surely, if the transition state of the Government excused inaction on its part, the Geographical Society could have organised a meeting, even although a prince was not at hand to take the chair. Possibly after all our insular want of sympathy with foreign enterprise, however great, may account for the absence of that enthusiasm which greeted our own abortive expedition of three years ago. The English edition of Prof. Nordenskjöld's narrative will be published by Macmillan and Co.; it will appear simultaneously in English, Swedish, German, and French.

M. J. PALMARTS has published at Brussels a pamphlet entitled "Projet d'Exploration au Pole Nord," in which, after a preliminary disquisition of a general nature, he expounds his plan for the construction of a submarine apparatus to attain the object in view. The *Times* Naples correspondent states that the *Cristoforo Colombo* is now in course of preparation for an exploring voyage in the North Seas.

THE current number of the Geographical Society's *Proceedings* contains Mr. J. Thomson's report of his journey from the head of Lake Nyassa to the south end of Lake Tanganyika, followed by Maj. Gen. Sir M. A. S. Biddulph's paper on Pishin, and the routes between India and Candahar, which furnishes a vast amount of new topographical information. In order to make this more readily intelligible, it is illustrated by some excellent wood-engravings from, we believe, the author's own sketches, and a good map of part of southern Afghanistan, constructed from surveys made during the late expedition, on which the unexplored country to the east is usefully indicated. A proposal is made by Admiral Ryder to found medals for the encouragement of surveying by naval officers, which the council of the Society, after careful consideration, think had better be placed in other hands. Among the remaining matter is Dr. Holub's address on the subject of the Marutse-Mabunda empire, but the publication of the map to illustrate his former paper appears to be unavoidably postponed.

IT is stated that a new Belgian expedition is to leave this month for the purpose of establishing commercial stations along the Congo.

M. SLATIN, an Austrian traveller, is about to visit Dara, in Darfur, and proposes to explore the country to the south of Hofrat-el-Nahas and Kalaka. MM. de Müller-Capitany and de Lucken have recently left Cairo for Massowah, whence they intend to visit the region bordering on Northern Abyssinia. After spending a year there they will direct their course to Fazokl, by way of Valkait and Gallabat, and they will then endeavour to penetrate southwards into the Galla country.

MM. POPELIN AND CARTER, with the second Belgian Expedition, have arrived at Karema, M. Cambier's station on Lake Tanganyika, but it is said that only one elephant has survived the journey. Under the auspices of the King of the Belgians an establishment is to be formed in Eastern Africa for the capture and training of elephants. A further Belgian expedition is to be despatched to Karema under Capt. Ræmaekers and his brother, who will take with them three artisans and also a small steamer for use on Lake Tanganyika.

THE French Committee of the International African Association have despatched M. Bloyet to Zanzibar to undertake the formation of their station in Usagara.

COL. GORDON-PASHA has recently informed the Church Missionary Society that the Egyptian military station on the Uganda frontier had been moved back, and that consequently the country between Egypt and Mtesa's kingdom is in an unsettled and insecure state, being overrun by Kaba Rega's men. The road to the Victoria Nyanza by way of the Nile is therefore not now practicable. The two members of the Nyanza Expedition, the Rev. C. I. Wilson and Mr. Felkin, with three Waganda chiefs, are expected to arrive in England during the present month, as they had reached Suakim on March 16. Mr. Wilson will thus be the first Englishman, since Speke and Grant, who has traversed Africa from Zanzibar to Uganda, and thence down the Nile.

HERR CARL LAMP gives some striking illustrations in *Globus* of the hatred that exists between the Mayos of Yucatan and the Mexican Creoles. He shows how important the exploration of the country would be, but the explorer must take his life in his hand. The same number (13) of *Globus* contains some interesting details of Mr. C. M. Doughty's journeys in North Arabia.

THE leading contribution to the new number of the *Annales de l'Extrême Orient* is Count Meyners d'Estrey's paper on Sumatra, being a communication recently made by him to the Société Académique Indo-Chinoise.

THE new part of *Le Globe* contains a suggestive paper on the *rôle* of missionaries, looked at from a geographical standpoint.

ON the 16th inst. Prof. Vambéry is to read a paper at the Society of Arts on "Russia's Influence over the Inhabitants of Central Asia during the last ten years." Prof. Vambéry's intimate knowledge of Central Asia lends great value to anything he may say, though it is well known his opinions are rather violently anti-Russian. He is coming to London expressly to read the paper, and is expected here on the 13th. Sir Douglas Forsyth is announced to preside at the meeting.

ACCORDING to an evening contemporary the Moscow correspondent of the *Kölnische Zeitung* writes that a war between Russia and China may result in the occupation of Tchikislar, and that the fanatical Mahommedan population of Tchikislar is the surest ally for Russia! At first sight this was rather confusing, but the further statement that Russia "has a pretender for Tchikislar *in petto*—an elder son of Yakoob Khan," inclines us to the belief that the writer may not impossibly be confounding Kashgar with Tchikislar!

