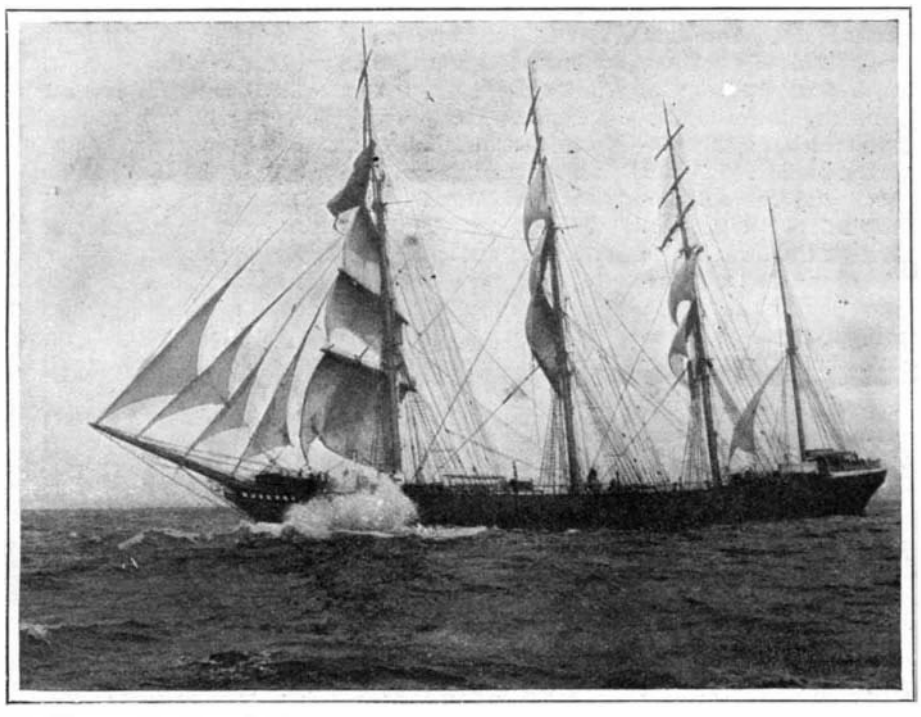
tives of the Bavarian railways. The ratio of volumes, high-pressure to low-pressure cylinders, has, at the same time, been decreased. The driving wheels are the largest that have yet been employed for four-cylinder compounds on the European continent. The principal object in the design is high speed with a light load, for which the 32 tons maximum adhesive power will be fully adequate. Compounding and superheating are introduced as contributing to this end, while the total mechanical efficiency is increased at the cost of some few tons of weight extra, which has, in large part, been compensated for in the general design of the locomotive.

This engine, the first of a new series, was designed and built by the firm of J. A. Maffei at the English Garden Works, near Munich.



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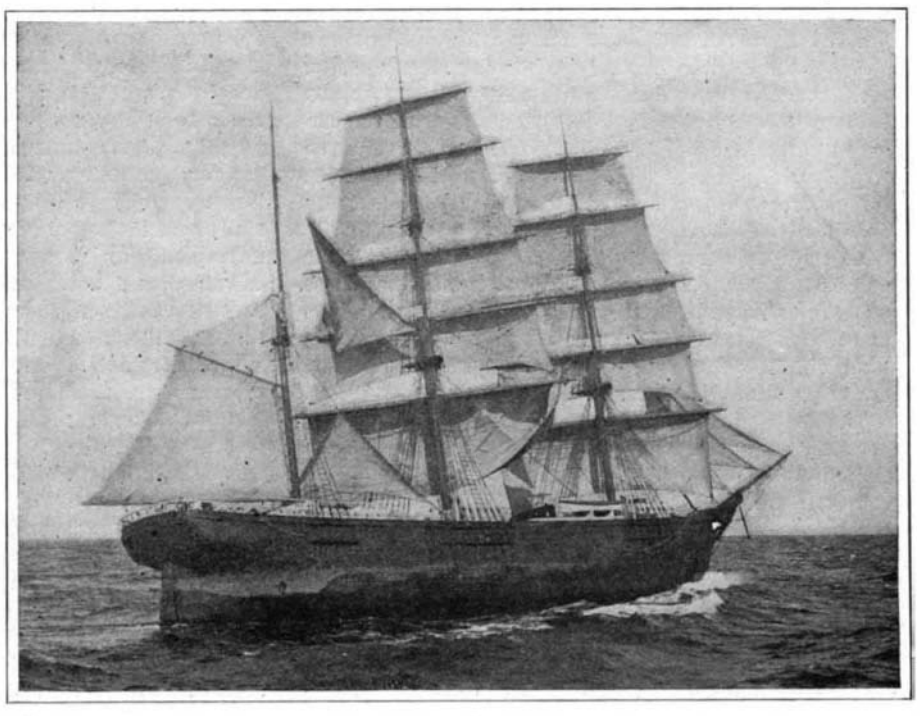
The English Ship "Muskoka," One of the Types of Vessel Charged with Running the Regulation Square-Rigger Out of Business.



