

cause of the difficulty with this axle. For the benefit of the others we may say that seamy bottoms of ingots are now usually explained by wet or insufficiently dried bottoms of ingot molds. The steam or other volatile material generated by the heat of the molten metal can apparently only escape up through the molten metal itself, forming a seam which the subsequent treatment does not weld up.—From a paper by Charles R. Dudley.

#### SPECIFICATIONS OF MATERIAL USED IN HIGH-SPEED AUTOMOBILE AND MOTOR-BOAT ENGINES.

By THOMAS J. FAY, E.E.

In the early days of motor-boat building, critics were wont to say that automobile builders could not build motor boats; but these same critics are now busy trying automobile methods, for as one might reasonably suppose, a good motor such as is demanded in automobile work does not become a bad motor simply because it is placed on girders in a motor boat.

As a matter of fact, boat building is a fine art understood by thousands of skilled men and hundreds of naval architects, so that the building of a hull is easily accomplished, given suitable material.

Motors, however, are quite new as yet, especially the kind of motors that must be depended upon to survive in service, and do the required work under satisfactory conditions and for a length of time worth while taking into account.

Any one can build a motor, and for that matter, the fact of its having been built by anybody would not prevent its operating in service. But to build motors that will deliver say 30 horse-power in continuous service month in and month out within a weight of less than 500 pounds for the motor complete, is entirely another matter.

The motors to be used in the twin-screw boat illustrated in the current SCIENTIFIC AMERICAN are claimed to be of that character, and it is a reasonable expectation that either one of them would run the boat all summer with never a service interruption. Moreover, a higher speed and double assurance of continued good service will surely follow the use of two such motors.

The reason why these motors are likely to serve thoroughly well in practice is wholly a matter of design and of the materials of their construction; for in the construction of these motors, only "specification" materials of the highest order are given consideration.

With a view to a more specific statement of facts, reference will be made herein to the exact qualities of the materials used in the motors of this boat, as follows:

Table I. refers to the crankshafts of nickel-chrome steel, the strength of which is marvelous as compared with the ability of any carbon-steel product possible to secure.

Table II. shows a test of the finest acid open-hearth carbon steel possible to secure by resorting to special heats; and by comparing the two an insight will be gained by which to gage the fine qualities of the nickel-chrome steel crankshafts actually employed in these engines.

For the piston pins, which are very important parts in motors of great power per pound of weight, Table III. will expose the qualities of the material. This nickel-chrome steel is the same as is employed in making the famous Krupp guns.

Table IV. represents nickel-chrome steel for gears of the substantially unbreakable sort, such as must be used in motor-boat gears to serve in a thoroughly satisfactory manner.

The connecting shafts and other important parts are of still another grade of nickel-chrome steel, as shown in Table V., so that it is proper to say all important transmission parts are of the finest alloy steel possible to secure, either in America or abroad.

In the early days of the motor car and the motor boat as well, the foreign builders were wont to talk about their superior products; and for some reason not at first plain to us, these did have qualities that gave the foreigners a substantial lead. The Smith & Mabley Company, as importers of the well-known makes of foreign products, realized that something was amiss, and as a result of a thorough investigation it was found that the foreign products were made of "alloy steel." In due course these same grades of steel were imported and put into Simplex motors, which accounts for their unexceptionable endurance. The matter was put up to the American mills, with the result that to-day the same grades of material are to be had at will in America as well as from France and Germany.

TABLE I.—CRANK SHAFT.

#### Chemical Composition.

Carbon .....	0.25
Nickel .....	4.40
Chromium .....	1.53
Silicon .....	0.24
Sulphur .....	0.012
Phosphorus .....	0.013
Manganese .....	0.73

#### Physical Properties.

Tensile strength in pounds per square inch....	154,400
Elastic limit in pounds per square inch.....	133,300
Elongation taken in 3 inches, per cent.....	11
Reduction of area, per cent.....	25

Test specimen cut from finished crank shaft.

#### Treatment.

Oil tempered at 900 deg. C. and annealed to 570 deg. C.

#### Process.

Furnished by the mill in slabs of rectangular section and cut to size from the solid.

Pins are ground to + or - 0.001, making crank shafts interchangeable and obviating elliptical formations.

TABLE II.—SPECIFICATION OF ACID OPEN-HEARTH STEEL FOR CRANK SHAFTS.