THE HISTORY OF MUSICAL PITCH[1]

"PITCH" is itself merely a sensation due to, and hence measured by, the number of double or complete vibrations, backwards and forwards, made in one second of time by a particle of air while the sound is heard. It is convenient to call the pitch of a musical sound the number of vibrations to which it is due. "Musical pitch" is the pitch of the "tuning note," or that by which all other notes on an instrument with fixed tones is regulated according to some system of tuning or "temperament." Of these, two are of prominent importance in the history of pitch, the "Mean-tone" and the "Equal," the first being also frequently called "unequal." In mean-tone temperament, completed by Salinas in 1577, all harpsichords and pianos were originally tuned in England till 1844, and all organs till 1854. It may still be heard on Green's organs at St. George's Chapel, Windsor, Kew Parish Church, and St. Katharine's, Regent's Park, and on a few country organs. It consists in flattening the Fifths of the scale sufficiently to make the major Thirds perfect, so as to sound without beats. As long as the player did not employ more than two flats or three sharps this answered very well indeed. But on introducing a third flat or fourth sharp he had to play them by substitution, and hideous noises, called "the wolf," were produced, and hence players have agreed to accept the much less perfect equal temperament, in which the Fifths are scarcely perceptibly flattened, and the major Thirds are made very much too sharp (producing the unpleasant "grittiness" of the harmonium), because at any rate all the keys are alike and the wolves are reduced to cubs.

It is convenient to consider A as the tuning note in all cases, but pianos and organs are usually tuned to C. The following relations give an easy sum in the rule of three for passing from A to C, and conversely. In equal temperament A 444, that is, the note A making 444 double vibrations in a second, corresponds to C 528, and conversely. In mean-tone temperament A 418 corresponds to C 500, and conversely, whereas for a perfect minor Third between A and C, A 440 corresponds to C 528, and conversely.

Man's memory of pitch is generally weak and short, though there are a few exceptions. Even in running down an octave unaccompanied singers will often flatten pitch. Hence some means of handing down pitch is necessary. The only carriers of pitch which need be noticed are the organ-pipe and the tuning-fork, which dates from 1711, so that for all older pitches the organ-pipe is the sole, as it still is the principal, authority. Both pipe and fork alter with temperature. The pipe alters, roughly speaking, by one vibration in every thousand for each degree Fahrenheit, sharpening by heat and flattening by cold. This is an extremely important change, and all pitches of organs must be reduced to one standard temperature, for which 59° F. =

[1] Re-arranged and abridged by the Author from a paper on the same subject read before the Society of Arts on March 3, 1880, by Alexander J. Ellis, F.R.S., F.S.A. For a detailed authentication of the facts herein mentioned reference must be made to the *Journal* of the Society of Arts for March 5 and April 2, 1880.

15° C. = 12° R. is here selected and used. The tuning-fork alters only by 1 vib. in 21,000 for each degree Fahrenheit, flattening by heat and sharpening by cold (the exact contrary to an organ-pipe), but this minute change may generally be disregarded. It is best, however, to reduce forks also to the same standard temperature. The tuning-fork, if carefully treated, will probably retain its pitch exactly for any number of years, since we know by examination that some forks have not varied one-tenth of a vibration from 1837 to 1880. Even very bad rusting does not flatten a fork by more than 4 vib. in 1,000.

Suppose then that we had a series of forks, tuned in unison with the different A's of different organs and other instruments, how are we to appreciate the difference between them, independently of the ear, which, even when well trained, is found to be most unsatisfactory in the judgments it forms as to the magnitude of an interval? The only satisfactory method is to measure them, that is, to determine the number of vibrations in each fork. For this purpose there are elaborate contrivances, but only one is easy of application, and, as has been ascertained by experiment, the results I have obtained by it do not differ by so much as one-tenth of a vibration from those yielded by the beautiful machines of Prof. McLeod and Prof. Alfred Mayer, who kindly tested my determinations by them. The "tuning-fork tonometer" was invented by J. H. Scheibler (1777-1837), silk manufacturer of Crefeld. Its principle is this: Two tuning-forks of nearly the same pitch, when sounded together, break up their continuous tones into a succession of loudnesses and weaknesses, called beats. The number of such beats that take place in ten seconds can be easily counted when it lies between ten and fifty, and most easily when it is forty. The number of beats in one second is exactly equal to the difference of the pitches of the two forks. Then again each fork can be made to produce its own octave by being held over a proper resonance jar, and this octave will beat with another fork nearly of its own pitch. Then from any selected low fork, say about A 220, a series of sharper forks, each beating (roughly) four times in a second with the preceding, is constructed, until one is reached which beats with the octave of the lower fork. Then all the forks are allowed several weeks to cool and settle, and the beats are afterwards counted with perfect accuracy, a very long, tedious, and extremely difficult operation. The sum of all the beats between the lowest fork and its octave is the pitch of the lowest fork, whence that of all the intermediate forks is immediately known. This done, the determination of the pitch of any fork or pipe, whose note lies within the octave counted, is very easy. The forks I used belonged to Scheibler himself, and were kindly lent me by Herr Amels, but I had to do the counting myself, and Professors McLeod and Mayer kindly enabled me to verify the results. It was by means of these forks and others tuned from them that I was able to measure the pitches of other forks and of pipes, and thus obtain the materials for this history.

