ent motion, and for that purpose to make experiments under proper directions. While it is well settled in the federal practice that the chancellor cannot abnegate his duty to hear the fundamental issue in a cause without the same being clouded or prejudiced by a master's report (Kimberly v. Arms, 129 U. S. 512, 524, 9 Sup. Ct. 355; Davis v. Schwartz, 155 U. S. 631, 637, 15 Sup. Ct. 237), yet it is a common practice to permit inquiries by a master incidental to the principal labor which rests on the court (Field v. Holland, 6 Cranch, 8, 22; Lawrence v. Dana, 4 Cliff. 1, 87, Fed. Cas. No. 8,136; Daniell, Ch. Prac. [6th Am. Ed.] 1203, 1646). Indeed, on bills for specific performance it has been the settled course in England to direct a preliminary inquiry as to title by a master. Having no doubt of our power to obviate in this way the difficulty which the complainant thinks now meets it, if it becomes necessary to do so, we deny complainant's motions, without prejudice to its right to apply for a master, as we have indicated, in connection with the final hearing.

The complainant also moves that we require the respondent to produce a certain witness for further cross-examination. The cross-examination having been closed after notice to the complainant, there is no propriety in our exercising this power if we could. The circumstances stated by the complainant suggest that on an application to the court the court might be justified in entering an order authorizing it to summon and examine the witness referred to as its own witness; and, if the circumstances are as stated by the complainant, the rule stated in U. S. v. Budd, 144 U. S. 154, 165, 15 Sup. Ct. 575, will probably give it practically all the same opportunities as though the witness still continued subject to nominal cross-examination. The motion of complainant, filed October 29, 1897, is denied.

ELECTRIC SMELTING & ALUMINIUM CO. v. CARBORUNDUM CO.

(Circuit Court, W. D. Pennsylvania. July 26, 1897.)

1. PATENTS—INFRINGEMENT—ELECTRIC SMELTING PROCESS.
   The Cowles patent, No. 319,795, for a process of smelting ores by an electric current, contemplates a process in which the fundamental idea is the diffusion or distribution of heat, as contrasted with its localization,—this effect being secured by mixing with the ore a body of granular material of high resistance, such as electric light carbon; and the patent is not infringed by the Acheson method for the manufacture of carbide of silicon, or "carborundum," in which the electric current furnishing the fusing heat is localized along a central core, from which the heat is radiated into the surrounding charge so as to fuse and unite into a new chemical product the atoms of carbon and silicon contained therein.

2. SAME—ELECTRIC SMELTING FURNACE.
   The Cowles patent, No. 319,945, for an electric smelting furnace, construed, and *held* not infringed by the form of furnace used in the Acheson method of producing carbide of silicon, or "carborundum."

This was a suit in equity for the alleged infringement of two patents relating to the art of smelting by electricity.

E. N. Dickerson and C. M. Vorce, for complainant.

Geo. H. Christy and Thomas W. Bakewell, for defendant.

BUFFINGTON, District Judge. The Electric Smelting & Aluminium Company filed this bill against the Carborundum Company, alleging infringement of three patents owned by the complainant company. At the hearing the infringement of patent No. 335,058, granted January 26, 1886, to Alfred H. Cowles, was not pressed, but was of all the claims of patent No. 319,795, issued June 9, 1885, to Eugene H. Cowles et al., for a process of smelting ores by the electric current, and of patent No. 319,945, issued June 9, 1885, to Eugene H. Cowles et al., for an electric smelting furnace. The large mass of testimony presented in this record, the conflicting views of skilled experts, the elaborate and protracted oral arguments of able counsel, and the multiplicity of their briefs, present such a vast field for examination and study that confusion might result if sight were lost of the comparatively simple statutory enactments regulating the grant of patents, and determining the rights vested by such grants. Turning to such provisions, we find a chart by which we can steer the way through the sea of facts, theories, and arguments which characterize the case. In a general way, a patent may be said to consist of two parts: First, the specification, which discloses the invention or discovery; and secondly, the claims allowed, by which the invention disclosed may be secured to the patentee. The specification is the foundation on which the claim rests.

Section 4888 of the Revised Statutes provides that:

Before any inventor or discoverer shall receive a patent for his invention or discovery, he shall make application therefor in writing to the commissioner of patents, and shall file in the patent office, a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound and use the same * * * and he shall particularly point out and distinctly claim the part, improvement or combination which he claims as his invention or discovery.

It will thus be seen that the statutory requirement embraces certain elements, viz. a description of the discovery, and of the process, etc., of using, etc., the same, in full, clear, concise, and exact terms, and a particular pointing out and claiming of what is claimed. "The leading purposes of the whole of the statute directions," says Curtis' Law of Patents (page 256), "are two: First, to inform the public what the thing is of which the patentee claims to be the inventor, and therefore the exclusive proprietor during the existence of the patent; second, to enable the public, from the specification itself, to practice the invention thus described, after the expiration of the patent." Patents being wholly a right of statutory creation, the statutory requirements and limitations, respectively, are the foundation and limit of the rights thereby created. Upon a compliance with such requirements depends the existence and validity of the patents issued by virtue of their provisions. The validity of a patent is therefore dependent, among other things, upon the patentee having given such a description of his invention or discovery, and the manner and process of using it, as the statute requires.