#### Chemical Composition.

Carbon .....	0.28
Silicon .....	Low
Sulphur .....	0.019
Phosphorus .....	0.023
Manganese .....	0.50

#### Physical Properties.

Tensile strength in pounds per square inch....	85,000
Elastic limit in pounds per square inch.....	66,000
Elongation taken in 2 inches, per cent.....	24.5
Reduction of area, per cent.....	63.3

Fracture, silky.

#### Treatment.

Acid open-hearth process, pickled and annealed.

Note.—Not good enough for high-power motor service.

TABLE III.—PISTON PINS.

#### Chemical Composition.

Carbon .....	0.31
Nickel .....	3.30
Chromium .....	1.40
Silicon .....	0.26
Sulphur .....	0.028
Phosphorus .....	0.015
Manganese .....	0.41

#### Physical Properties.

Tensile strength in pounds per square inch....	233,000
Elastic limit in pounds per square inch.....	221,000
Elongation taken in 2 inches, per cent.....	6
Reduction of area in per cent.....	40

#### Treatment.

Given physical properties, result of cementing and annealing.

#### Process.

Turned to rough size from natural bar, holes drilled, and after treatment, is ground to press fit dimensions. In some cases treated government nickel steel is used.

TABLE IV.—TRANSMISSION GEARS.

#### Chemical Composition.

Carbon .....	0.238
Nickel .....	3.38
Chromium .....	1.87
Silicon .....	0.183
Sulphur .....	0.026
Phosphorus .....	0.025
Manganese .....	0.350

#### Physical Properties.

Tensile strength in pounds per square inch....	123,800
Elastic limit in pounds per square inch.....	80,000
Elongation taken in 8 inches, per cent.....	10
Reduction of area in per cent.....	53.2

Values somewhat altered by subsequent treatment.

Improved.

Diameter of test proof..... 0.767

#### Process.

Gear blanks are forged from convenient sizes of mill bars and annealed.

After blanks are machined and teeth cut, gears are treated, thus making the armor glass hard, and the core of great strength.

TABLE V.—CONNECTING SHAFTS.

#### Chemical Composition.

Carbon .....	0.30
Nickel .....	3.40
Chromium .....	1.50
Silicon .....	0.25
Sulphur .....	0.026
Phosphorus .....	0.014
Manganese .....	0.45

#### Physical Properties.

Tensile strength in pounds per square inch....	120,000
Elastic limit in pounds per square inch.....	100,500
Elongation taken in 2 inches, per cent.....	16
Reduction in area in per cent.....	67

#### Treatment.

Used as received from mill, unless forged for flanges, in which event annealing at 570 deg. C. is resorted to.

#### Process.

Forged within definite exact limitation of temperature, annealed, roughed, and ground to size.

#### STEEL FOR REINFORCED CONCRETE\*

By A. L. JOHNSON, M.Am.Soc.C.E.

THE history of the origin of reinforced concrete has been published so often that the speaker will not enter into this part of the subject further than to say that he thinks too little credit has been given to Thaddeus Hyatt, an American, for the work he did in the years 1876 and 1877 in England. He made numerous tests of reinforced concrete beams at Kirkaldy's laboratory, reinforced with bars of different patterns and arrangements, developing at this early date the advantages of stirrups, of having them connected to the bar, of bending bars up at the ends for shearing provision in short beams, and in a general way the advantage of a mechanical bond, though his investigations here did not enable him to learn the criteria for differentiating the efficient from the non-efficient.

Up to the time of Hyatt very little work in reinforced concrete had been done abroad, other than in tanks,

\* Paper read before the Cement Users' Association.

vases, pots, etc., in which the section was entirely in tension, and in which, therefore, there was little tendency for different movement on the part of the metal and the concrete, such as occurs in reinforced concrete beams. Neither had there been anything of consequence in the United States, about the only instance now known being a building constructed entirely of reinforced concrete by Ward in 1875, in the State of New York.