First a large number of forks were obtained, most kindly lent or copied for me by numerous helpers; then I determined the pitch of a large number of organs, or obtained forks tuned to them at known temperatures. Organ-builders helped me with ancient pipes they had preserved from old organs. Pipes, of which the dimensions were given in old books, were reconstructed full size or to a scale, and their pitches measured. Then the records of other investigators of pitch were searched, and their procedure ascertained. The chief of these were the measures made by Scheibler; by Näke with Scheibler's forks; by Delezenne with a sonometer tuned to a fork of Marloye's, the accuracy of which I tested; by Lissajous, probably with the siren and bellows of constant pressure; by Cagnard de la Tour with the siren; and the older determinations of Dr. Robert Smith (master of Trinity College, Cambridge), Fischer (of Berlin), Euler, and Marpurg made with a weighted string. From these, together with my own, I collected more than 320 pitches, nearly half of which were for the first time measured by myself, reaching from A.D. 1361 to the present day, and on these the following history is based.

Early musical pitch was of two kinds, known as the *Church pitch* (*Chor-Ton, Ton de Chapelle*) and the *Chamber Pitch* (*Cammer-Ton, Ton de Chambre*), the former adapted to the ecclesiastical tones, the latter to the freer secular music performed in the private apartments or "chamber" of the prince, for his own pleasure, as the band used both in church and chamber consisted generally of his paid servants. Chamber pitch was also generally used for private, secular, and convivial music of all kinds. The confusion in most books between these two pitches is exceedingly great, and the confusion has been increased by Prætorius, 1619, who insists upon calling the higher pitch the chamber pitch, whether it was used in church or chamber, and who introduces a new pitch, which he considers suitable to church (*chormässig*).

That the general reader should be able from the first to form some practical notion of differences of pitch, it may be mentioned that "mean pitch," as it will be called, or Handel's and Prætorius's suitable pitch, is still used in the three churches I have described as using mean-tone temperament, and with equal temperament at All Hallows the Great and Less, Upper Thames Street, at the German Chapel Royal, St. James's Palace, and in many country organs, as Wimbledon, St. George's Chapel at Great Yarmouth, St. Nicholas at Newcastle-on-Tyne. The "French pitch," about a quarter of a tone higher, may be heard at Fulham parish church, in many country churches, as Arundel, Barking, St. Mary's, Shrewsbury, and will be probably heard at the Covent Garden Opera this season. An ancient "medium pitch," about the tenth of a tone sharper than the French, now adopted as a church organ pitch by all the principal organ-builders, unless some other pitch is specially ordered, may be heard on a genuine old organ at Hampton Court Palace, and on the present modern alterations of the old organs at Westminster Abbey, St. Paul's Cathedral, the Temple Church, Whitehall and St. James's Chapels Royal, and many other organs. It is practically what the Society of Arts pitch was intended to be. The modern high "orchestral pitch" used at present in England, which is also the *highest* pitch used by Broadwood, Erard, Steinway, Brinsmead, and other pianoforte makers, may be heard on the organs at the Albert Hall and Alexandra Palace, and at the Crystal Palace; also at St. Michael's Church, Cornhill. Exeter Hall organ is a little flatter, and about the pitch used in France just before the introduction of the Diapason Normal. To get the true sensation of these pitches, however, the organs should be heard at nearly 60° F., as they rise and fall rapidly with the temperature. But the interval between the highest and lowest of these pitches is only five-eighths of a tone, and merely represents the rise in pitch since the Congress of Vienna.

