

# SCIENTIFIC AMERICAN

## SUPPLEMENT. No 1541

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Scientific American, established 1845.

Scientific American Supplement, Vol. LX., No. 1541.

NEW YORK, JULY 15, 1905.

Scientific American Supplement, \$5 a year.

Scientific American and Supplement, \$7 a year.

### EXTENDING THE SANTA FE RAILROAD INTO SAN FRANCISCO.\*

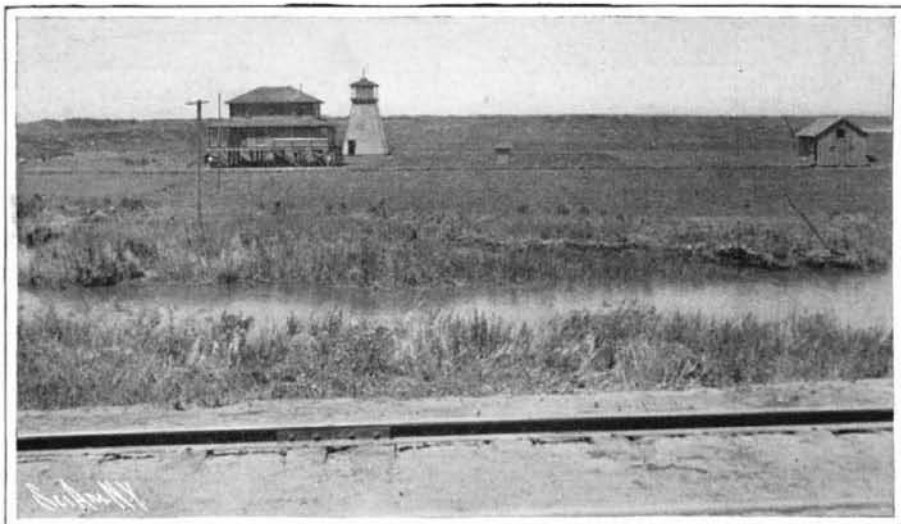
By HERBERT I. BENNETT.

Among the most unique and interesting pieces of railroad construction to be found anywhere, is that portion of the Atchison, Topeka & Santa Fé Railway between Stockton and San Francisco in California, or particularly between the stations of Holt and Bixler on the division in question. Between these two stations the railroad crosses the tule swamps of the San Joaquin

River and tributaries for about ten miles, and the road-bed was constructed in a peculiar and original manner to conform to the soft ground and sliding soil, which abounds in this soggy and swampy land. The engineers, when building the railroad, knowing that the ordinary rock and dirt ballast would fail utterly in such a region, decided upon putting down an embankment of peat and decayed tule grass, and accordingly this method of track construction was carried out with success. The Stockton and Point Richmond line was built by the San Francisco & San Joaquin Valley Railway, just prior to its becoming a Santa Fé Route prop-

erty. Point Richmond is the rail terminus of the Santa Fé line on San Francisco Bay, from which point passengers are transported across the bay on ferryboats to the metropolis of California, the water distance being eight miles. In order to make the railroad embankment over the ten-mile stretch between Holt and Bixler, it was necessary to employ several large dredgers, which were operated day and night for more than a year, and it was in connection with the dredgers that some pioneer and extraordinary labor was introduced in railroad building. These machines literally cut their way through the tules from Middle River to Holt,