Assuming for present purposes the validity of the process patent in question, No. 319,795, and that the patentee has complied with these statutory requirements, we turn to an examination of its contents, to ascertain what was the invention or discovery which Messrs. Cowles disclosed to the public, and what they claimed when they were awarded the rights which they now assert are infringed. In these respects the patent is exceptionally explicit and clear. While it pertains to a general subject, in which a vast deal of learning is requisite to constitute one, in the words of the statute, "a person skilled in the art or science to which it appertains," yet its teachings and disclosures are so plain and void of uncertainty that a person who is not versed to that extent can quite clearly comprehend them. While the superior skill and learning of those versed in the art is of value in amplifying and more thoroughly discussing its terms, yet the explicit and fundamental teachings of the patent may be quite thoroughly understood and appreciated by the lay mind. The patent recites that it consists in "improvements in processes for smelting ores by the electric current," an art which, by the subsequent statements of the patent, was concededly not new. The improvements relate to that "class of smelting furnaces which employ an electric current solely as a source of heat." Heretofore, the patentees state, it had been attempted to reduce ores and perform metallurgical operations by means of an electric arc, and the material to be treated was brought within the field of the arc, or passed or fed through it; that objections exist to the arc system, viz. that it is not adapted to long operations on a large scale; that there are very great difficulties in the regulation of the arc and the preservation of a constant resistance, and "the heat generated, though intense, is localized, and difficult to control." After reciting these conditions, which have been found objectionable in practice, the patentees recite that the object of their invention is to provide a process where they will "secure a distribution of the intense heat, which it is well known electricity is capable of generating, over a large area, or through a large mass, in such a manner that a high temperature can be sustained for a long time, and controlled." It will thus be seen that the primary and fundamental idea—the basis and the dominating purpose of the disclosed process—was the diffusion or distribution of heat, as contrasted with localization. Localization had been weighed in the balance and found wanting. They turned away from this faulty and supposed objectionable practice, and sought its opposite,—diffusion and distribution. The ingredients and process for securing such diffusion of heat are then described. A body of granular material, of high resistance or low conductivity, is interposed within the current so as to form a continuous and unbroken part of the same. This granular body, by reason of its resistance, is made incandescent, and generates the heat required. The ore or substance to be reduced has been mixed with the body of granular resistance material, and "is thus brought directly in contact with the heat at the points of generation at the same time the heat is distributed through the mass of granular material, being generated by the resistance of all the granules, and is not localized at one point, or along a single line." The patentees then suggest the possible use of several resistance materials,—preferably, electric light carbon, which is to be pulverized or granulated to a degree to suit the size of the furnaces. As evidencing the general trend of the patentees' disclosures, we note the suggestion of the preferable use of coarse granules, rather than finely-pulverized carbon, as working better, and giving more even results. The better working conditions are, positively, "the electrical energy is more evenly distributed" (a distribution desired, and in consonance with the patentees' object), and, negatively, "the current cannot so readily form a path of highest temperature, and consequently of least resistance, through the mass along which the entire current, or the bulk of the current, can pass" (a localization not desired, and not in furtherance of the patentees' desired object).

In our study of this patent, we have not ignored the fact that in describing the composition of the charge the patentees stated that the ore "is usually mixed with body of granular resistance material." If, by the use of the word "usually" (upon which great stress has been laid by the complainants), is meant there are other ways of preparing the charge than by mixture of the ingredients, such ways are neither stated nor even hinted at elsewhere; nor is any other practice or method of bringing the heat to bear on the ore suggested than the one wherein ore is mixed with the carbon, "and is thus brought directly in contact with the heat at the points of generation." It would therefore seem that in face of the statutory requirement, requiring a full, clear, and exact description of the discovery and the process of using it, no controlling influence should be drawn from the use of the word in its present connection and relation to this particular patent, or that its use should avail to give this patent a broader scope than its teachings and disclosures warrant. While we are perhaps not called upon to solve what the patentees themselves have not made clear and explicit, yet we think what the draftsman had in mind is reasonably clear. If, instead of qualifying the verb "mixed" by the adverb "usually," implying there was another method than mixing within the range of the suggested process, we apply the phrase "usually mixed" to the "granular" resistance material, we have a reading in consonance with the entire patent, for we note that further on it is stated that the size of the carbon particles used "may pass beyond what is ordinarily understood by the term 'granular,' and be in fact pieces of carbon of considerable size." Thus construed, the patentees would say that the ore is usually mixed with a body of granular resistance material, implying that it might be mixed with a body of "pieces of carbon of considerable size," and "beyond what is ordinarily understood by the term 'granular.'" The patent states the operation must necessarily be conducted in an air-tight chamber, or a nonoxidizing atmosphere, after which it describes a zinc furnace, which is stated to embody the invention, and from which the application of the same to the reduction and smelting of other kinds of ores will be understood. In this furnace we find a cylinder of silica, or other nonconducting material, imbedded in powdered charcoal, mineral wool, or some poor heat-conducting substance. The rear end of the retort is closed by a carbon plate which forms the positive electrode, and is connected with the positive wire of the electric current. The other end is closed by a graphite crucible, which forms the negative electrode, and serves as a condensing chamber for zinc furnaces. Touching the preparation of the charge, the patent says:

The zinc ore is mixed with the pulverized or granular carbon and the retort is charged nearly full through the front end with the mixture.

And the operation of the current is thus described:

The circuit between the electrodes, so called, is continuous; being established by means of, and through, the body of broken carbon. * * * After the plug has been inserted and the joint properly luted, the electric circuit is closed, and the current allowed to pass through the retort, traversing its entire length through the body of mixed ore and carbon. The carbon constituents of the mass become incandescent, generating a very high degree of heat; and, being in direct contact with the ore, the latter is rapidly and effectually reduced and distilled.