The great organ at Halberstadt (twenty-nine miles south-west of Magdeburg, in Prussian Saxony) was perhaps the first organ with three manuals and a pedal. It was finished February 23, 1361, by Nicholas Faber, and restored in 1495 by Gregory Kleng. It existed, unused, in the days of Prætorius, 1619, who figured its keyboards, described it, and gave the measurements of its largest pipe, B *natural*, four octaves below the B just above the bass staff, which was probably unaltered in length by Kleng, so that it gives a pitch 500 years old, the earliest I have been able to obtain. I had a pipe constructed to a scale of one-sixteenth, sounding four octaves higher, and by measuring its pitch at 59° F. under three inches' pressure of wind, I obtained A 506 (to the nearest whole number of vibrations to which I here limit myself). This is a minor Third above mean pitch, and five-quarters of a tone above our highest orchestral pitch. This estimate agrees with Prætorius's. Now this high pitch and a corresponding very low pitch are thus justified by Schlick of Heidelberg, 1511, who says: "The organ is to be suited to the choir and properly tuned for singing, for where this is not considered, persons are often forced to sing too high or too low, and the organist has to play the chromatics, which is, however, not convenient for every one. But what is the proper length of the pipes for this purpose, and convenient to the choir to sing to, cannot be exactly defined, because people sing higher or lower in one place than in another, according as they have small or great voices. However, if the longest pipe, the F below the Gamma ut [that is, F just below the bass staff], has its body down to the [beginning of the] foot, sixteen times the annexed line [which was $4\frac{7}{8}$ Rhenish inches long, so that the pipe was $6\frac{1}{2}$ Rhenish feet in length], I think it will be a suitable length for the choir. But if you build an organ a fifth larger, then you must make C in the pedal [that is, C on the second leger line below the bass staff] of this length." And then he goes on to explain how these dimensions best suit the ecclesiastical tones, going through each in succession, and gives the preference to the first pitch with the $6\frac{1}{2}$ Rhenish foot pipe on F. Now, making models of the proper dimensions, I found the first pitch was A 377, which is a whole tone flatter than mean pitch, and more than a minor Third flatter than our highest orchestral pitch; and the second pitch was A 504, that is, the same as the Halberstadt organ (for one or two vibrations are an insensible difference in organ pitch for the tuning A). We have then the same man, at the same time and for the same purpose—the ease of playing and singing ecclesiastical tones—recommending two pitches a whole Fourth apart. The lower of these pitches was greatly developed in France. Delezenne found it as A 374 in a dilapidated organ near Lille, at L'Hospice Comtesse. I found it in a model of Dom Bédos's dimensions, 1766, and he is still the great authority on organ-building. Mr. Hopkins, of the Temple Church, found it probably in Strassburg on organs built for the French, about 1714, by the great German organ-builder, A. Silbermann. The Rev. Sir F. A. Gore-Ouseley says that most untouched organs in France are of this pitch. A great deal of this depth is to be attributed to the lengths of the foot to which builders worked. The old French foot was 6 per cent., the Rhenish foot 3 per cent. longer than the English; hence the pipes of a French, Rhenish, and English foot long differed so that the French was half and the Rhenish a quarter of a tone flatter than the English. Hence, when to raise the French pitch the French one-foot was made to sound B instead of C (as at Versailles, 1789, giving A 396), the pitch practically coincided with the English one-foot pipe put upon C (as at Trinity College, Cambridge, 1759). This seems to have been also the lowest Roman pitch very nearly (uncertain whether A 395 or A 404). Such was the low church pitch which was principally worked out in France, the English example being solitary so far as my researches extend.

The high church pitch was chiefly worked out in Germany, but seems also to have found favour in England before the Protectorate, and was also partially developed in France. In Germany we had Halberstadt and Schlick, already cited, and even at the present day we find A 484 at Lübeck Cathedral, A 481 at St. Catharine's, Hamburg, A 489 (formerly, now 494) at St. James's (St. Jacobikirche), in the same town. In England we had a pitch of A 474, recommended by Tomkins, 1668, and realised in Father Smith's old Durham organ, 1683, and his St. James's Chapel Royal Organ, 1708, and in Jordan's, St. George's, Botolph Lane, 1748, and probably in many other early English organs. Unfortunately the Puritans smashed all our English organs in 1644–46, so that with us organ tradition is rudely broken. Prætorius, however, mentions a pitch much used in churches in North Germany, which he persists, however, in calling chamber pitch. On examining the compass of the voice which he has written in this pitch, I find that it could not have been flatter than A 567, that is a Fourth sharper than mean pitch, so that it was related to mean pitch as Schlick's high to Schlick's low pitch. On comparing the highest notes which Orlando Gibbons (1583–1625) wrote for the different voices in his church music, with those assigned by Prætorius, 1619, it would seem that he used nearly this very high pitch, and Prætorius himself says that "the English pitch on instruments is a very little (*ein gar geringes*) lower." In France Mersenne's church pitch does not go higher than A 504, which agrees with Schlick and Halberstadt, that is it was a minor Third above mean pitch. And even in Prætorius's time organs were often at this pitch, or a tone flatter than his sharpest. In the Franciscan convent at Vienna we have the lowest form of this old high church pitch in its smaller organ, untouched since 1640, and giving A 458, practically our English highest concert pitch.

