

$s = 0$ and bending moment around circular arc, $G = 0$ at shore ($r = R$); shearing stress along circle of radius r :

$$2\pi r S = \int_0^r 2\pi r Z dr + P$$

for all values of r , P being any exterior vertical forces applied to single points inside the circle.

[*To be concluded.*]

CHEMICAL SECTION.

Stated Meeting of October 15, 1895.

DR. WM. C. DAY President, in the Chair.

WHAT IS BITUMEN ?*

BY S. F. PECKHAM.

The exact meaning of the word "bitumen," in modern scientific literature, has been a matter of perplexity for many years. It has appeared to me impossible that any one unacquainted with the different substances included by the makers of dictionaries and cyclopædias under their descriptions and definitions, could form any clear idea of what they are. For instance, in Genesis xi, 3, a Hebrew word occurs which designates the substance used in constructing the walls of the tower of Babel. In the Septuagint this word is translated *ἀσφαλτος*, and in the Vulgate, "bitumen." In the Bishop's Bible of 1568, and subsequent translations into English, the word is rendered "slime." In the Douay translation of 1600 it is "bitume." In the Protestant French translation it is "bitume." In Luther's German Bible it is "thon." In removing the magnificent alabaster slabs that were used to adorn the palaces of Nineveh and Babylon, it has been discovered that the material used to cement and hold the slabs in position, was melted or natural maltha. The word "asphaltum" is said to be derived from

a, privitive, and *σφαλλο*, "I cause to slip." It therefore signifies a substance that prevents one from slipping, and was applied to the solid forms of bitumen that soften in the sun. This substance was not rare in so-called Bible lands, embracing the valley of the Euphrates, the tablelands of Mesopotamia and the valley of the Jordan. It was of frequent occurrence along the shores of the Dead Sea, and was gathered and sold in the caravan trade that passed through the land of Moab and Petrea into Egypt.

During the Middle Ages, asphaltum and other forms of bitumen appear to have found but few uses, and they are but seldom mentioned. The words bitumen, asphaltum, petroleum and naphtha, appear to have been used with different meanings, and also interchangeably or synonymously; yet, the words were generally used to signify a thing that was located and defined by further description, so that the bitumen of the Dead Sea was recognised as asphaltum, or solid bitumen; that of Zante, as petroleum, etc. It is only within the last century that any serious confusion in nomenclature has appeared, and then the trouble has arisen out of commercial rather than scientific considerations. About the year 1830, the French schist oil began to assume importance. Later, the Scotch paraffine industry arose, and during the decade from 1850 to 1860 extended from Scotland to the United States, into which both the materials used and the methods of manufacture were imported. In France the materials used were properly called "the bituminous shales of Autun." In Scotland the material was called boghead coal, boghead shale and boghead mineral; it was also called Torbanite. The expense attending the importation of the boghead shale into the United States, led the Downer Kerosene Oil Company, of Boston, Mass. and Portland, Me., to make an exclusive contract for the use of the Albertite, of New Brunswick. It was called Albert coal, asphalt, pitch, etc.; and, for commercial reasons, became the subject of a very important lawsuit, in which, as experts, scientific men gave very conflicting testimony, one party claiming that the material was asphaltum, and the other that it was coal. It was finally decided that the material was not coal, and did

not belong to the Crown.¹ At about this time, a deposit occurring in West Virginia, and since known as Grahamite, and which, in appearance, is much more like splint coal than Albertite, attracted attention. There were veins of material in Cuba that were also included in the argument, Coal *vs.* Asphalt.

The word "petroleum" assumed commercial importance about the year 1860, as designating certain natural oily fluids obtained from springs or wells, and that, by refining, could be converted in large part into illuminating oils. At about the same time the solid bitumen of the island of Trinidad began to attract attention as a possible crude material for the same purpose. It was only as late as 1865 that the petroleum mania became general, and that the interest in the contest, Coal *vs.* Asphalt, was allowed to subside. At that time nearly every bitumen spring in the world became the center of developments for the production of petroleum by artesian borings. The result was the introduction into commerce of many grades of petroleum that were chiefly distinguished by differences in density and the amount of oils of certain specific gravities, and suitable for certain purposes, chiefly illumination, to be obtained from them.

