in regard to the rotary motion of the bushing *b*, but moves with this latter bushing in a longitudinal direction by means of four flanges, *g*, on the outside surface.

This second bushing is in its turn provided with spiral teeth on the outside, which mesh with teeth in the rod *h* connected with the regular reversing lever. It is now evident that a motion of the rod *h* in its longitudinal direction will cause the bushing *e*, and at the same time the bushing *b*, to move. The movement of the latter bushing, however, turns the eccentric around its support, and places it in any desired position. The valves themselves are operated by a horizontal shaft, turned by a small crank connected with the eccentric rod. The advantages claimed for this design are the comparatively small number of parts, and the possibility of making the mechanism perfectly dustproof. This construction has been practically tried in Germany in at least two instances, and proven to work entirely satisfactory. It is known as the Lentz reversing mechanism.—Machinery.

THE SPECIFIC HEAT OF SUPERHEATED STEAM.

THE National Physical Laboratory experiments on the specific heat of superheated steam have steadily proceeded during the year, and several improvements have been made in the apparatus used. It was found that though the mica lagging originally fitted to the superheater was efficient in reducing the loss of heat by radiation, yet its capacity for heat was so great as to cause other errors to arise. Very careful observations showed that if any change of temperature occurred in the steam in the superheater, the lagging either supplied or absorbed heat for a very considerable time before a new steady condition was obtained. It was, of course, impossible to prevent small changes in the temperature occurring during an experiment, and hence very different results were obtained according as to whether the general condition during the time of observation was rising or falling temperature. This lagging was therefore removed and a new protection constructed in the following manner substituted. A copper shield about 5 inches in diameter and made in two halves was fitted round the apparatus, leaving a 1½-inch space between the outside of the superheater and the inside wall of the shield. This was then insulated by a layer of asbestos paper on the outside, over which a coil of fine platinum wire was wound non-inductively, to act as a resistance thermometer. This wire was about 45 meters long and had a resistance of 250 ohms, changing by nearly one ohm for each degree of temperature. Over this was wrapped a second layer of asbestos paper on which were wound two coils of No. 16 Eureka wire in parallel to carry a heating current. A covering of asbestos paper completed the jacket, which could be maintained at any constant temperature by adjusting the heating current and could be very quickly heated or cooled. With the whole apparatus cold and no steam in the superheater, the jacket was raised to a steady temperature of 200 deg. C. in rather less than fifteen minutes.

During the experiments made with this addition to the apparatus, this jacket has been maintained at the mean temperature of the superheater, thus reducing the radiation loss almost to *nil*. There was, however, a serious loss still taking place by conduction to the condenser, which it was not possible to reduce without rebuilding the whole apparatus. This loss has been, however, kept constant for any particular temperature of the superheater, by always adjusting the cooling water through the condenser so as to give a temperature of 40 deg. C. at the outlet, which is at the end of the condenser near the superheater.

Two satisfactory sets of observations have been made, one with 250 watts dissipated in the heating coil of the superheater, and one with 350 watts. During these the superheat in the electrically heated superheater has been kept at 20 deg. C. by adjustment of the flow of steam, while the initial temperature has been varied from 150 deg. to 200 deg. C. by means of the gas heater on the steam pipe, the pressure being 4.3 atmospheres. The first of these sets of observations was made during the summer months and then the work was delayed for some time owing to alterations to the roof in connection with the extension being made to the laboratory, which necessitated the removal of the instruments to a place of safety. The second series was completed during the latter part of the year, and some check tests made after this agreed perfectly with those obtained in the summer. From these two sets of experiments the following values of the specific heat have been calculated.

Pressure = 4.3 atmos. Saturation temp. = 146.3 deg. C.

Mean Temperature.	Specific heat.
155 deg. C.....	.532*
165 deg. C.....	.497
175 deg. C.....	.472
185 deg. C.....	.455
195 deg. C.....	.442
205 deg. C.....	.432
215 deg. C.....	.424
225 deg. C.....	.417*

There still remained two possible sources of error which it was necessary to investigate. The first of these was the conduction of heat which might take place along the metal tubes of the platinum resistance thermometers. If this was considerable it would cause the hotter thermometer to read low and the cooler one to read high, thus making the observed value of

