Canal had 564 miles of main line and 2,050 miles of minor distributaries, and irrigated 519,022 acres of crops. From this it will be seen how important a line of irrigation this canal constitutes, and how urgent the reconstruction of the aqueduct was. The new aqueduct replaces one of much smaller size, viz., five spans of 35 ft., which was damaged by a high flood in October, 1884, and completely destroyed by another high flood in July, 1885.

The Kali Naddi, for the greater part of the year, is a very insignificant stream some 50 ft. in width only, but on the date mentioned it was swollen into a river a mile wide and in places 25 ft. deep.

In addition to the construction of the Nadrai Aqueduct, all the railway and road bridges below it were also destroyed, and many villages swept away.

The proportion of the foundation to the superstructure of the new Nadrai Aqueduct can be gathered from the fact that three-fourths of the expenditure of money and time were consumed by what is now hidden below the ground.

The foundations consist of 268 circular brick cylinders or wells, as they are always called in India, all sunk 55 ft. below the river bed. There are fifteen bays of 60 ft. divided into three groups of five each by abutment piers. The abutment piers consist of a double row of 12 ft. wells spaced 2 ft. apart and the ordinary piers of a single row of 20 ft. wells similarly spaced.

The wells are all sunk through a stratum of stiff yellow clay, averaging 15 ft. thick, into a substratum of pure sand. The wells are all hearted with hydraulic lime concrete filled in by skips, and in each pier the wells, by corbeling out the brickwork, are joined together for the superstructure of the pier.

The total quantity of well sinking was 15,019 lineal feet, or nearly three miles, and was executed by hand and steam dredging. It was commenced in May, 1886, and completed in May, 1888. The arching was commenced in November, 1888, and finished in April, 1889.

The well sinking and arching went on night and day, the work being lighted by ten arc lights of 2,500 candle power each. Now that the aqueduct is completed it forms a most striking object in the vicinity, and will, we hope, stand to bear witness in far distant ages to the beneficence of British rule in India and to the skill of our English engineers.

The solidity of the great arches and piers and the fine sweep of the bastion-like wings all unite to give an idea of vast strength and stability, while the monotony of such a large surface of facade is relieved by the effect of light and shade obtained by the bold corbeling out over the spandrels to form a support for a roadway on either side of the canal, and the long horizontal lines of the cornice and railings are broken up by a tower at each end and one at each of the abutment piers.

The wells were built up on wooden well kerbs laid *in situ*, at first in short lengths of 7 feet, and sunk by Bell's 2½ cubic feet sand dredger worked by hand through a nearly pure stratum of sand until the kerb rested on the clay, about 30 feet below river bed level; the remaining length of brickwork of 25 feet, with 8 feet of false work, was then added, and in the case of the 20 feet wells an additional load of 150–200 tons of scrap rails was imposed to force the kerb through the stiff clay stratum into the sand below. The dredging in and below the clay was performed by Bell's 40 cubic feet dredger worked by steam hoists.

The double row of 12 feet wells in the abutments and abutment piers were similarly sunk, and Bell's 10 cubic feet dredgers worked by steam hoists were employed to take them through the clay, but as there was no room for rails, additional weight was given by an extra length of 10 feet of false brickwork.

These double rows of wells, only 2 ft. apart, gave much trouble in sinking, owing to the tendency of the wells to draw together. The width of 149 ft. between the faces of the arches necessitated three shifts of the centring in each span; this was performed after a length of archwork had been completed by lowering the centering by sand boxes on to trolleys running on three parallel lines of railway, and the whole centering was then dragged forward or shifted to another bay *en bloc* by a steam hoist. Mr. W. Good was the engineer of the work.

Thirty-six Tons of Pennies.

There are 72,800 pounds of pennies encumbering the vaults of the Sub-Treasury. This is more than thirty-six tons, and the coins are still accumulating. There are 10,400 bags, weighing seven pounds each. The accumulation is partly the result of the general establishment of the penny in the slot machines. The headquarters of the companies owning these machines is in this city, and all the pennies are therefore sent here when the agents make their returns. The companies thereupon unload them upon the Sub-Treasury. The Treasury Department will send these pennies to be distributed among the country banks.

