coefficient of elasticity, the elastic limit being close to the breaking point, and much greater than the tension put upon the strings during the operation of tuning. Secondly, it must be of uniform diameter and uniformly round in cross sections, otherwise the over-tones to which is due the tone quality will not be perfectly secured; thirdly, it must have permanence, that is to say, it must not stretch under continued stress.

The number of vibrations per unit of time, corresponding to the fundamental tone produced by a string, varies inversely as the length of the string, inversely as the square root of its weight, and directly as the square root of its tension. If a wire be stretched between two points *A* and *B* (see accompanying diagram), and plucked or struck, it will vibrate above and below the line *A B*, giving what is known as a fundamental tone. This fundamental tone is without character, and would sound the same in all instruments, so that one could not distinguish whether it came from a violin or a piano.

In addition to its fundamental vibration between its points of attachment, the string undergoes a series of sub-vibrations, above and below its own normal curve, which it will pass at certain points, "nodes," dividing it into equal parts. Thus, in the accompanying sketch, *A*, *C*, *B* and *A*, *D*, *B* represent the fundamental vibrations, and *A*, *E*, *C*, *F*, *B* the first sub-vibration intersecting the fundamental vibration at the node *C*. Again, the string may vibrate in three parts, four parts, five parts, etc. The production of the proper sub-vibrations, and the determination of their power relative to the power of the fundamental vibration, constitutes one of the most abstruse problems in the art of piano making; for the effect of the sub-vibrations is added to the effect of the fundamental vibration, and their total effect is heard in the distinctive quality or "tone color," as it is called, of the instrument. The sub-vibrations are known as the upper partials or over-tones, and generally speaking, they are harmonious with one another and with the fundamental tone.

The over-tones which correspond to the division of the string into seven or nine aliquot parts, however, are inharmonic, and in order to destroy them the hammers are so placed that they will strike at one-eighth of the length of the string. The width of the striking surface of the hammer is sufficient to intercept and dampen out the seventh and ninth upper partials, leaving only those which are harmonic. In the accompanying diagram, the sinusoidal curve representing the condensation and rarefaction of the air produced by the fundamental tone is shown by a heavy dotted black line, and the effect produced by the first, second, and third upper partials by fine lines. The effect of the latter upon the fundamental is to produce the irregular heavy final curve, which is shown here by a heavy black line. It must be understood that three only of the upper partials or over-tones are shown, whereas they may run up to the thirty-fourth or thirty-sixth, all tending to give fine quality to the resultant tone.

In laying out the "scale," a certain standard tension (in the Knabe piano about 141 pounds) is adopted for all the strings, and it is invariable. The variable elements are the weight of the wire and its length. The scale starts in the treble with a short length of about 55 millimeters, and if the same weight of wire were used throughout, the lowest bass strings would have to be 32 feet in length, which is, of course, impossible. The piano builder chooses, therefore, the greatest length of bass string compatible with the size of the piano which he intends to build, and then to obtain the correct pitch, he winds on a sufficient weight of copper or other wire to reduce the pitch to the proper standard. The number of vibrations varies from 26 per second in the lowest bass string, to 4,136 in the highest treble string per second.

(*To be continued.*)

EARTHQUAKE OBSERVATIONS.

BY PROF. EDGAR L. LARKIN.

A cemetery filled with monuments, columns, and obelisks is a capital place to study the effects of an earthquake. Amplitudes and azimuths of disturbed monoliths and pillars reveal at once the action of the earth upheavals. I had no instruments with which to measure, so had to make estimates.

Laurel Hill Cemetery I found a field of distorted, shifted, turned, cracked, overthrown, and ruined columns, pillars, shafts, capitals in white marble, gray granite, and other materials. Angels' wings were broken, sculptures were round about, and heavy bases were twisted out of their original positions. At first I noted distortions on both sides of an avenue of tombs. Here are directions in which the tops of fallen columns and monuments were pointing along either side, in a distance of 150 feet: N. 1, S. 2, E. 9, W. 5, N.E. 4, N.W. 5, S.E. 5, S.W. 6. From this I thought that the chief distortion was toward the east. Then facings of those that were skewed around on their bases, but not overthrown, were noted, as follows: N. 1, S. 1, E. 2, W. 1, N.E. 4, N.W. 0, S.E. 2, S.W. 1. All these had been twisted around against intense friction at their bases. The one marked N. originally faced eastward, and the one shown as facing S. once faced westward. I examined many others, hoping to make order out of chaos, or find a general trend in direction, but could not. The conclusion reached was that the monuments were thrown over and twisted in every direction.