Not only is the intermixture of carbon and ore explicitly shown, but the result of such contact is emphasized:

It will be observed (says the patent) that the intimate mixture of incandescent carbon and ore affords the most effectual utilization of all the heat evolved. None of it is lost by transmission through any intervening bodies or spaces.

From this detail study of the patent, it is quite clear that the two substantial disclosures thereof were the diffusion of the current, and a mixture of the carbon resistance material with the subject of reduction, as the method of securing the diffusion and utilization of heat and current. Nothing else than what is consonant with these two dominant disclosures is stated or even suggested in the patent. This construction accords with that reached by the circuit court for the Northern district of Ohio in the case of Lowry v. Aluminum Co., 56 Fed. 495, where the patent was considered by that court. It was there said:

The gist of the Cowles invention is the use of the granular carbon, distributed through the mass of granulated ore, to carry the current from one electrode to another, and, by its low conductivity and resistance to produce intense heat, not at a single point, or in a single line, but throughout the ore, and to maintain it constant.

This same view was emphasized on final hearing of the same case (68 Fed. 354), where the court said:

The gist of the Cowles invention is the use of granular carbon, or other equivalent resistance material distributed through the mass of granulated ore, to carry the current from one electrode to another, and by its low conductivity or resistance to produce intense heat, not at a single point or in a single line, but throughout the ore, and by the heat thus generated to fuse the ore, and to separate the metal element by the chemical action of the carbon upon the nonmetallic element of the ore, just as iron and other like ores are smelted in a furnace.

An analysis of the several claims shows that these two fundamental disclosures—viz. diffusion of the current, and the mixture of carbon resistance material with the subject of reduction—characterize the claims. The first one, viz.:

The method of generating heat for metallurgical operations herein described, which consists in passing an electric current through a body of broken or pulverized resistance material that forms a continuous part of the electric circuit (the ore to be treated by the process being brought into contact with the broken or pulverized resistance material) whereby the heat is generated by the resistance of the broken or pulverized body throughout its mass, and the operation can be performed solely by means of electrical energy,

—Is for a method of generating heat for metallurgical operations. What are the constituent elements of the method? They are, first, "in passing an electric current through a body of broken or pulverized resistance material that forms a continuous part of the electric current." Now, what this body is, what its form, its purpose, and functional work, are all disclosed in the specification, for the claims are founded and based upon the discovery disclosed therein. The patentees say, "The material best adapted for this purpose is electric light carbon." It "is ordinarily composed of grains or pieces proximately equal in size." These grains are preferably coarse, because "coarse granulated carbon works better than finely-pulverized carbon, and gives more even results." And it is "interposed within the circuit in such a manner as to form a continuous and unbroken part of the same." Their use, and the manner of their use, are "in order to secure an even distribution of the electrical energy"; and such distribution is defined as where "the current cannot so readily form a path of highest temperature, and consequently of least resistance, through the mass, along which the entire current, or the bulk of the current, can pass." So much for the current and resistance material. The next element of the process is, "The ore to be treated by the process being brought into contact with the broken or pulverized resistance material." What is meant by the ore "being brought into contact" with the resistance material? The instruction of the specification in that regard is plain, unequivocal, unmistakable. In illustrating the process of zinc smelting, where the resistance element is carbon, and which process, it is stated in the specification, embodies the invention, and from which the application of the process to the reduction of other ores will be easily understood, the patentees say, "The zinc ore is mixed with the pulverized or granulated carbon;" and the condition of being mixed is defined as one where "the carbon constituents of the mass" are "in direct contact with the ore." We think, therefore, that by the teaching of the patent the element under consideration clearly means, and must be construed as meaning, "The ore to be treated by the process being mixed with the broken or pulverized resistance material," and that contact is a physical intermixing of the two ingredients is shown by the statement we have quoted above:

It will be observed that the intimate mixture of incandescent carbon and ore affords the most effectual utilization of all the heat evolved. None of it is lost by transmission through any intervening bodies or spaces.

No more thorough and effective intermixture of ingredients could be stated. To give the element in question any other meaning is to broaden its scope, so as to cover by it what was not even hinted at, much less clearly disclosed, in the specification; and to do this would pervert the beneficent provisions of the patent laws. The next element of the claim is that this relation of the two elements is one "whereby the heat is generated by the resistance of the broken or pulverized body throughout its mass." The teachings of the patent in that regard are that "the heat is generated by the resistance of all the granules, and is not localized at one point, or along a single line."

The second claim, viz.:

The method of smelting or reducing ores or metalliferous compounds herein described, which consists in subjecting the ore, in the presence of carbon, to the action of heat generated by passing an electric current through a body of broken or pulverized resistance material, that forms a continuous part of the electric circuit (the ore being in contact with the broken or pulverized resistance material), whereby the ore is reduced by the combined action of the carbon and of the heat generated solely by the resistance of the broken or pulverized body throughout its mass,

—Is for a method of smelting or reducing ores or metalliferous compounds. It consists in subjecting the ore, in the presence of carbon, to the action of heat generated by passing an electric current through a body of broken or pulverized resistance material that forms a continuous part of the electric circuit, the ore being in contact with the broken or pulverized resistance material, "whereby the ore is reduced by the combined action of the carbon and of the heat generated solely by the resistance of the broken or pulverized body throughout its mass," and is for a method of smelting or reducing ores or metalliferous compounds. It consists in subjecting ore, in the presence of carbon, to heat generated in the method specified in the preceding claim, "whereby the ore is reduced by the combined action of the carbon and of the heat generated solely by the resistance of the broken or pulverized body throughout its mass."

