I do not believe that the basic good sense of the American people will permit these things to happen. I believe that our tradition of freedom, initiative and individual rights will continue to develop men and women who will acquire wealth and who will wish to use it for outstanding benefits to the general social group, in which education is an important element. I do believe that the economic trends are making the path of the private institutions more difficult and that some of them will succumb. The trend, I believe, will be for state institutions to assume more of the burden of ordinary education, expanding from the public-school field into the junior-college field, thus substituting education in place of unemployment.

Conclusion

If these forecasts do not entirely miss the mark, they offer both encouragement and guidance in our efforts to make the privately controlled institutions of technology of the future preëminently strong and serviceable institutions. Above all, they indicate that the *criterion for survival of a private institution will be that it offers a quality of education and public service, definitely superior to that obtainable in government-operated institutions.* This is the challenge of the future to those who administer the affairs of private institutions and to those who wish such institutions to endure as vanguard and bulwarks of a free and progressive social order.

PIANO TOUCH

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One is tempted to say that touch is the touchiest subject in musical circles, because we are deeply impressed with the enormous possibilities for characterizing musical artistry and expression of musical feeling in terms of this art. The vocabulary descriptive of touch now current is extensive, loose and baffling. Historically, but little effort has been made to aid the student in music by bringing order out of this chaos from a scientific point of view. However, recent scientific approaches to this subject have made progress and give assurance of the possibility of an adequate analysis, description and terminology for many of these phenomena. The best available book on the subject for musicians is the volume by Professor Ortmann, director of the Peabody Conservatory of Music. It is based upon a searching analysis of historical, theoretical and experimental evidences. His principal findings may be summarized as follows:

The pianist has at his direct control only two of the four factors in music; namely, intensity and time. Pitch and timbre are determined primarily by the composer and the instrument.

The pianist can control the intensity only in terms of the velocity of the hammer at the moment at which it leaves the escapement mechanism, and by the action of the pedals.

There are only two significant strokes on the key: the percussion and the non-percussion. The difference between these is that the former contributes more noise to the piano tone and the latter gives the player better control of the desired intensity.

Aside from the addition of the noise, the player can not modify the quality of the tone by the manner of depressing the key or by manipulations after the key has struck its bed except, perhaps, by a momentary partial key release and immediate key depression, damping the tone somewhat but not entirely.

He can control the time factors which

influence quality only by the action of the dampers either through the keys or the pedals.

In general these facts have been known for a long time by instrument makers and leading musicians. But many musicians have failed to recognize their significance or admit the facts. Indeed, experts in various fields of acoustical science also have questioned the findings enough to justify taking the problem into their laboratories for analysis and verification. However, all the investigators have reached the same conclusion on the above points. Let us examine each of the essential factors in turn.

In so far as it depends upon the stroke of the key, intensity (the physical fact) or loudness (the mental fact) is a function of the velocity of the hammer at the moment that it impinges upon the string. After that the tone can be modified only by action of the dampers. The piano action for any key consists of a compound lever system, the purpose of which is to facilitate and control the force of the blow on the string. Let us consider the nature of the blow.

If a ball is placed on the inner end of a cleared piano key and the key is struck in the usual manner, the ball will fly from the key up against the string. Nothing can influence the velocity or the direction of the ball after it has left the key, and the ball can energize the string only at the moment of impact because, due to resilience of the compressed felt and the throw of the string, it bounds off instantly. The function and action of the hammer is analogous to that of the ball. The velocity of the hammer is determined by the velocity of the escapement lever at the moment the hammer is released for its flight, and the force of the blow is determined by the velocity of the hammer at the moment of impact. From this, several considerations follow:

(1) It makes no difference whether the key is struck by an accelerating, retarding, even, or any form of irregular movement; the only significant thing the player controls in the stroke is the velocity of the key at the exact moment that it throws off the hammer.

This easily observed physical fact has profound significance in the theory of playing, hearing, enjoyment and critical judgments about music. The economic aspect is not to be ignored when we consider what money is spent in trying to teach pupils to do something that can not be done. It takes away a great deal of glamor and grace of mannerisms in the mode of depression of the key. It reduces touch to the fundamental factor of intensity.

