Railroad in this city. Great as are the proportions of the superstructure, with its great façades reaching for 780 feet in one direction and 430 feet in the other, it forms but the lesser portion of the station considered as a whole, with its tracks, switching yard, platforms, stairways, carriageways, baggage rooms, and other etcetera of a great terminal structure such as this. Moreover, this latter and larger half of the station, when the whole thing has been completed, will be entirely hidden from sight in a huge excavation lying entirely below the surface of the ground. It is to the vast preliminary work of preparation involved in digging out the underground portion of the terminal, that the present article is devoted.

If the reader will turn to the front page engraving, and bear in mind that it is a reproduction of a photograph which was taken from the tenth floor of a building lying to the northeast of the station site, he will get a clear idea of the form and size of the vast hole which is being dug in the heart of New York city. The excavation, which forms a parallelogram, includes two large city blocks. It is bounded on the north by Thirty-third Street, on the south by Thirty-first Street, on the west (the further end of the excavation as shown in the picture), by Ninth Avenue, and on the east, immediately in the foreground, by Seventh Avenue. Since the original dimensions were determined upon, however, two additions have been included—one on the southerly side, and the other on the easterly end. The southerly addition consists of a square plot for a power house measuring 90 by 160 feet. It will be noticed in the engraving, lying a little to the east of the long trestle that bisects the excavation at its center. The easterly addition, which measures 250 by 200 feet, will be seen in the immediate foreground. It extends from Thirty-second to Thirty-third Street, and it was purchased in order to afford accommodation for the convergence of the tracks where they leave the station to pass by two tunnels under Thirty-second and Thirty-third Streets, below Manhattan Island and the East River, to Long Island City. The total length of the excavation, including this last-named addition, is 2,050 feet, and its width is 500 feet. The total depth to which it must be finally excavated is 45 feet at the easterly end and 60 feet on the Ninth Avenue end, the average depth being about 50 feet. The total amount of material to be taken out is 2,000,000 yards, of which about one-half is rock.

As one looks at the long stretch of desolation presented by the station site to-day, it would be easy to suppose that either fire or a tornado had swept it bare of human habitation. Only three or four years ago the site was covered with over four hundred houses, stores, and other buildings, and was filled with some five or six thousand souls. The preliminary work of clearing away the buildings was not by any means the smallest task connected with the preparatory work for the new terminal station. The site once cleared, the work of excavation was of a very straightforward character and consisted of drilling, blasting, and steam shovel work. It was on July 1, 1904, that the cleared ground was ready for the New York Contracting Company, who had the job of excavation in hand, to commence operations.

Among the first portions of the work to be attacked was that of building the massive concrete retaining wall which runs entirely around the excavation. This is a big task in itself; for the wall is everywhere carried down to rock and for much of the distance extends to the full depth of the excavation which, as will be seen, averages 50 feet. The top of the wall is everywhere 5 feet in width, and it is built on a batter which brings the width in the deepest portions of the wall to an extreme base of 30 feet.

One of the problems which had to be met was that of maintaining the important thoroughfares which cross the station site. The principal of these is Eighth Avenue, and it was necessary, as the excavation proceeded, to build a massive trestle work with which to support not only the full width of the roadway, but the heavy sub-structure of the underground trolley electric road. Similar provision had to be made for Seventh Avenue, on that part of it which crosses the northeasterly addition to the excavation already referred to.

The problem of removing the 2,000,000 yards of excavation was a serious one in itself, and it will interest our readers to know that not a single cartload has been taken through the streets of New York city, the whole of it having been hauled by locomotives to the North River and dumped into scows to be disposed of on the Jersey shore. For handling the material a new wharf was built at the foot of Thirty-second Street and the North River. Along the wharf was constructed an elevated railroad which was extended through Thirty-second Street to about the middle of the block between Ninth and Tenth Avenues. At this point the tracks were carried down to, and under, Ninth Avenue, and into the station excavation. The whole of the work is covered with working tracks, which are shifted from time to time as the excavation proceeds, and all of these tracks converge to the deep cut below Ninth Avenue, of which we present an illustration. The material is loaded upon the cars either directly by steam shovels or derricks, and the loaded trains are hauled out to the North River dock, where the material is dumped into the chutes and discharged into the waiting scows. It is then towed down to Greenville on the Jersey shore of New York bay and used for filling in the huge freight yard, which the company is constructing at that point.