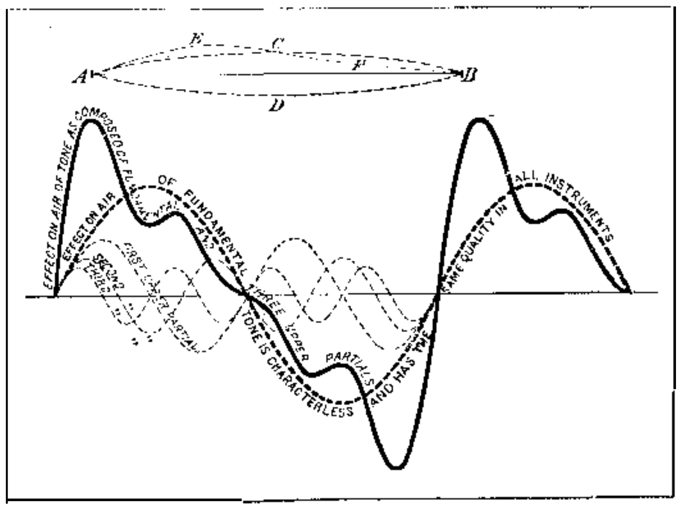


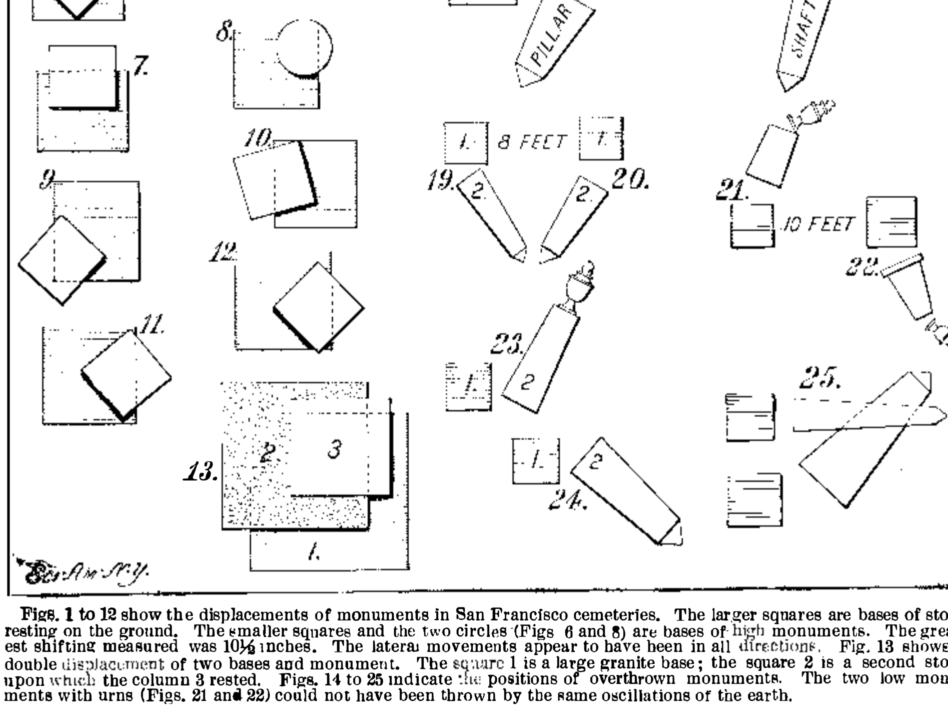
Diagram Showing Effect of the Upper Partials in Modifying the Fundamental Tone.

The Oddfellows' Cemetery was explored. This is more modern than Laurel Hill; the monuments are higher and heavier. They were fastened down by lead in some cases. The most complete confusion reigned. The displacements likewise were in every direction. An observer with instruments, upon making surveys during a month, might find a majority of fallen columns pointing one way, or facings, but it is doubtful. The earth's surface surely moved in every direction. As nearly every brick and stone building was destroyed, they could not be studied. The great Fairmount Hotel has rents in the corners, and several high up, along near the middle of the façades. The new $5,000,000 post office is torn near the corners. The towering steel and stone Spreckels Building stands as a skeleton, but looking down on a wilderness of ruins of all old-type buildings. For the new city will be erected around ribs of rigid steel. The accompanying diagrams show roughly the distortions in the cemeteries. The line N.S. is due north and south, in cuts Nos. 1 and 2. Twistings of obelisks that did not fall range from five to seventy degrees in all directions from their original foundations. My impressions gained in the cemetery were confirmed upon receipt by mail of the seismograph shown on page 419. It was sent me by F. M. Clarke, steward and executive officer of the California Veterans' Home, Yountville, Napa County. My thanks are hereby extended to him for the faithful record. It indeed shows that the ground moved in every possible direction. On leaving the cemetery I wrote an article for the papers, saying that it was a circular disturbance, and the graph reveals a circle near the center. Mr. Clarke says: "The first movement had a N. and S. direction, but was swiftly compounded with a circular, twisting movement, accompanied with severe upward thrusts. The first movement was decidedly wave-like; then a cessation, followed by the severe twist." Napa is 45 miles north of San Francisco, and San José, 50 south. Both were destroyed.