This should in no way detract from the resourcefulness of the instrument and the opportunity for individual expression or the indirect effects of intensity, which are legion. On the other hand, it clarifies, glorifies and reveals the extraordinary refinement that is necessary in this artistic touch. The elaborate care taken in the development of form, weight, pressure and rate of arm, wrist and finger movements is fully justified in so far as it results in a refined control of the intensity of the tone but not for any independent change in tone quality.

(2) The hammer is released just a trifle before the key reaches its bed. Like the ball, it has only one form of contact with the string; namely, an instantaneous impact followed by immediate rebound. The movement of the key can not influence the hammer after it has been released any more than it can influence the flight of the ball after it has been thrown off. Therefore no amount of waggling, vibrating, rocking or caressing of the key after it has once hit bottom can modify the action upon the string. The only way in which the key can further affect the string is by a new stroke of the hammer. This can easily be verified by manipulating a key near its bed and looking at the action of the hammer.

Probably the only exception to this

statement is the rare or doubtful possibility that a partial release of the escapement mechanism may re-engage the hammer stem so that the hammer may again be thrown against the string and a partial damping may result. However, even if physically possible, this is merely a stunt and is not attempted by artists under normal conditions of playing. Yet this fallacy plays a rôle in musical circles in at least three important respects. First, whenever this stunt is affected, the observable finger action serves as a suggestion which produces the desired result in the form of an illusion of hearing. Such normal illusions have a very great influence upon musical hearing. Second, in ignorance or defiance of the physical limitations, teachers often attempt to train pupils in the supposed art of this type of finesse. And third, theorists who oppose the limitation of touch to intensity control frequently fall back upon this phenomenon to sustain their claims. However, all well-informed musicians recognize that this feature is not important in their artistic playing. Therefore, we may ignore it in the discussion of the real factors in musical touch.

(3) Indirectly the pianist can produce a great variety of tone qualities, but only by his control of the intensity of the tone. Having imparted a given velocity to the hammer, the pianist is entirely at the mercy of the instrument for the determination of qualitative changes taking place in the tone, except for manipulation of the dampers. The piano is so constructed that it can produce a vast series of tone qualities, each one a function of the intensity of the tone. Each instrument has its own relatively fixed characteristic in this respect. In general, the louder the tone, the richer it will be in quality.

If we represent a series of intensities by the letters a, b, c, d, *etc.*, and the corresponding degrees of richness and other characteristics of the quality by the symbols a′, b′, c′, d′, *etc.*, then whenever a tone of intensity a is sounded, a quality a′ is produced; intensity b for the same tone will always yield a quality b′; intensity c or any other intensity will always yield its corresponding tone quality. It is possible therefore to calibrate any particular piano in this way and to set up a scale of intensities which will yield approximately the corresponding scale of tone qualities. However, the situation is complicated by the fact that each instrument has its own resonance characteristics and responds differently to different chords.

This setting up of a scale of equivalents for intensity and tone quality is just what every pianist has to do empirically. Rarely is it a clearly conscious effort or scale; probably it can best be described as a relationship which he has felt himself into more or less subconsciously.

(4) In 1933 Ghosh demonstrated that within a considerable range of the intensities normally functioning in music, the wave form of the vibrating string and therefore the resulting harmonic constitution remains constant. Thus, within a moderate range of changes in intensity, the player can not modify the quality of the tone as it emerges from the string.

The qualitative changes which come with changing intensity are the result of resonance, reverberation or damping effects of the sounding board and the rest of the piano, the thuds and rattlings on the keys, as well as the acoustical characteristics of the room. The wave emitted by the sounding board and its accessories is very much stronger than the wave emitted from the string, and therefore becomes dominant in hearing. The wave form that impinges upon the ear is an amplification and modification of the wave form emitted by the string. This principle applies to all other musical instruments.

