being often burned away by the intense heat of the furnace or clogged by the adhesion of cinder, which sometimes backs not only into the tuyeres, but runs into the tuyere pipe also.

Prior to the patent in suit the usual method of connecting the tuyere and tuyere pipe was as follows: The front end of the tuyere pipe was made of smaller diameter than the interior of the butt end of the tuyere, and extended some distance into the latter, a bead or projecting rim being formed on the extremity of the tuyere pipe. The interspace between the outside surface of the tuyere pipe and the interior of the tuyere was then closed by ramming wet clay and fragments of pounded fire brick therein. The bead or rim upon the front end of the tuyere pipe served as a sort of dam against which to ram the packing, and, when no bead was used, it was necessary to prop up the tuyere pipe within the tuyere with little pieces of brick, so as to get an even or uniform space, around and within which the packing should be inserted. Under the heat of the furnace the clay baked into a hard mass, and a rigid immovable joint formed. The objection to this method was obvious. The temperature of a furnace changes frequently, or, as one of the witnesses says:

"Every stop of more than a few minutes means a cooling down of all the exposed surfaces, and a contraction of the same. When the blast is put on again, as it warms up the surfaces, we find more or less leakage taking place where there are packed joints. The blast is always taken off when the iron is run, and that takes place from three to six times per twenty-four hours, according to the capacity of the furnace, each time involving from ten to thirty or more minutes, according as any difficulties may arise. There are also many stoppages arising through the loss of the tuyeres, or the bad working of the furnace causing stoppages in the pipes which introduce the blast through the tuyeres. These stoppages may be from ten minutes to a half a day or more."

It will be seen that, as one of the witnesses expressed it, there was a constant creeping or moving of the tuyere, the tuyere pipe, and the bustle pipes from the contraction and expansion. As no provision was made for these changed conditions, leakages frequently occurred.

The labor of changing tuyeres under the old system is thus described by Hartman, the patentee:

"Taking the case of the old-style wrought-iron tuyere having sprung a leak, the blast is taken off the furnace, which stops it. Two men with steel bars about eight feet long, and two other men with sledges, cut away the brickwork and packing around this tuyere, leaving a space of about three inches between the tuyere and the wall. On the end of the tuyere in the furnace the iron has accumulated in the form of a ring, which requires a large hole to pull the tuyere through. After the tuyere is out, the fuel in the furnace falls into the cavity made by the tuyere. This fuel has to be raked out cautiously, and a sheathing of clay packed up against the upper part of the cavity to hold the fuel in check. The new tuyere is then inserted and got into an alignment in a rough sort of a way, as quickly as possible, and the clay-packing was rammed in tight between the clay and the wall. After this was done, the tuyere pipe was placed in the tuyere, the ball joint bolted together at the end of the tuyere pipe, and the clay joint was rammed up between the tuyere pipe and the tuyere. The blast was then turned on the furnace. This work required six men, and about three quarters of an hour stoppage. If the end of the tuyere had got 'ironed up' badly, it took a longer time. After the blast was turned on, the tuyere pipe heated up, and the clay joint had begun to shrink, the workmen took their rammers and drove up the joint tighter

between the tuyere pipe and the tuyere. The joint had to be watched until the clay had hardened, for fear of its springing a leak, for in many cases a large piece would blow out."

And, as adding to the difficulties, another of the witnesses called attention to the surroundings under which this work had to be done, as follows:

"The space is very limited in which the work must be done. The surfaces with which one is liable to come in contact are so hot as to burn one most seriously when touched; and, if the furnace is working badly at the time, there is a likelihood of there having been an outpour of cinder or molten iron. The consequence is, the work must be done rapidly and under great inconvenience and risk."