Early chamber pitch, like early church pitch, by which it was primarily determined, was also both high and low. As the same band played in church and chamber the differences were always some definite interval of the scale, so that they amounted to a transposition often very troublesome. The mean-tone scale may be considered to have been always in use at this period, as the numerous others which were invented were generally slight alterations of it. This scale differed from the modern equal scale in having a narrower whole tone and having two kinds of semitones, the large from B to C and E to F, the small from F to F *sharp*, B *flat* to B, that is for chromatic intervals. Expressed in vibrations, the great semitone was 7 per cent. of the vibrations of the lower note, the small semitone $4\frac{1}{2}$ per cent., while the equal semitone is 6 per cent. and the just $6\frac{2}{3}$ per cent. The mean tone is 12 per cent., the equal tone $12\frac{1}{4}$ per cent. All this rendered the mean-tone scale unsuited for transposition or for shifting of pipes in re-arranging an organ; yet both constantly occurred in former times. The higher chamber-pitch was generally a great semitone to a mean tone, or mean minor Third, or even a Fourth flatter than its corresponding higher church pitch. And these chamber pitches came to be used in churches in place of the highest church pitches. There seems little doubt that the high church pitches, except the very highest, were similar depressions of the very highest. In France, however, Mersenne, 1636, gives us a chamber pitch, A 563, which was a tone *higher* than his own high church pitch A 504, and corresponded to Prætorius's highest pitch already mentioned. These depressed church pitches were, however, still too high for most chamber music, and they were still further flattened. The most curious instances are in Hamburg, where the St. James's organ, 1688, built after the ecclesiastical tones of Roman Catholicism had become a tradition, was yet so high as A 489, and had on it one stop (as late as 1761, when it was removed), which was a whole minor Third *flatter* than the rest of the organ, that is, in the chamber pitch of the time and place. And Mattheson the composer (1681–1764), an early friend of Handel, had St. Michael's Church organ, to the building of which, in 1762, he contributed upwards of 3,000*l*., tuned to A 408—most certainly the true chamber pitch of the time. It is curious that this pitch, a small semitone flatter than mean pitch, was as nearly as possible that used by Taskin, A 409, who was court-tuner to Louis XVI. in France, 1783, very nearly of the same time, and that this corresponds well with the pitch A 407 found by Sauveur in 1704. This became a low chamber pitch, and conflicted with that derived from the low-pitched organs.

Mean pitch, as I have termed it, seems to be the result of this conflict. This pitch was formally introduced by Prætorius as the most suitable pitch he could find for Protestant church music, and it was fixed by a drawing of the dimensions of his pipe, 1619, whence I had one constructed which gave C 507, corresponding to mean tone A 424, and this was also the precise pitch to which the London Philharmonic Society played from its foundation, 1813, to 1828. The mean pitch varied slightly within the limits A 415 (found in G. Silbermann's organ at the Roman Catholic Church, Dresden, 1722, as determined by forks chained to it by King Frederick August der Gerechte, which remained till 1824, one of which I have myself measured—this organ gave A 418 in 1878), and A 428, used by Renatus Harris, 1696. The mean of this is A $422\frac{1}{2}$, which is the pitch of Handel's own fork, a pitch which I also found at Verona, and at Padua about 1780, and Delezenne found at Lille about 1754. This is also the pitch of Green's organs at St. Katharine's, London, and Kew Parish Church, both A 423, and St. George's Chapel, Windsor, A 428. The fork of Stein, maker of pianos to Mozart, was A $421\frac{1}{2}$. Seville Cathedral and all Spanish church organs are about A 420 even now, which is also the pitch of G. Silbermann's Freiberg Cathedral organ. In recent times, 1860, this was the pitch of the Russian Court church band. The fork of the Opéra Comique in Paris, 1820, was A 423, and in 1823 was A 428. The fork of the Dresden Opera under Carl Maria von Weber (1813-21) was at A 423. In short throughout Europe this pitch prevailed, as shown by above sixty pitches which I have collected. The resonance of the air in the Cremona violins, about 1700, shows two maxima, the principal about C 270, and the other not so well marked, about C $252\frac{1}{2}$, corresponding to A 451 and A 422. The latter is mean pitch; the former, a great semitone higher, was the corresponding chamber pitch. It was during this period that the founders of modern music wrote, and hence adapted their vocal music to mean pitch, which must be considered as the classical musical pitch, to which our present orchestral pitch stands in the relation of a chamber pitch a great semitone higher. The establishment of this fact is perhaps the most important practical conclusion of my investigations. A curious metrical relation also leads to a useful classification of old organs having the mean-tone temperament. Mean pitch corresponded to organs with a B-pipe one English foot long, and I call these B foot organs, A 419 to A 428. The old sharp English pitch of Father Smith at Durham had the one foot pipe on A, and I call these A foot organs, being a tone sharper than the other, A 468 to A 475. An intermediate medium pitch, also used by Father Smith at Hampton Court, into which his sharp pitch was frequently altered by shifting the pipes, had the one-foot pipe on B flat, A 438 to A 444. The lowest organs, of which that in Dr. R. Smith's time at Trinity College, Cambridge, is the only example I know for certain in England, had the one-foot pipe on C, and was a C foot organ, A 395 to A 404, which was equivalent to a French B foot organ, pitch A 396. The variation of pitch here indicated depends mainly on the difference of the "scale" or ratio of the diameter to the length of a pipe used by different builders. Of course the introduction of equal temperament has slightly altered these relations.