* Extrapolated from the curve,

the superheat much too low. Since, however, any value of the specific heat depends on the difference of two experiments at the same temperature, the effect of such an error on the final result would be small. To determine whether this error existed or not, one of the thermometers was removed and an Iron-Eureka thermo-junction put in its place. Two tests were made, similar to a previous experiment, and all the results agreed with this experiment so well that there does not seem to be any appreciable cooling or heating of the thermometers by conduction. The second and more important possible source of error was the throttling effect of the superheater. Although the superheater is amply large enough for the flow of steam, yet its bore is so filled up with the heating coil that considerable throttling seemed not only possible but probable. If the fall of pressure amounted to 2 lbs. per square inch, the effect on the value of the specific heat would be quite serious, as this error does not

angles of the cylinder but placed parallel with it are two spring brass brushes supported at the base by brass blocks while the upper and free ends make contact with the arcuated brass strips or segments when the current is on, or with the surface of the cylinder when the current is off, as the case may be.

By referring to Fig. 1, which represents a cross section of the revolving element of the commutator, it will be seen that one of the brass strips is connected with one end of the spindle through one of the screws securing it to the rubber cylinder, while the opposite segment is likewise in connection with the opposite end of the spindle. The standards and the brass blocks may be secured directly to the bed of the coil or mounted on a hard rubber base, as preferred, the latter insuring the best insulation. A front elevation is shown in Fig. 2 and a plan view in Fig. 3, while the dimensions of the different parts may be ascertained from the following table:

TABLE OF SIZES OF PARTS FOR COMMUTATOR.

Hard rubber cylinder.....	Length. 1 9/16	Diameter. 1 1/4	Thickness. 3/8	
Brass commutator strips (2).....	1 9/16	Width. 3/8	Diameter of shank. 1/8	Length of shank. 1 1/4
Brass spindle (right hand).....	1 3/4	Diameter. 3/4		
Brass spindle (left hand).....	1 1/8	3/4		
Brass standards (2).....	2 1/4	3/4	Thickness. 1/4	
Brass blocks (2).....	3/4	Width. 1/4		
Hard rubber handle.....	1 7/8	Diameter. 3/8		
Spring brass brushes (2).....	2 1/4	Width. 3/8		
Hard rubber base.....	4 1/4	3/8	1 1/2	

tend to eliminate itself on taking the difference of two experiments with different rates of flow. A second pressure gage was fixed to the end of the superheater and two series of observations were taken of the pressure of the steam on entering and leaving the superheater, one at a low rate of flow and the other at a high rate of flow. For these it appeared that the fall of pressure could not be more than 0.02 lb. per square inch, the effect of which is negligible.

During the year a second apparatus working on a modification of the same method has been constructed and is now ready for erection, together with a low reading potentiometer for use with Iron-Eureka thermo junctions. This apparatus does not use such large quantities of steam as the last one, but has the advantage of giving much quicker results and of reducing the radiation and conduction losses to a minimum.

HOW TO CONSTRUCT A REVERSING COMMUTATOR FOR AN INDUCTION COIL.*

By A. FREDERICK COLLINS.

An induction coil, however small, should be provided with a switch for making and breaking the primary circuit, and as it is often desirable to change

CROSS SECTION OF REVOLVING ELEMENT.

the direction of the current through the inductor, as the primary winding is called, a reversing commutator can be employed to an advantage.

In Great Britain and on the Continent the reversing commutator devised by Ruhmkorff is used extensively on coils of every size from the smallest to the largest, but in this country nearly all the small coils sold in the open market are provided with pole changing switches of the three-point pattern, while in large coils equipped with independent interrupters an interlocking switch is generally preferred.

The Ruhmkorff commutator comprises a solid cylinder turned of hard rubber or hard wood to which are screwed in grooves cut on oppositely disposed sides arcuated strips of brass, or segments; each of the latter take up about a quarter of the circumference of the cylinder, and these set in flush with its surface. The ends of the cylinder are drilled and tapped and a

FRONT ELEVATION.

short brass rod is screwed in either end to form a spindle which in turn is supported by brass standards. To one of the ends of the spindle is attached a handle so that the cylinder can be rotated. On a line at right

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

PLAN VIEW.

screw; in each of the brass commutator brushes two holes corresponding to those in the side of the block and having a diameter of 3/32 inch are drilled at one end. The holes in the base are drilled in accordance with the plan, Fig. 3.

In mounting the commutator the brushes are screwed to the brass blocks, and these in turn to the bed of the induction coil or the hard-rubber base. The left-hand standard is then secured to the bed or base, and the shank of the shorter spindle end is inserted in the bearing formed by the hole in the top; this done, the second standard is slipped over the shank of the longer spindle, when it is screwed to the base, and finally the handle is adjusted and the set-screw in its end is tightened up. A heavy insulated wire leads to each of the standards as well as to each of the commutator brushes through the screws holding these parts to the base. When completed the commutator presents the appearance shown in Fig. 4.