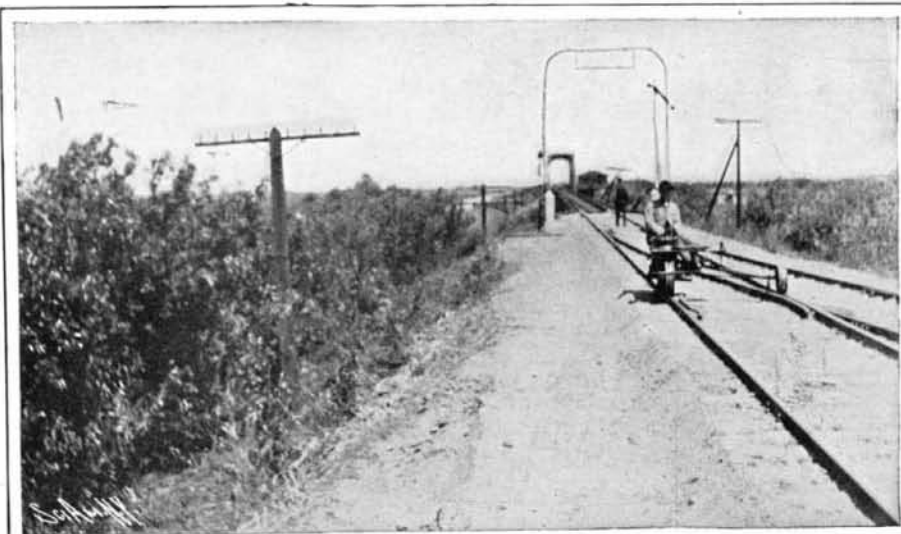
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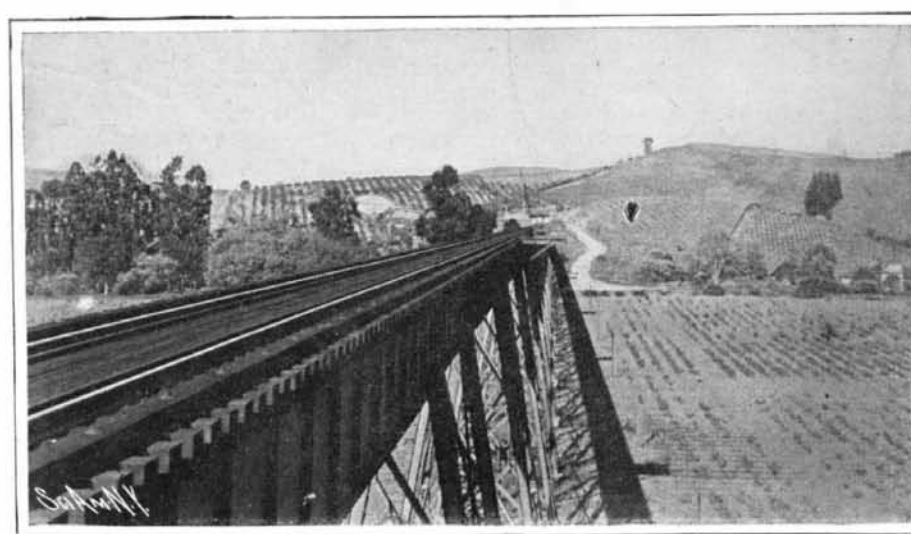
FARMHOUSE ON RECLAIMED TULE LAND. FOREGROUND SHOWS SANTA FE PEAT ROADBED COVERED WITH BERMUDA GRASS, ALSO WATERWAY CUT BY DREDGERS DURING CONSTRUCTION OF THE LINE.



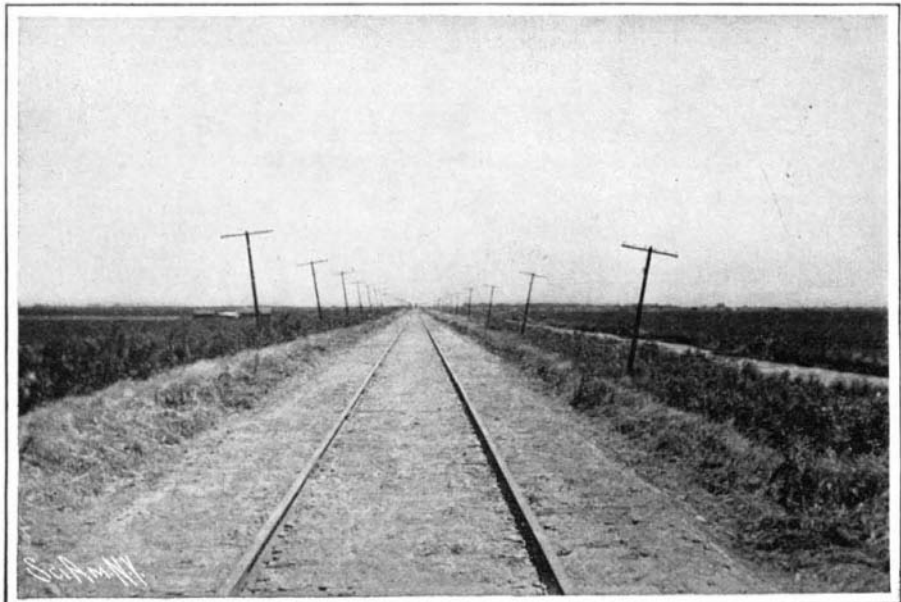
WEST APPROACH TO TWO-MILE TRESTLE WHICH FORMS PART OF THE PEAT RAILROAD EMBANKMENT. TRESTLE WITH TWO DRAWBRIDGES RUNS ENTIRE DISTANCE BETWEEN ORWOOD AND MIDDLE RIVER STATIONS ON THE SAN JOAQUIN RIVER.