The force employed on the work has varied according to the conditions, nature of material, etc. The maximum force employed was about two thousand men, of which two-thirds were employed in day work, and the other third at night, and as much as 125,000 cubic yards a month has been taken out. At present the work is almost entirely rock excavation, and for this a total of about 700 men, including drillers, blasters, trackmen, etc., is engaged. Between sixty and seventy per cent of the work has been completed. As soon as the excavation has been carried down to grade, the steel columns will be erected and the steel and concrete floors put in place. When this work has been brought up to street level, the walls of the great station proper will begin to go up. It is the object of the company to so time the progress of the various sections of the work that no portion will have to wait upon any other, and the whole of this stupendous scheme of tunnels, terminal yards and passenger station may be brought to completion with the least loss of time and money through the enforced idleness of plants or delay of working forces.

Automobile Notes.

At the automobile carnival held last week at the Empire City track, some tests of technical interest to automobilists were held. Among the first day's events for touring cars were a flexibility test to show the range of speed on the high gear, and a braking test. In the former of these tests a circuit of the mile track was made at high speed, and then one-quarter mile was covered at the slowest possible pace that could be maintained on the high gear. The results were as follows: 50-horse-power Welch, mile in 1:21 2-5 (44.22 m. p. h.); ¼ mile in 2:34 (5.84 m. p. h.); speed variation, 39.38 m. p. h. 30-horse-power Marmon (4-cylinder air-cooled), mile in 1:37 4-5 (36.80 m. p. h.); ¼ mile in 2.17 1-5 (6.54 m. p. h.); speed variation, 30.26 m. p. h. 24-horse-power Clement Bayard, mile in 1:40 (36 m. p. h.); ¼ mile in 2:32 (5.92 m. p. h.); speed variation, 30.08 m. p. h. 24-horse-power Aerocar (4-cylinder air-cooled) mile in 2:07 2-5 (28.25 m. p. h.); ¼ mile in 3:27 4-5 (4.66 m. p. h.); speed variation, 23.59 m. p. h. 20-horse-power Northern (2-cylinder opposed) mile in 2:13 3-5 (26.87 m. p. h.); ¼ mile in 2:42 2-5 (5.84 m. p. h.); speed variation, 21.33 m. p. h. A 24-horse-power Autocar made a mile in 1:40 2-5 (35.85 m. p. h.), but the driver was disqualified for slipping his clutch when making the low-speed test. In making the brake tests the cars were obliged to travel at the rate of 40 m. p. h. for ⅛ of a mile before the brakes were applied. An Oldsmobile touring car stopped in 168 feet, and two other touring cars in 175 and 177 feet respectively. A Welch touring car ran an exhibition mile in 1:14, and a 12-horse-power Franklin touring car carrying four passengers beat a 24-horse-power Frayer-Miller touring car, winning a mile race in 1:45. Both these cars were air-cooled, and both have an enviable record for efficiency and economy.

Two hill-climbing tests of interest were held recently, one at Wilkes-Barre, Pa., on a hill christened "Giant's Despair," and another at Worcester, Mass., on what is known as "Dead Horse" Hill. The former hill is about 1⅛ miles in length and is full of "thank you ma'am's" and curves. The average grade is around 15 per cent and at places it reaches 27 per cent. The best time was 2 minutes 11 1-5 seconds. This was made by a 45-horse-power English Daimler touring car. A 50-horse-power 6-cylinder Stevens-Duryea touring car scored second in 2:27; and a 24-horse-power Pope-Toledo third in 2:56 4-5. A 22-horse-power double-opposed cylinder Buick car made the climb in 3:00 4-5; a 45-horse-power Pope-Toledo in 3:12, and a 35-horse-power Rambler in 3:18 1-5. The "Dead Horse" Hill course is one mile in length and straight. S. B. Stevens, on his 80-horse-power Darracq that ran in the last Vanderbilt cup race, covered this distance in 1 minute and 2 seconds, thus reducing by 7 seconds the record he made last year in his 90-horse-power Mercedes. A special 100-horse-power Stanley steamer, which is said to have made the climb in 50 seconds, was damaged and did not run. A 6-cylinder Stevens-Duryea was second in 1 minute 9 3-5 seconds, a 20-horse-power Stanley steamer third in 1:26, a 24-horse-power Pope-Hartford car fourth in 1:50, a 22-horse-power Buick fifth in 1:52, and a 16-horse-power Reo sixth in 1:58 1-5.

