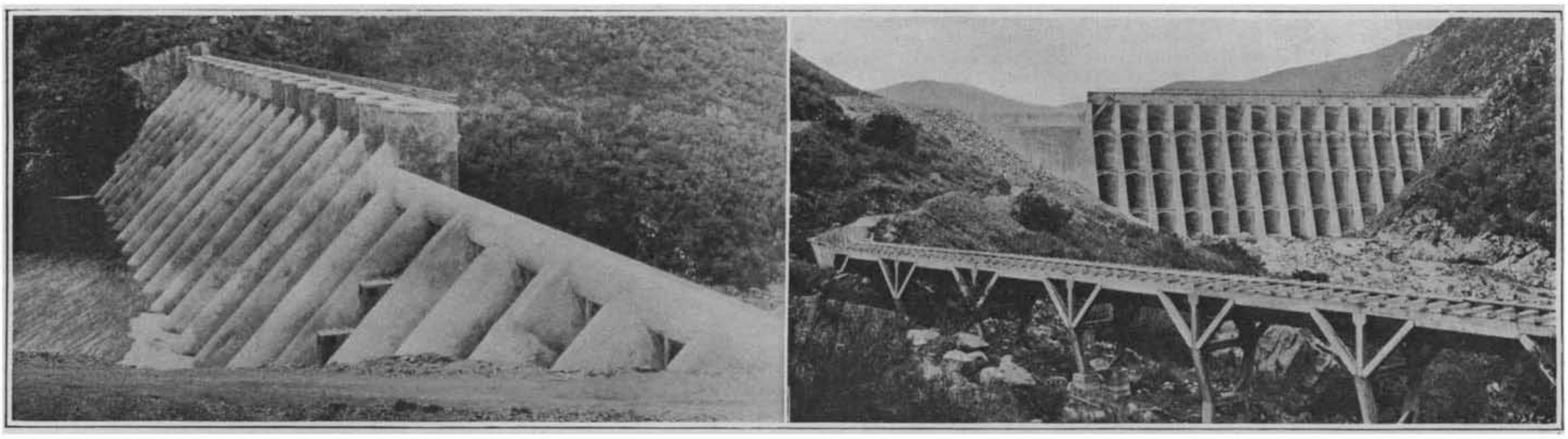

Upstream and downstream views of the Lake Hodges multiple-arch dam, showing the novel concrete construction employed

The Big Dam on the Little San Diego

A Multiple-Arch Structure of Unusual Height and Some of the Principles Involved in Its Construction

By J. F. Springer

WHETHER a multiple-arch dam is the most economical one to build turns upon the local conditions. As a rule, they grow expensive as they are made tall. The reason for this needs some explanation. A single-arch dam may have a fairly vertical face upstream; but this is not permissible when there is a plurality of arches. Naturally, the water pressure must somehow be resisted. With a single arch, the sides of the canyon receive a great part of the hydraulic thrust. These sides are in fact the supports of the arch. But this is changed when one, two or more arches are to span the stream. The arches of a multiple-arch dam uniformly exert their arch action upon the foundation. In order to do this, they must lean in such way that the crest of the dam is farther downstream—on the upstream side—than is the base. A system of braces and the like sustains the system of multiple arches. This system of braces receives the arch action and transmits it to the floor of the foundation. Now these braces and the coacting uprights, etc., constitute a more and more serious problem the higher the crest of the dam is set above the base of the structure. The width of the base may equal or exceed the height of the whole dam. With dams of moderate height, the expense of the supporting framework may be rather reasonable; but when the height goes up to considerable figures the cost is apt to be considerable, too. Nevertheless, in southern California there has been built a multiple-arch dam 136 feet high. So far as I know this is the record for this type of structure.

There are 24 flutes or arches in this dam. The end ones have almost no depth; but there are a dozen intermediate ones that reach to considerable depths. The structure is of reinforced concrete. In fact, it is doubtful whether it would be practical to use another construction material. There is nothing massive about the dam. It does not depend upon its weight to resist the water, but upon the way it receives and transmits the thrust. On one side of the ravine, the bank has been leveled off for about 192 feet. This bench or ledge provides part of the spillway section for the dam, the remainder, 168 feet, being a rollway over the top of one end of the concrete dam. The concrete structure fills the ravine from side to side, and is 558 feet long.