The Bark "Coloma." A Type Which Made Its Appearance Many Years Ago, and May be Considered a Forerunner of the Modern Sailing Freighter.

THE PASSING OF AMERICAN SQUARE-RIGGED VESSELS.

BY JAMES J. M'CURDY.

That the American square-rigged sailing vessel is being gradually forced from the ocean highways, where it was long an important factor in the world's carrying trade, has been apparent for some time to those well versed in maritime affairs. That the conditions which have brought about this result were likely to continue, thus rendering the future of this portion of our deep-sea merchant marine one of extreme uncertainty, was also quite well understood.

Yet few have realized that the outlook for vessels of this type is as serious as has been set forth by the Commissioner of Navigation in his last annual report, lately from the press.

Under the caption "Decline in American Square-rigged Shipping," the commissioner discusses the situation at some length, and places himself on record as of the opinion that the existence of our square-rigged fleet cannot under present conditions extend beyond the period of twenty years. The statistics submitted in support of this estimate seem logical and convincing.

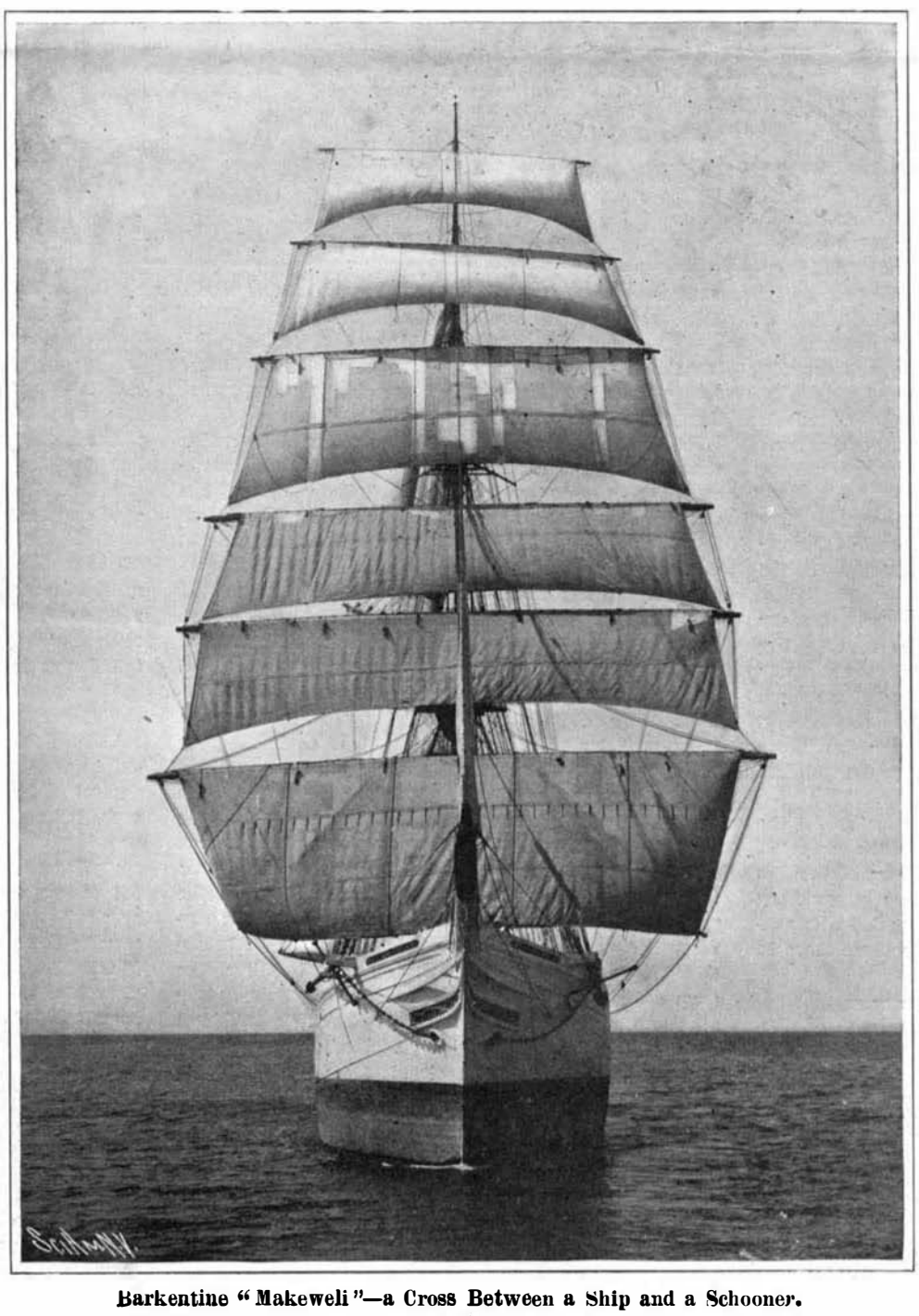
On June 30, 1894, there were 633 square-rigged vessels flying the stars and stripes. By June 30, 1904, the number had diminished to 322, a decrease of 311, or 49+ per cent. This, too, in face of the fact that by the annexation of Hawaii, 18 fine square-riggers were added to our merchant marine.

