polarity about diamagnetic substances. They always turn the shortest way to get equatorially no matter which way the current is flowing.

The bismuth ball suspended closer to one pole than the other was repelled by the nearer pole, regardless of the way in which the current was flowing. By placing the poles close together and suspending the bismuth ball directly between them the lines of force seem to have no effect upon it at all. It was in stable equilibrium ~~upon it~~ with reference to the magnetic lines. If the ball was moved a little to one side to get it out of the uniform magnetic field, it would be repelled much farther out by the lines of force and keep apparently at the same distance from either pole. The ball would rotate freely between the poles when there was no current but it was stopped almost instantly on making the circuit.

I tested the diamagnetic strength of the bismuth bar in water at zero degrees by means of a torsion balance. I then heated the water to the boiling point and tested the strength of the bismuth again. The force seemed to be very slightly stronger diamagnetic at the boiling point than at zero. I do not know whether this was caused by the change in the density of the water or whether it was

really a change in the diamagnetic strength of the bismuth. I tried the same experiment with antimony and received about the same results This strengthened my belief that this variation was caused by the change in density of the water.

Finding it difficult to get anything neutral to the magnetic lines in which to put some of my metals that fused at a low temperature, I moulded some small shallow cups from clay and dried and burned them; but, on testing them, I found that they were paramagnetic. At a good red heat they lost most of their paramagnetic property but regained it at a dull red heat. The clay was slightly red colored and I think, from the temperature at which it recovered its paramagnetic property, it was mostly due to the oxide of iron in the clay. A piece of white unglazed jar from a battery cell was paramagnetic, but become diamagnetic at a temperature several degrees below a red heat.

A piece of white china was paramagnetic when cold but became diamagnetic far below a red heat. It was paramagnetic at the temperature of boiling water.

GLASS.

I lowered to zero the temperature of a small piece of hard glass that I obtained from a lamp-flue and then suspended it between the poles and found it to be diamagnetic. I heated it and as its temperature was raised it become more and more strongly diamagnetic.

A thin piece of watchglass was paramagnetic at the temperature of the room, but on being heated it become neutral and then diamagnetic.

I found a piece of ordinary glass tubing to be more strongly paramagnetic than the watch glass, but on raising the temperature it gradually lost its paramagnetic property and below a red heat it was diamagnetic. From the actions of the watch-glass and glass tubing it might be possible to make the lampflue paramagnetic by sufficiently lowereing its temperature.

CARBON.

My first experiment was with a small piece of battery carbon. I suspended it in the usual way and on making the circuit found that it pessessed strong paramagnetic properties. I heated the carbon with the Bunsen flame to a bright redness; but removing the flame and making the circuit, instead of arranging itsself axially as before, the carbon set equatorially. As it cooled it seemed to become neutral at a dull red heat then gradually recovered its paramagnetic properties.

I tested a small piece ofarc light carbon and found it strongly paramagnetic when cold but it lost most of its paramagnetic property on being heated with the Bunsen flame; it did not however change over to diamagnetism as the battery carbon did.

I suspended a piece of charcoal between the poles and found it to be strongly paramagnetic at the temperature of the room. On heating, it gradually lost its paramagnetic property and become diamagnetic. I tried several pieces, all giving me the same results.

A piece of graphite from a lead-pencil was strongly paramagnetic but lost most of this property when heated.

I do not know whether all these phenomena that I have observed are strictly true or not as I have no assurance that my metals were absolutely pure. Some of the phenomena would indicate that they were caused by impurities in the metals; but in the main, I am convinced that they have given phenomena true to the metals used.

The general effect of heat on substances seems to be to lower their paramagnetic and raise their diamagnetic properties.

Cold air is paramagnetic with reference to hot air; so from this we might expect a hot body surrounded by a layer of hot air to

appear to be more diamagnetic than it really is. The hot air is repelled and tends to carry the substance with it.

If we accept the theory of transverse polarity of the molecules this phenomenon may be explained from the fact that heating expands the substance and weakens the force between the molecules, thus causing them to be more and more easily turned and thrown out of position. As the molecules become more active in bombarding each-other more of them are thrown out of magnetic line and the forces, more and more, neutralize each-other. When the temperature is raised high enough, the oscilations of the moleculas become so violent and mixed that the polar molecules neutralize each-other and we say the substance has lost its paramagnetic property. If the polar molecules of the surrounding medium are more rigid to temperature than the substance, the substance will be replaced by the surrounding medium and we say that it is diamagnetic.

From M. Becquerel's point of view, that as the temperature of a substance is raised it becomes a poorer conductor of electricity, so it becomes a poorer conductor of magnetic lines and the resistance of the substance becomes greater than the resistance of the surrounding medium, the substance is repelled.

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Approved,
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