The site is inland from San Diego at a point on the San Dieguito River about 30 miles distant. Back of the dam has been created a reservoir having a capacity of some 13,000,000,000 gallons. The water impounded is to be used for irrigation purposes in the semi-arid coast lands lying between Del Mar and Oceanside and on the road connecting Los Angeles and San Diego. The rainfall is insufficient for the growth of regular crops. The dam has the duty of impounding the river water, which is then piped to desired points of use. Part of the land served is a total of some 12,000 acres whose value was less than $1 per acre. In short, the land was practically waste. Water was supplied first in 1919. One man put 28 acres in potatoes and harvested them in February, 1920. They brought when sold something over $28,000. So the land itself appears to promise well.

Not only is the dam of concrete; but a flume and pressure pipe have been constructed of the same materials. Apparently a chief factor in selecting concrete for the flume and pipe rather than wood is the desirability, or perhaps necessity, of using something that will not burn. Fires in the brush have caused a good deal of trouble, but they will naturally not do much to the concrete.

The cost of the dam, exclusive of accessory structures, has been about $4,000,000. Its site is some 10 miles from the mouth of the river. The flutes or arches are supported by 25 buttresses which are spaced at intervals of 24 feet, center to center. At the bottom the buttresses are much thicker than at upper levels. That is, at the very bottom, the thickness is 4 feet. This thickness is decreased gradually to 1½ feet at the level, 63 feet above the stream. From this level up, the thickness remains undiminished. All this is testimony to the heavy pressures that have to be resisted at the lower levels. The curvature of the arches is on a circle having a radius of 13 feet 10¼ inches. This is on the upstream face. On the downstream face, the curvature varies, especially in the lower levels, with the height above stream. However, from a level 75 feet above the bed of the stream bed on up the arches each have uniform thickness. I have said that the structure is of reinforced concrete; but this is not entirely correct. The buttresses are without reinforcement. The arches, on the contrary, are reinforced both horizontally and up and down along the slant. The reinforcement is anchored in the upstream side of the buttresses. Moreover, the reinforcement is so located in the arches as to form a kind of "fabric" near the outer and also near the inner surface. The concrete in the arches is an especially rich mixture (1:2:4); that in the buttresses is nearly as rich (1:2½:5). The upstream face of the arches was given a coating by the use of an apparatus which throws a jet of mortar or grout.

The spillway, consisting in part of one end of the concrete dam and in part of the rock ledge, is altogether 360 feet long and is 15 feet lower than the crest of the main portion of the concrete structure. It seems that the maximum flow accurately known was a flood of 72,100 second-feet. The requirement was imposed by the State that the spillway should provide for the passage of this flow. Hence the cut into the side of the ravine. A tunnel in line with the length of the dam has been constructed underneath the spillway. It is 192 feet long and 4 x 6½ feet in cross-section. It is concrete lined. Its purpose is to provide for access to the control valves underneath the dam. At its terminus, on the stream side, the tunnel connects with a series of concrete foot bridges which extend through the remainder of the dam. From these bridges in the buttresses, the blowoff and service gates may be operated. All this provision is especially for use during high water. Control might have been arranged at the crest; but then a bridge would have been needed along and over the spillway. The objection to this is that the necessary piers would cut down the capacity of the spillway to pass the 70,000 second-feet.

During the low water periods, there is access through the downstream face of the spillway for the operators, admitting to the control chamber for the irrigation supply. Here the water is turned on and off. There are half a dozen outlet gates, so set as to draw water from the lake at vertical intervals of 10 feet. Each of these gates has its individual pipe-connection with the irrigation main-conduit. These pipes are of strongly reinforced concrete and are bedded on the rock and secured to the buttresses. At the very lowest region of the dam are several blow-off valves. To reach the control device, the operator comes down a concrete stairway extending down from one of the foot bridges already mentioned.