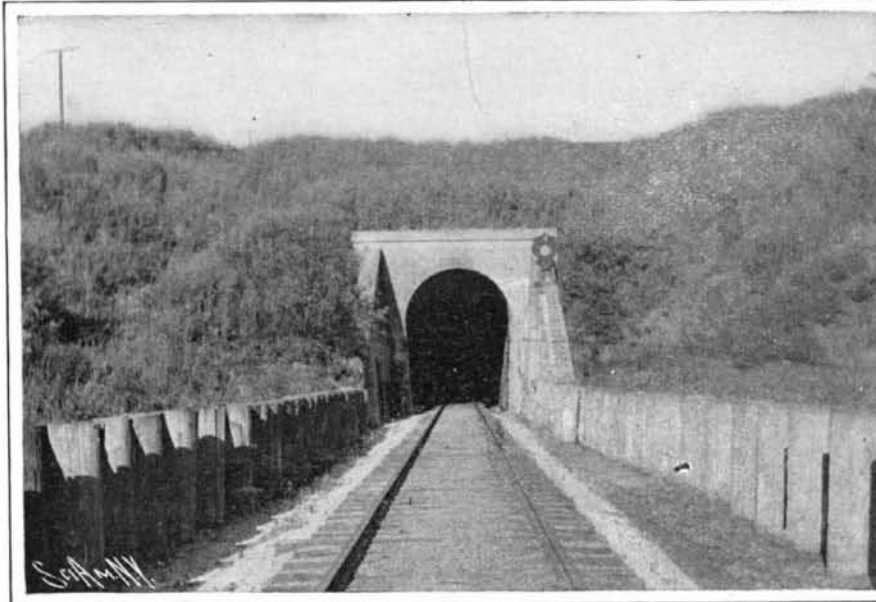
WEST APPROACH TO TWO-MILE TRESTLE AND DOUBLE DRAWBRIDGE BETWEEN ORWOOD AND MIDDLE RIVER STATIONS. PEAT ROADBED.



THE ALHAMBRA VIADUCT, 1,600 FEET LONG, 75 FEET HIGH. LOOKING EAST.



PEAT ROADBED BETWEEN HOLT AND BIXLER. YOUNG WILLOW TREES AND BERMUDA GRASS ON EITHER SIDE OF TRACK. DREDGER CHANNEL ON RIGHT.



THE ENTRANCE TO THE 300-FOOT TUNNEL.

EXTENDING THE SANTA FE RAILROAD INTO SAN FRANCISCO.