Mr. Edward Pickersgill, Alameda, Cal., sends me a series of photographs of great upheavals, distortions, and displacements of the ocean shore, four miles from Colma. Vast banks of sand slid into the sea, and a new high point of land was formed as shown on page 419. A place where gas escaped from soft mud is also shown. The soil is a foot or more high, and six wide.

Without doubt, gas had to do with the great earthquake. Newspaper reports say that from April 18, 5:18:57 A.M., to April 26, 3:15 P.M., thirty-two shocks left their imprint on the seismograph at Berkeley, and that twenty-six occurred on the first day, the 18th. I felt the sharp shock that came on the 20th, 4:34:17 P.M., in a three-story frame building. It was my fourth earthquake. The priceless collection in the magnificent Lick Academy of Sciences vanished. All the replicas of historic, paleontological and geological finds were consumed; also early Spanish records of exploration. The great libraries and many private collections of literary treasures exist only in cherished memories.

Mt. Lowe Observatory, Cal.



Figs. 1 to 12 show the displacements of monuments in San Francisco cemeteries. The larger squares are bases of stone resting on the ground. The smaller squares and the two circles (Figs 6 and 8) are bases of high monuments. The greatest shifting measured was 10½ inches. The lateral movements appear to have been in all directions. Fig. 13 shows a double displacement of two bases and monument. The square 1 is a large granite base; the square 2 is a second stone upon which the column 3 rested. Figs. 14 to 25 indicate the positions of overthrown monuments. The two low monuments with urns (Figs. 21 and 22) could not have been thrown by the same oscillations of the earth.

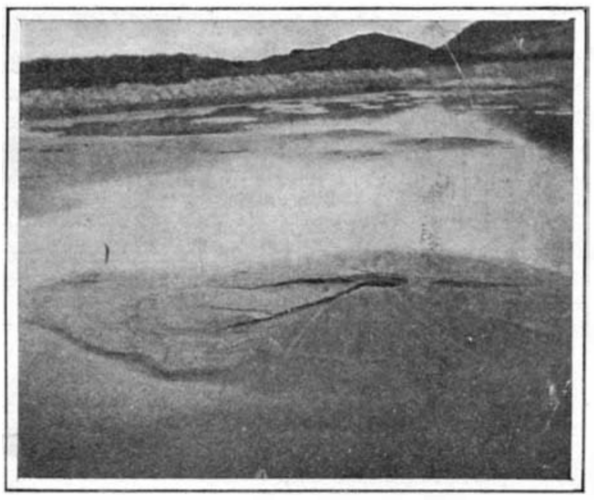
CEMETERY MONUMENTS OVERTHROWN BY THE EARTHQUAKE.

EFFECTS OF THE EARTHQUAKE AND FIRE UPON THE CITY OF SAN FRANCISCO AND ITS BUILDINGS.

BY ARTHUR INKERSLEY.

About ten days after the San Francisco earthquake, which occurred at 5:13 on the morning of Wednesday, April 18, the city engineer sent out three parties for the purpose of ascertaining whether or not the whole city had sunk as a result of the shock. Many places were found where the ground had sunk considerably; especially on Valencia Street between 19th and 20th Streets, at the easterly end of Market Street near the ferry depot, on Howard Street between 17th and 18th Streets, on Van Ness Avenue from Vallejo to Green Streets, and on Folsom Street near 17th Street. The sinking is almost wholly on made ground in the lower parts of the city. At the southeast corner of the United States post office on Mission and Seventh Streets, there is a depression and a corresponding raising up of about four or five feet. That part of the post office was built over an old swamp. The building retained its position, but the concrete sidewalk pulled away from it, leaving a gap of six to ten inches. The city engineer's conclusion is that the city as a whole did not sink. There was no distinct subsidence of any considerable portion of the peninsula.