THE frying sound in the telephone is caused by induction from other lines, earth currents, and static discharges.

Scientific American.

ESTABLISHED 1845.

MUNN & CO., Editors and Proprietors,

PUBLISHED WEEKLY AT

No. 361 BROADWAY, NEW YORK.

O. D. MUNN. A. E. BEACH.

TERMS FOR THE SCIENTIFIC AMERICAN.

One copy, one year, for the U. S., Canada or Mexico.....$3 00
One copy, six months, for the U. S., Canada or Mexico..... 1 50
One copy, one year, to any foreign country belonging to Postal Union. 4 00
Remit by postal or express money order, or by bank draft or check.
MUNN & CO., 361 Broadway, corner of Franklin Street, New York.

The Scientific American Supplement

is a distinct paper from the SCIENTIFIC AMERICAN. THE SUPPLEMENT is issued weekly. Every number contains 16 octavo pages, uniform in size with SCIENTIFIC AMERICAN. Terms of subscription for SUPPLEMENT, $5.00 a year, for the U. S., Canada or Mexico. $6.00 a year to foreign countries belonging to the Postal Union. Single copies, 10 cents. Sold by all newsdealers throughout the country. See prospectus, last page.

Combined Rates.—The SCIENTIFIC AMERICAN and SUPPLEMENT will be sent for one year, to any address in U. S., Canada or Mexico, on receipt of *seven dollars*. To foreign countries within Postal Union, *nine dollars a year*.

Building Edition.

THE ARCHITECTS AND BUILDERS EDITION OF THE SCIENTIFIC AMERICAN is a large and splendid illustrated periodical, issued monthly, containing floor plans, perspective views, and sheets of constructive details, pertaining to modern architecture. Each number is illustrated with beautiful plates, showing desirable dwellings, public buildings and architectural work in great variety. To builders and all who contemplate building this work is invaluable. Has the largest circulation of any architectural publication in the world.

Single copies 25 cents. By mail, to any part of the United States, Canada or Mexico, $2.50 a year. To foreign Postal Union countries, $3.00 a year. Combined rate for BUILDING EDITION with SCIENTIFIC AMERICAN, $5.00 a year; combined rate for BUILDING EDITION, SCIENTIFIC AMERICAN and SUPPLEMENT, $9.00 a year. To foreign countries, $11.50 a year.

Spanish Edition of the Scientific American.

LA AMERICA CIENTIFICA E INDUSTRIAL (Spanish trade edition of the SCIENTIFIC AMERICAN) is published monthly, uniform in size and typography with the SCIENTIFIC AMERICAN. Every number of *La America* is profusely illustrated. It is the finest scientific, industrial trade paper printed in the Spanish language. It circulates throughout Cuba, the West Indies, Mexico Central and South America, Spain and Spanish possessions—wherever the Spanish language is spoken. $3.00 a year, post paid to any part of the world. Single copies 25 cents. See prospectus.

MUNN & CO., Publishers,
361 Broadway, New York.

☞ The safest way to remit is by postal order, express money order, draft or bank check. Make all remittances payable to order of MUNN & CO.

☞ Readers are specially requested to notify the publishers in case of any failure delay, or irregularity in receipt of papers.

NEW YORK, SATURDAY, DECEMBER 5, 1891.

Contents.

(Illustrated articles are marked with an asterisk.)

TABLE OF CONTENTS OF

SCIENTIFIC AMERICAN SUPPLEMENT

No. 831.

For the Week Ending December 5, 1891.

Price 10 cents. For sale by all newsdealers.

THE UNITED STATES LEADS THE WORLD IN IRON.