The unfortunate break-up of mean pitch in modern times seems to have been entirely accidental, and certainly bears no trace of systematic plan or execution. It has been both aimless and vacillating—often merely capricious. I find no mention of any opposition to mean pitch till the French Conservatoire in 1812 used A 440, apparently as an experiment, for it found no adhesion. This pitch, afterwards proposed by Scheibler, and adopted by a congress of physicists at Strassburg in 1834, was really a resuscitation of the English B *flat* foot organ pitch. The great change was initiated by the presentation by the Emperor of Russia and an Austrian Archduke of sharper brass instruments to two household regiments in Vienna in 1816, and this subsequently entailed a rise at the two Vienna operas, which had to use these bands occasionally. The sharpening spread slowly and grudgingly through most of Germany. At Dresden it rose from the flutist Fürstenau getting a new flute from Vienna, but had not quite reached A 440 in 1862. At the celebrated Gewandhaus concerts at Leipzig the sharpening went on more rapidly to A 449 in 1859, and in France, after a very chequered career, the pitch of the Grand Opera, which was A 427 in 1811, and A 434 to 440 in 1829, where it remained to about 1854, became A 448 to 449 in 1858, when the great increase of pitch and the diversity of standards used in different towns induced the French Government to issue a commission, which resulted in establishing the French Diapason Normal A 435 in 1859. This pitch, being a quarter of a tone above mean pitch and about the same below the high orchestral pitch then reigning, enabled music of both kinds to be sung with tolerable ease. And this is of great importance, for we cannot afford to discard either classical or modern music, and to sing either to the pitch of the other is to do injustice to both composer and singer. The sudden change was, however, troublesome and expensive, although France, like England, had passed through that pitch without any complaint a few years before.

In England the increase of pitch abroad apparently induced Sir George Smart to alter the Philharmonic pitch about 1828, after consultation with singers, and he raised his fork to A 433, keeping, however, mean-tone temperament. This is practically the French normal, and the mean-tone C of Sir G. Smart actually coincides with the equally-tempered C of the French. This fork was long in use, and copies of "Smart's C" were greatly in vogue down to 1846 and later, stamped "Philharmonic," although the Philharmonic Society never issued a fork. But under the *bâton* of Sir Michael Costa the pitch rose rapidly, and the mean pitch from 1846 to 1854 was A 452½. The Society of Arts in 1859, in imitation of the French Commission, called together a large committee of musicians and men of science, who decided on C 528, to which they supposed would correspond A 440 (which would be just intonation), instead of A 444 (in equal temperament). Mr. Griesbach was commissioned to make the standard, but his C 528 turned out to be C 534·5, giving A 449·4, but incorrectly tuned as A 445·7 by a short monochord. Hence, in the market, the Society of Arts pitch is one of those very sharp pitches which it was intended to moderate. In 1874 the Philharmonic Concerts reached their maximum of A 454·7, and Steinway's pianos—which in England are at this pitch, in common with Broadwood's, Erard's, Brinsmead's &c.—at New York have gone up to A 457. Hence we have most undesignedly reached a chamber pitch, a great semitone above the classical music, and most unmusicianly play classical compositions written for mean pitch at this disfiguring sharpness. Covent Garden Opera has, however, resolved to adopt the French compromise system this season. Abroad in Germany, after a very general adoption of the French Normal, orchestral pitch again rose, and Vienna, which had reached A 456 before 1859, was at A 447 in 1878. The rest of Germany seems to be lower, Dresden intending to be A 440, but really slightly flatter. Bologna was A 443 in 1869, and the rest of Italy is probably not greatly different. There is, however, but one standard of pitch now in the world, the Diapason Normal at the Conservatoire at Paris, actually A 435·4, and even Belgium, which has a military standard of A 451 (the same as the British Army Regulation), had decided by a Commission to adopt French pitch, which only the expense of providing new instruments to the army at present prevents.

The above rapid survey of the history of musical pitch may be condensed into the following table, in which all such pitches as I have here mentioned, together with a few others, are included. The column T gives the number of *tenths* of an equal semitone by which any pitch exceeds the initial zero pitch, so that by subtraction of their *tenths* the interval between any two pitches in the table may be instantly ascertained. The column marked A gives the nearest whole number of vibrations of A in numerical order from the lowest to the highest, embracing an interval of a whole Fifth. As it takes an increase of two or three vibrations at these pitches to rise by the tenth of a semitone, the same tenths will be found to correspond to different numbers of vibrations, all being given to the nearest whole number only.