A second consecutive year has passed without the building of even one square-rigged vessel in the United States, something never heard of before. As the commissioner tersely expresses it, "the construction of square-rigged vessels has probably not entirely ceased in the United States, but the future output will not equal the loss through wreck, abandonment, and cutting down into barges."

The history of the square-rigger is inseparably interwoven with that of our country, and those who are conversant with the career of this type of vessel, will view its retirement with feelings of genuine regret. Authorities all agree that it was the handsomest rig of vessel that has ever engaged in traffic upon the ocean. There was beauty in every curve of the famous clippers that sped across the deep, and long before the era of arrogant steam, they had carried our flag to every seaport of the globe, and had given us a standing among the nations of the world.

Sentimental reasons do not alone enter into the feelings of regret that the rapid disappearance of these vessels excites. Originally the craft "which drew the world together and spread the race apart," they developed a type of seamen such as the world had never seen, and which can never be duplicated under steam navigation.

Those competent to express an opinion, hold that there would be a serious national loss to safe navigation if the square-rigged fleet were allowed to die out as rapidly as it seems destined to do under prevailing conditions. The time will doubtless come when ship training will not be deemed essential to the successful navigation of an ocean steamer; but at the present moment many cling to the idea that those in command of steamships should have had preliminary schooling on a square-rigger. In other countries, notably Germany, large steamship corporations keep in reserve sailing vessels, where the future officers of their steam fleets can receive training.



Barkentine "Makeweli"—a Cross Between a Ship and a Schooner.

It is quite the fashion at the present time to place the responsibility for the decadence of American sailing vessels entirely upon the foreign ships that have entered into competition with them; but this is only half a truth. It is a well-known fact that these foreign ships can be operated much more cheaply than ours. Then, too, some are helped by government bounties, as for instance the French vessels, which can sail around the world in ballast and still make a profit. Vessels of this character, placed in competition with ours, necessarily tend to depress freight rates, and likewise secure considerable business that would otherwise go to American vessels. But the fact remains that the foreign square-riggers are having almost as keen a struggle for existence as our own. When foreign shipowners allow fine large vessels to lie idle month after month in American ports, rather than attempt to run them at the ruinous rates that have prevailed for the past few years, it proves conclusively that the foreign owner of sail tonnage is not receiving much in the way of profits. Many foreign vessels, in the endeavor to keep in commission, have left Puget Sound ports with every cent of freight money drawn in advance and expended for loading and port charges, with the discharging expenses a dead loss to be borne at their journey's end. It was the foreign owners of sail tonnage that entered into an agreement not to accept charters below a certain figure, a movement that has had a tendency to improve rates, but to which American vessels have