The third claim:

The method of smelting or reducing ores or metalliferous compounds herein described, which consists in pulverizing the ore, and mixing with it pulverized or broken carbon, or like material, then introducing the mixed ore and carbon within an electric circuit, of which it forms a continuous part (the said circuit being established through the carbon constituents of the mass), whereby the heat is generated by the electrical resistance of the carbon throughout the mass, and the operation can be performed entirely by means of the carbon reagent and the electrical energy,

—Consists in the method of smelting or reducing ores or metalliferous compounds wherein pulverized ore is mixed with pulverized broken carbon, and subjected to an electric current operating as in the two preceding claims, and "the operation can be performed entirely by means of the carbon reagent and the electrical energy."

The fourth claim, viz.:

The method of smelting or reducing ores or metalliferous compounds herein described, which consists in subjecting the ore, in the presence of a reducing agent, to the action of heat generated by passing an electric current through a body of broken or pulverized resistance material that forms a continuous part of the electric circuit (the ore being in contact with the broken or pulverized resistance material), whereby the ore is reduced by the combined action of the reducing agent and of the heat generated solely by the resistance of the broken or pulverized body throughout its mass,

—Is identical with the second, save that for the carbon of that claim it substitutes a "reducing agent."

From this detail study of the specification and claims, it is quite clear to the unbiased mind that the entire teaching and disclosure of the patent is a reduction or smelting process in which diffusion or distribution of the current is studiously sought, and localization as studiously avoided; that the resistance material used, the mode of its preparation, and the position in which it is placed, unite to secure the most marked diffusion of the current and of the heat-generating points, and the material to be reduced is also so relatively placed to, and intermixed with, the resistance material particles, as to be subjected to the heat at the relatively separated points of heat generation. These two elements of an intermixture of the resistance material and the substance to be reduced, and the diffusion of the current through the resistance material of the mass, are either expressly or by necessary implication embodied in the claims. If, as we stated before, the patentees had any idea of the possible successful use of a localized path of current circulation, it was neither described in their specification nor asserted in their claims. Indeed, it seems to us that the construction we place on the claims is the only one that is in harmony with the disclosures of the patent. In the light of those disclosures, the claims are quite clear and void of uncertainty; and, thus construed, they give to the patentees the full measure of protection for the discovery which they revealed to the public. To give them such a broadened, unnatural construction as would make them cover subsequent advance in the art in lines which the patentees never disclosed, and in directions which they deprecated and sought to avoid, is to shear the claims of that certainty and fixedness which are desirable to both patentee and public, and should be their distinguishing feature. In our view, the construction we have placed upon them was the just one, in the state of art as it existed when they were granted. If such be the case, it is manifest that such construction should not be modified to meet the subsequent shifting and development of the art; and, moreover, it is significant to note that the Cowles specification would seem by implication to teach that, when the current once found a path of least resistance and highest temperature through the charge mixture, it continued to retain it. Such teaching would seem remarkable, if the present contention of the complainants is correct, that the continued passage of the localized current increased the conductivity of the surrounding mass to the extent of substantially disintegrating the localized current, and diffusing it through the mass; for, if such be the case, then it was needless for the patentees to warn and provide against localization of the current, when such localization was self-adjusting, and could only end in the patentees' desired method of nonlocalization, and a diffusion of the current through the mass.

We next turn to the question whether the respondents infringe. They are the owners of letters patent No. 492,767, issued February 28, 1893, to Edward G. Acheson, and are engaged in the manufacture of carborundum in pursuance thereof. What are the terms and scope of that patent are not questions pertinent to the present case, and upon them we express no opinion. The simple question here is, do the respondents infringe complainants' patent, and not what is the scope of their own? We simply allude to it here as a fact in connection with the respondents' operations. From the proofs it would seem that, some years after the Cowles patent in suit, Mr. Acheson, who was an electrician of experience, discovered the possibility of uniting a single atom, each, of carbon and silicon, and producing a new chemical product. It is chemically known as "carbide of silicon," and com-