The researches of Pelouze and Cahours² and Warren and Storer showed that the Pennsylvania petroleums examined by them consisted chiefly of paraffines and isoparaffines, the lowest member of which is marsh gas.³ Although I had shown in 1868⁴ that the Pacific Coast petroleums contained a notable percentage of nitrogen, and that they could not be made to yield illuminating oils equal in quality to those obtained from Pennsylvania petroleum; also, that asphaltum and maltha were products of the decompo-

¹ Taylor's Statistics of Coal, Philadelphia, 1855, p. 516. Taylor's deposition before the Supreme Court at Halifax, N. S., respecting the asphaltum mine at Hillsborough, Philadelphia, 1851. On a New Variety of Asphalt. C. M. Wetherell. *Trans. Am. Philos. Soc.* (N. S.), **10**, 353.

² *Compt. Rend.*, **56**, 595; **57**, 62. *Annales de Chimie et de Physique*, (4) **1**, 5.

³ *Mem. Am. Acad., N. S.*, **9**.

⁴ *Proc. Am. Philos. Soc.* (N. S.), **10**, 445.

sition of these petroleums from natural causes; nevertheless, some of the ablest writers on petroleum continued to speak of the "petroleum springs of the Southwest," as though petroleum, maltha and asphaltum had never been defined, and millions of dollars had not been lost in attempts to obtain petroleum, as it was then known in Eastern commerce, in the valleys of Southern California, and to refine it into the best qualities of burning oils. In the fall of 1865, Drs. John Torrey and C. T. Jackson visited the center of operations on the Ojai³ Ranche, now known as the Upper Ojai, and described as "a petroleum cascade," a hillside where a stream of maltha issued high up towards the crest of the Sulphur Mountain, and, spreading in the sun, trickled over several hundred feet of shale precipices. Any one ascending to the crest of the Sulphur Mountain, by the road leading from the Upper Ojai, can now see the same thin stream of maltha glistening in the sun, as it appeared to Messrs. Torrey and Jackson. As I saw it a year ago, there had been no apparent accumulation of material in twenty-nine years.

The wrangle over the question, whether there was any petroleum in Southern California at all, was carried on with great bitterness in 1864-5. It was really a wrangle over words more than things, for at that time, practically no petroleum worth mentioning had been found in Southern California—only just a little, enough to give a color of truth to the assertion that it was found there, thus making it possible to impose on Professor Silliman, as was done.

I have lately re-read the report that I made to the California Petroleum Company in January, 1866, and find that I then supported my statements that the bitumen of that region was maltha, and not petroleum, by references to Dana's "Mineralogy" and Dr. Ure's "Dictionary of Arts, Manufactures and Mines." These works were then well known, and had been printed many years. I thus proved that maltha was no newly discovered substance, and that, like petroleum and asphaltum, it had long been known and

³ Ojai, pronounced O-hi.

described. These definitions are not confined to the English language, but are just as well recognised in both the French and German languages.

It therefore appears to me to be quite worthy of careful consideration that, within the last five years, a patent case should have obtained any standing at the Patent Office or before the Courts of the United States, wherein the only real point at issue was the continued misuse and misconstruction of the word bitumen and the species under it.

The history of the case was as follows: One Beardsley, who was in Southern California when I was there in 1865, patented a process for smearing paper with hot residuum from the distillation of California petroleum. As described by him, the material might also be purified asphaltum, obtained by dissolving asphaltum in petroleum, allowing the dirt to settle and distilling to a residuum the solution thus obtained. If he had called his residuum "asphalt," as others do, the patent would have been rejected; so he called it "maltha," and described it as the "solid residuum of heavy petroleum." He might just as well have called it "butter" or "guava jelly," and have defined it as he did, for no such definition of the word maltha was ever given before. This patent was allowed and issued. Then he applied for another patent on an operation that consisted in dissolving his "maltha" in carbon disulphide and applying the solution to paper. This patent was also issued, probably for the reason that the Patent Office officials did not understand the misuse of the word "maltha," and thought that a new substance was being dissolved in carbon disulphide. After various commercial evolutions, these patents became the property of the Paraffine Paint Company, on the Pacific Coast, and of the Standard Paint Company of New Jersey, in the Eastern States. They obtained their "maltha" from the Union Oil Company of California, whose works are located at Santa Paula, Ventura County, Cal. After a time, one H. J. Bird commenced the manufacture of coated paper by applying a mixture of Trinidad pitch, Carnuaba wax, wax tailings and coke pitch, neither of which was Beardsley's "maltha," or any other maltha. Meantime, the Stand-

ard Paint Company began using coke pitch, a well-known commercial product, obtained as a residue from the destructive distillation of petroleum tar. The case was brought against Bird for infringement, and has just been decided in Bird's favor, from first to last, by the full bench of the U. S. District Court, sitting at Trenton, N. J. The case was in litigation five years and ruined Bird financially.