When filled to capacity, the dam will restrain a lake 115 feet deep. The 30,000 acre-feet of water stored here is to be used at more or less distant points. There is a conduit 4½ miles long which serves to carry the water toward the coast. It consists of a ditch which has been lined with concrete. At places, the conduit is covered with concrete slabs, the object in view being to prevent the invasion of rocks rolling down the mountain side. There are a number of inverted siphons. These are used to get the water across ravines or other depressions. Some of these are, at their lower part, under a pressure corresponding to a 90-foot head—that is, to 39 pounds pressure per square inch. There is also an amount of steel flume. The steel flume and the lower parts of the concrete siphons are carried by concrete trestles. The siphons are 42 inches in diameter and are reinforced. The trestles have been constructed of pre-cast interchangeable units. It is said that the cost of the trestles was much less because of this substitution for the ordinary method which proceeds by pouring the concrete *in situ*.

The dam which impounds the water is Hodges Dam and the body of water Lake Hodges. The conduit delivers to a second lake which is known as San Dieguito Reservoir. This second lake is created by another multiple-arch dam. It is 50 feet high and 650 feet long. Concrete

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Forty-two-inch concrete siphon on the San Dieguito project a remarkable sense of smell, and keep away from certain odors, such as tobacco and dead rats.

In various cities of the world a lively warfare against rats is under way. In Paris, 25 centimes per rat captured either dead or alive is being offered. In London a vigorous campaign is under way. New York has taken certain measures, and more thorough steps are being contemplated. New Orleans has constructed her warehouses to shut out rats, and the same can be said for San Francisco. Many other cities are now engaged in waging what appears to be a successful fight against one of the worst pests that confront the well-being of the human race.

The Big Dam on the Little San Diego

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tubing carries the water from this equalizing reservoir to the coast lands. This tubing varies from 20 to 26 inches in diameter.

One of the views shows the downstream face of Hodges Dam. On the right is to be seen the system of buttresses. In the center of the picture, this system ends and is succeeded by the concrete portion of the spillway. Back of the whole structure is to be seen the valley of the San Dieguito River, now occupied in part by Lake Hodges. Another view shows a siphon resting on its trestlework. Still another view shows the upstream face of the great dam. The flutes of the main dam and also of the concrete spillway (on the right) are plainly to be seen here.

Hodges Dam and San Dieguito Dam are two of four distinct dams that have been built to one general type of design in a single California county, San Diego County. The former of these is perhaps the tallest multiple-arch dam in existence. One of the others is Murray Dam. It was built to increase the storage at that time provided by the old La Mesa Dam. In January, 1916, this old structure, a hydraulic-filled dam 65 feet high, was nearly carried away by the great flood then rampant. The Lower Otay Dam had failed with severe loss of life and property and the south dyke of the Sweetwater Dam had also gone out. The water had risen to within just about one foot of the crest of the old La Mesa Dam. Overtopping the crest meant the failure of the dam and great damage to property and loss of life. However, there was a sluice gate at the base of the dam which was closed. It was finally opened and the dam thereby saved. The new dam which supplements the old structure is Murray Dam. It has 30 arches of a span of 30 feet each. The height is 117 feet and the length 900 feet. Just as is the case with Hodges Dam the slope along the crown of the arches is 45 degrees. Both dams have their inclined flutes surmounted by short vertical ones. Murray Dam has in one bay at the extreme north end a self-charging siphon spillway. Its capacity is double the flood inflow of the great flood already mentioned. It is claimed that this device will regulate the level of the reservoir within 3 inches of the summit of the main coping. The spillway level is the same as that of the cope and the result of the automatic arrangements is a regulation of 100 per cent efficiency.

A multiple-arch dam may often be built very rapidly. Murray Dam was built in 7 months; San Dieguito Dam in less than 4 months. They are sometimes quite economical. Thus, the designer claims that the Murray Dam cost less than any other dam of its size in the world.

The remaining multiple-arch dam of San Diego County is Eagles Nest Dam. This is a little fellow built to create a fish pond and to impound water for a small lighting plant. The designer, Mr. Eastwood, calls the type exemplified here a Matilija or Butterfly Dam. The plan presents a butterfly appearance. There are three arches. It is the first of its kind ever constructed. The central arch has a span of 70 feet and the side ones a span of 25 feet each. This dam closes an opening of 125 feet wide. There are only 184 cubic yards of concrete in the structure.