In addition to these difficulties, a long tuyere had to be used to allow for the insertion of the tuyere pipe, and to get a sufficient depth of packing to make a tight joint. The drawbacks of this method of tuyere connection were heightened by events occurring about this time. The great fall in the price of pig metal consequent upon the panic of 1873 forced furnacemen to changes in methods, to increased efficacy in means, and to reduction of expenditure in fuel and labor. As a result, systems treating the hot blast came into use, by which its pressure was doubled, and its temperature rose from 600 to 1200 degrees. These changes, while increasing the output of the furnace, obviously increased the liability to leakage.

It was to meet such serious obstacles lying in the path of successful furnace operation that Mr. Hartman, who was a theoretical and practical furnaceman, devised the mechanism covered by the patent in suit, in the shape of a flexible joint that would adapt itself to the contraction and expansion of the parts. It was at once simple and effective. He used a tuyere the butt end of which was of about the same size as the front end of the tuyere pipe. He turned a corresponding globe face on each, so that the nose of the pipe fitted into and seated itself in the tuyere, thus forming a globe joint. The edge of the pipe formed a metallic connection with the water-cooled tuyere, and its temperature was thus reduced. From a staple in the furnace wall near the tuyere he extended a connecting link, upon which a constant pressure was maintained by a weighted lever fulcrumed at the other end of the tuyere pipe. "By this arrangement," he briefly adds in the specification, "any expansion of the tuyere pipe is taken up by the yielding of the weighted lever, H, and the joint remains tight."

Two claims were allowed him, viz.:

"(7) The combination of the fulcrum, h', the connecting-link, h^2, and a yielding tension upon the said link by the weighted lever, H, or its equivalent, to secure the joint, C', by a flexible pressure, as herein described.

"(8) The combination of an oscillating joint upon a water-cooled tuyere, an oscillating tuyere pipe, and a link connecting the same by a yielding pressure, substantially as specified."

Both are alleged to be infringed. The device has gone into general use. Some 75 per cent. of the furnaces in the country have adopted it. Of its utility the evidence is quite convincing. Hunt, a furnace master of experience, says it is far superior to the clay-packed joint. It saves the leakage of the blast, and avoids the an-

noyance of having to look after the packing to make it tight; that it causes a great saving of time; that he had no difficulty in getting the pipes together and ready to put on the blast. He says:

"I have had twenty-three tuyeres to change in one week in one furnace owing to the furnace working so badly. If this had been with the old form of tuyere and connections, it is quite a possibility that we would have had to blow the furnace out, as, owing to its bad-working condition, the many prolonged stops would have shut it up altogether."

It would also appear from the testimony of this witness that the flexible connection by means of the globe-faced joint made possible the use of a short bronze tuyere instead of the long water-coil cast-iron tuyere, and by this means a real saving of time in changing tuyeres was first made.

Roder, a witness of practical experience and theoretical knowledge in furnace operation, says that, under the old system, change of a tuyere would average an hour; that, by Hartman's device, they can do it in 15 minutes; that the joint is tighter than the clay one, is not apt to blow out, and is adjustable to the heat to which it is subjected.

As bearing on the merits of this device, and more particularly with reference to the use of the short tuyere being made possible by it, we note the testimony of the patentee, who says:

"Up to the latter part of 1876 long tuyeres in breasts were used exclusively. The tuyeres were required to be long, to give them sufficient bearing on the clay-packing. Short tuyeres were introduced with a taper surface on the butt end, fitting into a corresponding opening in the nose end of the tuyere breast. This gave a rigid bearing, which always brought the butt end of the tuyere to a definite point, and allowed the use of a tuyere pipe of a fixed length. * * * The globe face on the butt end of the tuyere, to dispense with the clay-packing, became absolutely necessary, as with the high pressures now blown there was not room for the nozzle, and the proper depth of clay-packed joint in the short tuyere. * * * The difference in time, etc., between changing a long tuyere and a short tuyere would be—First, removing the clay-packed joint between the tuyere and tuyere pipe; second, removing the joint between the tuyere and tuyere breast; third, in claying the fuel in the hearth; fourth, inserting the tuyere, and making a new joint; fifth, inserting the tuyere pipe; sixth, blocking it up to its proper position; seventh, making the joint between the tuyere and the tuyere pipe; eighth, repairing the joint as the water evaporates from the clay-packing, this clay-packing having to be driven up tighter as the water evaporates from the joint. The clay joint has to be watched by the men, who must quickly stop any leakage to prevent the blast from tearing a large hole in the packing. With a short tuyere a hook is inserted in the tuyere, the tuyere jerked out, a new one pushed in, and the pipe coupled. Blast is then put on. The joint being a metallic one, there is no danger of its blowing out, and it requires no further watching. * * * In the case of a tuyere burning off or starting a leak where the device was of the character of the Hartman invention No. 2, for instance, the blast was turned off and the furnace stopped. The horizontal tuyere pipe is taken down, a hook is inserted through the tuyere, the tuyere pulled out, a new tuyere is quickly inserted, the horizontal tuyere pipe put up, the yielding tension attached, and blast thrown on the furnace. We generally allowed fifteen minutes for this. In case of the Illinois Steel Company, they have their men so perfectly trained that their records show they change a tuyere in six minutes, using this device."

To our mind this device, seemingly simple after it was disclosed, was effective in operation, valuable in results, beneficially affected one of our largest interests in an important detail in the very start-

ing point of its manufacture, and was not the development or mere natural advance of the mechanical practice incident to the art. It required skill of a higher order than that coming from such sources. Indeed, a study of the step by step growth towards the finally perfected device shows clearly that it was not such a one as the mere advance incident to the art would have naturally produced, but that it was the result of thought, experiment, and inventive genius on the part of one skilled to the highest degree in all the practical and theoretical details of the industry. Without entering into detail or analyzing the successive steps from the Coleraine draft, in 1869, when Hartman first took up the problem, to the perfected device for the Cooper & Hewitt furnace, in 1876, we may say that, in our judgment, the latter involved invention of marked character. Such being the case, we turn to the next question, namely, whether anticipation has been shown.

A careful examination of the device shown in Dingler's Journal, a German publication of 1870, does not disclose, so far as the issues in this case are concerned, anything in common with Hartman's device. Certainly the text mentions nothing. As to the drawings, the bead on the front end of the tuyere pipe and the space back of it between the tuyere and tuyere pipe are strongly suggestive of the clay-packing then common in the art, and therefore of a rigid joint; nor is there anything in the nature of a connecting link between tuyere pipe and tuyere. The alleged similarity between the devices, so far as the issues involved are concerned, is one based on mere conjecture, and lacks the certainty of proof which should avail to defeat the right vested by the grant of the patent.

While the extract from Osborn's Metallurgy, a Philadelphia publication of 1869, shows a globe joint between the tuyere pipe and tuyere, and the extract from Annales Des Mines (Paris, 1869) the conceded equivalent of such a joint between these two parts, yet in the latter there is no suggestion of a link to connect these parts to make or maintain a yielding pressure upon the joint, or any mechanism to continue it as an oscillating joint in the functional sense of the Hartman device. As to the former device, it is affirmatively shown the connection was rigid. These comprise all the prior publications in blast-furnace construction. In none of them is anything akin to the real gist of Hartman's device foreshadowed, much less disclosed. In addition to these we are referred to three prior patents, in which it is alleged that was an analogous use, and it is said that Hartman's was a mere double use of the device therein shown. The first of these is the Shurtleff, of 1872, No. 128,760, for a flexible pipe joint for conveying air for air brakes or steam or hot water for heating purposes between railway cars. While it may be conceded the device shows a general resemblance to the Hartman device in that both exhibit a flexible pipe connection, yet the resemblance virtually ends there, while the radical differences are manifold. Among these we may refer to the ponderous mechanism of the blowing system of a blast furnace as compared with the relatively delicate connection of flexible pipe connections between railroad cars, the pres-