The United States now takes the lead in the production of pig iron. The schedule for 1890 stands as follows, allowing for Great Britain and the United States 2,240 pounds to the gross ton; Germany, France, and other states, 2,204 pounds to the metric ton:

United States, 1890	9,202,703	tons.
Great Britain, "	7,904,214	"
Germany, "	4,563,025	"
France, "	1,970,160	"
Sweden, "	781,958	"
Austria-Hungary, 1889	816,156	"
Belgium, "	832,226	"
Russia, 1888	612,000	"

It will be seen from the above that the American production for 1890 was more than sixteen per cent greater than that of Great Britain.

The recent report of the Commissioner of Labor says: Only twenty-five years ago Great Britain was so far ahead of all other countries in the manufacture of these products that her manufacturers and statesmen did not dream that she would ever have serious competitors in the world's markets. The iron and steel consuming countries of the world were supposed to be dependent upon her for Welsh rails for their railroads, the finer qualities of Scotch pig iron for foundry purposes, Low Moor and other favorite brands of plate iron for boilers, Crown and other choice brands of bar iron from Staffordshire, English drawn wire, English hoops and cotton ties, Sheffield cutlery and edge tools, and all kinds of iron and steel machinery, in the manufacture of which great skill is required. At that time the Bessemer steel industry had not been established in the United States, and its possibilities were not understood even in England, where it originated, and we had but just commenced to develop our rich stores of Lake Superior iron ores and to apply our excellent Connellsville coke to their reduction. Germany lagged far behind as a producer of pig iron and steel and all their products.

The basic process of manufacturing steel from highly phosphoriferous ores, with which Germany is abundantly supplied, had not then been invented. But Great Britain was busy making steel by various new and old processes; she had an abundant supply of cheap coal; she had long known the virtues of Durham and other coke; and she had a variety of iron ores in abundance everywhere.

Since those days the United States and Germany have rapidly and even phenomenally increased their production of pig iron and steel, and of all articles made from them. The whole world, indeed, has greatly increased its production of iron and steel in the last twenty-five years, a result which is largely due to the extraordinary development in that period of railroad enterprises in all civilized countries, and to the invention of the Bessemer process, which has made cheap steel rails and cheap transportation possible; but the United States and Germany have made more progress than any other countries, and very much more relatively than Great Britain.

AUTOMATIC CAR COUPLERS.

Although the vertical spring hook style of couplers has been extensively adopted and its universal employment urged by car builders, the automatic couplers of the link and pin style seem to find most favor with brakemen and switchmen. They are the men who are obliged to work and deal with the couplers, and know what they are talking about. At the recent meeting in this city of the National Committee on Safety Appliances, Mr. D. B. Sweeney, of the Trainmen's Aid Association, favored the link and pin type. The vertical hook was too dangerous. They had to go between the cars to open the knuckle. The uncoupling apparatus was always broken. With the link and pin they knew when a car was cut, but when they threw up a lever they could never tell whether it would open or not. There was nothing better than a link and pin.

Mr. John A. Paul, editor of the *Switchmen's Journal*, described vividly the duties of the yard and switchmen, and the difficulties they labored under. Something should be done for them. The railroads were, he thought, doing all they could for them. He had many years' experience in yard work, and preferred the link and pin. The conditions under which these men worked were getting worse, and legislation was necessary unless the railroads accomplished more. A greater number of men were hurt every year. If nothing but vertical planes were used, they would still have to go between the cars—they were out of order so much. He believed the link and pin could be as automatic as the vertical plane. Yet, if all cars had vertical plane couplers, the conditions would be a thousand times better than they were to-day. The switchmen favored uniformity.

Mr. Heberling, of the Switchmen's Aid Association, said that they favored a uniform link and pin type or a uniform drawbar, anyway. If two cars of the M. C. B. type were set together without opening the knuckles, they were sure to break. Give them a uni-

form drawbar of some kind, and it would save the lives of many men.

Mr. Roach, of the same association, followed, speaking of the danger of coupling the link and pin with the M. C. B. type. All of the new type couplers were a detriment and annoyance to the switchmen.