The ground of contention was that coke pitch, being a residuum of petroleum, was Beardsley's "maltha." While the word maltha was well known to mean "mineral tar," and had had that meaning for an indefinite period, it was claimed that the action of the Patent Office in granting Beardsley's patent had "fixed the meaning of the word 'maltha' for the purpose of coating paper;" hence, Bird infringed, although he used a mixture of four substances, in neither of which was Beardsley's "maltha" as used by him. A noted expert maintained that Bird's mixture was identically the same thing as Beardsley's "maltha," because both were black, shiny, had a conchoidal fracture, and were tasteless and odorless. Since the confusion of tongues at Babel, no such confusion of names and things and mixtures of things was ever witnessed as, in this case, confounded all forms of bitumen, and all of the artificial products having properties similar to, or identical with, natural bitumens. And yet, in spite of a vigorous and able defence, it was allowed to drag along for years in an attempt to monopolise a business where invention can only apply new materials by an old process long since exhausted of patentable elements.

Again, the *Bibliothèque Scientifique Internationale* has just issued a posthumous work by the late eminent Swiss geologist, August Jaccard. The work is entitled "*Le Petrole, l'Asphalte et le Bitume*,"⁶ a title in which the species is made to include the genus. The work presents the subject "*au point de vue geologique*," and for this reason many errors and defects may be overlooked from the standpoint of other branches of science. The book seeks the

⁶ *Le Petrole, l'Asphalte et le Bitume*, par A. Jaccard, Paris. Germer Baillière et Cie, 1895.

plane of the general intelligent reader, and, despite the many grave defects that I have elsewhere pointed out, has much to recommend it; yet, in respect to the nomenclature of its principal subject, "Bitumen," it is particularly and unfortunately confused. Indeed, I do not see how a person who is not to some extent familiar with the subject, and who, therefore, reads with considerable discrimination, can clearly understand the meaning of many passages. The entire nomenclature of bitumen is used with such a confusing disregard of clear distinctions—the same word being used in different places with a different meaning—as to detract much from descriptions otherwise of great value, for there is probably nowhere to be found so complete a *résumé* of the literature extant relating to the asphaltic limestones of the upper valley of the Rhone.

It therefore seems to me desirable that the word bitumen should be once more, and clearly, defined, as the generic name of that large class of substances occurring in nature as minerals, and consisting chiefly of mixtures of compounds of carbon and hydrogen, with nitrogen, sulphur and oxygen as more rare constituents. Under this genus should be ranged, as species and sub-species, all of the natural combustible gases, naphthas, petroleums, malthas and asphaltums.

These gases include free hydrogen, carbon monoxide and all of the initial members of the different series of hydrocarbons that have been found in petroleums, together with others in each series that exist as free gases at comparatively low temperatures. These natural gases are not constant in composition, even when issuing from the same spring or well; nor are they found to be alike in composition when gases from localities yielding essentially unlike varieties of bitumen are compared. It would, therefore, be a fruitless task to attempt to give a name to natural gas as a mineral species that was in any manner derived from the chemical composition of any particular specimen of gas. It can only be described as a gaseous form of bitumen, distinguished from other natural gases by being combustible.

The word naphtha is said to be derived from the Persian

word *nafta*, and was originally used in Western Asia to designate certain fluid forms of bitumen that have an ethereal, rather than an oily consistency. In those localities, notably Asia Minor and Persia, where this class of bitumens abounds, the name "naphtha" was applied to all of the fluid forms of bitumen. From this source the word passed into Europe, where, until quite lately, it was generally used instead of petroleum. Practically, in the languages of modern Europe, the words naphtha and petroleum are synonymous, as applied to the fluid forms of bitumen.