CONDENSED HISTORY OF MUSICAL PITCH

T.	A.	
		1. *Church Pitch Lowest.*
0	370	Zero pitch, not observed.
2	374	L'Hospice Comtesse, Lille.
3	377	Schlick, low, 1511; Bédos, 1766; French C foot organs; A. Silbermann at Strassburg, 1714.
		2. *Church Pitch Low.*
10	392	Euler's clavichords, St. Petersburg, 1739.
11	395	Trinity College organ, 1759; English C foot organs; Roman pitch pipes, 1720.
12	396	Versailles Chapel, 1789; French B foot organs.
		3. *Chamber Pitch Low.*
15	404	Roman pitch, 1730, from a fork.
16	407	Sauveur, Paris, 1713.
17	408	Mattheson, Hamburg, 1762.
„	409	Pascal Taskin, Paris, Court Clavecins, 1783.
		4. *Mean Pitch for Two Centuries, English B foot Organs.*
20	415	Chained fork of the Roman Catholic Church organ, built by G. Silbermann, 1722.
21	418	Same organ in 1878. Euler's organs, 1781.
22	420	G. Silbermann's Freiberg organ, 1714; Torje Bosch's Seville Cathedral organ, 1785; and all church organs in Spain.
23	422	Stein's fork for Mozart's pianos, 1780; Lower resonance of Cremona violins, 1700; Old fork at Lille, about 1754; Verona and Padua, 1780; Russian Court church band, 1860.
„	423	Handel's fork, 1751; Green's St. Katharine's, 1778, and Kew, 1790; Dresden Opera under Weber, 1815-21; Paris Comic Opera, 1820.
24	424	Prætorius's "suitable" church pitch, 1619; Original Philharmonic Concerts, 1813-1828.
25	427	Paris Grand Opera, 1811.
„	428	Renatus Harris's organs, 1696; Green's St. George's, Windsor Castle, 1788; Paris Comic Opera, 1823.
		5. *The Compromise Pitch.*
27	433	Sir George Smart's fork, 1828.
„	434	Paris Grand Opera, 1829.
28	435	French Diapason Normal, 1859.
		6. *Modern Orchestral and *Ancient Medium Pitch.*
30	440	Paris Conservatoire, 1812; Paris Opera, 1829; Scheibler's Stuttgart pitch, 1834; Dresden, 1862.
31	442	*Father Smith's (=Bernard Schmidt's) low pitch at Hampton Court Palace, 1690; English B flat foot organs.
„	443	Bologna, Liceo Musicale, 1869.
32	445	Madrid, Opera, 1858; Naples, S. Carlo, 1857.
„	446	Broadwood's medium, 1849-80; Paris, Grand Opera, 1856; Griesbach's A 445·7, 1860, for Society of Arts, meant for A 444.
33	447	Vienna Opera, 1878.
34	449	Paris Grand Opera, 1858; Leipzig, Gewandhaus Concerts, 1859; Griesbach's C 534·5, 1860, for Society of Arts, meant for C 528.
35	451	Lille Opera, 1848 and 1854; British and Belgian Military Instruments Standard, 1879; Higher resonance of Cremona violins about 1700.
„	453	Mean of the Philharmonic Concerts under Sir M. Costa, 1846-54.
36	455	Highest Philharmonic, 1874; Broadwood's, Erard's, Brinsmead's, and (English) Steinway's concert pianos, 1880.
„	456	Vienna celebrated high pitch before 1859.
37	457	(American) Steinway's pianos.
		7. *Church Pitch High.*
37	458	Vienna, large Franciscan organ, 1640.

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43	474	Tomkins's standard, 1668; Father Smith's high pitch at old Durham and old St. James's Chapel Royal organs, 1683 and 1708; the Jordans, at St. George's, Botolph Lane, 1748; English A foot organs.
45	481	St. Catherine's, Hamburg, 1543.
46	484	Old smaller organ in Cathedral, Lübeck.
48	489	St. James's (S. Jacobi), Hamburg, original pitch, 1688.
		8. *Church Pitch Highest.*
50	494	St. James's (S. Jacobi), Hamburg, present pitch, 1879.
51	496	Rendsburg organ, 1668.
53	504	Schlick's high pitch, 1511; Mersenne's *ton de chapelle*, 1636.
54	506	Halberstadt organ, 1361.
		9. *Church Pitch Extreme and Chamber Pitch Highest.*
73	563	Mersenne, *ton de chambre*, 1636.
74	567	Usual church pitch in North Germany in 1619, called chamber pitch by Prætorius. Probable pitch of church music of Orlando Gibbons (1583-1625).

ALEXANDER J. ELLIS

THE ATOMIC WEIGHT OF ANTIMONY [1]

IN a previous paper on this subject,[2] we gave our reasons for the opinion, since fully confirmed, that the bromide of antimony is the most suitable compound of this element, as yet known, for determining its atomic weight; and the results of fifteen analyses of five different preparations of the bromide were published, which gave for the atomic weight in question the mean value 120·00 with an extreme variation between 119·4 and 120·4 for all the fifteen analyses, and between 119·6 and 120·3 for the six determinations in which we placed most confidence. The antimonious bromide used in these determinations was purified first by fractional distillation, and secondly by crystallization from a solution in sulphide of carbon. In the crystallised product thus obtained, the bromine was determined gravimetrically as bromide of silver in the usual way. Although it seemed at the time that the results were as accordant as the analytical process would yield under the unfavourable conditions, which the presence of a large amount of tartaric acid in the solution of the bromide of antimony necessarily involved; yet it was obvious that the agreement was far from that which was desirable in the determination of an atomic weight, and our chief confidence in the accuracy of the mean value—independently of its remarkable agreement with previous results—was based on the fact that the known sources of error tended to balance each other. Hence our conclusions were stated with great caution, and the hope was expressed that after a more thorough investigation of the subject we might be able "to return to the problem with such definite knowledge of the relations involved as will enable us to obtain at once more sharp and decisive results than are now possible." Unfortunately this investigation has been delayed by causes beyond our control.