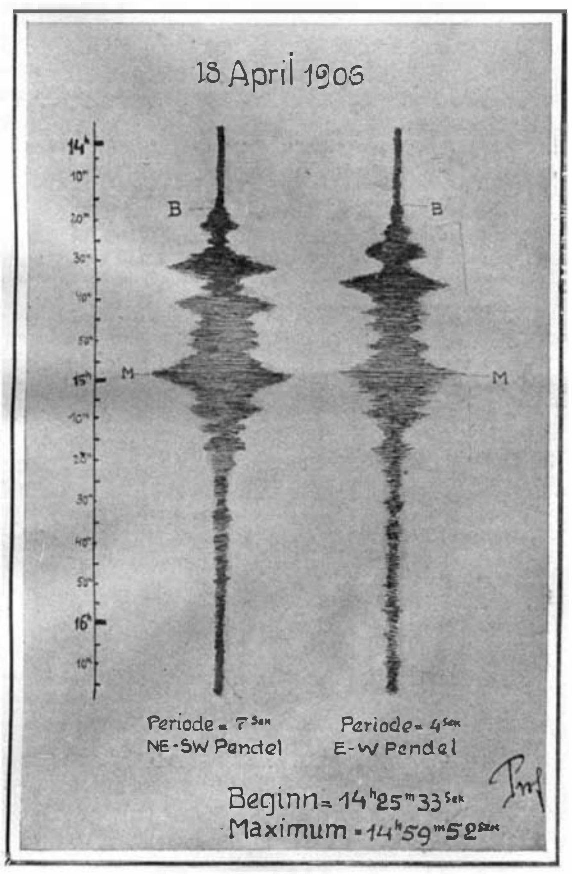
The disturbance of the earth's crust on Wednesday morning, April 18, in San Francisco and its vicinity was really inconsiderable. The vibration was sufficiently great and sustained to shake down chimneys, bad masonry, and old frame buildings on rotten or insecure foundations. According to Prof. O. A. Leuschner, of the astronomical observatory of the University of California at Berkeley, Alameda County, the damage caused would have been vastly more serious had the vibrations not been distributed over so many seconds. If the shocks had been instantaneous, very much greater ruin would have resulted. The standard clock of the students' observatory stopped at 5:12:38 A.M. Pacific time, some less severe temblors being recorded at 5:12:03. The earthquake came chiefly in two shocks, the first series of vibrations



Blowhole on Beach Near Colma. There Was No Sign of Water Here Before the Earthquake. Mounds Were Formed Five and Six Feet in Diameter and One Foot High.

lasting about forty seconds; then diminishing in force for ten seconds; the second series lasting more strongly for about twenty-five seconds. The direction was mainly from S.S.E. to N.N.W. The remarkable feature about it was its rotary motion. The sum total of all the displacements represents a very regular ellipse, and some of the lines that indicate the movement of the earth's crust can be traced along the entire circumference. The slowness of the vibration was the saving feature of the visitation.

The most severe recorded earthquake that preceded

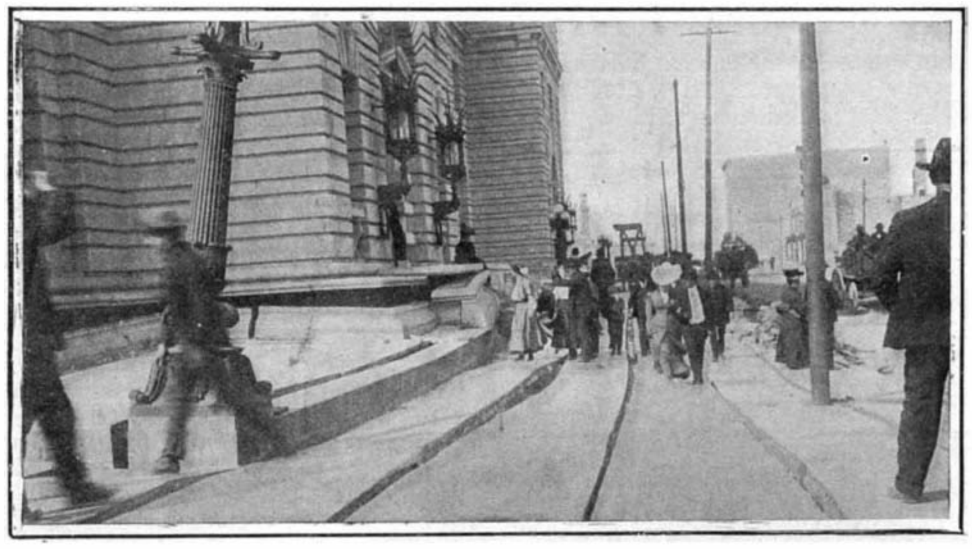


Record of San Francisco Earthquake Made at Austrian Imperial and Royal Seismological Observatory of Laibach.