J. T. Chamberlin, master car builder of the Boston and Maine R.R., said that their employes who had spoken knew better what was wanted than the officers. The men of his road all favored the link and pin type of coupler. The vertical plane drawbars had broken badly on his road, and now they had none.

Wm. McWood, of the Grand Trunk R.R., said that, personally, he was opposed to the vertical plane type. The switchmen's views coincided with his. He did not think the M. C. B. type gave good satisfaction. The pin still remained, and if it became bent the knuckle would not work. Neither were the knuckles interchangeable, which was a serious objection. More satisfaction and better results could be had from a good automatic link and pin coupler.

Commissioner Rogers asked: What can we do? Shall we go back to the link and pin, or compel the adoption of the M. C. B. type? Mr. McWood said he would not like to anwer that question.

Col. H. S. Haines said the vertical hook type was defective as long as the knuckle had to be opened by hand. But a majority of railroad men felt that the M. C. B. type of coupler had come to stay.

Mr. M. N. Forney outlined the difficulty the Master Mechanics and Master Car Builders' Associations had experienced in arriving at standards on anything, and told what had been done in adopting the M. C. B. type of coupler. Also the trouble in keeping the various parts in stock. No organization could say what coupler was complete and perfect. A forced adoption now would mean a device imperfect and incomplete, and would stop progress. The best couplers of to-day were all defective. Investigation and progress would settle this in time.

From the information placed before the committee, it appears there are 1,200,000 freight cars in the United States, of which 200,000 are equipped with the M. C. B. vertical plane spring hook couplers. It costs $25 a car to put on this form of coupler. To equip the entire rolling stock would cost fifty millions of dollars.

The number of locomotives in this country is stated to be 27,150.

For the year ending June 30, 1890, 300 railroad employes were killed in coupling cars, and 7,841 were injured.

OIL FUEL UNDER STATIONARY BOILERS.

Oil fuel, though for a long time used with success in forges for heating iron and steel, it is within comparatively a recent period that users have become convinced of its economy for use under boilers. Among its advantages are increased intensity of heat, lessening of labor and riddance to ashes.

The *Safety Valve* recently obtained a statement of results from those who have been using various types of oil-feeding apparatus for this purpose. Out of a total of 35 users distributed over the country who furnished our contemporary with their experiences with oil fuel, only three have abandoned it, and these because situated close to the coal mines, where coal or its refuse is to be had for scarcely more than the cost of carting it away. The first of these, an iron company of Sharpsville, Pa., discarded oil, and now use gases from their blast furnace for raising steam; the limited amount of fuel required in addition being more economically supplied by the cheap coal of the vicinity. The second, a salt company, of Le Roy, N. Y., say that in estimating the difference in cost between oil and coal, they weighed all the coal used under one of their 150 horse power boilers for 15 days, which proved to be 110½ gross tons of hard coal dust costing $1.70 per gross ton. They then put in two oil burners and burned one tank of oil. It lasted 180 hours steady burning and cost two cents the gallon. This they calculated made the cost of oil 88 cents per hour and coal a little more than 52 cents per hour. Then they tried a better type of oil burner and did still better, but it could not compete with coal at $1.70 a ton.

The third was an iron works company, of Erie, Pa. They use the cheap slack coal of the vicinity, and oil fuel could not, they found, compete with it. Against this thirty-two witnesses appear, not, of course, so favorably situated for cheap coals. Few of them seem to have adhered to the type of oil-feeding apparatus they started with, but all have had such success with oil fuel from an economical standpoint as to lead them to pin their faith to it.

A rolling machine company, of Fitchburg, Mass., say their oil fuel costs them 10 per cent less than coal or coke and that they save from 25 to 50 per cent in time and make similar gains in point of production. A maker of mowers and reapers, of Akron, O., says oil fuel costs him not much, if anything, over one-third what he used to pay for coal. The oil is stored in a large underground tank located close to the railway track, and is drawn from this tank and fed to the burners by a small rotary pump. It saves him what used to be a large cost for labor, handling coal and ashes, and he no longer needs a fireman. A bicycle making concern, of Hartford, Conn., say that the use of oil in their furnaces has resulted in very largely increasing their product with a less number of men.

