workers. Many of them have had new and thicker bass-bars to withstand the increased tension of the strings due to the rise in the standard of pitch. Many have been repaired after accidents or have suffered from exposure to changing atmospheric conditions. The first stage in the inquiry was to obtain the ' response curve '

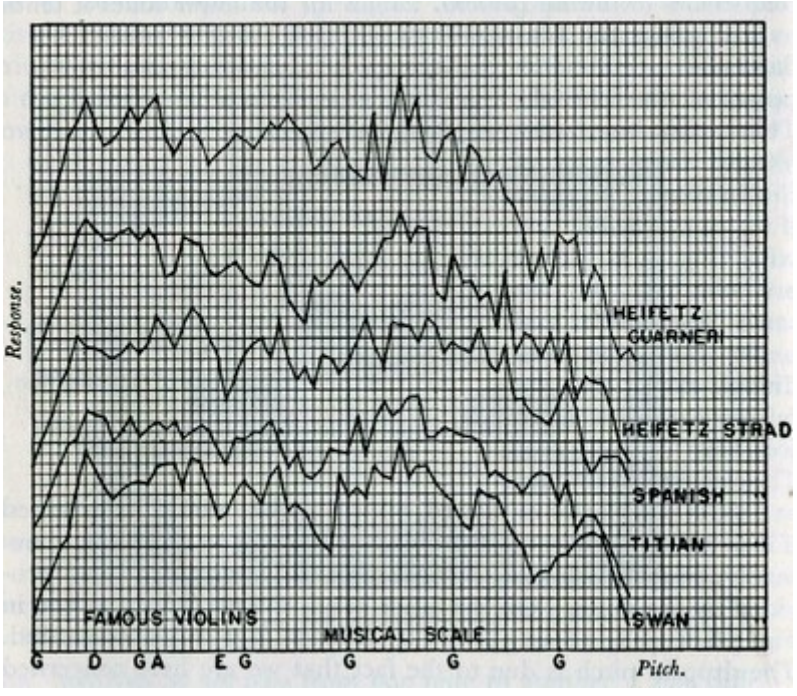

FIG . 7.10.—Response curves of famous violins. The first G is that of the open string

of each violin. This represents the intensity level (approximately the loudness) of each semitone given by the violin from the open G string to the E four octaves above the open E string. A method of bowing is used which eliminates the idiosyncrasies of the performer. In this way it was possible to get results which could be relied upon to repeat themselves. The curves for five famous violins are shown in Fig. 7.10. Each peak on these curves corresponds to a natural frequency of some part of the bridge-belly-back—contained-air system. All of them show a marked peak at C or C# on the G string. This is the resonance of the contained air—a fact which may be established by filling the violin with a

dense gas, such as carbon dioxide, and repeating the experiment when the position of the peak shifts to a lower pitch. This resonance strengthens a range of pitch which would otherwise be weak. All the other prominent peaks represent some mode of vibration for the belly or back, as is indicated by the fact that they all shift towards the bass if the mute is mounted on the bridge.

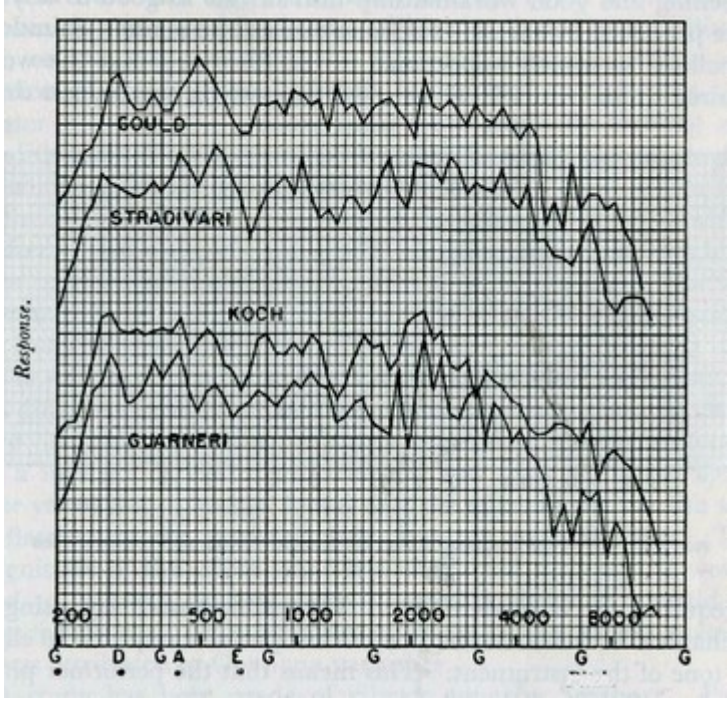

FIG . 7.11. Response curves in pairs, one an old violin, the other a new violin

There is no agreement in detail between the curves, and they show that quality must change from note to note on a violin. To take an obvious case from the top curve, there is a peak at the second A and a depression near the third. Thus, if the second A is played, its second partial will be weak. On the other hand, there is a depression at the B just above it, and a peak near the octave above this, so that if the B is played, its second partial will be strong. The best violins seem to give a fairly uniform response level over most of the range, with a little excess in the region near the top of the E string (2,000-3,000 Hz) and a rather sharp dropping off to nothing at the highest pitches (5,000 to 10,000