The Austrians use a stone blotting-pad that never wears out. A little scraping with a knife cleans it effectually.—Philadelphia Bulletin.

Correspondence.

Liquid Air and Powder Chamber Temperature.

To the Editor of the Scientific American:

In your issue of May 5 your editorial calls attention to the report of the National Coast Defense Board, in which it practically acknowledges defeat so far as greater velocity is to be obtained by large-caliber guns.

I have not noticed a report of liquid air being used for the purpose of keeping down the temperature of the gases; and while I have not had the opportunity of making tests in this line, I would like to see some experiments made to see if liquid air can be successfully made use of to this end, by placing a small quantity, say 25 or 30 cubic inches, at the back of the shell, or use a double shell, so there will be a wall of liquid air all around the explosive, the intense heat of which will instantly expand the liquid air eight hundred times, thereby reducing the temperature sufficiently to preserve the gun from erosion. L. C. M.

Houston, Texas, May 17, 1906.

Earthquakes and Steel Construction.

To the Editor of the Scientific American:

In your copy of April 28 I read the article about "Earthquake-Proof Construction" in which you recommend concrete steel for the reconstruction of San Francisco. Why not use steel and iron only, the same as on steamboats and other strong sea-going vessels? After a good, strong steel framework put in iron or steel panels between and also iron or steel floors and partitions; let such walls or panels and partitions be very light, perhaps not much thicker than sheet iron, which also could be made very ornamental and artistic, the same as steel ceilings are made now. The floors, naturally, should be made stronger. Such a building should be strong and elastic enough to withstand any earthquake; besides, it would be fireproof, and on account of the mild climate in California it would be comfortable to live in. Another thing which you advocate is a water tank on top of each building, at least in the business part of the city. Now, why not build large water tanks right under the streets in front of every large building?—because, if put on top of a building, they are apt to tumble down in case of an earthquake. If such tanks were put in the center of the streets with a manhole on the top, the firemen could very easily let down a hose and suck the water up with their fire engine; besides, such tanks would be most available at all times.

If my idea is wrong, kindly let me know where and why, because I would very much like to have your opinion about this. Please give me an answer through the Scientific American. A. Mayn.

Amsterdam, N. Y., April 28, 1906.

[It would be practicable to erect all-steel buildings; but concrete-steel would be cheaper and equally earthquake and fireproof. Water tanks under the streets would be too costly to be practicable.—Ed.]

The Metric System.

To the Editor of the Scientific American:

The Scientific American has committed itself as in favor of the introduction of the metric system of weights and measures, and this supposedly means the metric system exactly as it is used in France and other countries and without any modifications whatever. Scientists, as a rule, take this position with the exception of those whose work is in connection with the manufacturing end of a business; manufacturers, whom the change would affect most, are almost all against it; the most eloquent argument in this respect is the array of names and opinions recently collected by Mr. Halsey.

The metric system is consistent and excellent in many respects, and, had it been introduced into English-speaking countries at the time when it was introduced in France, it would have stayed and possibly have flourished. At the present time, however, a law such as that proposed by Mr. Littauer could not be enforced; manufacturers who will not or cannot face the expense, and buyers who are satisfied with the present measures, would stand united, and government interference would be impossible. There is no demand for metric measures from the buyers of mechanical or mechanically made goods. If the government insisted on purchasing metrically, the number of bidders would decline, prices go up, and deliveries be slow.

The division into halves and quarters is the most natural, and I will ask you to take a look with me at certain details of the domestic life of the country which has had the metric system in use for the longest period of time.

Come with me to a French market. The first stall is the dairyman's. "How much is this butter?" you ask. "Thirty-eight sous a pound," is the answer; not "Three francs sixty a kilo." If you ask the vender to give you 125 grammes, he will take you for a foreigner, and will bill it as "un quart." Eggs will be thirty sous a dozen; nothing is sold by tens. Potatoes you buy by the bushel (*boisseau*), which is not metric, and a *barrique* of wine holds 227 liters. You buy cloth by the meter, half-meter, and quarter-meter, and the salesman would lift his eyebrows if you asked for 60 or 70 centimeters of ribbon.