A drop-forge works, of Gloucester, Mass., do not find any difference between the cost of coal and oil, but "the oil fuel needs no attention, once it is started, and will run all day without ashes, clinkers," etc.

A bicycle manufacturer, of Toledo, O., says he is unable to speak as to the comparative cost of oil and coal fuels, as he never got anything like the amount of heat from coal that he is now getting from oil, but is sure that oil is the cheapest besides being more convenient and cleanly.

A steel company, of Steelton, Pa., finds no difference in cost between oil and coal, but saves largely in cost of labor.

A manufacturer of Plantsville, Conn., says: "In comparison with coal we save about 25 per cent, also gain from 10 to 20 per cent more work in same time."

A maker of agricultural implements, of Clayville, N. Y., says he effects a saving of about 40 per cent by the use of fuel oil in his furnaces instead of coal.

A bridge building company, of Toledo, O., pay one cent per gallon for oil delivered, the price of coal being $2.25 per ton. At these figures they find oil to be far cheaper.

An axle company, of South Egremont, Mass., do not find any difference between the cost of coal and oil, using the latter.

A saw company, of Middletown, N. Y., find oil fuel far cheaper than coal, and still more important to them, they get an intenser heat, the same being maintained steadily throughout the day, "thus," so they say, "improving the quality of our goods over that which it was possible to attain with coal as fuel. On the whole, we can say it is a grand success with us."

An agricultural implements company, of York, Pa., say: "We have made tests between oil, coal and coke. As bituminous coal is cheap here, there is no advantage in point of economy farther than the men can work more continuously and there is less lost time. We find oil fuel a good thing, all things considered."

A sand company, of Chicago, Ill., say: "We find it (oil fuel) very clean; it can always be regulated, always appears to be of uniform quality, and we find very little annoyance from its use, such as new grate bars and breakage of different kinds, which is always the case with the use of coal."

Irrigation in Arizona.

The proposition is to construct a diverting dam across the Gila River, at a point about twenty-two miles above Gila Bend Station, on the line of the Southern Pacific Railroad, where the stream has cut through a mountain range, leaving the rocky barriers standing opposite each other, and at a distance comparatively short. The site chosen for the dam is a good one, and affords conditions which could not be obtained at any other place on the river. The dam will be 1,800 feet in length, and about twenty feet in height at the channel. The dam will be constructed of piling and earthwork. It is not intended as a retaining dam, to impound a vast quantity of water, but simply to divert the water from its channel, and convey it in a great canal to the lands below the dam, which consist of 200,000 acres of as fine agricultural land as can be found in the Territory of Arizona. The overflow of the dam is to be 600 feet wide, though the natural channel is only 250 feet in width. The water will be taken out at a point above the highest overflow.

The canal will reach the railroad at Gila Bend station, on the line of the Southern Pacific. At that point it turns west, and lateral canals will be run out to every available point on the Gila River mesa.

It is one of the largest irrigation schemes on foot today, and will cost less money than any of those in California. The dam is estimated to cost $20.000, and will be completed by February 1.—*San Diego Union.*

The Silk Threads in Paper Money.

In spite of the skill and industry of counterfeiters, they have never made a bill which did not have one or more vulnerable spots. Some of the products of their handicraft may seem perfect to the untrained eye, but the expert will find that each one, like Achilles, has something lacking in his armor. Perhaps the feature of good United States Treasury notes which counterfeiters have found it most difficult to imitate is the two blue silk threads which run lengthwise through them. They are a little over an inch apart, and though sometimes almost invisible, they form part of every bill issued by the Government Bureau of Printing and Engraving. A. L. Drummond, chief of the secret service of the Treasury department, who has had a long experience with counterfeiters and their wares, explained to a *Tribune* reporter recently why it was so difficult to copy good bills in this respect.