When the commutator is connected in circuit with

COMMUTATOR IN PERSPECTIVE.

the primary helix of the coil and the source of electromotive force the positive terminal of the battery is joined to the left-hand standard as shown in Fig. 3, and the negative terminal to the right-hand standard. One of the brushes leads to one terminal of the pri-

mary coil while the opposite one leads to the other terminal through the interrupter.

Now since the brushes press upon the segments of the commutator and these are connected with their respective standards through the screws making contact with the spindles it is evident that when the handle is in the position shown in Fig. 2 the brushes will rest upon the oppositely exposed surface of the hard rubber cylinder and the circuit is broken; but if the handle is turned a quarter of a revolution to the right the circuit will be made and the current will, under the circumstances, pass from the positive terminal up the standard, thence through the spindle and screw to the commutator segment, and down the brush A to the primary coil. After energizing the latter it returns *via* the interrupter through the brush B, the segment upon which it rests, the screw, the spindle and the standard back to the negative pole of the battery. If, however, the handle is turned 90 deg. in the opposite direction the current will flow from the left-hand standard to the segment and brush B and returns through the segment and brush A and the right-hand standard, thus reversing its direction through the inductor.

PERNICIOUS EFFECTS OF ALTERNATING CURRENT OF HIGH VOLTAGE.

By FREDERICK H. MILLENER, M.D., E.E.*

THE Niagara frontier has become the great center of mechanical electrical development, and it is destined to be at the head in this regard for many years to come. Naturally one would expect in this field, pregnant with all the possibilities of electricity, that there would be first observed such phenomena as might result from the presence of such immense quantities of this vital force as are now being procured here, just as one in the mining regions looks for conditions arising from the occupation of mining. This expectation has not been disappointed. We find the phenomena.

In this brief paper I shall present but one phase of the great subject of electricity and its relation to mankind having reference specifically to its pathologic effect upon the health and lives of men engaged directly in the manufacture, transforming, or transmission of this mysterious fluid. This discovery was suggested by chance, and my subsequent investigations have justified me in the belief that here is a subject which the medical profession will do well to take up and further analyze. The Roentgen ray was a chance discovery, and so are many of the discoveries which are afterward taken up by our profession and utilized for the benefit of mankind.

I have spent much time in observing the various manifestations of electricity, and most specially those arising from the alternating, as distinguished from the direct current. And the results have been that I have witnessed in many different ways, some wholly unexpected, manifestations of this subtle influence, this pernicious influence of the alternating current, especially when of high voltage.

I have made careful investigations in twenty-four cases of individuals suffering from this influence during the past few months, and the phenomena observed have been so remarkable, and at the same time so uniform and unvarying that I presented the results to the medical profession as I now do to the general public, in the hope that in a multitude of counselors there might be found the wisdom necessary to work out the efficient remedy. All of the facts detailed to me have been given voluntarily, and not as the result of questioning, for I was seeking light, and not trying to furnish it; and I am sure that the similarity of the symptoms points to but one conclusion, namely, that continuous employment in the immediate presence of these great electric generators or transformers, where one is continuously in an atmosphere heavily charged with electricity, or ozone, or some light or ray as yet undiscovered, results in such disturbed conditions of the digestive fluids or of the secretions of the stomach and its cognate glands and organs as greatly impair the digestive function; and that persons so employed lose their appetite, and become of an almost chalky complexion, experience pain and distress after partaking of food, and often have to obtain short periods of vacation in order to recover their ability to eat and digest food in a normal manner.

Every one has observed the exhilaration felt, not only by human beings, but by birds and animals, and even by insects, just before the electric storm. Children run and jump and caper on the lawn, or in the fields, and feel almost as though they could fly, young animals frisk and sport about, birds dart through the air, and the insect is specially conspicuous in his tantalizing efforts. But when the storm has at last broke, the lightning flashed, and the air is filled with ozone and other electric fluids, there is a feeling of depression, and every thing alive seeks to find some restful position and quiet place. When the storm has passed, normal conditions again return, and the air is said to have been cleared.

This is a common experience. Another common experience is to find, immediately after a thunder storm, that all the milk in the house has turned sour in an incredibly short time. Here we can plainly see that a chemical force has been at work. What is that force?