Hz). Thus the lower notes will be rich in partials and the highest notes relatively pure. Fig. 7.11 shows for comparison two pairs of response curves. One of these curves in each case is for a genuine old violin, the other for a modern copy, and it will be seen that the old violin differs less from its copy than the old violins differ among themselves. It may be that with careful modelling and good workmanship instruments as good as any of those produced by the old craftsmen can still be made. Saunders is inclined to attach importance to the discovery that the work required to make an old violin speak properly is notably less than

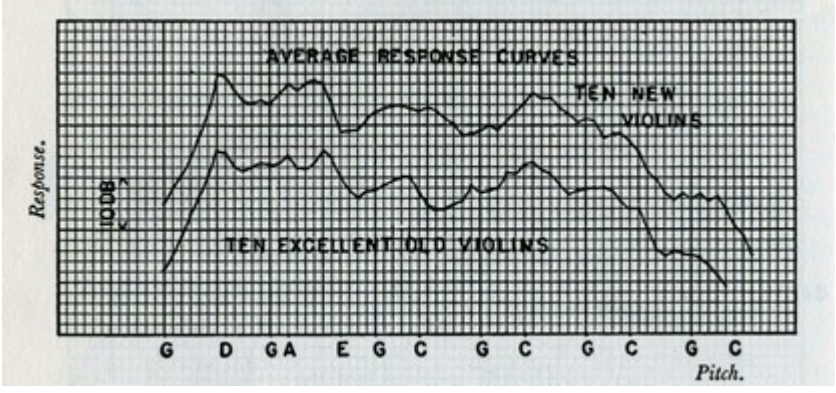

FIG. 7.12.—Average response curves for ten old violins and ten new ones

is required for a modern one. This is measured by using a mechanical bow and finding the critical pressure required to elicit the tone of the instrument. This means that the performer plays with less effort and that the response of the instrument is much quicker—a fact which is bound to tell in rapid passages. As a matter of fact, it is probable that the tone of the old violin is something of a fetish. This was tested before an audience listening to a lecture on ' A Scientific Search for the Secret of Stradivarius '. Three violins were played in rapid succession by an artist. One of them was a famous Stradivarius (the Rossignol, 1717), the other two were very good modern instruments. The result was that about one-third of the audience got the Strad right, the number which would have got it right by pure chance. It is admitted, however, that ' a few of the listeners, perhaps not more than a dozen, could recognize the tone of a Stradivarius at once and without hesitation', although ' some persons who are justly

regarded as experts did not vote correctly '. This correct judgement may have been based on a recognition of the quickness of response and economy of effort referred to above. Fig. 7.12 shows how much alike the tone-quality of old and new violins must be when taken in groups. A string orchestra entirely composed of Stradivarius instruments played in a concert in New York in December 1937, and many listeners could hear nothing unusual in their combined tone. This view is not pure philistinism, as may be seen from the following quotation: * ' In the opinion of many whose opinions are entitled to deference, the master pieces of the greatest makers are gradually arriving at a condition in which their value is appreciated by the curators of museums rather than by great contemporary artistes . . . a fine violin enjoys a sort of mysterious immortality, the effect of which is often enhanced by the groundless idea that no good fiddles have been made since the golden age of the Cremona makers, which terminated 130 years ago, and that the secrets of violin making are lost'.

The effect of varnish has been studied by Meinel in Berlin. It is a difficult research to carry out. Different varnishes cannot be tried on the same violin. We can only take the response curve for a number of violins unvarnished and then test them again after varnishing. Meinel found that the effect of the varnish was to flatten out the peaks slightly, but not to shift them. The magnitude of the effect was very small, and although it would tend to improve performance, it seems doubtful if it could be detected by ear. It is certainly no basis for the almost magical effects attributed to Cremona varnishes.

A study has been made of vibrato tone by Seashore. Pitch vibrato or tremolo appear in practically all tones of the violinists studied. The average rate is 6-5 Hz, and the average extent about 0.25 tone, which is only about half the average extent for the singers measured. The rate and extent are maintained with good consistency, and the form of the pitch pulsations is very smooth and regular. Intensity vibrato is less common than pitch vibrato, but when it appears it has about the same rate (6-3 Hz.) and an amplitude of 2-2 phons.

Plucked String.—This has played an important part in music in the past through its use in the harpsichord, spinet, virginal, lute, lyre, and psaltery. The only important orchestral instrument is

[1] Grove's *Dictionary of Music and Musicians*, 1911 Edition, Vol. V, p. 287.