working either side of the surveyed railroad right-of-way, and leaving broad water channels in their wake. The dredgers were clamshell devices that threw the peat up at the rate of about four hundred thousand yards to the mile, except in places where the embankment slid out, where a great deal more peat was required to establish solidity. The peat was applied in layers, and allowed to become thoroughly dry and hardened before the next application of embankment material was made, and it is surprising what a firm roadbed has been made of this decayed peat and grass, which carries the track across the most difficult character of ground for a railroad to get over. When Chief Engineer W. B. Storey, of the San Francisco & San Joaquin Valley Railway, expressed his intention to carry out this peat embankment construction, the idea was given little credence by engineers, but Mr. Storey went ahead and proved the efficacy of his plan, besides establishing an important new epoch in railway engineering in tule and marshy lands, where the quicksands swallow up rock and earth almost as fast as they can be dumped into place. Mr. Storey is now chief engineer of the Atchison, Topeka & Santa Fé Railway from Chicago to Albuquerque, with headquarters at Topeka, Kan. This is said to be the only piece of peat railroad embankment in the world at the present time. The base of rail is about thirty-five feet above solid clay base, upon which the embankment rests, and the ballast under the track is of coarse gravel from the Santa Fé's Stanislaus River gravel pits. The ballast is about twelve inches thick under the ties, and the rails are seventy-five pounds per yard. In order to guard against the sliding of the peat, the planting of willow trees on both sides of the embankment was resorted to, as the roots mat and tend to hold everything intact, besides effectually preventing damage from wave wash in the event of floods in this low-lying district. There has also been planted between the track and the willows Bermuda grass, which is a very tough salt grass that grows about six or ten inches high and mats into practically a solid mass, thus acting as a powerful medium for maintaining solidity along the peat roadbed. Not a little trouble has been encountered with fires in the tule lands, and the vegetation on the railroad embankment being dry causes it to burn readily, and it has required as long as three and four days to extinguish the smoldering blaze under the track at times; it sometimes appears to be all out, but perhaps the next day will find the fire springing out afresh. In order to eliminate this annoyance, the Santa Fé engineers have decided upon covering the entire embankment with a layer of gravel about twelve inches deep, and it is believed that this will prevent fires from working into the peat right-of-way from the surface. The new experiment is now being put into practice along the track between Holt and Bixler. A valuable fact regarding the Santa Fé track embankment through the tule region of the San Joaquin River, is that it acts as a levee, and the levees on reclaimed lands running at right angles to the railroad, are built up against the peat railroad track embankment. The railroad has opened thousands of acres of land now under cultivation, and pumps are employed to keep the water down to a proper level. Prior to the advent of the Santa Fé route, this land

five feet high, and is built of steel supported on towers resting upon concrete piers, and crosses above orchards and vineyards of picturesque aspect. Of the tunnels, the Franklin is the longest of the group, being 5,680 feet, or over a mile in length. This tunnel is built on a tangent, and passes through a soft stratum of earth, between a blue clay and soft rock, which had a tendency to swell when first exposed to the air; and when the railroad was first built through it, the



PEAT EMBANKMENT OF SANTA FÉ RAILROAD, SHOWING CHANNEL CUT BY DREDGERS.

crushed timbering had to be removed two or three times until the swelling ceased. The Franklin tunnel is now solid throughout its entire length, and it pierces the Franklin hills twenty-five miles from San Francisco. The seventy miles of difficult railroad building between Stockton and Point Richmond was begun in the fall of 1898, and was completed in the spring of 1900. The foregoing data were furnished by Mr. E. F. Henderson, resident engineer of the Valley Division of the Atchison, Topeka & Santa Fé Railway, with headquarters at Oakland, Cal., who also furnished the writer with a motor railroad vehicle, in order to procure desired photographs along the road described.

#### THEATRICAL ENGINEERING PAST AND PRESENT.\*

The dramatic compositions of every age, in so far as they were intended to be represented at all, have always stood in necessary relation to the stage equipment of their epochs. This was the case with the dramas of the Romans and Greeks, with the mysteries and passion plays of the Christian middle age, and with the culmination of the English drama in Shakespeare's time, and it is the case with the drama of to-day.

Even the old Greek theaters had a great variety of hoisting and suspending apparatus, and the old church plays and mysteries had effective scenery. The theaters of Shakespeare's time, on the other hand, appear to have possessed little or no scenic equipment. The opera grew out of the pastoral plays given at the theater of the Italian court. Theatrical pomp originated there, spread thence to Spain and the Netherlands, and, gradually, effective scenic illusion found its way to Germany.

which they grew, but the consideration of the gradual development of our scenic theater will lead us to interesting conclusions in regard to the gain resulting from scenic changes continued for a long period, and also to the gradual loss of certain old and effective arrangements.

