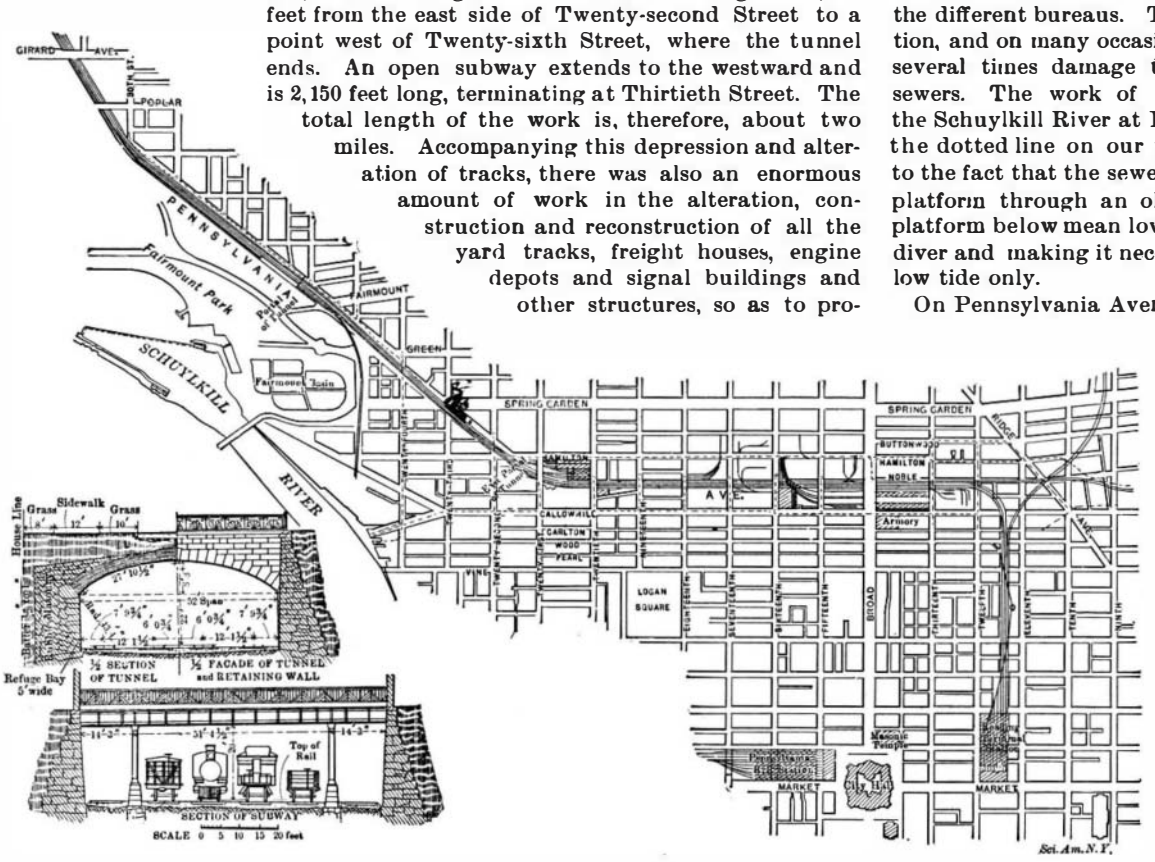
THE PHILADELPHIA SUBWAY AND TUNNEL.

The engineering problems which have been met and solved in Philadelphia in the new Pennsylvania Avenue Subway and Tunnel are of peculiar interest at the present time, when the subject of rapid transit in New York and other cities is, awakening such widespread attention. These problems are also similar to those which will face the engineers of the East River and other tunnel projects which are contemplated.

The Philadelphia Subway and Tunnel which has been completed. abolishes seventeen dangerous grade crossings of the Philadelphia and Reading Railway on the line of Pennsylvania Avenue in the heart of the city of Philadelphia and involves an expenditure of approximately $6,000,000.