In our previous paper we described a simple apparatus which we devised for subliming iodide of antimony; and in a note to the paper we stated that we were applying the same process to the preparation of the bromide of antimony, and that it promised excellent results. Our expectations in this respect have been fully realised, and the product leaves nothing to be desired either as regards the beauty or the constancy of the preparation. The fine acicular crystals are perfectly colourless, and have a most brilliant silky lustre. With ordinary precautions they can be kept indefinitely without change, and it is easy therefore to determine the weight of the material analysed to the tenth of a milligramme.

We have carefully studied the causes of error involved in the analytical process of determining bromine in an aqueous solution of bromide of antimony and tartaric acid by the usual gravimetric method. These causes we propose to discuss in a future more extended paper. In this preliminary notice we have only space to state that we have satisfied ourselves that the small differences between the results previously obtained arose wholly from the analytical process, and not from any want of constancy in the material analysed; and further that these sources of error are to a very great extent under control. Moreover, we have found that the volumetric determination of bromine by silver was not materially affected, if at all, by the same causes. We have thus been led to devise a mode of testing the atomic weight of antimony, which, while it has all the advantages of the gravimetric method previously employed, is free from its sources of error.

If the atomic weight of antimony were 122·00, it would require 1·7900 grammes of pure silver to precipitate the bromine from a solution of 2·0000 grammes of antimony bromide, while if the atomic weight of antimony were 120·00 it would require 1·8000 grammes of silver. Now it is easy to estimate volumetrically $\frac{1}{100}$ of this difference with great certainty. We therefore prepared with great care a button of *pure* metallic silver, which we annealed and rolled out to a thin ribbon. We then weighed out from two to four grammes of bromide of antimony, prepared by sublimation as described above, and dissolved this salt in an aqueous solution of tartaric acid, which we then transferred to a litre flask and diluted to about 500 cubic centimetres. We next very accurately weighed out a quantity of silver slightly less than that which calculation showed was required for complete precipitation. This silver was dissolved in nitric acid, and the solution having been evaporated to dryness over a water bath, the silver salt was washed into the flask containing the bromide of antimony. As soon as the supernatant liquid had cleared, the small additional amount of a normal silver solution required to produce complete precipitation was run in from a burette, and measured with the usual precautions. We used no extraneous indicator, because it was important not to introduce any possibly new disturbing element into the experiment, and in the titration of bromine with silver the normal and familiar phenomena, which mark the close of the process, furnish a very sharp indication. The details of one of the determinations were as follows:—

The weight of the bromide of anatomy used amounted to 2·5032 grammes. To precipitate the bromine from the solution of this material 2·2404 grammes of silver would be required if Sb = 122·00 and 2·2529 if Sb = 120·00. We weighed out, with as much accuracy as if we were adjusting a weight, the smaller of these two quantities of metallic silver, and after dissolving the pure metal in pure nitric acid, evaporating the solution to dryness and redissolving in water, we added at once the whole of this silver solution to the litre flask containing the solution of bromide of antimony, in the manner described above. It was then found that $12\frac{4}{10}$ cubic centimetres of a normal silver solution (one gramme of silver to the litre) were required to complete the precipitation. It will be seen that the weights of the bromide of antimony and silver used could be thus determined with the most absolute precision, and we have the greatest confidence in these values to the $\frac{1}{10}$ of a milligramme. Moreover, it will be noticed that the volumetric method is only used to estimate the difference in the atomic weight which has been in question, and that if the method were only accurate to the $\frac{1}{10}$ of the quantity to be measured it would give us the value of the atomic weight within $\frac{2}{10}$ of a unit; while if, as we had reason to believe, the process was accurate within 1 per cent, it would fix the atomic weight within $\frac{2}{100}$ of a unit.

By the method just described, the following results were obtained. The letters *a* and *b* indicate different preparations.

Wt. of $SbBr_3$ taken.	Total wt. of Ag used.	Per cent. of Br Ag=108 Br=80.	Corresponding value of Sb.
a 1. 2·5032	2·2528	66·6643	120·01
a 2. 2·0567	1·8509	66·6620	120·02
a 3. 2·6512	2·3860	66·6644	120·01
b 4. 3·3053	2·9749	66·6696	119·98
b 5. 2·7495	2·4745	66·6653	120·01
Mean value		66·6651	120·01

Mean value of fifteen gravimetric determinations previously published	66·6665
Theory Sb. 120 requires	66·6666
,, Sb. 122 ,, ...	66·2983

In order still further to control the work, we collected the bromide of silver formed in the last two determinations, washing the precipitate with the precautions which experience had shown to be necessary, and determining its weight, first, after drying at 150° C,. and, secondly, after heating to incipient fusion. In

[1] Contributions from the Chemical Laboratory of Harvard College. Preliminary notice of Additional Experiments. By Josiah P. Cooke, Erving Professor of Chemistry and Mineralogy.

[2] *Proc.* Amer. Acad. Arts and Sciences, vol. xii. page 1.