At the present time artists regard inharmonic and percussion accessories to piano response as legitimate and essential contributions to tone quality. Is it possible that this attitude may change? We are facing an era of radical change in the nature of music. It is difficult to predict what will happen to concepts of piano playing. Several factors must be taken into account.

First, the piano of to-day, the manner of its use and the tastes and habits of hearing are determined in large part by the heretofore existing mechanical limitations to construction of the instrument. This piano quality involves a variety of thuds, rattlings, raspings and various other forms of noise which are utilized for musical effect and add pronounced characteristics significantly to the tonal elements, especially in the louder intensities. It is, to a considerable extent, in the impurities of tone that we differentiate instruments.

Second, it is now possible to construct a synthetic-tone instrument in which we may include any desired sound quality, and therefore eliminate any of the present characteristics which may be redundant or undesirable.

Third, in such an instrument, it is now possible to introduce a vast variety of tone qualities which we have not been able to produce with our present instruments. We must, therefore, consider the possibility of thinking of the future of music in terms of instruments in which the characteristics are not due to the limitations in mechanical construction but are the deliberate choice, the result of invention and discovery of entirely new tonal complexes for musical satisfaction.

Fourth, it is a matter of history and psychology that likes and dislikes, tolerance and intolerance, artistic cravings and urges, are matters of development contingent upon the tendency to make the best of what we have, the biological tendency toward new habit formations and the inherent artistic merit in innovations.

These situations the piano shares with all other instruments. Conservatism tells us that there will be no sudden change, but insight into the nature of the situation tells us that the change will be radical, and that it must of necessity be in the interest of higher levels of musical achievement with new problems for the composer, the performer and the listener.

Is it probable that the electrical flute, clarinet, trumpet or violin will introduce new satisfaction in the purity of harmonic factors so that we can dispense with the noises which at the present time give us the characteristics of the instrument? We may venture to answer that these new resources in electrical instruments will vastly enrich our world with harmonic tones and will "chasten" or replace many of our present instruments, but there may always be an artistic demand for inharmonic elements, and other noises and percussion features.

(5) Pianists have fairly clear concepts of characteristics of tone quality, such as harsh, brilliant, mellow, full, singing, round, shrill, dry, metallic, steely, brittle, shallow, poor, ringing, clear, velvety, bell-like, jarring and strident. Ortmann performed an experiment in which a number of distinguished artists participated and were able to produce the qualities just named to their general satisfaction. But a recording device attached to the piano revealed that the only two variables that had been under their control were the velocity of the hammer blow and the action of the dampers which affected the duration and loudness of the tone, and that, whenever qualitative differences were present, they were differences in intensity and time relationships.

(6) The countless varieties of temporal movement are also reduced to the operation of time, with some modification by

intensity. Ortmann performed experiments in which accomplished pianists gave artistic expression to such marks as *accelerando, ritardando, affettuoso, espressive, scherzando, etc.* The recording device on the piano revealed the fact that all these characteristics of musical movement were completely controlled by the two factors, the time relationships and the intensity of the tone.

(7) The pianist can modify quality through controlling the time factor in three ways: the tempo and the temporal aspects of rhythmic features are determined largely by the duration of vibration as determined by the moment of application of the dampers through the release of the key; the vibration may be continued by overholding the notes with the sostenuto pedal.

It is well known that the piano tone fades out rapidly soon after the hammer stroke; but the listening ear tends to ignore this and, instead of hearing tones as having sudden changes in intensity and timbre, tends to hear the initial characteristic of the tone until the next key is struck, in spite of the fact that the physical change in the tone is very radical. For this reason, it seems to make relatively little difference whether a key is held down for the entire time assigned to it in the score. As a matter of fact, the player is often irregular and relatively indifferent in regard to the time for release of the key, especially in rapid movements. He depends on this tendency in hearing to carry over. In musical hearing the effect of overholding the note by pedal is perhaps more evident in its modification of resulting tone quality than in the awareness of the continuation of the note or chord as such.

(8) The most profound change the artist can give to tone quality comes through pedal action. By means of the sostenuto pedal tones may be carried through a series of chords after the respective keys have been released, thus producing great enrichment in the harmony through the gradual overlapping and fading of antecedent tones. Refinement in the use of this medium is an outstanding mark of artistry.