On December 26, 1890, the city of Philadelphia authorized the construction of the Philadelphia and Reading Terminal Railroad to Twelfth and Market Streets upon condition that at the points where its allied companies' tracks crossed Broad Street at Pennsylvania Avenue and near Lehigh Avenue, Broad Street should be raised about 21 feet so as to carry it by bridges over the tracks of the railroads. After the construction of the bridge and its approaches near Lehigh Avenue in the northern part of the city, it was clearly demonstrated that a similar raising of the grade of Broad Street at Pennsylvania Avenue, which is almost in the heart of the city, would not only seriously damage valuable property, but would also ruin the city's finest avenue which is one of the notable streets of the world and which is used for all military and civic displays and there would still be left sixteen dangerous grade crossings unprovided for, so that other means of obviating the difficulty were sought for. The question of elevating the railroad tracks from Thirteenth Street to Thirtieth Street was considered. But as such construction would have entailed the crossing of the intersecting street by bridges which would probably have to be of the plate-girder type, and as many of the streets crossed were important highways, it was seriously objected to by the citizens of the southern part of the city. The bridge over Broad Street itself was vigorously opposed to in view of the fact that not only the tracks leading to the terminal, but also the connection to the Willow Street branch and the sidings to the freight house on the east side of Broad Street would have to be provided for. This would have resulted in a bridge 265 feet long, which would be objectionable. The engineers of the city of Philadelphia and of the Railroad Company, assisted by the late John A. Wilson as consulting engineer, had consultations which resulted in the preparation of plans and estimates for the depressing of the tracks by an open subway crossed by bridges and by a tunnel under Pennsylvania Avenue, thus abolishing at one stroke all grade crossings and at the same time providing adequate facilities for both freight and passenger traffic. The subway does not disfigure any of the streets which it crosses and the grades have been so arranged that the superstructure of the bridges are beneath the level of the streets so that they present an unbroken appearance. The tunnel itself is destined to work a great reformation in an entire section of the city which will result in an increased value to private property, and Pennsylvania Avenue itself will soon be a splendid driveway furnishing an appropriate entrance to Fairmount Park.