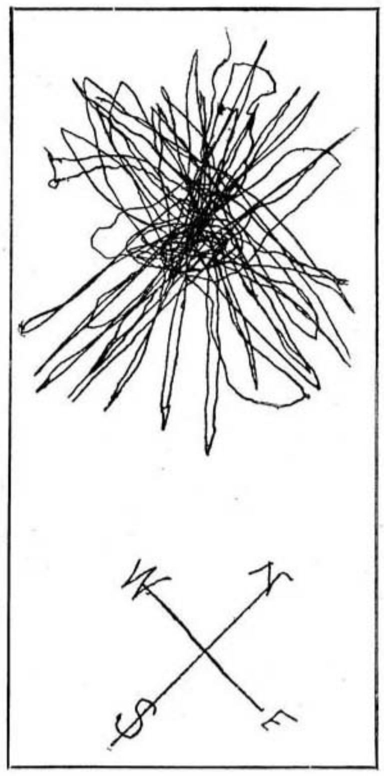
the one of April 18 occurred in San Francisco on October 21, 1868. The direction of that was northerly and southerly and its duration was 42 seconds. A second shock, lasting five seconds, came later and was succeeded by several lighter and shorter tremors at intervals of about half an hour for three hours. The first shock was felt most severely in the eastern part of San Francisco on the filled-in ground between Montgomery Street and the bay. No serious damage was done to well-constructed houses built on solid ground. The custom house, a poorly-constructed building on bad ground, suffered severely, and a small fissure opened on Howard Street. The tall chimney of the United States mint was damaged, and a ferry steamer near Angel Island felt the shock strongly. Waves came fifteen or twenty feet farther inland than usual. A dozen shocks were observed, the prevailing direction being from S.S.E. to N.N.W. Not one well-built house, whether of stone, brick or wood, on solid land, was damaged seriously. The actual displacement of the earth's crust was about half an inch, and the velocity during the heaviest shocks was, roughly estimated, two inches per second.

Prof. Burkhalter, of the Chabot Observatory, Oakland, Cal., says that earthquakes are divided by scientific men into ten classes, according to their intensity, and that the earthquake that visited California on April 18 belongs to class 9. He says that during the disturbance of its equilibrium the earth moved in every direction, but the general motion was rotary; that the strain on the earth's crust that caused the earthquake of April 18 had been growing for half a century, or perhaps for a whole century. It is likely, though no man can tell, that there will be no more serious disturbances for a long time.

The net result of a century's study of earthquakes is that,



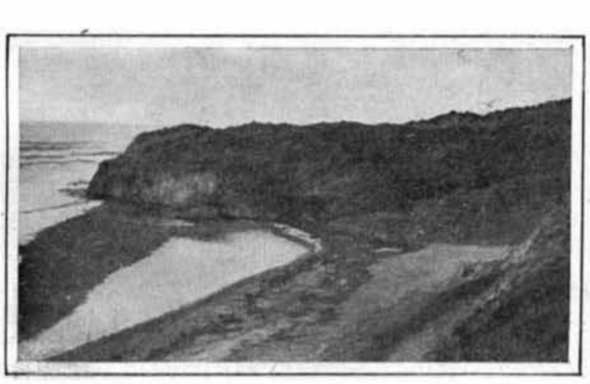
The Post Office and the Neighboring Sidewalk Were Torn Apart Leaving a Crack That Varied from Six to Ten Inches.



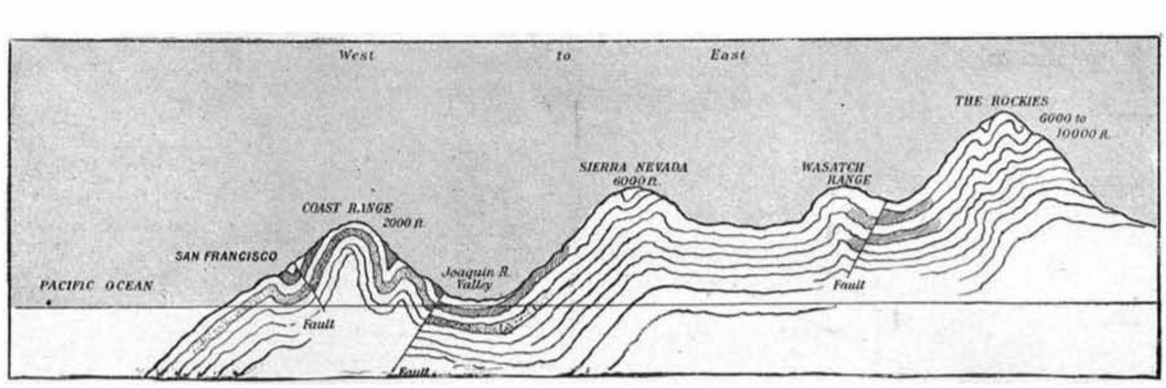
Record of Earthquake Made at Napa, Cal.