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"Indian Uses of Kelp". is the title of an interesting article by J. C. Leachman, in which he tells of various articles made by North American Indians out of different kinds of sea weed. These include fishing lines, bottles, and even toys, sections of stem being used to make the wheels of toy wagons. Sea weeds were also used in ceremonials and as amulets. Unfortunately, owing to the perishable nature of the materials, many examples of the use of kelp have been lost, but enough have been preserved to illustrate the value of marine vegetation to these primitive peoples.

With the all-seeing eye of the Roentgen ray experts are now examining old paintings to determine whether they are genuine. It has been found that the pigments used in previous centuries are much more opaque to X-rays than are modern paints made of aniline and vegetable dyes. The antiquity of paintings can therefore be determined by noting their opacity to the X-rays. The process is described in the February Monthly and is illustrated with some very interesting photographs and radiographs.

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Jupiter is in the eastern part of Leo, and rises a little after 7 P. M. in the middle of the month, so that he is well placed for observation before midnight. Saturn is on the western edge of Virgo and about seven degrees east of Jupiter, rising approximately half an hour later. He is a telescopic object of extreme interest, for his rings are turned almost edgewise toward the earth. During most of the month their plane passes between the earth and the sun, and only the dark side is visible, so that with all but the greatest telescopes the planet appears merely as a disk, while with very powerful instruments the rings may be faintly seen illuminated by the light reflected from the planet, together with that which filters through from the sunlit side between the fine particles of which the rings are composed. On the 22nd the rings are turned exactly edgewise toward the earth, and (as previous observations at this phase have shown) they will be wholly invisible in even the greatest instruments. Then for about seven weeks we will see the sunlit side of the rings, very nearly edgewise, as a thin spike of light projecting from each side of the planet.

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Skjellerup's Comet

An orbit of this comet has been computed at the University of California from observations covering an interval of nearly three weeks, and should be very near the truth. According to the comet passed perihelion on December 11, at a distance of one hundred and thirty million miles from the sun. Its orbit is inclined 22° to the ecliptic, and it passed through the ascending node about two weeks after the perihelion. It is now slowly receding from the sun and more rapidly from the earth and growing steadily fainter, and there is no chance that it will ever become conspicuous.

Clearing Away the Scars of War

THE recent war, considered in an atmosphere three thousand miles away from the former battlefields, may be an old story. But to those who have had to live in the shambles of the great conflict, the war is by no means over so far as its effects are concerned.

Thanks to the courtesy of President Andre Tardieu of the Comité des Régions Dévastées, we are enabled to present a number of striking facts and figures concerning the gigantic task facing the French people, and what progress they have already made despite the serious limitations imposed by lack of sufficient finances, scarcity of coal, and absence of German assistance.

Of 2,728,000 persons driven out of the devasted region by the invading armies, 2,023,000 have returned. The war caused the destruction of 4.068 municipalities, of which number 4,006 have been re-established. Before the war there were 6,445 schools in the devasted region; to-day 5,345 have been re-established. In all, 574,777 houses were either entirely destroyed or at least half destroyed. By last June the French had rebuilt 13,100 houses, repaired 178,500 houses, and erected 46,570 temporary structures. These structures afforded shelter to 887,000 inhabitants; the rest of the population in the devastated region have been living in such houses as remained undestroyed. The problem of rebuilding is a two-fold one: first, the land must be cleared away, and, secondly, the rebuilding must be carried on with such materials and labor as are available. In many instances the ruins are such that it is not feasible to clear them away. One cannot imagine what a destroyed town means in terms of broken stone, loose brick, piles of plaster, shattered glass, and huge, deep holes. To remove such a mass of débris is often more difficult and costly than to select a new site and build a new town from the ground up.

Of arable lands, the war ruined 9,810,000 acres, of which 8,068,000 acres have been cleared of projectiles, and 6,687,000 of iron wire. The French have plowed 3,756,000 acres; 134,000,000 cubic meters of trenches have been filled in, and 182,000,000 cubic meters of iron wire networks have been cleared away.