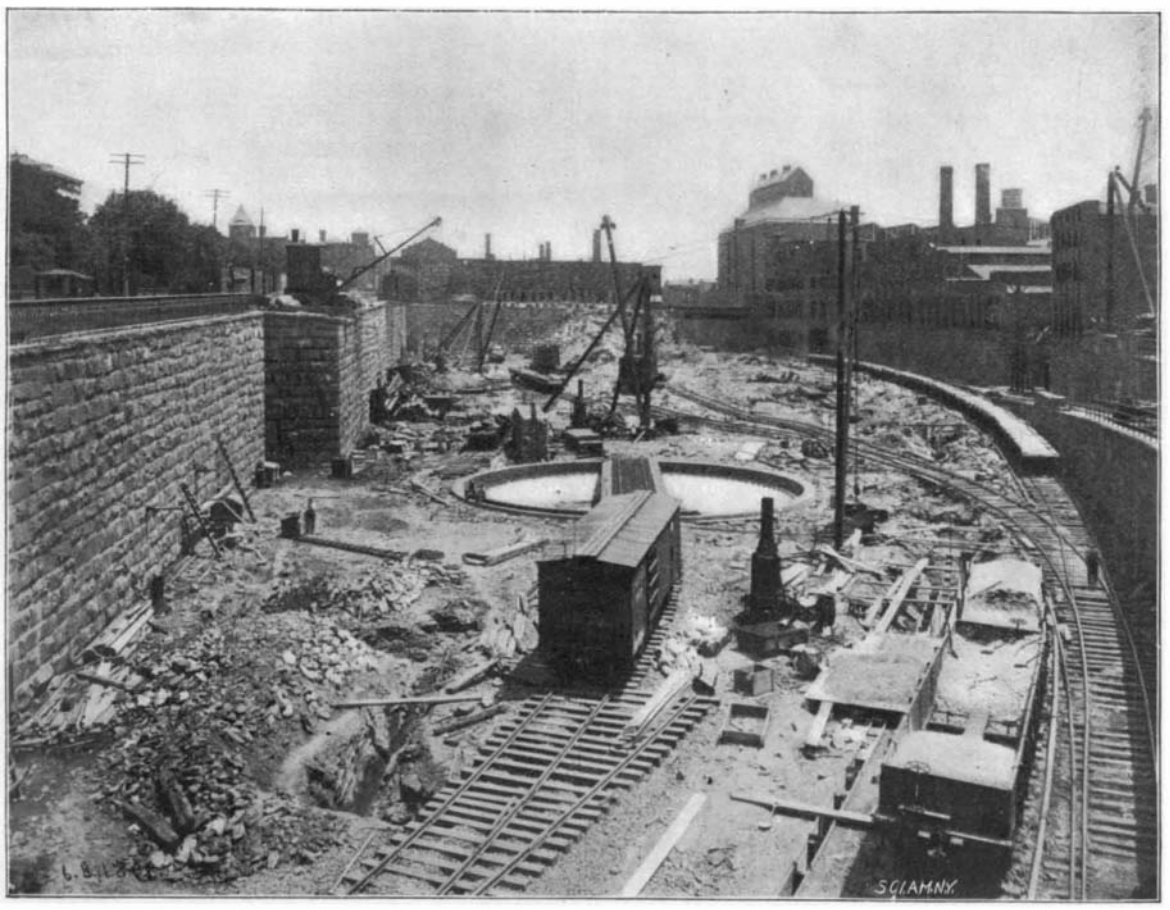


MAP OF THE PHILADELPHIA SUBWAY AND TUNNEL, WITH SECTIONS.

It is believed that the new system will result in a partial financial return to the city in increased taxes, on account of the increased valuation of the property. A reference to the map will give some idea of the enormous amount of work which was required. From Callowhill Street, between Eleventh and Twelfth Streets to Thirteenth and Noble Streets, extends an elevated structure 959 feet in length. The subway from Thirteenth Street to a point east of Twenty-second Street, is 4,180 feet in length. The tunnel has a length of 2,711 feet from the east side of Twenty-second Street to a point west of Twenty-sixth Street, where the tunnel ends. An open subway extends to the westward and is 2,150 feet long, terminating at Thirtieth Street. The total length of the work is, therefore, about two miles. Accompanying this depression and alteration of tracks, there was also an enormous amount of work in the alteration, construction and reconstruction of all the yard tracks, freight houses, engine depots and signal buildings and other structures, so as to provide as much accommodation and as full and convenient a method for operation and conducting business as then existed, adequate track connections to the various industrial establishments along the line of the Philadelphia and Reading Railroad had also to be provided, for the new subway passes by the Baldwin Locomotive Works and other great establishments which help make Philadelphia one of the greatest manufacturing cities in the world. The entire reconstruction of the sewage system between Twelfth and Thirtieth Streets was necessary, and considerable alterations in the gas and water mains, and electric conduits were also required.

Three independent systems of sewers having a total length of 3½ miles were necessary to drain the territory with its new conditions, so that entirely new sewers were constructed, as the then existing system was not deep enough for use. On account of the new sewers being in the heart of the great city, they were constructed in tunnel, so that the interference from street traffic was reduced to a minimum. Fifty-five shafts were sunk at various points and tunnel headings were driven from them. Hoistings engines with derricks, generally driven by compressed air, were placed over each shaft to lift the excavated material. The tunnel headings were worked with rock-drills driven by compressed air. After the tunnel was begun it was found that Philadelphia had a considerably larger number of mains for water and gas, conduits for electricity and sewers than was known to exist at the different bureaus. They were all in active operation, and on many occasions offered serious menace and several times damage to the building of the new sewers. The work of constructing the outlets into the Schuylkill River at Powelton Avenue, as shown by the dotted line on our map, was most tedious, owing to the fact that the sewer had to be built on piles and platform through an old wharf, with the top of the platform below mean low water, requiring the use of a diver and making it necessary to work for a time at low tide only.

On Pennsylvania Avenue, between Green Street and Fairmount Avenue, the tunnel excavation was carried on beneath dwellings, of which a large number were occupied. Driving tunnels and constructing sewers beneath the streets in the heart of a great city, maintaining the flow in existing sewers and other municipal structures, requiring blasting, and the close proximity to industrial establishments containing delicate machinery, meeting with treacherous quicksands, fighting the tides—all these were circumstances which required the greatest diligence on the part of engineers of known ability in order to attain the desired end. One of our engravings shows one of the difficulties with which the engineers had to contend. This was the raising of a 48-inch water main which crossed Pennsylvania Avenue on the line of Fairmount Avenue, Green Street, and Twenty-fourth Street, and at such an elevation as to interfere with the arch of the tunnel. It was, therefore, necessary to reduce the diameters of the mains to allow them to cross. This was accomplished by dividing the 48-inch main into two 36-inch mains at Fairmount Avenue, while at Twenty-fourth Street and Green Street the diameter was reduced by means of a reducer-cone on either side of the throat, using the principle upon which the Venturi meteris based.