Ransome made some experiments in San Francisco on reinforced concrete beams, and on September 16, 1884, received a United States patent on a floor construction of concrete reinforced with square bars twisted, claiming as advantages over plain material an increase in tensile strength and a more secure bond. Later, he applied for and secured a patent on a triangular twisted bar, the contention for patentability being that this bar would not split the concrete ribs in which the bar was embedded, owing to the deeper cupping that would be obtained in the triangular type. Mr. Ransome's theory of the splitting action noticed is explained in the patent as follows:

Assuming a tee beam, or ribbed floor construction, in which the rib is reinforced with a steel bar, when the floor is loaded, the bar being bent up at the ends, it is as if the rib were held up by the bar, or sitting on the bar. If the floor is loaded to, say, 400 pounds per square foot, and the ribs are, say, 3 feet apart, then there is a vertical load of 1,200 pounds on top of the rib for each foot of length. Hence, the rib acts as a column, being supported on the bar at the bottom. As the bar is narrow, there is a tendency for the concrete to flow each side of the bar, or, in other words, there is a movement of the concrete above the bar, crosswise of same. In a plain bar there would be no obstruction to the movement. In the square twisted bar there was not, according to Mr. Ransome, sufficient obstruction to the movement, as the cupping was not sufficiently deep. Hence the superiority of the triangular type.

The above theory was, of course, fallacious, and the type never came into commercial use. The vertical load on the rib for any given length is carried by vertical shear in the concrete, and the rib is not acting as a column at all. If it were, in the case mentioned where the rib carried 1,200 pounds per lineal foot, supposing the rib to be 4 inches, this would only give a compressive stress in the rib of 25 pounds per square inch, and would be too small to be noticeable even if many times this amount.

The ribs do not act as columns, but as beams, lengthening on the bottom and shortening on top, and it is the movement of the concrete lengthwise of the bar which the bar must be calculated to resist, and it is in this resistance that it begins to help carry the load and become an integral part of the structure. To offer reliable and satisfactory resistance to this movement of the surrounding concrete along the bar, it is necessary for the bar to have on its surface projections, or depressions, the sides of which are nearly at right angles to the direction of the movement, which is to say, to the bar itself. It is not necessary that the sides of these ribs or depressions should be exactly at right angles to the bar to develop this efficiency, however, it being possible to vary therefrom an amount equal to the angle of friction between the concrete and the metal, which, on the average, will be between 30 and 45 degrees. But if the surfaces against which the concrete presses are nearly parallel to the direction of the movement, we have the same action as when an ax is forced into a block of wood, a very heavy splitting component resulting, which may be many times as great as the direct force itself, similar to the action of a toggle joint.

Of course, this splitting action is of little effect until after the so-called adhesion of the concrete to the surface of the metal has been overcome. This adhesion is not really adhesion at all in the sense that two pieces of wood may be made to adhere to each other by means of glue. The appellation has been given to the resistance of a bar against withdrawal from a block of concrete. As a matter of fact, this resistance is made up of two parts, friction and a mechanical bond caused by the entering of the cement particles into microscopical pores on the surface of the metal, which particles have to be sheared off in withdrawing the bar. For short depths of imbedment these two forces amount to about 500 pounds per square inch of bar surface for bars of ordinary mill surface and for good concrete, where perfect union exists between the cement and the metal. Of this, friction contributes about 25 pounds per square inch, the remaining 475 being due to the mechanical bond. There is therefore no reason in advocates of plain bar reinforcement decrying mechanical bond, inasmuch as the plain bar has really no value not contributed by this same quality. The bond, it is true, is of a microscopical nature, but nevertheless its value is considerable, and if it would remain intact we could design and execute reliable concrete structures with plain bar reinforcement.

There are a number of things, however, tending to impair a bond of this nature, among which we may mention the following:

1. Shocks and vibrations continued through years of service are liable to injure, if not wholly destroy, the bond, and have done it in cases under the speaker's own personal observation.

2. Where the concrete is continually wet, the adhesion will be cut down from 50 to 60 per cent in less than one year, as indicated by the experiments of Breuille.

3. The development of the working stress in the metal slightly stretches same, and the cross section is therefore slightly reduced. Suppose the metal has a working stress of 15,000 pounds per square inch, then the proportionate elongation is 0.0005, and the decrease in the

diameter is, with practical exactness, one half this, or 0.00025, a quantity which, though small, could be readily measured by an ordinary micrometer, and certainly is far from microscopical.

The advisability of reinforcing bar with a more positive grip on the concrete than that afforded by the roughness of the mill surface of a plain bar, which is, of course, very slight, is not merely due to the necessity of maintaining continuously the strength of the beam, but also to the necessity of keeping the bars from being exposed to the atmosphere.