The war destroyed 1,397 miles of standard gage, and 1,483 miles of local track. Of this mileage, only 737 miles had been replaced up till last April. Of the French canals, 992 miles were destroyed, and 488 miles have been repaired. The roads suffered heavily, 32,031 miles being destroyed. The French have repaired 1,215 miles and improved 9,962 miles. Of factories, the war destroyed 11,500. Since the termination of hostilities the French have re-established 3,540 factories, which are now operating, and 3,812 are being rebuilt.

A New Sweet Clover Harvester

AS a soil builder sweet clover is rapidly gaining favor in all parts of the country. The great drawback to a more universal use, in one sense, has been the lack of adequate machinery to harvest the seed for planting or sowing purposes. Until lately the only way to obtain the seed was to cut the crop with a binder or mower and thresh in a clover huller, and should the residue be returned to the land it would be difficult to plow under with satisfactory results. With a new harvester invented by an Illinois man it is now possible to remove the seed and the plant is left standing to be plowed under in order thoroughly to enrich the soil.

Virtually the machine is pushed through the clover field, when in operation, by four horses, while two men operate it. One man tends to the screening and sacking while the other drives the team.

The machine is carried by two wheels while the end of the tongue is supported by a center wheel to facilitate turning at corners. A chain sprocket on the larger axle drives an overhead shaft bearing four large paddle or threshing wheels at a high speed. Parting guides compact the stalks as they are drawn through a series of fin shaped paddles, some rigid, others mounted on the sides of the threshing wheels. These notched paddles mesh loosely. The stalks of the plant are stiff when the seed is ripe and upon being drawn through are bent into series of angles which hold while the seed is beaten off. A draft of air drops the seed into conveyors that carry it back to a bin, where it is screened and sacked. A nine foot swath is taken by the machine in the field being harvested. The mechanism is easily raised or lowered as it is necessary.

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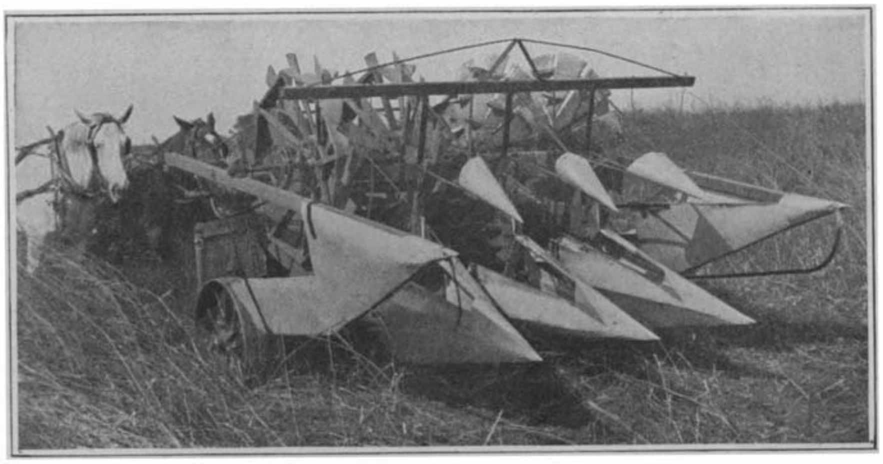
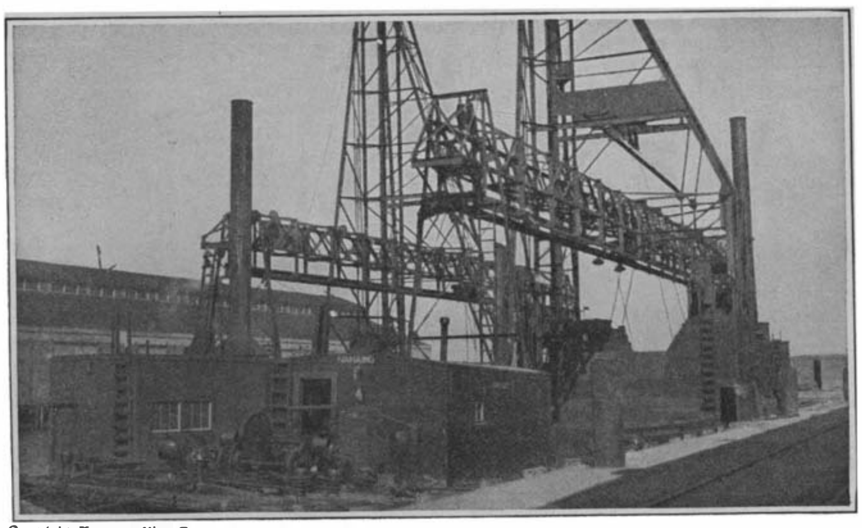
Reconstructed Verdun, showing the library and print shop. Most of the rebuilding in France is in the form of frame construction