In the use of the una chorda pedal the artist has a choice of striking one, two or three strings. Two effects result. The softer felt tends to dampen partial vibrations of the string and the remaining string or strings vibrate in sympathetic resonance. A combination of such tones obeys precisely the same laws as tones produced without pedal although the basic tone-complex is altered. The action of the soft pedal involves, of course, purely the factor of intensity.

(9) The great tonal resources of the piano as an instrument lie in the richness of tone produced by the possibility of playing one or many keys, with or without pedals, and thus utilizing both harmonic and melodic progressions. But these are as a rule set in the score by the composer, and the possibility of legitimately introducing variants and ornaments not so indicated is limited.

(10) It is, of course, recognized that the pianist has many devices for changing the quality of tone by freedom in the use of intensity or in time. For example, tone coloring is a very conspicuous feature in artistic playing, but it ordinarily means that the pianist strikes the notes in the chord with different force and thus can produce varying resonance effects from the same chord. Likewise, there are considerable resources in the variety of uses of the pedals, both as to time and intensity. The pianist has various devices by which he can get sympathetic vibrations and modulate overtones. There are also many ways of enhancing subjective tones which may play an important rôle, clearly modifying the perceived tone quality, and we must not overlook the vast array of illusions which have qualitative significance. Last but not least, there is the power of suggestion.

(11) The artist may legitimately think

and perform with tone quality as his objective, and consciously control his touch in terms of tone quality. Likewise the listener may regard tone quality as the primary factor and think of intensity as a secondary and even unrelated factor. But the fact remains that, in general, the only way in which the pianist can produce qualitative changes is through dynamic and temporal changes, and then only within the limits set by the characteristics of the instrument.

(12) It follows from these considerations that a fairly adequate record of musical performance can be made by recording the velocity of the hammer blow and the action of the dampers. With a given composition and a given instrument of which the characteristics are known, we can describe the essentials of artistic performance on the piano in terms of the artist's command and use of these two factors.

The Iowa piano camera is built on this principle. It registers the performance in minute and serviceable detail in a permanent photogram. This can be transcribed into a scientific performance score, in terms of which objective analysis of the tonally significant features of the rendition may be made.

The purpose of this analysis has been to pave the way for a synthesis. In acoustics we have analyzers which may dissect any rich tone into its component partials; conversely, we have synthesizers which can take all known partials of any rich tone and reconstruct the original single sound wave. On this analogy it is here suggested that the principle which justifies our reducing a rendition to its two operating media justifies our assuming that, by reversing the process, we may derive all the salient elements in the performance from an adequate record of these two media. Such matters as phrasing, personal interpretation, the principles of art involved, errors, idiosyncrasies and exhibitions of skill are embodied in such a piano camera record.

FOR SCIENCE

By Dr. A. S. PEARSE

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We live, then, in an age of grave social disorder and threatening chaos; and it is in the main due to science.—*McDougall*, 1935.

Scientific civilization has destroyed the world of the soul. . . . Civilization has created new stimuli against which we have no defense.—*Carrel*, 1935.

THE rewards of success are power, position and hard work; not affluence and ease, as the unsuccessful believe. The penalties of success are jealousy and responsibility. The tycoons of the earth are always the subjects of green-eyed envy. They must care for the so-called unfortunate and tell them what to do. They are blamed for hard times, plagues, famines, hurricanes and other "acts of God."

During the past century science has been successful. It has made the world more or less cosmopolitan, safe, comfortable, healthful, tolerant, honest, sensible and understanding. Naturally it is blamed by non-scientists for the troubles of society. Critics of science gleefully point out that scientific theories grow into dogmas which impede the progress of civilization as much as those of theologians, politicians or economists; though scientists have labored for generations to explain natural phenomena, the world is still full of mysteries; though knowledge has increased enormously, man is still wicked. Perhaps the worst sin that science has perpetrated is the giving to civilized man comfort, convenience and