sure and high temperature to which the one is subjected, and the extent of contraction and expansion to which the parts are liable, and the frequency of such changes, and the liability of cinder to back into the joints, the adjustment that must be made in cumbersome appliances, and the fact that from the exigencies of the case the mechanism must be made so as to be capable of being rapidly put in place by the crude labor employed about a furnace. When we consider these as some of the needs and difficulties in the construction of such a device as Hartman's, we think it must be apparent to the common sense of an unprejudiced mind that the Shurtleff patent would afford no aid to one who was working out the problem for a blast-furnace tuyere joint. The divergence between the uses is so extreme, the conditions so radically different, and the difficulties so peculiar to the one, that the adaptation of what was useful in one sphere to use in another would possibly require more inventive faculty than the creation of something novel in itself.

To this case, as bearing on the question, we may apply the pertinent language of the supreme court in a late case of Potts & Co. v. Creager, 155 U. S. 607, 15 Sup. Ct. 194, where the grounds for asserting an analogous use were certainly stronger than here:

"Indeed, it often requires as acute a perception of the relation between cause and effect, and as much of the peculiar intuitive genius which is a characteristic of great inventors, to grasp the idea that a device used in one art may be made available in another, as would be necessary to create the device de novo. And this is not the less true if, after the thing has beeen done, it appears to the ordinary mind so simple as to excite wonder that it was not thought of before. The apparent simplicity of a new device often leads an inexperienced person to think that it would have occurred to any one familiar with the subject; but the decisive answer is that, with dozens and perhaps hundreds of others laboring in the same field, it had never occurred to any one before. The practiced eye of an ordinary mechanic may be safely trusted to see what ought to be apparent to every one."

We think what we have said applies with equal force to the flexible pipe connection in the steam and smoke conveyer for railway cars of De Codezo (patent No. 151,099), and to the boiler appliances of Weigand. With these devices known and made public in the patent office for years, it is not without significance that furnacemen have not before or since the Hartman device adopted them or any similar device in furnace construction. Indeed, we think the two ball and socket joints, which were found at the elbow and upper joint of the old-style tuyere, but which are not alleged as an anticipation, afforded a more pertinent ground for such a contention, for, though clamped up as a tight joint when the blast was in operation, yet their initial function as an oscillating joint while the tuyere was being adjusted was recognized as old in the art.

This brings us to one of the remaining questions which has been urged with great earnestness by the learned counsel; namely, that the combinations recited in the claims are incapable of producing the result for which the invention was designed. It is said, and such appears to be the case, that, for the successful operation of the Hartman device, it is necessary to have three flexible parts or joints, one at the globe joint between the butt of the tuyere and the

front of the tuyere pipe, which is recited in the claims, and two others which are not specified therein, viz. one up under the valve and one at the foot of the vertical pipe. While it is true that the patentee must make a full disclosure of his invention in all its parts, so that the public may have the benefit of it in its entirety at the expiration of the patent, and that there is no reference made in the specification other than mentioning the second joint, K', as a globe joint, and showing a like joint in the drawings where the third one is used in practice, still we must remember the patent is addressed to those acquainted with the art and the construction and appliances then in use.

As is said in 2 Rob. Pat. § 491:

"Immaterial parts are often so connected with the material that the description of the latter inevitably draws after it the delineation of the former; and, on the other hand, many material objects and operations are so familiar to the inventor and his readers that their specific description, or even an illusion to them, would be superfluous. The law recognizes these difficulties in the way of an absolutely complete description, and overlooks the defects which they occcasion, * * * though it omits appliances, modifications, or processes which persons skilled in the art would know were necessary, and would themselves supply. Though it fails to describe implements and materials that are in common use, or methods of construction generally practiced in the arts, it may be complete enough to put before the already trained and informed intelligence of the reader an accurate and entire picture of the invention, from which he can understand it, construct it, and use it as easily as if all these familiar acts and objects were particularly described."