"In the first place," he said, "the silk threads are put in the paper when it is made at the factory. To make paper of the kind used by the government requires a big plant and lots of capital. So counterfeiters are kept out of it. Even if they had the necessary money, they wouldn't be fools enough to risk it all for the chance of making bogus bills. It would be exceedingly unprofitable for a paper manufacturer who already has a factory to make the paper, because to do so is a penitentiary offense."

Mr. Drummond then showed the reporter a counterfeit two dollar bill, which had a single thread running lengthwise through its center. "This is the only bad bill that I ever saw with a silk thread in it. Even this has only one thread instead of two, so it would not be dangerous to a skilled teller. I have never heard of more than two other bills like this one. It is easy to see that the counterfeiter split this note, put in his thread, and then pasted the two parts together again. The frayed edges showed that. The fellow must have been very stupid not to know that genuine money has two threads instead of one. An expert can easily tell when a bill has been split in two and pasted together again, so the silk threads would not deceive him."

Pyrophosphoric Acid as a Manure.

BY DR. JAEHNE.

A process for preparing a manure containing pyrophosphoric acid consists in acting upon ferruginous phosphates with a weak solution of sodium bisulphate, evaporating to a paste, when a reaction takes place, calcium sulphate separating out. The mixture of sodium sulphate and monocalcic phosphate is heated until the pyrophosphate is formed.

As an example, a sample of ground coprolites having the following composition was employed:

Tricalcic phosphate	50·20 per cent.
Calcium carbonate	8·80 "
Ferric oxide	15·00 "
Aluminum oxide	1·00 "
Silica	20·00 "
Other constituents	5·00 "
	100·00 "

On treating this sample with one and a half times its weight of $NaHSO_4$ dissolved in 4 parts of water (constituting a solution of 1·162 sp. gr. or about 20° B.), and thoroughly agitating the mixture, the ferric oxide is not attacked, but the calcium carbonate is decomposed, and the phosphate converted into monobasic phosphate. The liquid after separating the $CaSO_4$ by settling tests 24° B. at 15° C.

By evaporating in the open, the air coming in contact with the pasty mass forms a yellowish salt, having the composition $2\,Na_2SO_4 + CaH_4P_2O_8H_2O$.

This salt can be utilized by mixing with all kinds of compositions. It can be obtained in a state of complete dehydration by heating it to the fusion point.

By so doing a compound, containing 4 parts of sodium sulphate, 1 part of calcium pyrophosphate, and 1 part pyrophosphoric acid is obtained, which is universally used as a manure.—*L'Engrais.*

Life-Shortening Occupations.

The *Medical Age* contains the following abstract from the *Journal of the American Medical Association*:

One of the curious features of modern life is the extent to which the most hazardous trades are overrun by applicants for work. The electric light companies never find any difficulty in obtaining all the linemen they need, notwithstanding the fact that the dangers of that kind of business have been demonstrated times without number. The men who work in factories where wall paper is made frequently joke one another over the tradition that a man's life, in this trade, is shortened ten years. A similar belief is prevalent in factories where leather papers are made, and among men who have to handle them, and whose lungs are said to become impeded by inhaling the dust arising from such papers. In certain other factories, where brass ornaments and fittings are made, the air is laden with very fine brazen particles, which are, when inhaled, especially irritating to the lungs. But one of the most singular advertised calls for employes that was ever printed appeared recently in a Connecticut newspaper, signed by a firm engaged in the business of building towers. It called for applicants only among those who are young, strong, and courageous, and closed by saying: "We warn all seekers for this job that it is of the most dangerous nature, and that few men continue in it more than a few years. In fact, it is almost certain death to the workman who follows this occupation."

A Word to Mail Subscribers.

At the end of every year a great many subscriptions to the various SCIENTIFIC AMERICAN publications expire.

The bills for 1892 are now being mailed to those whose subscriptions come to an end with the year. Responding promptly to the invitation to renew saves removing the name from our subscription books, and secures without interruption the reception of the paper by the subscriber.