RAILROAD YARD AT TWENTIETH STREET DURING CONSTRUCTION.

Another of our engravings shows the method used in building a temporary front for one of the Baldwin shops at Eighteenth Street. The old front was removed and after the retaining wall of the subway was built the new front was constructed with the wall for a foundation. At various other points similar work was carried on.

We will now proceed to describe the subway and tunnel in detail. Our bird's-eye view of the subway and yard looking east from Sixteenth Street shows at the extreme right the tracks of the Philadelphia and Reading Railway Company, which descend by a grade of 2½ feet per hundred into the depressed yard. The tracks cross Thirteenth Street at about the present grade, necessitating the lowering of that street so as to pass under the railroad. Between this street and a point near Sixteenth Street, the entire space between the northern side of Callowhill Street and the north side of Pennsylvania Avenue has been excavated, forming an immense depressed yard. Broad Street and Fifteenth Street are carried over this yard on bridges, as shown in our engraving, Broad Street being the first bridge shown. The streets are carried over the subway on plate girder-decked bridges from Sixteenth to Twenty-second Streets, the tracks running on a comparatively flat grade to a subway whose width

is about 80 feet, and having 20 feet clearance between the top of the rail and the bottom of the girders at the street crossing, as shown in our sectional plan of the subway. The side walls of the tunnel are vertical and are built of rubble masonry in the best manner. At Twentieth Street the subway opens out into a large yard which is triangular in shape, and is one of the most impressive pieces of work in the whole subway. It will contain the new engine house, freight houses, and repair shop. None of these are built at present. From a point east of Twenty-second Street a tunnel extends to a point near the entrance of the B. & O. R. R. tunnel west of Twenty-sixth Street. From this latter point to Thirtieth Street the tracks ascend with a 1·3 per cent grade to the original grade at Thirtieth Street. In order to carry on the work along the line of the Pennsylvania Avenue it was necessary to lay temporary tracks on Hamilton Street from a connection at Tenth Street with the Willow Street branch to the main line at Twenty-second Street, and from this point westward to shift the old tracks on Pennsylvania Avenue to the south side so as to admit of the construction of the northern wall of the tunnel, after which the temporary track was shifted to the extreme north side of the avenue and supported in part by the newly constructed wall. This, of course, allowed the south wall of the tunnel and the arches to be built. Railway facilities were maintained with business establishments by means of temporary tracks during the construction. After the completion of the temporary tracks, buildings on both sides of Pennsylvania Avenue were underpinned, and where the tracks ran down into the subway at Thirteenth Street it was necessary to lower this street about 13 feet in order to avoid the grade crossing. The work on the south side of Pennsylvania Avenue west of Fifteenth Street included heavy retaining walls. At one or two places along the line of the subway, sharp inclines will permit cars to ascend to the level of the street, and at one place, at least, there is an opening made from the subway into the present ground floor of buildings by means of a hydraulic lift.

It is a most interesting walk to descend to the subway by one of the inclines and walk through it. The workmanship has been of the best, and the subway and tunnel solve the problem of rapid communication through a city as far as Philadelphia is concerned. The tunnel itself consists of a segmental arch with 52 feet span and 8 feet 8 inches rise; the crown is 22 feet above the top of the rail and the arch radius is 43 feet 4 inches and it is designed for four tracks. The arch roof is of brick 3 feet thick at the crown and 4 feet thick at the springing line. Over the top of the tunnel and in the center of Pennsylvania Avenue are thirteen openings for ventilation. These are constructed of steel protected by a terra cotta covering. The visible openings in the street are 10 feet wide by 47 feet 10 inches long for twelve of the openings and 10 feet by 78 feet for one. These openings are surrounded by a rustic masonry wall 3 feet 8 inches in height, around which vines will be planted, and around this wall is a grass plat 6 feet wide, in which shrubs will be planted. An ornamental iron fence, protected by an 8-inch graphite curb, will surround the whole. In appearance Pennsylvania Avenue will soon resemble Park Avenue in New York, although it does not do so at present. There is no doubt that the tunnel will cause a vast improvement in the section of the city through which it runs, for the avenue itself is now 120 feet wide and the sidewalks 20 feet in width; the six feet nearest the curb are sodded and planted with selected trees. Between the main curbs, 80 feet apart, the street will be of asphalt, the distance between the main curb and the ventilating openings being 27 feet on each side of the street. At the western end Pennsylvania Avenue widens out into a plaza where the Washington monument is located. When the tracks are finally removed and the streets properly repaired, it will be a most advantageous means of access to Fairmount Park. There is an open subway east of the tunnel. When the original plans of the tunnel were prepared, an artificial system for ventilating was devised, but owing to the expense it was not carried out, and the tunnel is so admirably ventilated that it would hardly seem necessary to install such a system. The total weight of the bridges is 7,529,783 pounds and of the vent openings 1,710,000 pounds, making a total of 9,239,783 pounds, or about 4,600 tons. The work of constructing the subway and tunnel has been carried out under the direction of the Bureau of Surveys of the Department of Public Works, of which Mr. George S. Webster, M. Am. Soc. C.E., is chief engineer, and we are indebted to him for courtesies in the preparation of the present article.