All these logs represent but one Douglas fir tree, a species that often attains a height of 250 to 300 feet



This machine strips the clover plants of the seed but leaves the plant standing



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New system of unloading coal recently installed on barges in San Francisco Harbor

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"ONLY the other day some dull and tedious occupant of a professor's chair solemnly remarked that the metrologist must be compared to the plow-horse, patiently digging his furrow, while the man of new and original ideas is the race-horse, swiftly covering space to the plaudits of an admiring crowd. The metaphor is not entirely displeasing to me, for when once the race is over, what is there to show for it, but a little dust and a little noise, while in the furrow traced by the steady plow-horse, the coming harvest will tomorrow lift its head." Thus spake M. Charles Edouard Guillaume, winner of the Nobel Prize for Physics, in an interview for the SCIENTIFIC AMERICAN MONTHLY. M. Guillaume is the director of the International Bureau of Weights and Measures, located at St. Cloud. The article proceeds to describe the interesting apparatus developed and employed at that famous Bureau.

Fifteen years ago Vesuvius blew off its head in a very violent eruption. Since then it has been gradually building up a new cone on the floor of the old crater. The process has been studied by Frank A. Perret, the well known volcanologist, and he explains this bit of volcanic archi-

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A Tree to the Train Load

DOUGLAS fir is the name given to one of the finest timber trees in the western part of the United States. And it doesn't require more than one tree to make a train load, when one is dealing with Douglas fir.

Proof of this is found in the accompanying illustration which shows such a tree cut into car lengths for convenience of transportation. The diameter of the log in the foreground is 10 feet 7 inches. That is by no means an extraordinary growth, for specimens with a diameter of 15 feet are common, and travelers in the belt where they grow report having seen them 20 feet in diameter and tapering straight to a height of from 250 to 300 feet.

The Coast Range of the Sierras provides the best trees. Only the famous redwood and two or three other growths exceed the fir in size, and none except the yellow pine produces so much commercial timber. The tree is sometimes styled the Oregon pine, but foresters say it is more of a hemlock. Its botanical name is "false hemlock," although that designation is not generally approved.

Doing Away with Hand Shoveling

THE equipment shown in the accompanying illustration has recently been installed on some barges at San Francisco, for the purpose of doing away with hand shoveling. The shape and size of the bottom of each barge are such that the clam-shell bucket can pick up every bushel of coal without the necessity of employing any men for hand shoveling. When the bucket is filled with coal, it is raised to the overhead truck and carried to the center of the barge. Here the coal is dropped into a hopper. From the latter the coal is delivered into a skip which is attached to a cable and adapted to be elevated by the cable to a great height where it is automatically dumped into a spout which delivers the coal into the bunkers of the ship.

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The moon is new at 5:37 P. M. on the 7th, in her first quarter at 1:53 P. M. on the 15th, and full at 11:32 A. M. on the 22nd. As this calendar month is shorter than the lunation, the moon does not pass through her last quarter in February at all. She is nearest the earth on the 20th, and remotest on the 5th. While making the circuit of the sky she passes close to Uranus and Mercury on the 9th, Mars early on the morning of the 11th and Venus on the same evening, Neptune on the 20th, and Jupiter and Saturn on the 23rd. The conjunction with Venus is close, and an occultation is visible in Asia; but we are unfortunately on the wrong side of the earth and will see nothing of this.

Skjellerup's Comet

An orbit of this comet has been computed at the University of California from observations covering an interval of nearly three weeks, and should be very near the truth. According to this the comet passed perihelion on December 11, at a distance of one hundred and thirty million miles from the sun. Its orbit is inclined 22° to the ecliptic, and it passed through the ascending node about two weeks after the perihelion. It is now slowly receding from the sun and more rapidly from the earth and growing steadily fainter, and there is no chance that it will ever become conspicuous.