Fissure Produced by the Earthquake in a San Francisco Street.

Street and Railroad Track Elevated by the Earthquake at the Post Office.



Point of New Land Formed Four Miles from Colma, Cal.

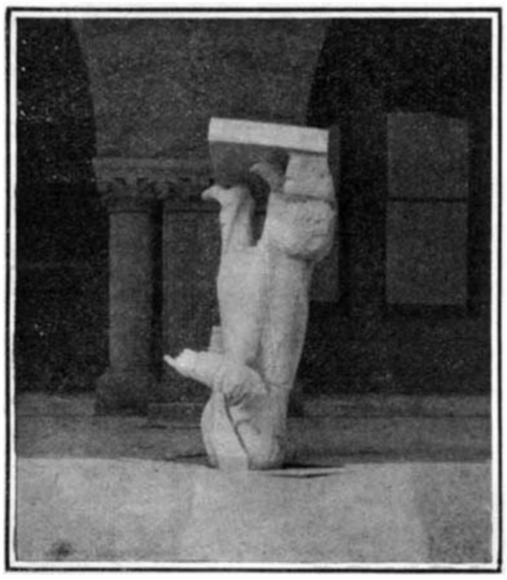


The Crumpling of the Pacific Coast Strata; the Earthquake Was Due to the Slipping at a Fault.

EFFECTS OF THE EARTHQUAKE AND FIRE UPON THE CITY OF SAN FRANCISCO AND ITS BUILDINGS.

when the first impulse is single, or, if compound, the varying impulses seem to be merged into one severe shock, then this initial shock may be followed by one, two, or three others; they rapidly grow weaker and wane into imperceptible tremors. That is what the San Francisco earthquake did. There were from twenty-five to thirty impulses. At the students' observatory at Berkeley, from April 18 to 26, inclusive, thirty-two tremors were recorded, the highest intensity registered according to the Rossi-Forel scale being 5, and the longest duration being eight seconds.

After a careful examination of the business district of San Francisco, some of the best architects and structural engineers have come to the conclusion that Class



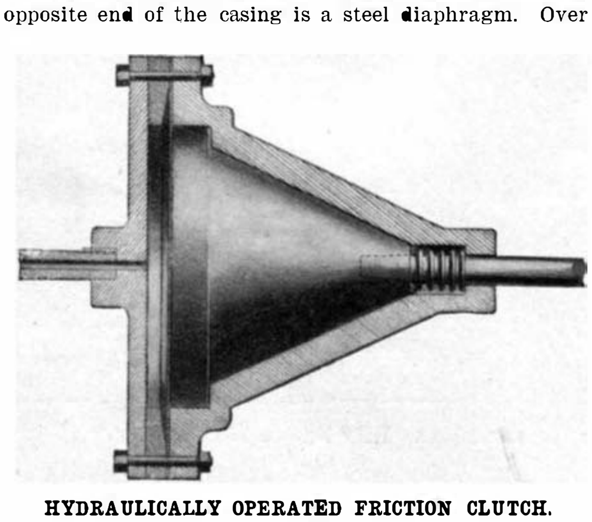
THE STATUE OF AGASSIZ IN ITS PRESENT POSITION.

A buildings can be made fire-proof and earthquake-proof. The Merchants' Exchange Building, the Claus Spreckels Building, the Kohl (formerly Hayward) Building, the Grant Building, the Chronicle Building, the St. Francis and Fairmount Hotels, show that a city can be built of structures that will come almost unscathed out of such an ordeal as the earthquake and fire that recently laid San Francisco waste. A strictly Class A building is one into the construction of which wood does not enter.

The finest buildings of the city, though gutted of everything that was not steel, concrete, granite, or marble, are still structurally sound. The principal ones standing are the Merchants' Exchange Building, the Mills Building, the Kohl Building, the Crocker Building, the Union Trust Building, the United States mint, the new United States post office, the James Flood Building, the Hotel Hamilton, the St. Francis Hotel and the Hotel Alexander next to it; the Shreve Building, the Claus Spreckels Building (the tallest building in the city), the Mutual Savings Bank Building, opposite to it; the new fifteen-story Chronicle Building, the Sloane Building and the Telephone Company's building on Bush Street. The Pacific Mutual Life Building and the great Fairmount Hotel are structurally sound. The Appraisers' Building on Washington and Battery Streets, though surrounded by ruins, was undisturbed by earthquake or fire.

AN IMPROVED ADJUSTABLE CLUTCH.