mercially as "carborundum." While extremely cheap to manufacture, it has proved to be an abrasive harder than emery, and, indeed, than any abrasive material except the diamond; and the dust of the latter is so expensive that its use is restricted to the cutting of gems. The uses to which carborundum has been applied are varied, its adoption rapid, and its sale extensive. Prior to January 1, 1892, there were manufactured about 50 pounds; during 1892, 2,145 pounds; during 1893, 15,200; and during the first nine months of 1894, 32,085 pounds. It has been used as an abrasive for the cutting and polishing of gems by lapidaries, for grinding and seating of valves, for cutting and grinding glass, in the form of wheels for general metal grinding, as in cutlery manufacture, saw manufacturing, and sharpening of saws, watch manufacturing, optical work of all kinds, and, indeed, has been applied to all the varied uses to which emery wheels have been adapted. In dentistry, small wheels or points of it are extensively used for operations on natural and artificial teeth. It has been adapted to these and various other uses, and the proofs show that it has attracted the attention and favorable notice of the scientific world. The respondents' method, ingredients, their mode of treatment, and the results obtained, are substantially these: The apparatus used consists of the ordinary engine, dynamo, transformers, and other appurtenances belonging to the generating and regulating of an electric current, and what might be termed an "electrically heated furnace." Upon an ordinary pedestal of brick is constructed a box of fire brick 9 feet 8 inches in length, 1 foot 11 inches wide, and 1 foot 9 inches deep. No cement or mortar is used in the construction of the side walls of the furnace, nor in its ends. In the construction of the pedestal or base on which the furnace proper is built, cement is grouted into the brickwork for the purpose of excluding the gases; but in the walls the joints are quite open, to prevent escape of such gases. Through the center of the box, extending lengthwise, is a core or conductor for the conveying of the electric current. This conductor is formed of granular coke, and has relatively a large cross section. Its terminals are contracted to nine solid carbon rods. These carbon rods extend through the ends of the furnace, and connect with two metallic plates, through which electrical connection is made to an alternating current dynamo. The materials used in forming the mixture of the charge, and from which the carborundum is produced, are coke and anthracite coal, in the form of fine powder, salt, sand, and sawdust. These materials are taken in the proportions, by weight, of 31 parts sand, 29 parts coke or coal, 2 parts salt, and 4 parts sawdust. They are all thoroughly mixed together, and then form what is called the "charge mixture." A sufficient quantity of the prepared mixture is placed in the furnace to fill it half full. A trough or trench is then dug along the center line of the furnace in the mixture, this trough forming a bed for the conductor of coke. Being thus prepared, 100 pounds of granular coke are placed uniformly throughout the length of the trough, and rounded up to form, as nearly as practicable a cylinder. When complete, the core measures from 8 to 9 inches in diameter, and extends through the length of the furnace for a distance of about 8 feet, leaving a small space between its ends and the carbon rods. A good connection is made between the granular core and the carbon rods by introducing finely-powdered carbon, thus completing the electrical conductor through the furnace chamber and the walls. The remainder of the furnace is filled with another portion of the prepared mixture, reserving at the ends a small space which is filled with the fine carbon, and on top of this bricks are placed to improve the contact by pressing the fine carbon against the terminal rods. When the current is first turned on, it usually has a volume of 150 amperes. As a result of the passage of the current through the core, its resistance is reduced, and the current is proportionately increased, until eventually the resistance of the carbon core has become sufficiently low to permit of the passage of 1,000 amperes. The volume of the current is maintained at 1,000 amperes until the operation of the furnace is completed. During the period of the increasing volume of the current the temperature of the core has been raised, by reason of its resistance to the passage of the current, to a very intense heat, sufficient to effect a direct conversion of the amorphous form of carbon, as represented in coke, into the graphitic form. The temperature required for this transformation is, approximately, 7,000° Fahrenheit. The sample of a run exhibited shows that surrounding the core is a well-defined zone of crystals, of brilliant luster. This zone is compact, separate from the core, and, after removal, retains its circular shape, corresponding to the contour of the core. These crystals are the carborundum, or carbide of silicon. There is an appreciable diminution in the size of the outer crystals, as compared with the inner ones, and further out they are not found at all. The outer portion of the charge mixture, save that the salt is melted and the sawdust charred, does not seem to be affected. Between this outer portion and the crystal zone already described there is a zone of about an inch thick, which seems to indicate an intermediate state between the original charge and the crystallized carborundum, and between the core and the carborundum crystals is sometimes found a layer of graphitic carbon and silicon in mechanical mixture. The purpose of the several charge ingredients, and the operations they undergo, are stated by respondents' witness Acheson thus:

The fine coke or anthracite coal is introduced for the purpose of providing carbon; the sand is introduced for the purpose of providing silicon. These two materials have sufficient within themselves for the making of carborundum, as it is a product resulting from the simple union in chemical combination of one atom of carbon and one atom of silicon. In the furnace, when the carbon and the sand or oxide of silicon are exposed to the high heat there produced, a portion of the carbon unites with the oxygen in the sand, together forming carbon monoxide, while another portion of the carbon unites with the free silicon to form carbide of silicon. The salt, which is the ordinary chloride of sodium, is introduced into the mixture for the purpose of cementing the black mass together, that it may the more easily be removed from the furnace after the operation is complete. It also has the effect of decreasing the possible oxidation or burning away of the carbon in the mixture, which would naturally occur by reason of the contact of the oxygen of the air with the carbon at a high heat. The sawdust is introduced for the double purpose of increasing the resistance of the mixture to the passage of the electric current, and to afford a greater looseness or porosity to the mass, so that the gases which are produced during the operation of the furnace may more readily escape.