A DOUBLE-TRACK drawbridge over the Chicago River was recently shifted bodily a distance of 83 feet. The method employed was to jack it up 26 inches from its central pier, thus allowing a cradle to be built underneath it. This cradle ran on ways which were lubricated with tallow and the weight of the bridge having been transferred to it the whole was hauled bodily to its new position. The weight was over 600 tons.

Correspondence.

The Eruptions of Mauna Loa and the Sunspot Period.

To the Editor of the SCIENTIFIC AMERICAN:

In your number of September 2 you furnish some very interesting details concerning the recent eruption of this celebrated volcano and give the dates of the known eruptions. Having lately read a paper (not yet published) before the Royal Irish Academy on the relations observable between the dates of volcanic eruptions and the sunspot period, and with reference to five volcanoes of Europe, I was greatly interested by learning the dates of the Mauna Loa eruptions as communicated in your article, and beg leave to submit the following details as representing the connection observable between the dates of the eruptions mentioned and the years of Maxima and Minima sunspot periods as known, the Maxima being marked + and the Minima–

Years of Eruption as mentioned.	Intervals in years.	Corresponding sunspot period years.	Differences.
1789		+1789	
	34		
1823		−1823·2	0·2
1824			
1825			
	17		
1840		−1837·2	2·8
	12		
1852			
	3		
1855		−1856·2	1·2
	4		
1859		+1860·2	1·2
	9		
1868		−1867·2	0·8
	13		
1881		−1879	2·0
	6		
1887		−1889·6	2·6
1899		(−1901 ?)	

It may be observed that the sunspot year's herein presented are for the most part years of Minima (there being in fact, but two years of Maxima). This would be quite in accordance with Kluge's theory as to the correspondence of years of marked volcanic activity with Minima sunspot years. It would be very interesting to treat in the same way the data ascertainable as regards the other American volcanoes and I have the certainty that the results would prove very interesting and help to the elucidation of the causes of volcanic activity in general.

J. P. O'REILLY,
Ex-professor Mining and Mineralogy, Royal College of Science, Dublin.

September 12, 1899.

The Twentieth Century Problem.

To the Editor of the SCIENTIFIC AMERICAN:

I have just noticed an article in your excellent paper under the caption of "Some Calendarial Facts About the Twentieth Century." In this article you make the statement that, "of course, the first century began with the year 1 and closed with the year 100." This seems a trite statement, and yet even in this there is room for cavil. Some of those who have been discussing the question on this coast are prone to get mixed up on just what they mean. A child is not one year old until it has passed the last day of the twelve months since its birth, and yet it was in its first year during the whole of the time up until it can be said to be a year old. The fact of its being one year old, or being in its first year, are two entirely different things. But the mistake of confounding these two ideas is what makes the difficulty in the minds of many in the application of the same principle to the counting time when we have to deal with centuries. A century is not one year, old, if you will allow that expression, until the first year is passed; so likewise the hundredth year is not so denominated until it has also passed. When we write dates we write the time that has passed, counting from the supposed birth of Christ up to and including the day which is then in progress. For instance, when we write the present date we say that 1899 years have passed away, and that we are in the 9th month and the 26th day of that month, which month and day belong to the 1900th year. Or, in other words, we are now in the 1900th year; and the 1900th year will close on December 31, 1899. We do not begin to write our date (which refers to time passed) as 1900 until after the real year is passed.