lent no assistance whatever. Steam tonnage and vessels of the schooner type are largely accountable for the retirement of the square-rigger, whether it be American or foreign-built. The advantages of steam need no enumeration here. Schooners have many points of superiority over the square-rigger. They make quick passages, are good carriers, and can take on large deck-loads. They require but half as many men as a ship-rigged craft, as their sails can all be handled from the deck, and mostly with steam power.

Upon the Pacific coast the schooner is no longer merely a coaster, but has invaded the field formerly held by the square-rigger. We find them taking cargoes to China, Japan, Australia, South Africa, and even to Atlantic ports. As they can run so economically, they can make a profit on charters that would mean a dead loss to a ship.

As the schooner can do the work of a square-rigger, and do it at less expense, it stands to reason that those wishing to increase their sail property will build fore-and-afters instead of barks or ships. In like manner, later on, if conditions justify, they will build steamers in place of schooners.

The firm of Arthur Sewall, of Bath, Me., have endeavored for years to keep a fleet of square-riggers on the high seas, but now, after building ships since 1823, have announced that they will build no more. To-day, their fleet flag, which has been a familiar sight in all the great ports of the world for the last three-quarters of a century, is rapidly disappearing, even as their great shipbuilding plant is rusting to decay.

About sixteen years ago the Sewalls projected a fleet of fine ships, to bear the names of southern rivers. The "Rappahannock" was the first constructed, followed by the "Susquehanna," "Shenandoah," and "Roanoke," ranging in size from 2,700 to 3,500 gross tons. Misfortune followed in their wakes, and of these fine ships, only the "Shenandoah" remains. They made but little money for their owners, but demonstrated conclusively that under present conditions to build more vessels of their kind would be folly.

The practice of dismantling old ships and turning them into towing barges has been in vogue for some time, but converting stanch square-riggers into schooners is a somewhat new idea. Nevertheless, it has been done in several instances upon the Pacific coast with perfect success, and bids fair to become a general custom. Recently the "Snow and Burgess," an old State of Maine bark, was transformed into a five-masted schooner and has been beating all her previous records, besides cutting down her running expenses and increasing her carrying capacity. The old ship "Invincible," built in Bath in 1873, has also been converted into a schooner, and is again in commission after having been laid up for an indefinite period.

Of the 298 square-riggers in commission June 30, 1905, a large majority are in the hands of western owners, and are operating upon the Pacific coast. The lumber trade of the Pacific Northwest offered some inducements to these vessels, and some years ago a general exodus took place from the congested Atlantic ports to the Pacific, where ready employment was found as lumber carriers.

But now the time has come when even this trade is being rapidly absorbed by steamers and schooners, and to-day a number of these fine old vessels are loading cargo for Atlantic ports, to be dismantled upon arrival at their destinations, not many miles from where they entered upon their careers years ago. Dismantling, or conversion into schooners—such seems the fate of the remainder of the square-rigger fleet.

It is doubtful if any plan could be devised whereby the decadence of these vessels could be stayed. Any scheme of subsidy that could be enacted would apply to other forms of carriers as well, and would not tend to lessen the handicap under which ships are laboring. Nor does it seem probable that circumstances will so adjust themselves as to bring about a revival of this class of shipping.

The square-rigger has fulfilled its mission in the world's transportation system, and like the canoe of the trader on inland waters, or the ox-team of the pioneer upon land, it seems destined to pass into history as one of the utilities that was good enough in its generation, but must now be superseded by those more in keeping with modern requirements.