The contention of the respondents is that in the commercial manufacture of carborundum, as thus carried on by them, the electric current passes wholly through the core; that any portion of it that might wander off and pass through the charge mixture is a leakage or loss, and plays no part in producing carborundum; that the heat is generated wholly in the core, and reaches the charge by radiation, and is not generated in the charge mixture by the passage through it of the electric current; that their purpose, means, practice, and result are on wholly different lines from, and at variance with, the suggestions and disclosures of the Cowles patent, and that their method is one based on localization of the current, heat generation along such localized central line; and that the heat reaches the substances to be affected only by radiation. In considering this question of infringement, it is quite clear to our mind that in the use of a core composed wholly of resistance material, in the selection of such resistance material, in the relative size of such resistance material as compared with the resistance material necessarily used in the charge mixture, and in the location of the core with reference to the electrodes, the respondents have chosen the most effective agencies for localizing the current. So far as means and method go, they have designedly followed a course the reverse of that advised and disclosed by Cowles, —actions not usually characteristic of a copyist and infringer. The granular coke of the respondents' core, being of a larger cross section, relatively, than the powdered coke of the surrounding charge mixture, and being in the direct line of the electrodes, attracts and localizes the current initially, and, as generation of heat continues, its conductivity and current-carrying capacity also increase. It would therefore seem clear, and indeed it is conceded, that initially the Acheson core is the current's chosen path of least resistance and highest temperature; and it cannot be gainsaid that no such practice was taught, suggested, much less disclosed, in the Cowles patent. Nor is such a central core embodied in the elements of any of the claims. Indeed, instead of following the lines of Cowles' teaching, the central-core method would seem—at least, so far as localizing the current goes—more in the line of a return to the arc notion of a localized current, which Cowles was seeking to avoid. Nor is the mere presence of carbon in the charge mixture proof that its purpose is to afford a current path. It is a necessary ingredient to unite with silicon in producing carborundum, and in the respondents' working the quantity of carbon in the charge mixture is limited to the amount necessary for that purpose only. While the carbon of the core mixture remains intact at the close of the operation, the carbon of the charge mixture does not. It is clear, too, that the other ingredients of the charge are not relatively good conductors, and the silicon, which is the largest ingredient, is lacking in a marked degree in that regard. Moreover, the clear weight of the testimony satisfies us that in the practical commercial making of carborundum by the respondents (and it is in this the respondents must be held to infringe, if at all) the core is not used as a mere choice of different methods, a thing indifferent in itself, or one which could be omitted. The proof is that its use is an absolute necessity, that its very proportions are considerations of extreme importance, and that the absence of such nicely-adjusted proportions results disastrously. Its preparation constitutes one-half the expense of building the furnace. Its resistance and surface area are adjusted to the length of the furnace, potential, and quantity of current employed. Its surface area controls the thickness of the resultant carborundum shell, for the proofs show that, when the core is too small in cross section, its mass becomes so highly heated that the carborundum crystals formed in immediate proximity to its surface are destroyed, and when too large the heat conveyed from the surface to the charge mixture is, owing to its increased area, not sufficient to produce the usual thickness of carborundum shell. "It has been determined," says the witness Acheson, "purely by experimental work prolonged over many months, that the size of the core should be adjusted to the point where it will be brought to, or slightly under, the temperature at which the crystals of carborundum are decomposed into free carbon and free silicon." The central core being an indispensable factor in the process employed by the respondents, being concededly the initial path of the current, and the very decided weight of proof and reasoning being that it continues to carry the substantial bulk of the current in this localized path, and that the resultant product is the result of such localization, the case might well be disposed of on that ground; for the use of such current-localizing central core is wholly without the discovery disclosed by the patent in question, and an element not found in its claims. Waiving, however, this point, for the present, let us pass on to the inquiry whether the weight of the evidence satisfies the court that the current, or any part of it, ceases to pass through the core, and is established through the carbon constituents of the charge,—a burden which rests upon the complainants to show by a fair preponderance of proof, if infringement is to be decreed. From the nature of things,—the impossibility of observing the inner working of the furnace, and the subtle character of the electrical agents,—absolute demonstration or certainty is impossible. Any conclusion reached is at best a mere deduction from certain observed phenomena. The interior workings can only be surmised by a consideration of the structure, ingredients, operation, and results. When Mr. Cowles was asked how he would determine the relative quantities of the current flowing through respondents' core at any given zone of the outer mass, he frankly stated:

I know of no way of exactly determining it. Judgments and inferences might be drawn as to the current density in different parts of the cross section of that apparatus, and possibly some measurements, but I do not think reliable ones could be secured as to the fall of potential between different portions, but, to my mind, the conditions inside of that furnace are so varied in different parts, and so subject to the actions of gases evolved, variations in temperature, and various other conditions, that exact statements could not be made.

The divergent conclusions or views deduced may be seen in the evidence of Messrs. Cowles and Acheson. Mr. Cowles says:

Electrical tests I have made have given me conclusive evidence that with a core present, similar to that described in the descriptions of the defendant's furnaces, that all the current does not pass through the core. These experiments were made during the process of the run of December 15th, which I have already described. * * *. A large proportion undoubtedly follows the core, when it is operated as I have read the description of the operation. It is impossible to say, in my judgment, exactly what portion follows the core.

He then stated that, comparing his experiments and the respondents' operation, there would not be much difference in the manner in which the current would follow the central core in the two cases. He had already expressed the opinion that, in such experiments "probably over seventy per cent., and possibly ninety-five per cent.," of the current, passed through the central core. Mr. Acheson gives his views as follows:

The working current is confined to, and passes through, the core. Any current that may wander off from the core and pass through the mixture can only be considered in the light of leakage, precisely as we consider the current that escapes from the ordinary telegraph line as leakage. A leakage must always be looked upon as a source of loss, and it is in this sense that I look upon the current that by any chance may be deviated from the core to the mixture. It is not, however, a quantity of any particular value, and plays no part in the manufacture of carborundum.