The centime is to the American cent as the millimeter is to the inch. It is too small, and everything therefore goes by five centimes, commonly known as a *sou*. The centime does not harmonize with the coins in use.

The millimeter for engineering purposes is very inconvenient. I speak from experience. The natural divisions of the inch into halves, quarters, and eighths do not give us over three decimals; and if into sixteenths—which is a better working size than the millimeter and not very much longer—four decimals, the last being in all cases a 5. With the French system an 18-inch lathe becomes a 225-millimeter H.D.P. lathe; and to form a mental image of the swing a man is compelled to think of a height of 2¼ decimeters from the ways to the center. For very fine measurements the one-thousandth of an inch is in every way as satisfactory as the one-hundredth of a millimeter—I have found it more so—and all natural divisions down to thirty-seconds can be read in thousandths and halves or quarters of thousandths. We are, therefore, getting the benefits of both the natural and decimal divisions, and there seems to be no reason whatever for adopting a different standard unit which is as arbitrary as ours, when we, Anglo-Saxons, hold the controlling interest in the markets of the world.

When it comes to the laboratory, matters are very different, and I will agree that the interrelations of the gramme, the cubic centimeter, and the centiliter are of the greatest utility. For analysis, the milligramme and the centiliter are vastly superior to the English measures; but the quantitative work done in the laboratory in no way influences the weights and measures of the works to which these laboratories are attached.

Let us have the metric system by all means for laboratory work, but not for the vastly greater amount of work which does not require delicate instruments and intricate calculations. We cannot use a microscope on the stars or a telescope on bacteria, nor can we use a reading glass for either. A system which will suit both science and industry has not yet been devised.

If you will expend your spare energy on introducing the centigrade thermometer, killing off antiquated wire gages and the like, you will be working with a better chance of success than by backing a change which is not warranted by necessity, and not demanded by the majority of those who would be affected by the change. It is even opposed by the manufacturers of gages, whom you might expect to find in the forefront of its champions. ALFRED SANG.

Pittsburg, Pa., April 14, 1906.

Wood and Concrete Construction.

To the Editor of the SCIENTIFIC AMERICAN:

When your expert on concrete construction next discusses his specialty, please let him take up the practicability of using concrete or armored concrete in wooden framework. In brief, could it be used in walls between laths and weather boarding? If so used, would it do away with the necessity of rough-boarding? Could it do away with the laths, too? Would the steel bands, screwed or nailed to and between the joists, hold the joists and concrete sufficiently tight to prevent the joists from falling away as they dried out? If practical in walls, would it also do for use in floors, and if so, would it be of enough advantage from a fireproof and noise-deadening standpoint to warrant its use?

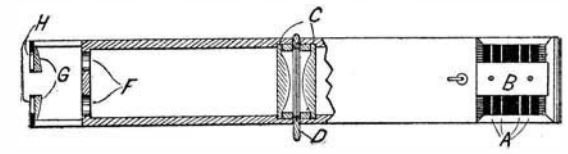
All these questions are asked by a decidedly amateurish delver into the mysteries of how to build the best home at the least expense consistent with good work. MORTON WATKINS.

No. 223 West 106th Street, New York city.

[It would hardly seem desirable to combine concrete construction with wooden framework, notwithstanding that there are apparently no technical difficulties to prevent this. The impracticability of the construction would lie in the fact that while the concrete would, of course, be fireproof and moisture-proof, the woodwork could not be considered to answer these requirements, and, therefore, the resulting structure would correspondingly be only semi-fireproof or semi-impervious to moisture. The woodwork would probably pull away from the concrete as the latter dried out, for not only would the concrete contract, but the wood itself would shrink when the moisture which it had absorbed from the water in the cement had evaporated. This shrinkage both of the wood and of the concrete would probably not be sufficient to cause much damage, and the steel bonds imbedded in the concrete secured to the wood would doubtless hold the structure rigid. If such a construction were used, the builder would probably be able to dispense with rough-boarding, and the resulting partitions and floors would undoubtedly be more nearly soundproof than an ordinary frame construction. It would be far better to build directly of concrete, and probably the expense would be no greater in that case.—ED.]