Although we shall confine our attention chiefly to the conditions which have prevailed in the German theater, we shall be obliged to glance at the development of the scenic art in other countries, in so far as it has exerted a clearly recognizable influence upon us. Such influence has been chiefly, and strongly, exerted, at divers times and in divers ways, by the Italian and English theaters.

The theater of the Greeks and Romans lies outside the purpose of our sketch. In the middle ages, when the true Christian popular theater began to develop in Germany from the public religious-theatrical exhibitions, not a trace of the peculiarities of the ancient stage passed over to it. The break with the heathen past was so complete, that even the theater of the medieval passion plays at first developed quite independently from the Christian church, and had to go through a new infancy before it could be educated into artistic forms. Not until a later period in the history of the modern theater did certain fundamental principles of the ancient stage make themselves felt, and then only transiently and in much disguised form, because of the essential difference of the conditions.

As is well known, the ground plan of the ancient theater was a circle, more than half of which was surrounded by the spectators' seats. The stage proper, that is, the raised platform at the back, was broad but of little depth, because only a few personages appeared in any scene. Exits and entrances were made through three doorways in the temple-like structure which formed the back of the stage.

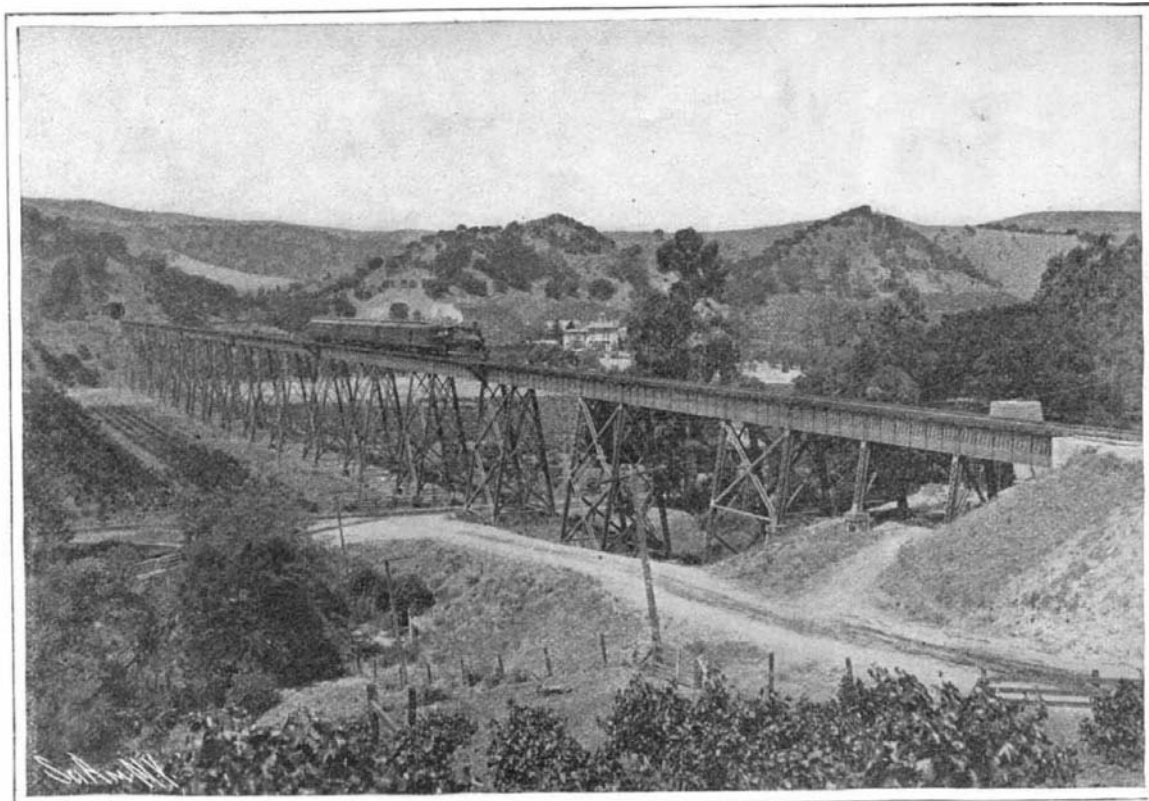
That the ancient theater did not, as some have asserted, make use of plastic and graphic decoration in the modern sense of realistic illusion, is evident from the general construction of the stage and from the circumstance that the performances took place by daylight, for it is well known that scenic illusion cannot be produced without the aid of artificial light. In many tragedies the dignified architecture of the stage building, adorned with columns and statues, was suited, in itself, for the representation of the scene of action and it needed, therefore, no further indication of place given by scenery. When the stage had to represent a forest, a cliff, a tent, a street, etc., such indications must suffice as were given by pieces of scenery attached to the front of the building. The Greek stage also possessed a scenic device, analogous to our side scenes, in the *periactes*, large triangular columns, with various scenes painted on their faces, which, mounted on pivots at the sides of the stage, near the *parascenes*, could be turned to represent three different scenes. For even in ancient plays, such as the "Eumenides" of Aeschylus and the "Ajax" of Sophocles, visible changes of scene were required. There is no doubt that the ancient stage had an upper and a lower story, which, moreover, were made necessary by the requirements of the ancient dramas.