We know, now, that in a reinforced concrete beam cracks begin to form in the concrete on the tension side, at an elongation which gives a stress of from 12,000 to 15,000 pounds per square inch in the bars, which is at just about, or even a little below, the working stress usually employed. If plain bars are used these cracks will be far apart and correspondingly large, while if a bar is used having a positive grip on the concrete for every inch of bar, there can be no accumulation of cracking tendency for a considerable length, but there will be a great many cracks, mostly invisible to the naked eye, until the metal has passed its elastic limit. Such cracks will not be injurious, while the cracks that form with the plain bars might. They amounted to considerable in the tests made about five years ago by M. Considere, as a result of which he reported the wonderful stretchability of reinforced concrete that misled us all for some time. In these tests he bent the beam several hundred times, so that the tension fiber had been stretched from 15 to 20 times as much as plain concrete would stand, then cut a piece 8 inches long out of the middle surrounding the  $\frac{1}{4}$ -inch round rod that he used for the reinforcement, and then with great pains and labor cut the rod out of this 8-inch piece of rectangular section, leaving a hole through same from end to end. Now this concrete had been stretched, according to M. Considere, many times as much as plain concrete would endure, but instead of falling apart when the rod was finally gotten out, it was perfectly intact, and he put it on supports, loading it in the middle, and obtained as much carrying capacity as he could have secured with the same kind of concrete which had never been subjected to such severe usage. This seems like proof positive of M. Considere's conclusion. But it developed later that he had taken this 8-inch specimen from between two cracks of considerable size, and that while the rod had undoubtedly stretched as much as assumed the surrounding concrete had not, the end sections slipping back and relieving the concrete. In other words, there was a slip between the rod and the concrete. If the rod he used had been a rod of mechanical bond, giving a good positive grip for every inch of its strength, he would not have had this slip between the rod and concrete.

The distance between cracks on the bottom of a reinforced concrete beam subject to uniform bending moment, may be discussed as follows:

Let  $d$  = spacing of bars in inches.

$e$  = distance from center of bar to surface in inches.

$ft$  = tensile strength of the concrete in pounds per square inch.

$s$  = bonding value of bar in pounds per square inch of surface.

$l$  = spacing of cracks in inches.

The cracks will come at such distance apart that the bond of the bar for the distance equals the tensile strength of the concrete immediately around the bar, having in this respect a close analogy to the distance apart of the shrinkage cracks in a retaining wall.

Then we have for a square bar,

$$\frac{deft}{deft} = \frac{4sl}{4s}$$

On plain bars with real smooth surface  $s$  has been found less than 100 pounds per square inch, though, as before stated, for the ordinary rolling mill surface, with careful imbedment, it has a value originally of about 500 pounds per square inch. Assuming for allowance for ordinary working conditions, and for reduction due to shrinkage of bar section, an average value of 250 pounds where there is no vibration of consequence, and where the concrete is not wet, as it would generally be in open-air work, we have

$$l = \frac{deft}{1000}$$

For a mechanical bond bar, such as the corrugated bar, for example, this value will be in the neighborhood of 750 pounds per square inch, a value also which will be practically permanent, and for this,

$$l = \frac{deft}{3000}$$

That is to say, the latter type would give cracks of only one-third the size that would be the case in the beam reinforced with plain bars, even under the best average conditions. In the case of open-air structures, subject to vibration for some years, the disproportion might be very much greater than this.

The speaker has often been asked the question, Why is it necessary to use bars of mechanical bond, when abroad, where their experience is much greater than ours, they use only plain material? The question is a very proper one, and requires an explanation. As before stated, it is only in beam work that the necessity for absolute bond between the concrete and the metal exists, and in this line of work the beginning was made in this country in 1882. These structures were intended for floors, and to carry people and loads of different kinds, and not vases, flower pots, etc., of which the foreign work up to that time mainly consisted, all

of which was reinforced with plain material. For floors and beam work in general plain bars did not seem a rational material to use, just as a common sense proposition; and the speaker doubts very much whether, if the construction of such work had been presented first abroad, the foreign engineers would have considered the use of plain bars, either. The natural development would have been to have used a form of mechanical bond first, and later if investigation showed it feasible, come to the simpler and cheaper form of plain material.