APPARATUS FOR VIEWING DIFFRACTION COLOR PHOTOGRAPHS.

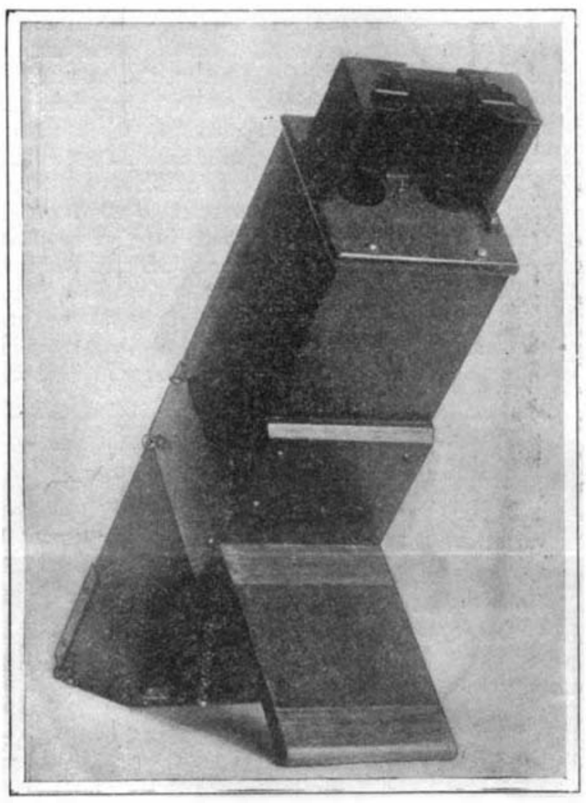
Some seven years ago Prof. R. N. Woods, now of Johns Hopkins University, Baltimore, described his new diffraction process of color photography, which was a novelty on account of its simplicity. The process is fully described in the SCIENTIFIC AMERICAN SUPPLEMENT No. 1227. Until recently no satisfactory instrument was invented for viewing the diffraction color photographs. The improvements in this line



INTERIOR OF THE DIFFRACTION CHROMOSCOPE.

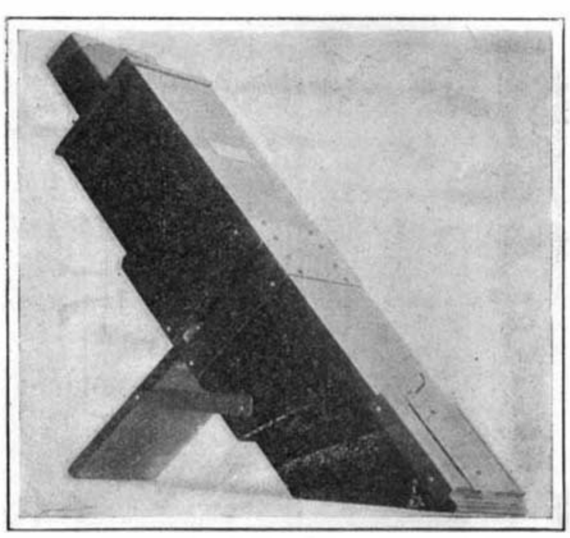
have been made by Mr. Herbert Ives, B.Sc., and Mr. Fred. E. Ives, the inventor of the kromoscop, which greatly simplify the necessary apparatus and considerably reduce its cost. It is called a multiple-slit diffraction chromoscope.

The diffraction color photograph is preferably made on a small plate of glass about the size of a lantern slide for convenience of handling and viewing, although there is no reason why it may not be made larger. The diffraction photograph is a mosaic com-



VIEWING END OF THE DIFFRACTION CHROMOSCOPE.

posite image in regularly spaced microscopic indented lines of three photographic color records, representing the primary colors, red, green, and blue. The red element of the composite color record is made up of 2,406 lines to the inch, the green of 3,000 lines, and the blue of 3,606 lines. The method of manufacture is to print on a bichromatized film respectively one after the other and over each from negatives originally taken in the camera, through screens of red, green, and blue with gratings of lines as above mentioned;



THE IVES DIFFRACTION CHROMOSCOPE.

then developing the composite print in the usual way by hot water. From this plate duplicate impressions can be made by a special method. This duplicate, exactly a counterpart of the original, is bound between two plates of glass, and becomes the medium for producing the colors when viewed in the instrument. If the glass plate is held up to the light behind a sheet of white paper, it appears to be perfectly clear. When put in the instrument the light is dispersed evenly as it passes through the plate, and the colors are reproduced exactly as in nature.