The word petroleum, signifying rock oil, from its derivation, is properly applied to oily rather than viscous fluids. The viscous forms of bitumen, passing by insensible degrees into semi-solid or solid forms, have been designated by some French writers as "bitume glutineux," and by others as maltha. In the United States some writers describe all forms of bitumen, between natural gas and asphaltum, as petroleum, sometimes qualifying given specimens as "very light," "very heavy," "viscid," etc. This obscurity first arose in Europe, from a lack of detailed knowledge concerning the chemical constitution of fluid bitumens. De Saussure analysed the "Naphtha of Amiano," in 1817,⁷ as if it were a homogeneous substance, and Boussingault, in 1837,⁸ prepared his celebrated memoir upon the "Composition of Bitumens," apparently with the idea that he had separated the maltha of Bechelbronn into petroleum and asphaltum, each of which were analysed as if they also were homogeneous substances. In the United States, prior to the discovery of the Trenton limestone oils, it was assumed that there was no essential difference in petroleums, except in the proportions of the several ingredients mixed together in the oil.

True, Warren and Storer had shown, in 1865,⁹ the essential unlikeness of Rangoon and Pennsylvania petroleum, and later, I, myself, showed the large amount of nitrogen in

⁷ *Annales de Chim. et de Phys.* (2) **4**, 314-320.

⁸ *Ibid.*, (2) **64**, 141. *Jour. Frank. Inst.*, **24**, 138.

⁹ *Mem. Am. Acad.*, N. S., **9**.

California oils; but Prof. J. D. Dana¹⁰ apparently preferred to consider petroleums as rocks rather than species, and in his "System of Mineralogy," inserted Warren's series of paraffines and isoparaffines as species, although at the same time he made species of Albertite, Grahamite, etc., which we now have a right to believe, I think, only differ from liquid petroleums in the members of the paraffine and other series of hydrocarbons, which they contain. Quite lately, Maybery¹¹ has shown that the Trenton limestone oils contain compounds of sulphur; and Salathé and myself have discovered the esters of the pyridin and other benzole bases in California petroleums,¹² and there are very good reasons for concluding that they are constituents of all the tertiary petroleums of the Pacific Coast of both North and South America. It has been further shown that the Russian petroleums consist of hydrobenzoles,¹³ while there are many reasons for believing that there are several other groups yet to be determined among European liquid bitumens. In the United States, also, there is clearly to be distinguished from all others yet investigated, a group found in the great interior valleys of the eastern slope of the Rocky Mountains, extending from Texas north into British America and the valley of the Mackenzie River.

Some of these fluid varieties of bitumen, both in Europe and America, pass, by insensible degrees and through natural causes, into maltha, which is a semi-fluid, viscous form of bitumen, known as mineral tar, and just as clearly to be distinguished in consistence from petroleum as common tar is to be distinguished from olive oil. I have found the change by which California petroleum is converted into

¹⁰ Dana's Mineralogy, fifth edition, 1869. I am aware that in the edition of 1892 the arrangement more nearly approaches that suggested in this paper.

¹¹ *Jour. Frank. Inst.*, **139**, 401.

¹² *Am. Jour. Sci.*, (3) **48**, 250.

¹³ Beilstein u. Kurbatow, *Ber. d. Deut. Chem. Ges.*, **13**, 1818; Schützenberger et Jonine. *Bul. Soc. Chim.*, Paris, 1880, p. 673. Since the above was written, a memoir by Wanklyn and Cooper has appeared in the *Chem. News.*, **72**, 7, in which it is shown that a new group, called by them "keroses," exists in Russian kerosene.

maltha to be due to two causes, viz.: evaporation and indirect oxidation.¹⁴ By this latter term, I mean, not that oxygen becomes to any extent a component of the maltha, if at all, but that by oxidation and removal of hydrogen the molecules are condensed as the proportion of carbon increases. Prof. Henry Wurtz would have us believe that this change is due to polymerisation.¹⁵ I cannot interpret the results of my experiments as indicating such a result alone. When air, ozone, or chlorine, is passed through the paraffine petroleums, they are condensed by evaporation to a residue resembling vaseline. When California petroleums are treated in the same manner, they are condensed by decomposition into, first, maltha, and then asphaltum. Chlorine will effect this change just as readily as ozone.¹⁶ Destructive distillation will also effect the same or a similar change, the residue being either an asphaltic residuum, or coke, and the distillate a hydrocarbon richer in hydrogen than the original bitumen. The natural malthas contain both water and air in mechanical admixture.