A year ago last May the Prussian government specifications on reinforced concrete were issued, and they cut down the safe allowable working stress in adhesion to about 30 pounds per square inch, recommending at the same time mechanical bond whenever possible. The above restriction on the working stress in adhesion made it very expensive, and in many cases impossible to use plain material, so that the recommendation in favor of mechanical bond was scarcely necessary. In France, too, much greater care is now taken, the bars being bent up and down and around about in the effort to obtain a better anchorage, as well as to provide for shearing stresses.

In specifying bars for reinforcement, there are a few fundamental principles that should be observed. In the matter of elastic limit, the general proposition is that the elastic limit should be as high as is consistent with the ductility required by the case in hand, up to, say, 60,000 pounds per square inch. There is no object in having a higher elastic limit than this unless the modulus, too, could be raised, which is, at the present time, not feasible. Preference should be given to more bars of small section, rather than to few bars of large section, as it is desirable to have the metal well distributed through the stretching concrete area. The bars should not be painted. A slight film of rust is no injury at all, and will totally disappear after imbedment. But if the bars have been exposed long enough for scale to form, this must be removed before use.

In designing, the factor of safety should, generally speaking, be four at least, certainly never less than three, which is based upon the elastic limit. That is to say, the working stress for the actual loads should be only one-fourth of the elastic limit. Many of the municipal building laws are seriously in error in that particular. This will require about three-quarters of 1 per cent reinforcement for material having an elastic limit of 60,000 pounds per square inch, and 1.3-10 for metal having an elastic limit of from 30,000 to 35,000 pounds per square inch. These are the percentages required to develop the full strength of the section in bending. Short beams, having a ratio of height to span of more than one-twelfth, will have to have some of the bars turned up at the ends, where they are not required for moment, to take care of the shear. This bending is readily done on the job cold, unless the bars are exceptionally heavy in section.

#### ELECTRICAL CONDUCTIVITY AND REFLECTING POWER OF CARBON.

PROF. E. ASCHKINASS some time ago made certain observations on the reflective power of polished carbon fragments, obtaining remarkably high figures even in the case of moderately great wave lengths. In view of the simple relation between the electrical conductivity and the reflective power for infra-red rays, which has meanwhile been discovered by Hagen and Rubens, the author recently resumed his experiments, an account of which is found in *Annalen der Physik*, No. 12.

From his observations it is inferred that the reflective power of carbon nearly throughout its spectrum, is determined almost entirely by the electrical conductivity. It is further shown that conductive carbon in the infra-red does not show the least analogy to what is called a "black" or even a gray body. This fact may be of some importance in the problem of the economy of certain illuminants. In illuminating flame reflection, it is true, it will not play an appreciable part, the carbon there being in an extremely finely distributed state. The case of flame arcs and especially of carbon filament incandescent lamps is, however, quite different, as reflection there plays an undoubtedly important part.

Prof. Aschkinass a short time ago showed that the laws of heat emission of bare metals were largely determined by their electrical conductivity, metals being for instance blackened more and more with increasing temperatures in the infra-red spectrum if their resistances were increased with rising temperatures. Now, the resistance of carbon is known to decrease with increasing temperature. Reflection will accordingly become the more intense as the temperature rises, so far as it depends on conductivity, and the economy of an illuminant including reflecting carbon will probably increase with rising temperatures at even higher rate than that of an absolutely black body.

#### TRANSMISSION OF ELECTRICAL ENERGY FROM SWEDEN TO DENMARK.

BOTH Sweden and Norway have doubtless an industrial future before them owing to the extensive water power available in both these countries, which makes them exceedingly suitable for the installation and operation of electrical power stations. Some plants utilizing the power of waterfalls are either in operation or being contemplated; some of these are intended to supply whole cities with electrical light and power derived from comparatively distant waterfalls. According to a recent notice in the *Vossische Zeitung* it is, for instance, proposed in the city of Lund to utilize certain waterfalls of the Laga River to supply with electricity not only that city, but quite a number of

others in the south of Sweden. It will be interesting to learn that a Danish syndicate intends purchasing the same falls, with a view to utilizing them as a source of electrical power. The Laga River, coming from the Smaaland Highlands, traverses the province of Halland for a distance of 23 miles, terminating near Laholm. This river forms in its course two large waterfalls—the Magefos, about 25 feet high, and the Katefos, about 30 feet high. The Danish syndicate, it is stated, will install electrical power stations near these waterfalls, whence the electricity is to be transmitted by cables to the south Swedish coast city Helsingborg and thence by submarine cable through the Oeresund to Denmark. This interesting project of transmitting electrical energy through submarine cables from one country to another will be quite a novel development in the electrical industry.