As soon as we have passed into the 1901st year, we begin to write our date as 1900, and so many months and days. But the month and days belong to the new year. Hence, we can but conclude that we are now in the 1900th year, and that the year closes the century. If this be true then the 20th century will begin on January 1, 1900.

Will you please let me know whether I have your idea or not, and, if not whether my reasoning is correct? I would like to have this subject set clearly before your readers, for, although it is of minor importance, yet it is a question which puzzles many of them.

E. H. VAN PATTEN.

Dayton, Washington, September 26, 1899.

[The first century began on Jan. 1 of the year one. January 1st of the year 100 was still of the first century, otherwise that century would only have continued ninety-nine years. The second century began on January 1st of the year 101.

The same custom holds true with reference to numbering years that is in vogue with reference to naming months and numbering the days of a month. We name a month or number a month as soon as we enter upon it, and it retains that name or number during its entire term, so the moment we enter upon a new year, the year is identified with its own number in the series of years, which number it retains to the close of the year. Hence the date referred to is not the 26th day of the 9th month of the 1900th year, but the 26th day of the 9th month of the 1899th year. Putting it otherwise, we may say that the length of time from the beginning of the Christian era to the close of September 26, 1899, was 1898 years 8 months 26 days. It is evident, therefore, that the length of time from the beginning of the Christian era to the close of December 31, 1900, is just 1900 years, which completes the 19th century, this century having been so called ever since the first moment of January 1, 1801. The moment we enter upon January 1, 1901, we begin the 1901st year, which is the first year of the 20th century. That we really begin to write the number of a year as soon as that year has begun, and not after it has passed, as our correspondent maintains, is a matter not to be settled by logic, of course. It is a simple matter of fact, universally recognized by historians and astronomers, such having been the custom from the beginning of the Christian epoch, and even in earlier times in other epochs. Whether we write "September, 26, 1899," or "9—26, 1899," we have simply an abbreviated form of writing in full "the 26th day of September in the year of our Lord 1899."—ED.]

Automobile News.

In Germany trials are being made with ambulance carriages provided with 5 horse power petroleum engine, with sufficient fuel to run for fifteen hours. The engine drives a dynamo, and a powerful projector is also furnished.

An automobile party to make a journey to the Mammoth Cave, of Kentucky, is being organized. The party will be made up of eight persons, traveling in two automobiles, while a third will carry the baggage of the party. The start will be made about October 15.

One great reason for the popularity of the automobile is that it can be more readily managed by women than horse-drawn vehicles. Many women object to driving horses on account of their liability to shy or bolt. The automobile offers marked advantages in this respect, but no lady should try running an automobile until she thoroughly understands the mechanism.

The Mechanical Science Section of the British Association is in favor of an amendment of the laws regulating the use of motor wagons on the highways. At present all motor cars in England are limited to three tons weight unloaded. It is now found that the economical load is from 8 to 10 tons, and to carry this it is considered desirable to be allowed a heavier weight when unloaded than 3 tons. Of course some light metal can be used in the construction of motor carriages, but it is not considered desirable in heavy wagons. It is believed that the whole matter will be brought up before Parliament during the next session.

Dr. Lehwess proposes to undertake an automobile trip from Pekin to London, or a distance of 8,000 miles, the greater portion of which is through a practically unknown country. A special carriage, built to order for the extraordinarily severe work, is being made by a Paris firm. The car has a carrying capacity of fuel and water sufficient to propel the car 300 to 400 miles. The start will be made about the end of February or March. The car will be run through Brindisi and from there it will be taken by water to the East. The doctor's companions will be two mechanics. There is no question that this is a serious attempt which is being made. The automobile industry has always suffered from races, excursions, etc., which are not properly planned or which are beyond the limits of present construction. We are afraid that the present instance will be no exception to the general rule.

German Amber Production Acquired by the State.

By virtue of the law of May 1, A. C., the entire amber production of East Prussia has passed into the hands of the government. Paragraph 1 of the law reads: "The Imperial government is empowered to apply the sum of M. 9,750,000 ($2,450,000) to the purchase of the real estate situated in the districts of Fischhausen and Memel and in the city of Konigsberg i. p., belonging to the firm of Stantien & Becker or Privy Councilor Becker of Konigsberg i. p., as well as the entire business and establishment carried on under the said firm in Germany for the production and working up of amber and trade in raw amber, ambroid, melted amber (colophony) and by-products.—Farben Zeitung.