When the solid forms of bitumen are reached, the want of clear distinctions becomes still more pronounced. The work of M. Jaccard affords an illustration of the lack of clear ideas expressed in clear language, in which some authors indulge. The late Dr. T. Sterry Hunt, as long ago as 1863,¹⁷ separated pyrobituminous from bituminous minerals. This important consideration, while not wholly disregarded by M. Jaccard and other authors, does not appear to be fully appreciated by him. The fundamental principle underlying the use of this word exists in the fact that "pyrobituminous" coals, schists and shales yield, on being heated to destructive distillation, products that resemble bitumens. Why this clearly scientific, wholly reasonable and very convenient basis of classification has not been made the foundation upon which all scientific dis-

¹⁴ *Am. Jour. Sci.*, (3) **48**, 254.

¹⁵ *Engineering and Mining Journal*, 1889, 1890, 1891.

¹⁶ *Proc. Am. Philos. Soc.*, **10**, 445.

¹⁷ *Am. Jour. Sci.*, (2) **35**, 157. *Chemical and Geological Essays*. J. R. Osgood & Co., Boston, 1875.

cussions relating to bitumens proceed, whether from the point of view of geology or any other point of view, it is difficult to explain. Yet, until this distinction is fully recognised, writers will continue to mix up bituminous coals, schists of Autun and Mansfeld, boghead mineral, etc., with all sorts of bitumens, as M. Jaccard has done, to the infinite confusion of the discussion of bitumens. These coals, schists and shales are nearly as insoluble in the solvents of bitumen, viz.: ethyl ether, chloroform, benzole, etc., as they are in distilled water; hence, Dr. Hunt made the action of these solvents exclusive of the two classes of substances. All true bitumens are miscible with, or almost wholly soluble in, chloroform, a test that clearly separates them from pyrobituminous minerals. So-called "asphaltic coals" are not coals at all, but are simply geologically old asphaltums.

In whatever manner bitumens may be classified, it is apparent from the outset that there are a large number of minerals, consisting in part of true bitumens, that are, strictly speaking, rocks. To this class of substances belong the bituminous sandstones and limestones of the upper valley of the Rhone, the Limmer and Ragusa rocks, the Niagara limestone of Chicago, the bituminous limestones of Utah, the Turrellite of Texas, the sandstones of Kentucky, the Indian Territory and the Athabasca River and California. These are found as beds of sedimentary or crystalline rock, often of immense extent and thickness, impregnated with bitumen of varying consistency and quality, sometimes nearly fluid, but never solid, after being separated from the rock. In some instances the bitumen appears to be convertible into asphaltum, and in others not. The French writers have called these rocks "asphalte," but unfortunately they have also called asphaltum by the same name, as if the things were identical and the words synonymous. Among English writers no uniform custom prevails, but German authors use generally the French word. I think it would promote clearness of expression if this word "asphalte" were uniformly introduced into all modern languages to designate these bituminous rocks, with the quali-

fying words, siliceous, calcareous or argillaceous, added as required.¹⁸

The so-called Trinidad pitch, as it is found in and around the lake, is a unique mixture of bitumen, water, mineral and vegetable matter, the latter usually determined as "organic matter, not bitumen," and the whole inflated with gas. When removed from the deposit, the water rapidly dries out, the gas escapes, the mass becomes brittle and changes from a brown to a blue-black color, acquiring a sticky consistency as it loses water. At a rough estimate, less than 25 per cent. of the mass of the natural cheese pitch is bitumen; it is, therefore, quite improperly called the largest deposit of bitumen in the world. I think that the Trinidad pitch, so-called, is properly to be considered a mineral species, and I suggest for it the name "Parianite," in reference to the formation in which the celebrated lake occurs.