While, as we have said, absolute certainty is impossible, we are, by a most patient and detailed study of the case, led to two conclusions: First, the weight of the proof and the reasons advanced fail to show that a substantial, effective part of the current passes through the charge mixture in respondents' process; and, secondly, the clear weight of the evidence tends strongly to show that the working, effective current is confined to the central core in respondents' workings. In reaching such conclusions we are strongly impressed with the fact that the physical indicia at the close of a run of respondents' furnace all point to the idea that, whatever be the concealed working of the current, the core is the center of heat, energy, and effectiveness. The relative effects of such centrally located energy, and the central localization of the energy as well, are shown in the existence in equidistant surrounding series of zones of similarly affected ingredients, and by the fact that these rings of zones exhibit different conditions of the material acted upon, and such conditions varying according to the relative distances of such zones from the central core. Then, too, the atoms of the charge zones nearest the core, and on all sides of it, have been shifted into radial lines uniformly converging from the core, and at right angles to its axis; thus showing that the influence or energy which fixed their position emanated from a common, central source. That such is the case is also evidenced by the fact that the crystal particles varied in size according to their relative distance from the core, diminishing the further they are located from it. If the electric current is the basis of energy, the formative cause of these crystals, and of the changed condition of the charge mixture when subjected to it,—and such must be the case if infringement exists,—it would seem to follow that the diffusion of the current, in effective, appreciable quantity, through the body of the charge mixture, would result in varying and irregular conditions throughout the mass, and that there would be an absence of those regular, graduated, and systematic conditions which we find in symmetrical order at the close of run of a core furnace, and all of which seem in relative relation to the central core. Nor would we find the production of crystals confined to any particular portion of the charge. The indisputable phenomena found at the end of a core-furnace run are, to our mind, consistent with the theory that the seat of the thermoelectric energy which causes such phenomena is in a common, central current, and are not consistent with the theory of a number of effective working currents following numerous diverging paths through the mixture, and each constituting an individual radiating center of effective thermoelectric energy. Assuming that a number of fugitive, shunt, subsidiary currents do branch off from the central-current path, yet it must be apparent, if the evidence of the senses can be relied on, that their relative size and influence, as compared with the dominating and masterful effect of the central-core current, is unappreciable. No traces of their path, or even of their existence, are found at the close of the run. They have left no carborundum in their vicinage. Assuming that such currents exist, it may be assumed, if they are judged by their fruits, that they are noneffective, and a matter of indifference in the production of carborundum in respondents' process. If we assume that carborundum is produced by thermal radiation from a localized line or current, and that such localized current is the dominant and efficient cause of the production, then the mere presence of fugitive, inefficient currents, which leave no traces of their path, or evidence no result from their passage, cannot well be urged as an infringement of a process whose gist, substance, and effectiveness are based upon the diffusion of working and effective currents which produces the desired effect along their several paths throughout the mass. And in this connection we might say that if the escape of fugitive side currents from the main-current path, in obedience to the shunt law, and their passage through the charge mixture, were in themselves, and without reference to their effectiveness, to be deemed infringements of the Cowles patent, then the arc method of smelting to which Cowles refers in his specification, and in which there must have been shunt currents in certain conditions, might be urged as a substantial anticipation of Cowles' patent, since, in its practical operation, there were diffusive currents as well as localized ones. That the heat is generated in the core, and reaches the charge mixture by radiation, and not by currents diffused through the mass and generating heat in their passage, is also shown by the fact that within an hour after respondents' run begins the heat generated within the core is sufficient to drive off vapors, while the outside of the charge does not become red hot for five hours, and even this is hastened by the burning of the gases at the surface. It is also significant, as emphasizing the same view, that when powdered anthracite coal, which is well known to be of higher resistance material to an electric current than powdered coke, was substituted for the latter, it produced no effect upon the operation or the output of the furnace; thus showing that, if side currents were diffused through the charge mixture, they were of such trifling character that their increase or decrease in volume was a matter of no relative importance. The wide variation between the heat extremes at the exterior and interior of the charge mixture is shown by the fact that the exterior zone of the charge undergoes no appreciable change, further than the fusion of the salt and the charring of the sawdust,—changes which take place at moderate temperature,—while the inner zone shows a thin layer of graphite, indicating the most intense heat at that point. Such wide variations of results point to equally widely separated causes, and, as the current is the heat-generating source, would indubitably, we might almost venture to say, point to a localized central location for it. The fact that graphite, and not carborundum, forms where the charge mixture abuts against the core, indicates that if the charge mixture was intermixed with the core ingredients, and, in the words of the Cowles patent, were "thus brought directly in contact with the heat at the points of generation," the respondents' process would be a failure. The conceded results of respondents' operations would therefore seem to show that the desired effect was reached, not by contact of the to be treated substance with the heat at its point of generation, and where, as in Cowles' process, none of it is lost by "transmission through intervening bodies or spaces," but where the heat radiates from its point of generation in order to reach such substance, and where some of such heat is lost by transmission through both intervening bodies and intervening spaces. Indeed, the process, preparation of ingredients, and means employed, in the two methods now under consideration, are diverse, and the desired objects unlike. The like thermoelectric agent is employed in both, but with it the substantial likeness ends. Cowles' object was reduction, while Acheson's was composition. One reduced a substance already in existence; the other, by composition, produced a new product. With Acheson, the new product consumed the carbon constituent of the charge; with Cowles, an excess of the carbon constituents remained at the close of the process. In Cowles, the charge for functional purposes occupied the central space between the electrodes; in Acheson, for functional purposes it was removed from such central space, and from electrode contact. In Cowles, an excess of carbon was required in the charge mixture as a current-conductor; in Acheson, no such excess was required or used, but the carbon for that purpose was isolated in the central core. Their methods are so radically unlike, and are carried out on such diverse lines, that we are firmly convinced that the charge of infringement has not been sustained.

After what we have stated in reference to the Cowles process patent, we do not deem it necessary to protract this opinion by a detailed description of the apparatus patent, No. 319,945. It has been strongly assailed as void for lack of patentable novelty; but, as we are of opinion that respondents' apparatus does not infringe its claims, a discussion of its patentability is needless. Two species of furnace are illustrated in the drawings and described in the specification. One is for the reduction of zinc ores; the other, for nonvolatilizable metals, which require a very high temperature for their reduction. Though different in construction, these two furnaces are substantially similar in principle; the broad or basis idea being, in both, that the material under treatment, mixed with pulverized carbon or other resistance material, is isolated in such a manner that the electric current may pass through the mixture, and spends its entire energy within the mixture. After a discriminating analysis of the patent, the respondents' witness Laureau well says (and we agree with his conclusions):