Pictured in the accompanying engraving is a clutch of such construction that it can be very accurately adjusted for transmitting various powers. The clutch is a friction clutch of the cone type, and its chief novelty lies in the fact that it is operated by hydraulic pressure, the water being admitted to the clutch through a hollow shaft. Carried by the other shaft is a cone formed with a step or annular shoulder at its base. Fitted over the cone is a casing formed with a recess to admit this shoulder. At the apex of the cone another recess is formed in the casing to receive a coil spring which presses against the cone and holds it clear of the casing. The cone shaft passes freely through an opening in the casing. Attached to the opposite end of the casing is a steel diaphragm. Over this diaphragm a ring is placed, and it serves to space the diaphragm from the rear cover plate of the clutch, which is bolted to a flange of the casing. A chamber is thus formed between the diaphragm and the plate, and this chamber communicates through a port in the plate with the hollow shaft of the clutch. The plate is keyed to this shaft, so that when the latter turns it carries with it the diaphragm and the cone casing, but normally it moves independently of the other shaft and its cone. However, when water is admitted into the chamber, it flexes the diaphragm against the cone, firmly seating the latter in the casing, and thus coupling the shafts together. The frictional engagement of the cone and casing may be easily regulated by controlling the pressure of the water. The inventor of this improved clutch is Mr. Rutgers S. Kasson, of 1306 Delaware Avenue, Wilmington, Del.



HYDRAULICALLY OPERATED FRICTION CLUTCH.

The International Aeronautic Cup.

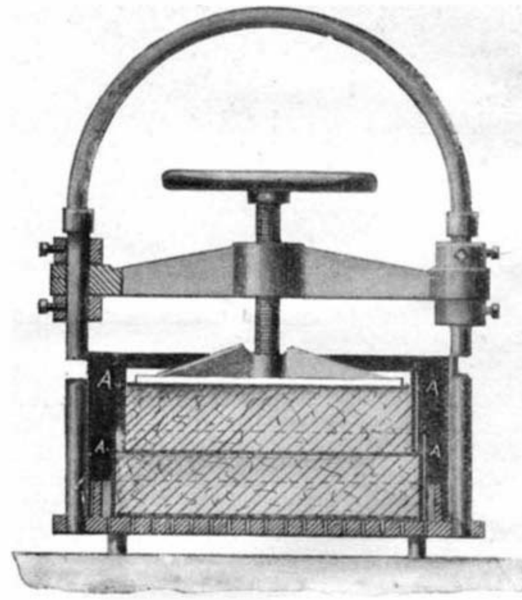
We have been able to obtain some particulars as to the engagements which have been entered at the Aero Club of France for the International Aeronautic Cup. This event has been founded by Mr. James Gordon Bennett and bids fair to be of exceptional interest, seeing that a number of balloons of different types and coming from several countries of Europe as well as from America are to be represented. The list of engagements has already closed at the Aero Club. Among the balloons which are to take part in the event we note the following: From Germany we have two entries from the aeronautic club known as Deutscher Luftschiffer Verein. The first is Baron von Hewald, of Berlin, who has a record of seventeen balloon ascensions, and will pilot a large balloon. Second comes M. Hugo (an assumed name) who has already made fifty-nine ascensions. Belgium enters the ranks under the auspices of the Aero Club de Belgique. M. Van den Driesche, who distinguished himself in different events held in Belgium last year, will mount the "Ojouki," a balloon of 2,500 cubic yards, made of China silk. The Spanish champions are J. F. Duro, the winner of the Pyrenees Cup; Capt. Kindelau, winner of the Madrid concourse; and Don Esteban Guteriez, of Salamanca. The Spanish aeronauts will have three balloons of 2,300 cubic yards. Italy is represented by Alfred Vonwiller, a member of the Societa Aeronautica Italiana, and a well-known champion, having made one of the most recent passages across the Channel and several other fine performances. He will mount a balloon of French silk, of 1,800 cubic yards, the "Elfe." As regards the English, American, and French entries we will give the details very shortly. The event is to take place on the 30th of September, 1906, and will no doubt be one of great interest as well as an aid in the development of aeronautics.

A Prize for an Automobile Road Indicator.

Baron Henri de Rothschild has offered the sum of $200 to the Paris Academy of Sports to establish a prize for the best form of "odotachymeter" or instrument for use on an automobile or any other kind of car for indicating at the same time the distance which has been traveled over and the instantaneous speed at any given moment. A concourse of such devices is to be held by the academy and the above amount will be awarded in one or several prizes. The Technical Committee of the French Automobile Club has been charged with drawing up the regulations for the concourse and naming the jury. According to these rules the international concourse will be held on the first of May and the following days. The prizes will be awarded for one or several apparatus which best answer the conditions of the tests. The competitors are to furnish a drawing or detailed description of the apparatus and also an actual instrument mounted upon an automobile of a type which is accepted by the Commission.