I have visited a number of dairies where they use separator machines, and I find that they invariably use the direct current, because souring of the milk does not occur where the direct current is used instead of the alternating current. The possible reason

for this may be because of the fact that the direct current is a commutated alternating current and all the component parts of a true or natural current are not present. All up-to-date dairies have the direct-current machines, and in one instance I know of a dairyman who at an added expense of several hundred dollars installed a direct current machine, when he had been offered an alternating current at a remarkably low figure. The proprietor told me that he could not use the alternating current because he had found that the milk did not keep so well when they used a separator run by the alternating current as when it was run by the direct current.

I have many times visited the larger, in fact practically all of the great power houses and transforming plants in the entire Niagara frontier, notably those in Buffalo, Niagara Falls, Lockport, Niagara Falls, Ont., besides many of the smaller plants; but it is particularly of the large plants I speak where the manufacture of electricity or its transformation is the sole business.

I recently visited one of the power plants and the man in charge told me that after working for some time in the plant he found that tea and coffee did not agree with him. He drank no intoxicating liquors of any kind. He then tried bringing a bottle of milk with him to drink with his lunch, but the milk always turned sour before noon, although it was perfectly fresh when delivered in the morning. To test this I went to a nearby barn and milked about a quart from an obliging cow, and brought it to the plant, placing it where it would have the direct influence of the waste electricity from one of the large transformers. In less than an hour and a half it was sour, as the direct result of the chemical effect of the high voltage alternating current.

The man himself had been at work there for six months, and he said that when he came to the plant he was hearty, red-faced, full-blooded, and had a good appetite, good digestion, and was a perfectly well man. When I saw him his face and hands were of an almost chalky whiteness; he had no appetite, and when he ate his lunch, he nearly always felt distress from it in a short time, if he remained in the plant. Whereas, if he went home to lunch and stayed there during the afternoon, he had no distressing feeling. The same was as true of breakfast or dinner as of lunch. If he ate at home and then went to the plant, he would feel the distress just the same as if he had eaten at the plant.

This condition was not due in any degree to a sedentary life, for his work kept him very active, and he got all the exercise a man ought to have to keep well and healthy. Neither was it due to bad ventilation, as in these power plants there is always the very best of ventilation; windows and doors are open, and to test the currents of air in one of them I lighted a candle and found a uniform current of air from the outside inward toward the machines. These power plants are kept scrupulously clean. Drainage, lighting, heating, etc., are perfect. In fact no stove or heating apparatus is ever employed, as the waste energy, in the form of heat, which comes from the machines, is always found sufficient to keep the buildings warm. One might say that a power house was an ideal place in which to work, so far as all conditions of hygiene or sanitation are concerned. But there is this mysterious force flowing all around, about, above, below, and on every side. Is it ozone? Is it the Roentgen ray? Is it the violet ray? Or the ultraviolet ray? Or is it some ray or light that science has not yet observed? What is it that throws the digestive apparatus into such disorder? What is it that sours the milk? What is it that produces the chalky complexion?

These men are all at present able to work, but their work is not a pleasure to them. They are "off their feed," food does not agree with them, they suffer from the symptoms cited, and all, I believe, because of the pernicious effect of the alternating current of high voltage in and under the influence of which they have to perform their work.

I can add but little. I have stated a problem to the medical and electrical professions and the people in general. What the remedy will be I cannot predict. It may be some sort of a grounding of that wasted fluid that now fills the rooms of the power houses. It may be some neutralizing ray, or some form of insulation which can be devised and applied. It may be one of many things, but which one none of us is at present able to state. Perhaps this waste energy can be utilized for some form of by-products of electricity, or again, it may be employed for the artificial fermentation of milk or other fluids, or the more rapid aging of liquors.

But the important question is: What does this mean to the men engaged in the business of manufacturing electricity? It means personal discomfort and distress, which alone would make it enough of a problem to engage our most serious attention. It means that these men will be put in substandard lists for purposes of life insurance. It means, possibly, deterioration, more or less permanent, of the individual, of his vital organs, his powers of healthful assimilation of food, which in turn means anemia for the victim himself, and if he becomes the father of children, they will probably suffer the secondary effects of this unnatural condition of the parent.

The problem is of sufficient moment and interest to warrant the medical and electrical professions in giving it further study and investigation. If my article has the effect of awakening an interest in this problem, it will have served its purpose.

[Concluded from SUPPLEMENT No. 1632, page 26152.]