An aerial screw propeller working on a novel system has been invented by Major Hoernes, an aeronaut, says the Cologne Gazette. In his new contrivance the inventor takes advantage of the fact that the screw to be used in air has a wholly different medium to encounter than the ship's propeller, working in water, since air is capable of compression. He has, therefore, made use of a screw which is driven in a series of impulses, and not at one continuous speed, as is usually the case. He effects this by means of a system of screws, which not only revolve round their own axes, but also rotate round a common axis, planet fashion. The screw is thus driven alternately fast and slow.

THE TELHARMONIUM—AN APPARATUS FOR THE ELECTRICAL GENERATION AND TRANSMISSION OF MUSIC.

Dr. Thaddeus Cahill's system of generating music at a central station in the form of electrical oscillations, and of transmitting these oscillations by means of wires to any desired point, where they are rendered audible by means of an ordinary telephone receiver or a speaking arc, is now embodied in a working plant situated in the heart of New York. Although this apparatus constitutes but a portion of a plant that may ultimately assume very remarkable dimensions, and although it has limitations imposed by its size, the results obtained are so promising, that many applications have been made by prospective subscribers for connection with the central station. When a larger number of generators and keyboards is installed, as they doubtless will be in due time, there is no reason why the telharmonium, as the invention is called, should not give the subscribers all the pleasures of a full symphony orchestra whenever they wish to enjoy them. At present very beautiful effects are secured on a less elaborate scale, but in every way comparable with those of a good quintet. And several additional keyboards now in building at Dr. Cahill's works at Holyoke, Mass., where the New York plant was built, are nearing completion, and will probably be in service at Broadway and Thirty-ninth Street in the course of another month or two.

Perhaps the feature which most astonishes the technically uninformed man when Dr. Cahill's invention is first exhibited to him is the fact that music in the ordinary sense of the word, in other words, rhythmic vibrations of the air, is not produced at the central station. The vibrant notes of the flute, mingled with the clarinet or viol-like tones which are heard at the receiving end of the wire, spring from no musical instrument whatever. Nowhere is anything like a telephone transmitter used, although the electrical oscillations which are sent to the receiver and there

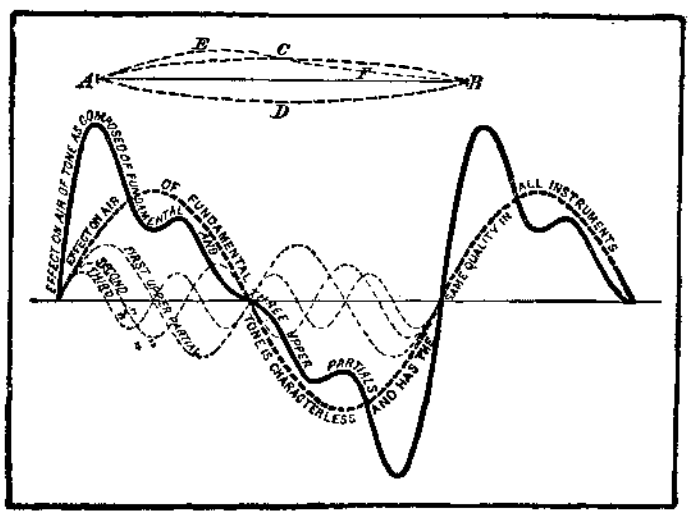


Diagram Showing Effect of the Upper Partials in Modifying the Fundamental Tone.

translated into audible vibrations are quite like those set up in an ordinary telephone circuit, except that they are enormously more powerful.

Briefly summed up, Dr. Cahill's wonderful invention consists in generating electrical oscillations corresponding in period with the acoustic vibrations of the various elemental tones desired, in synthesizing from these electrical vibrations the different notes and chords required, and in rendering the synthesized electrical vibrations audible by a translating device.