The words natural gas, naphtha, petroleum, maltha, asphaltum and asphalte, are not names of things, but words which indicate accidents of occurrence, to which any species of bitumen may be subject. When a true system of classification of the species and sub-species under bitumen has been reached, it will be found that a species may occur in nature in any or all of the several conditions, from natural gas to asphalte. A true system, therefore, must name and classify the bitumens themselves. As an illustration of my meaning, I would suggest that the constitution of Pennsylvania petroleum, having been first shown by C. M. Warren to consist in a mixture of paraffines, isoparaffines, etc., this species of bitumen embracing the natural gas and petro-

¹⁸ Last December, Miss Laura A. Linton published a paper in the *Journal of the American Chemical Society*, upon the "Technical Analysis of Asphaltum." In this paper the words asphalt and asphaltum were used interchangeably. The paper was reprinted in the *London Chemical News*, and the careful editor added the letter e to asphalt wherever it occurred. I have looked through all of the English and American dictionaries, from Samuel Johnson's down, and through all of the cyclopædias printed in English, to which I have access, including the ninth edition of the *Britannica*, and I cannot find the word asphalte anywhere as an equivalent for asphalt. Asphalte is not an English word.

leum of western Pennsylvania, eastern Ohio and West Virginia, may properly be named "Warrenite." As Prof. C. F. Maybery has first clearly pointed out the characteristics of the Trenton limestone oils by means of his researches upon the sulphur compounds contained in them, I would suggest for this species of bitumen the name "Mayberyite." As the California bitumens containing the esters of pyridin, etc., are largely found in Ventura County, I would suggest for them the name "Venturäite."

I am aware that these suggestions are based upon data very inadequate for the purpose of complete classification, yet I contend it is a classification that will classify things and not names, and, in time, may be made sufficiently complete for the purposes of mineralogy as well as technology.

The old terms will still have their places and uses by which to indicate the physical conditions under which these different mineral species are found. As an illustration, I will suggest that a description of "Warrenite" would include the statement that it is found as natural gas, naphtha, petroleum, etc.; that it consists of paraffines, isoparaffines, olefines, a trace of benzoles, etc. Analyses might be given from the researches of Warren and Storer, Pelouze and Cahours, Ashburner, etc. It occurs along the western slope of the Allegheny Mountains, from New York to southern Kentucky, in natural springs and artesian borings.

"Mayberyite" is found as natural gas, petroleum and maltha; it consists of paraffines (?), isoparaffines (?), olefines (?), esters of the pyridin bases (?), and Maybery's sulphur compounds. Give analytical references. It occurs in the petroleum region of Canada, in northwestern Ohio and Indiana, and southward.¹⁹

"Venturäite" is found as natural gas, petroleum, maltha and asphaltum; consists of hydrobenzoles (?) esters of pyridin bases, etc. It occurs throughout Southern California, as petroleum in artesian borings; as maltha saturating

¹⁹ In one instance, I obtained a qualitative reaction for the pyridin bases in a sample of commercial "lima tar." I have not yet been able to verify their presence in other and authentic samples.

sand at Las Conchas, in enormous springs on the Ojai, and in many other localities; as asphaltum, in veins of immense extent, probably the largest in the world, at Asphalto, Kern County, Cal.; also at La Patera, Santa Barbara County, in the same State.

It goes without saying that there has been no scientific examination of any solid bitumen that is worth mentioning, consequently any attempts at specific description like those given above are like a skimmer, consisting chiefly of vacant spaces. Nevertheless, shall we go on multiplying words about the "bitumen of the Dead Sea," "Trinidad pitch," "California asphalt," etc., or shall we begin to learn by first discovering how difficult it is to answer the question: "What is Bitumen?" Let those who think they can answer it first read M. Jaccard's book.

UNIVERSITY OF MICHIGAN,
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ON THE TECHNICAL ANALYSIS OF ASPHALTS.

BY SAMUEL P. SADTLER, PH.D.

In an article published in the *Journal of the American Chemical Society*, for December, 1894, Miss Laura A. Linton gave, under the above heading, a most valuable discussion of the present methods of asphalt analysis. As she well says, the "petrolene" of the writers on asphalt "is nothing but a name that covers a great variety of substances, radically unlike, that exist in different forms of bitumen, and are only related in this instance as being held in solution by a certain limited number of menstrua, and which include the whole list of paraffines and isoparaffines, the olefines, the benzenes and additive benzenes, with many other less abundant and well-known substances." Similarly, "in a general way, it may be said that asphaltene is that portion of the different forms of bitumen that is soluble in carbon disulphide, chloroform, benzene, and a few other less known

* Read at the meeting of the Chemical Section, September 17, 1895.