#### CONTEMPORARY ELECTRICAL SCIENCE.\*

RADIO-ACTIVITY OF BREATHING WELLS.—Gerlier has recently described a number of Swiss wells which alternately absorb and expire air in accordance with the state of barometric pressure. They equalize the atmospheric and subterranean pressures, but with some retardation owing to the slowness of the flow through the strata. The latter usually consist of coarse gravel. E. Sarasin has measured the radio-activity of air expired by one of these wells in a square in the village of Meyrin, near Geneva. He found a radio-activity about ten times that of ordinary air, positive charges being dissipated a little more rapidly than negative. The activity varied with the strength of the air current.—E. Sarasin, *Physikalische Zeitschrift*, October 26, 1905.

ANTI-VIBRATION SUSPENSION.—W. H. Julius, the inventor of the anti-vibration suspension which bears his name, points out that its principles are not yet sufficiently grasped by manufacturers. It must fulfill five conditions to be effective. The three wires of the suspension must be of equal length, equally loaded and perceptibly stretched. The center of gravity of the whole suspended body must be in the horizontal plane containing the bearing ends of the wires. Those parts of the apparatus whose freedom from disturbance is most important must be near the center of gravity. Vertical shocks must be eliminated by introducing a short length of spiral spring into each wire. And, lastly, the proper vibration of the suspended body must be damped by liquid immersion or cotton wool, mounted in the plane containing the center of gravity. If the apparatus on the suspension must be frequently handled it is best to have a clamping device. This consists of a triangular frame mounted on a table and surrounding the triangular plate of the suspension on all sides within 1 centimeter. A screw projects through each side of the frame, and when one of the screws is driven home it urges the suspension against the two others. The three screws then hold it until the manipulation is over.—W. H. Julius, *Annalen der Physik*, No. 11, 1905.

RARE ATMOSPHERIC GASES.—Dewar showed that charcoal at the temperature of liquid air possesses an extraordinarily high absorbing power for atmospheric gases, and used this property for discovering hydrogen, helium and neon in comparatively small quantities of air. S. Valentiner and R. Schmidt have now employed this same property for manufacturing neon, krypton and xenon for spectrum tubes. To obtain the neon, they collected a quantity of argon, which contains neon, and led it over coconut charcoal kept at the temperature of liquid air. In this manner they liberated the neon, and avoided any admixture of nitrogen. The pressure had to be low, not exceeding a few millimeters. To free the neon from traces of helium, they occluded it in pure charcoal at a somewhat higher pressure and drove it out again. They thus obtained spectroscopically pure neon. To obtain krypton and xenon, they used charcoal at  $-120$  deg., which absorbs krypton and xenon completely, but only a little argon. They again eliminated the argon by connecting with a tube of charcoal in liquid air. Heating to  $-80$  deg. liberated pure krypton. A similar differential method enabled the authors to eliminate the krypton and to obtain spectroscopically pure xenon at  $-15$  deg.—Valentiner and Schmidt, *Annalen der Physik*, No. 11, 1905.

HEAT EVOLVED BY RADIUM.—Knut Angström has endeavored to get some decisive answer to the question as to whether the  $\alpha$ ,  $\beta$  and  $\gamma$ -rays of radium account for the heat evolved by it or not. He finds that the energy represented by these rays is but a very small part of the total energy evolved. Paschen, on the other hand, thought that the  $\gamma$ -rays represented more than half the total energy evolved, but since announcing that result he has found an unsuspected source of error in his experimental arrangement. Angström's new experiments were made with calorimeters of lead, copper and aluminium, constructed with walls 1 centimeter thick, so that in the case of lead the  $\gamma$ -rays are absorbed by the walls. Two such calorimeters were used in each case, one containing a tube with 87 milligrammes of pure radium bromide, the other a manganin coil heated by a known current and producing the same quantity of heat as the radium, the comparison being made by thermo-couples inserted in the calorimeter walls. No difference could be detected in the action of the various metals, and it must be concluded that the absorption of all the rays given out by the radium does not appreciably add to the heat received by the calorimeter. Hence the bulk of the energy given out must be in the form of radiant heat.—K. Angström, *Physikalische Zeitschrift*, October 26, 1905.

\* Compiled by E. E. Fournier d'Albe in the *Electrician*.