Applying these legal principles to the case in hand, and adding to the patent as a whole (which includes specification and drawings) the then knowledge and practice of the art, we cannot say the claims do not disclose a practical working combination. That globe joints already existed at the second and third points of flexure is admitted; that they were tightened up to rigid joints in connection with the old clay-packed rigid joints is true. The mind which could not at once see that the making of the tuyere-pipe tuyere joint an oscillating one rendered the tightening of the two ball joints needless and undesirable could not have been one skilled in the art. We have searched the proofs in vain for the testimony of one thus skilled who said the patent failed to disclose to him the invention in its entirety.

We now turn to the question of infringement. The respondents use two devices which are alleged to infringe. In structure No. 1 they have an oscillating bevel joint between a water-cooled tuyere pipe and tuyere. They are kept in contact by means of a connecting link. One end of it is fastened to a hook in the breast wall, and the other passes through a lug on the lower side and back end of the tuyere pipe, and is secured by a nut. A strong spring between the nut and lug, and against which the nut is tightly drawn, affords a yielding pressure, and holds the parts of the first joint in contact under the varying conditions of contraction and expansion. Two other points of flexure are provided, as in the practice of the Hartman device. It is quite clear to us that the spring, taken in connection with the other operative appliances, is, in functional purpose and effect, the mechanical equivalent of the weighted lever of Hart-

man's device. We are therefore of opinion that structure No. 1 is an infringement on both claims.

Structure No. 2 presents a different state of facts. It appears a bustle pipe can be twisted or sprung from its normal position under certain conditions, and, when thus twisted, it acts as a torsional spring. In structure No. 2 this is done by means of a rod (adjustable by a screw to regulate the extent of the spring) connecting lugs placed on the upper sides of the bustle and the belly pipes. By this means the lower end of the belly pipe is supported, and the tuyere pipe is held in contact with the butt end of the tuyere by a pressure which adapts itself to the contraction and expansion of the parts. It is alleged by complainant that the rod between the bustle and belly pipes is a link which applies a yielding tension, and this brings it within the scope of Hartman's claim. We cannot so regard the claims of the two structures. To our mind, so far as the claims are concerned, they represent two distinct types of construction. The underlying thought, the "motif," so to speak, of Hartman's device, was a link or tie between the tuyere pipe and tuyere. Indeed, a study of the successive steps of his invention—first rigid clamps at the joint, then the extension of those clamps to a rod or link reaching to the end of the tuyere pipe, and then finally giving to the link the added capacity of exerting a yielding pressure—shows this. Through it all runs the idea of a link as something connecting or joining the two parts and drawing them together by pressure, the stack in which the tuyere was seated being stationary, the tuyere pipe movable. It is obvious that in his conception the stability of the stack was his starting point or base, by means of which his device was possible. This idea was embodied in the eighth claim (and we take it as being the broadest) in language that to our mind is capable of but one reasonable interpretation: "The combination of an oscillating joint upon a water-cooled tuyere, an oscillating tuyere pipe, and a link connecting the same by a yielding pressure, substantially as specified." "A link connecting the same." Connecting what? Obviously the tuyere and tuyere pipe. How? By pressure. What can this mean but the pressure operated through the rod itself? But this pressure of the rod, which would otherwise be fixed, is made yielding by the mechanism employed. The very word "link" means coupling or joining together, and "connecting" intensifies it, for the word from which it is derived means to bind. The language of the claim is not "means to exert a yielding pressure upon the same," but is restricted and limited to a link connecting the same by a yielding pressure. It is to be remembered that while the combination was new, and as such, and in the use of its equivalents, would be protected, yet separate and in themselves the elements of it were not. While Hartman was entitled to credit and protection as far as he invented and claimed, yet he did not block all paths of invention leading to the same result. The second structure reaches the same end, but by another path. In it a connecting link is wholly dispensed with. The stability of the stack as a base is not an element, and, instead of a pressure exerted from the stack