THE CHEMICAL COMPOSITION OF TOOL STEEL.*

MOLYBDENUM AS A SUBSTITUTE FOR TUNGSTEN IN HIGH-SPEED TOOLS.

MR. WHITE and the writer stated in our patent that molybdenum can be substituted for tungsten in modern high-speed tools, and that one part of molybdenum will produce approximately the same effect as two parts of tungsten. We also stated that molybdenum is not as satisfactory an element as tungsten to use in high-speed tools. The writer would repeat these assertions as giving our views at the present day upon the use of molybdenum in high-speed steels.

Under the head of "molybdenum substituted for tungsten" to the tools Nos. 55 (at the top of the list) to 63, inclusive (at the bottom of the list), it will be noted that, particularly in the case of tools Nos. 43, 54, 50, and 61, molybdenum tools having high cutting speeds were experimented with during the development of the Taylor-White process, and that from 4 per cent to 4½ per cent of molybdenum appeared to be a sufficient quantity to make a high-speed tool; whereas about 8 per cent of tungsten was required for this purpose. However, by noting our remarks made after most of these tools, it will be seen that they were brittle, had a tendency to fire crack, were weak in the body of the tool or else they were irregular in their cutting speeds. All of these faults are most serious in their nature, and they were at that time and are still regarded by us as so serious that when a tool clearly develops any one of these troubles we at once cease experimenting with it as not worthy of consideration among first-class tools.

The irregularity in molybdenum tools constitutes perhaps its most characteristic feature. By irregularities we mean that tools of the same chemical composition, and apparently treated alike, give large variations in cutting speed. We have as yet been unable to determine with certainty the cause for the irregularity existing in molybdenum tools. One explanation, however, for this trouble may lie in the fact that molybdenum tools appear to run at their highest cutting speeds when given a high heat slightly lower than the high heat required to produce a first-class tungsten-chromium tool. It may be that when the molybdenum tool is heated beyond that precise high heat which is necessary to make a first-class tool it suffers deterioration.

One of the most useful characteristics in the modern tungsten-chromium high-speed tool is that it requires little or no skill on the part of the blacksmith to heat it up close to the melting point, and that the tool itself shows clearly by its appearance when its high heat has been reached. Moreover, it is impossible to injure the cutting properties of these tools even if they are heated to a point at which the thinner or sharper edges begin to melt. The difficulty of judging by the eye an exact high temperature reached by a tool when close to or at its melting point is so great that if a definite treating temperature were required at these very high heats—that is, if tools were injured by heating beyond this temperature—much of the value of the high-speed tools would be lost.

Now, as stated, it appears likely that the irregularity in molybdenum tools may be largely due to the fact that a more accurate degree of high heat, considerably below their melting point, is required for them, and that this temperature must be closely judged by the eye of the smith, while no accurate judgment is required for the tungsten-chromium tools, because the tools themselves show when they are close to the melting point; and close to or at the melting point is the temperature which produces a tool giving the highest cutting speeds.

BEST MODERN HIGH-SPEED TOOLS COMPARED WITH ORIGINAL HIGH-SPEED TOOLS DEVELOPED BY US.

It will be a matter of interest to compare the various properties and chemical compositions of high-speed tools as developed by us at the time that our patent was written with those of the best of the high-speed tools that have been made up to the present time. Tools Nos. 26 and 27 are those recommended in our patent. By referring to their speeds in cutting, on the one hand, a medium steel, and on the other hand, very hard steel and hard cast iron, it will be seen that tool No. 26 gave the higher cutting speeds on hard steel and cast iron, while tool No. 27 gave the higher cutting speeds upon medium and soft steels. Thus, at the time of the writing of our patent, in order that a machine shop should have the best tool equipment it was necessary that tools made of two different chemical compositions be maintained as standards.

Referring now to tool No. 1 in Table I, the best high-speed tool experimented with by us in 1906, it will be noted that it has a higher cutting speed upon all the qualities of metal experimented with than any other tool. One of the gains, then, made by the latest high-speed tools lies in the fact that in one tool steel are combined all of the most desirable properties, and therefore only one need be adopted in a shop as standard.

We have previously referred to red hardness as the distinctive property of modern high-speed tools. Now, while red hardness is the most important property or quality sought for in high-speed tools, nevertheless, for certain classes of work—namely, turning the very hard qualities of steel and also hard cast iron—the property of hardness is desirable in addition to that of red hard-

* From "The Art of Cutting Metals," read by Fred W. Taylor, Philadelphia, before the American Society of Mechanical Engineers.

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