In the New York plant the electrical vibrations are produced by 144 alternating dynamos of the inductor type, having frequencies that vary from 40 to 4,000 cycles. These alternators are arranged in eight sections or panels, each inductor being mounted on an 11-inch steel shaft. One inductor dynamo is used for each note of the musical scale, each generator producing as many electrical vibrations per second as there are aerial vibrations in that note of the musical scale for which it stands. The fixed or stator part of each dynamo carries both the field and armature windings; the rotors are carried on shafts geared together, the number of teeth (pole pieces) on the gear wheels corresponding with the number of frequencies to be obtained. Because the rotors are geared together, the frequencies are fixed and tuning is unnecessary. The alternators are controlled each by a key in a keyboard upon which the musician plays. Each key serves to make and break the main circuit from seven alternators, not directly, but through the medium of plunger relay magnets wound with layers of enameled wire. Only feeble and harmless currents are needed to control the relay magnets, by which the task of making and breaking the currents from the main circuits is really performed. No appreciable time elapses between the depression of a key and the closing of a main alternating circuit, so that the keyboard is as responsive and sensitive as that of a piano. The elemental notes generated by the 144 dynamos cannot alone be used to produce the most pleasing musical effects. Why this should be so becomes apparent from a consideration of some simple principles in acoustics. If a wire be stretched between two points *A* and *B* (see the accompanying diagram) and plucked or struck, it will vibrate above and below the line *A*, *B* and give what is known as a fundamental tone. This fundamental tone is without distinctive musical character or timbre, 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 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 particular instrument played. The sub-vibrations are known as the upper partials or overtones, and generally speaking, they are harmonious with one another and with the fundamental tone. That very elusive and uncertain quality called timbre is dependent entirely upon these overtones. By properly controlling the blending of the overtones and the elemental tones, it ought to be possible to imitate the characteristic timbre of any musical instrument. This Dr. Cahill has in a large measure succeeded in accomplishing.

"Tone mixing," as this building up of harmonious notes and chords is called, is effected in the telharmonium by superposing the simple or sinusoidal waves of the alternators. By means of bus-bars the oscillations of the ground tones are all brought together in one circuit, those of the first partials in another circuit, those of the second partials in a third circuit, etc. The actual blending is done by passing the various oscillations through a series of transformers. In order to understand how a chord is blended, we must begin at the keyboard. As soon as the performer depresses his keys, the bus-bars electrically superpose the ground tone currents through the primaries of closed-iron magnetic circuit transformers, the secondaries of which are joined in circuit with impedance rheostats governing the strength of the currents, which rheostats are controlled from the keyboard by means of stops. Similarly the bus-bars superpose the first, second, third, and other desired partials in separate circuits. The composite ground-tone and overtone oscillations thus produced in the secondaries of the transformers are next passed through the primaries of an open-iron magnetic circuit transformer, in the secondary circuit of which a current is produced composed of all the ground tone and overtone frequencies of the particular chord under consideration. This secondary current is in turn passed through the primary of an air-core transformer, and the resultant secondary current is converted by telephone receivers or speaking arcs into the musical chord desired.

In order to listen to this musical chord, the telephone receiver is not held to the ear. It would be bad for the ear if it were, when a loud note is sounded. The current of the receiver is literally thousands, and at times millions of times stronger, measured in watts, than those to which an ordinary telephone receiver responds. Whereas less than six ten-millionths of an ampere are sufficient to produce a response from an ordinary telephone receiver, a current of an ampere is sometimes used in the Cahill system for an instant when loud tones are produced.

The composition or quality of a note or chord is controlled by eight rheostats called stops. By skillful manipulation of the stop rheostats, it is possible to obtain very accurate imitations of the wood-winds and several other orchestral instruments. Imitation, however, is hardly the right word; for the notes are built up of exactly the same components as the tones which come from the real instruments. Furthermore, beautiful effects are obtained that cannot be produced on any existing instrument. These stop rheostats control merely the timbre or quality of the music produced. Fluctuations in volume are produced by "expression rheostats." Both stop and expression rheostats are constituted by impedance coils, differing however in mechanical construction. The stop rheostats are manipulated very much like the stops of an organ, and the expression rheostats like the swell. Unlike an organ swell, however, the expression rheostats are used not only for producing captivating crescendos and diminuendos of individual notes and chords, but also in reproducing the peculiar singing tremolo of the violin and 'cello.

The rather complex system of transformers described serves not merely to blend partials with ground tones, but also to purify the vibrations corresponding with the different sets of partials by purging them of their harsher components. The air core transformers, fur-