AN IMPROVED HAND-OPERATED MEAT PRESS.

The accompanying engraving illustrates a new hand press which is adapted particularly for pressing meat, although it can also be used for pressing fruit and vegetables. Meat pressers as heretofore constructed have usually been made with but a single meat box. The construction here illustrated comprises a series of meat boxes, each fitting into the one below, so that the device can be used for compressing any desired amount of meat within the limits of the press by simply using the required number of meat boxes. Furthermore, by the use of different boxes, a number of different kinds of meat can be pressed at the same time. The boxes with the meat pressed therein can be placed in an ice box, or the press itself can be provided with an ice-holder, so that the meat can be left to cool under pressure. The press is of simple construction, comprising a perforated base supported on four short legs, and carrying two upright standards which are braced together at their upper end by an arched coupling member. A crosshead is mounted on these standards and can be secured at any desired height by means of collars adjustable on the standards. Threaded through the crosshead is a hand-screw, which is adapted to press the press-plate down onto the meat. The boxes for the meat are so made that they can be readily taken apart when desired, to remove the meat. Each box consists of two angle pieces, which are fastened together at opposite corners by hinge pins. The boxes have no bottoms, but perforated plates are placed between the layers of meat. Each box is formed with grooves at opposite corners, which serve as guides for the box above; also with a series of perforations, *A*, through which the water and grease expressed from the meat in the box above may pour out. Vertical walls on the base serve to confine these liquids so that

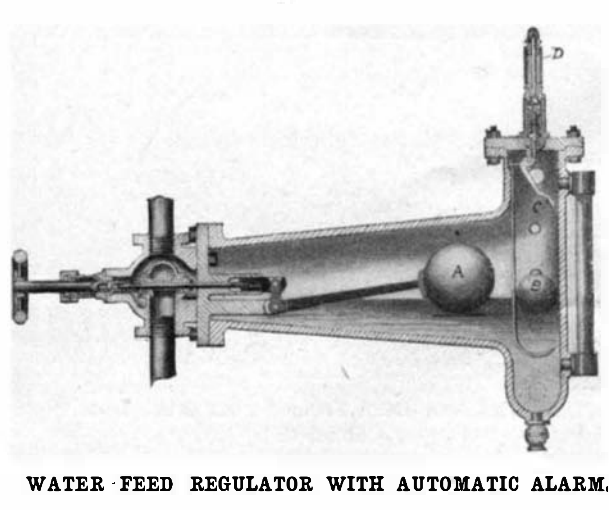


A MULTIPLE MEAT PRESS.

they will pour through the perforations in the base-plate. When it is desired to cool the meat in the press, a large box is placed about the meat boxes, as shown in the illustration, and this is filled with ice. Mr. Jacob Spengler, of 515 Tenth Street, North Great Falls, Mont., is the inventor of this improved meat press.

WATER-FEED REGULATOR WITH AUTOMATIC ALARM.

A patent has recently been granted to Mr. H. W. Adams, of Fargo, North Dakota, on an apparatus for regulating the supply of water to boilers, which is provided with both high and low water signal devices. Our illustration shows a section of the improved apparatus. The main casing of the regulator is formed with a horizontal body portion ending in a vertical head. The latter is provided with the usual steam and water connections, and carries the gage-glass and gage-cocks. Within the main body of the casing is a spherical float, *A*, attached to the longer arm of a bell-crank lever. This lever is fulcrumed to a bracket, and its shorter arm engages a slide. Connected by a threaded stem with this slide is a valve, which operates to close or open the feed-pipe of the boiler. The position of the valve can be regulated by screwing the stem into the slide. This is done by means of a short rod which has pin-and-slot connection with the stem, as clearly shown in the engraving. Under the float, *A*, is a plate, secured thereto, which serves to prevent the float from jumping or churning under the action of the feed pump. The signal float, *B*, is placed in the vertical head of the regulator, and at the upper end of the chamber is a bell-crank lever, *C*. Attached to the shorter arm of the lever is a rod, which serves to retain the float, *B*, in its proper position. At its lower end this rod is curved under the float. When the water falls dangerously low in the chamber, the float, *B*, will rest on the curved end of the rod, and swing the lever, *C*, on its fulcrum. A boss on the latter will then lift the valve, admitting steam to the whistle, *D*. The engineer will thus be signaled that there is something the matter with his feed pump or that the regulator valve has jammed. Similarly, when the water rises too high in the regulator chamber, the float, *B*, will strike the longer arm of the lever, *C*, lifting the whistle valve and sounding the danger signal.



WATER FEED REGULATOR WITH AUTOMATIC ALARM.