A comparison with the apparatus used by the defendant company, and the general mode of procedure in the manufacture of carborundum, would show that there are radical differences between them and the furnace and methods described and claimed by the Cowles patent in suit, No. 319,945. The furnace used by defendant is built loosely, without any attempt at making it airtight; the bricks being simply piled up, without any binding material whatever, and the top is left entirely open. The gases have no one particular means of escape, but in fact issue from sides and top with equal facility, the flames on the side being quite as large as those at the top. The material outside of the core is not packed so that it may exclude the heat produced by the electric current going through a core of resistance material. The core which was used is of pure carbon, unmixed with any material upon which the current might have a decomposing action; and the mixture from which the product sought for is obtained is not placed, as in the Cowles furnace, in the direct path of the current, but in the very place from which he specifically states that he wishes to exclude it. The material to be acted upon in the defendant's furnace is placed where the charcoal packing which confines the heat within the core is in the Cowles furnace. * * * The core of the defendant is inert and unproductive, so far as final results are concerned. The core of the Cowles patent in suit is the active and productive portion of the furnace.

A detailed examination of the claims shows that all the several elements embodied in the claims are not found in the respondents' furnace. The first claim is:

In an electric smelting or reducing apparatus, a chamber or casing having its longest dimension in a horizontal direction, and adapted to contain a charge of ore and electrical resistance material previously pulverized and mixed together, the oppositely located electrodes in conductive relation to the charge, but otherwise insulated from one another, and an exit for the escape of the gases and vapors evolved from the charge during the process of reduction, substantially as herein set forth.

When respondents' furnace is in use, it is not "adapted to contain a charge of ore and electrical resistance material previously pulverized and mixed together, the oppositely located electrodes in conductive relation to the charge." The electrodes of respondents are in conductive relation, not to the charge, but to a central core, through which, and not through the charge, the working current passes. In the second claim we find among the elements, "the smelting chamber, formed of side and bottom walls of closely-packed pulverized or granular material, and the permeable top wall, formed of a layer of granular non heat conducting material"; in the third claim, "the combination of a chamber or casing, the side and bottom layers of closely-packed pulverized or granular material, and the top covering of similar material, made permeable for the escape of gases and vapors"; in the fourth claim, "a smelting-chamber formed of closely-packed granular or pulverized material, of a non heat conducting nature, and of lesser electrical conductivity than the charge to be smelted in the furnace"; and in the seventh claim, "a smelting chamber formed of closely-packed pulverized material, of non heat conducting nature, and of lesser electrical conductivity than the charge to be smelted within it, a layer of similar material, permeable for the escape of gas, for closing the said chamber."

As bearing on these elements, the specification states:

The space between the carbon plates constitutes the working part of the furnace. This is lined on the bottom and sides with a packing of fine charcoal, O, or such other material as is both a poor conductor of heat and electricity (as, for example, in some cases, silica or pulverized corundum or well-burned lime); and the charge, P, of ore and broken, granular, or pulverized carbon, occupies the center of the box, extending between the carbon plates. A layer of granular charcoal, O', also covers the charge on the top. The charge thus forms a core extending lengthwise of the box, in contact with the carbon plates, M, at the ends, and incased on all sides by the jacket of fine charcoal. Fine charcoal, as is well known, is a very poor conductor of heat, and the charcoal packing confines the heat within the core, protects the walls of the furnace, prevents them from fluxing down and mingling with the charge, thereby introducing deleterious matter, and it forms a deoxidizing shell for the charge. The protection of the charge from the introduction of deleterious matter by the fluxing down of the walls is a very important matter, and the protection afforded therefrom by the charcoal packing immediately surrounding the charge is complete. It is also a much inferior conductor of electricity than the carbon used in the core, and hence it operates as an insulating jacket for the charge, and confines the current to its path through the charge, besides confining the heat. The protection afforded by the charcoal jacket, as regards the heat, is so complete that, with the covering slab removed, the hand can be held within a few inches of the exposed charcoal jacket; but with the top covering of charcoal also removed, and the core exposed, the hand cannot be held within several feet.

It will thus be seen the charge is enveloped, and, as stated above, "forms a core extending lengthwise." In respondents' process these elements are not present. The charge mixture has nothing outside of it whatever,—neither chamber walls nor inclosing jacket. Nor does respondents' apparatus use the form of core specified in the fifth claim, viz. one "having a greater number of points of contact in a cross section of the body taken close to the plates than in a cross section of the same taken at intermediate parts thereof." Moreover, the body or core therein interposed, which the claim states "is substantially as described," is, by reference to the specification, found to be composed of the charge mixture. Thus, "the charge thus forms a core extending lengthwise of the box, in contact with the carbon plates, M, at the ends, and incased on all sides by the jacket of fine charcoal." In respondents' furnace the charge mixture forms no part of the core, and these same remarks are applicable to the sixth claim. After careful examination, being of opinion that infringement has not been shown, the complainants' bill will be dismissed. Let a decree be prepared and submitted.

CARROLL v. GOLDSCHMIDT et al.

(Circuit Court of Appeals, Second Circuit. December 1, 1897.)

1. JUDGMENTS—CONCLUSIVENESS—PRIVIES.

Judgments are binding upon privies as well as upon parties; but only those are privies, within the meaning of the rule, who acquire their interest in the subject-matter of the suit after the commencement of the suit.

2. PATENTS—LEGAL AND EQUITABLE TITLE.

Persons acquiring the legal title to a patent, with notice of the prior equitable right of another to the invention, take the legal title in subordination thereto, and cannot hold as infringers persons who purchase a patented machine from such equitable owner.