Pollux mentions the *geranos*, a crane or hoist, by means of which, for example, the theft of the body of Memnon by Eros was effected, as well as the swings or suspension apparatus by which aerial flights of gods and heroes across the stage were managed. The assertion of Pollux, that the machinery by which sudden apparitions of deities were produced was placed, not in the middle but at the left *parascene*, is explained by the small depth of the stage, which compelled the actors to seek in its width a proper distance from which to regard and address the hovering divinity. It is not certain whether the curtain was used on the Athenian stage or is a Roman invention. It is generally assumed, however, that it was not lowered, but rose from below through a slit in the front of the stage.

The Christian, like the Greek, stage was devoted to divine service. Its conformation grew out of the dramatic rites of the Syrian church, and hence its continual suggestions of the ancient Greek theater become easily explicable. For the earliest dramatic religious representations the stage was built in the church, facing the lofty choir. The choir gallery above served as an upper stage or loft, from which angels descended and from which also the Star of Bethlehem, the Christmas manger, and the ascending figure of Christ in the Resurrection were directed. As the ecclesiastical plays or mysteries developed, it became necessary to remove the stage from the narrow church, first to the churchyard and then to the streets. As these exhibitions were really mere tableaux, which often had to be divided into separate pictures as numerous as the moments of the sacred story which it was desired to represent, the stage was increased inordinately in width, especially in France, which even in the middle ages was the leader in theatrical development.

But as the spectators could not well view so extended a stage, three stages were arranged side by side, but inclined at obtuse angles to each other, in a field or public square, and the spectators turned from one to another at the change of scene. Stages were also mounted on wheels, particularly in London, so that the exhibition could be repeated on holidays in different quarters of the city.

The need of several stages, one above another, made itself felt in all these religious plays, as it had in the kindred Greek drama. The active relations between occurrences on earth and in heaven, the continual interaction of human and divine agencies, exacted in both cases a visible above and below. As it had been found convenient to build the stage square across the end of a street, to use the windows of the adjoining



THE 1,600-FOOT VIADUCT ACROSS THE ALHAMBRA VALLEY, CONTRA COSTA COUNTY, CAL. AT THE END OF THE STRUCTURE APPEARS THE 300-FOOT TUNNEL.

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was entirely a tule marsh, but it is gradually coming under cultivation, and asparagus and other garden truck can be seen thriving, where the tule formerly reigned supreme. Between Point Richmond and Bay Point there are five tunnels and a great steel viaduct, the latter spanning the narrow and beautiful Alhambra Valley, situated in the Mount Diablo foothills, about 28 miles easterly from San Francisco. The Alhambra viaduct is sixteen hundred feet long, seventy-

The structure of a play, its dramatic composition and theatrical form, proceed naturally from the picture of the nature of the stage which the author has in his mind's eye. It is therefore not only necessary to the proper understanding of dramatic compositions of various epochs to study the stage arrangements out of

\* A n address delivered before the Polytechnic Club of Munich, January 9, 1905, by Carl Lautenschlaeger, formerly director of stage machinery at the Royal Bavarian Court Theater in Munich.