The diffraction chromoscope is essentially a dark box with a slit at each end and lenses in the middle to pick up light from one slit and concentrate it upon the eye at the other slit. If both slits are placed in the axis of the box, and the photograph inserted, it shows no color whatever; but if either slit is displaced in a direction parallel to itself, the direct light is no longer brought to the eye, but at the correct position light bent and dispersed by the microscopic diffraction lines takes its place, and owing to their disposition and distribution the colors seen correspond exactly to the colors of the object photographed. Mr. Ives's diffraction chromoscope has four primary slits instead of one, utilizing first and second order spectra on both sides of the axis, and thereby securing sufficient illumination to permit of use in diffused daylight, which would otherwise be impossible.

In the diagram *A* represents the four slits, with a central plate, *B*. Directly under *B* is a mirror which reflects the light upward through the plano-convex lenses, *C*, about three inches in diameter, also through the photograph, *D*, and openings, *F*, through the eye lenses, *G*, cemented to the inner side of the glass slits, *H*.

The hook shown just above the plate *B* is to hold an incandescent light for artificial illumination.

The upper illustration shows clearly the viewing slits, the hinged brace for supporting the box, and on the side is a pivoted plate which can be swung around by removing the screw eyes, for the purpose of taking out the lenses for cleaning.

The lower illustration shows the slot opening on the side of the box for inserting the picture, the latch for locking the supporting brace, the plate and slits at the bottom, and the hook for locking the hinged mirror. By releasing the hook the mirror can be folded back on the box to be cleaned.

By using four primary slits in the bottom, a greater quantity of light is admitted, giving correspondingly a more brilliant illumination of the image than would be the case if but one slit was used.

Altogether, it is about the simplest natural color reproducing apparatus yet devised, not liable to get out of order. It is calculated to excite wonder and astonishment to those unfamiliar with the optical principles involved, for from an apparently invisible picture without color is reproduced one perfect in color. Mr. Ives has devised special cameras for producing the original negatives.

The Current Supplement.

The current SUPPLEMENT, No. 1587, has for its first-page article two views of the Brunnen-Morschach Alpine railway. "Some Practical Experiences with Steam Turbines" is by C. E. Stanton, and will be welcomed by all engineers. "Reservoir, Fountain, and Stylographic Pens" is a continuation of a valuable series. "Cement Materials and Industry of the United States" is by Edwin C. Eckel. "Electricity in the Home" is a finely illustrated article showing novel electrical contrivances. "Surveying on the Farm" is a valuable article. The Science, Electrical, and Engineering Notes will be found in their accustomed places.

Lower Foreign Postal Rates.

The Congress of the International Postal Union, which has been in session at Rome, practically completed its labors on May 22. The Congress has inaugurated several changes which directly affect the public, and the most important of these is the reduction of the rates of foreign postage for heavy letters. Not only has the unit of weight been raised from 15 to 20 grammes, but the postage has been decreased as well from 5 cents to 3 cents for each unit of weight in addition to that constituting the first charge.

As the Anglo-Saxon countries do not use the decimal system, these changes will be even more favorable to them than to those which use the system, for the British delegates succeeded in obtaining the ounce as the unit equivalent to 20 grammes, while as a matter of fact an ounce is in excess of 28 grammes. Unfortunately, the British and Japanese proposals for a reduction of the initial rate to 4 cents failed. Universal penny postage advocated by New Zealand was not considered practicable. Other important changes were instituted relative to the internationalization of the right to use the left-hand portion of the address side of picture post cards for writing other than the address, and the use of post cards having an attached reply coupon.

The manufacture of cement in the United States continues to make remarkable progress. Whereas in 1890 there were sixteen factories, producing annually 335,000 barrels of Portland cement, there were, in 1905, eighty-two plants, with an estimated annual output of 31,000,000 barrels. The manufacture has increased about a hundredfold in sixteen years, for in 1889 the total production was 300,000 barrels. Since the great extension of the use of this material, the amount of natural cement produced in America has rapidly declined.