Brass instrument valve

This invention relates to a three-way, double-bore valve creating more versatile and durable brass musical instruments.

It substantially resolves five long-standing problems – the imperfections of the valve system; the requirements of historic scores; individual instruments' compromised notes; the variety of instruments modern conditions require and the practicality of brass.

The first problem is that all prior art valve systems have intrinsic imperfections. Over the last 180 years all methods to limit these problems have created noticeable sacrifices in clarity, response, weight and costs.

> The first major imperfection of all valve systems to date is intonation. Each valve tubing length is made in strict proportion to the entire unvalved length of the instrument, known as the "bugle". When two or more valves are used together the Laws of Physics rule that there must be intonation problems. "Compensating" systems do not solve the lowest notes, restrict the clarity and add physical weight.

> The second major imperfection is the corruption of an appropriate conical bore profile. This is because valves add tubing inappropriate to the profile of most instruments. A single valve chooses one of two alternative routes. These must be of the same bore because that valve's single moving chamber switches between them. These routes therefore must be served by tubing of identical bore which is by definition cylindrical tubing. However all instruments (except the trumpet and trombone families) rely on conical - gradually increasing bore as their length increases. This is quintessential to the sound of each instrument. All tubas, euphoniums, French horns, flugelhorns, cornets, saxhorns (Eb tenor and baritone) are severely compromised by valves. Ideally valve tubing should at least in part fit within the conical profile. At present half the total length may be non-conical when all valves are used.

The second major problem is that modern instruments are incompatible with historic scores Depending on their nationality and period, composers had in mind very different instruments when they used the terms "tuba", "horn" or "trumpet". This has resulted in a plethora of different instruments, with spectacular differences in size. For example the tuba Ravel or Berlioz wrote for is half the length and looks a quarter the size of a standard modern instrument. A modern 4 valve piccolo trumpet in c" is almost only a third of the length of the original D (unvalved) Bach trumpet and half of the standard b-flat trumpet. The "f descant" horn is half the length of an F French horn.

Thus quite regularly orchestral parts require extremely high notes which are unsafe and sound strained on larger instruments or lower parts for which smaller instruments lack power or the correct timbre. In a concert including Gabrielli, Ravel and Shostakovich or Bach, Berlioz and Bernstein, players will often change between three instruments or compromise by playing on an unsuitable instrument or in the case of tubas and French horns have five or six valves and much rarely-used tubing.

The Slide Trombone is also prejudiced. To preserve the beauty of sound most players prefer to play a simple slide trombone. However all bass trombones and most others must also use one or two thumb valves. Trombonists are understandably sensitive to the effect of this on the instrument. The slight aberration of the absolutely straight tubing created at the valve is seen as a major problem. Numerous trombone valves have been invented to try to solve this. A second challenge to trombonists is created by the earliest sackbut and trombone parts which often require persistent, dexterous and very quiet altissimo playing. Jazz soloists often desire alto-altissimo effects.

The third major problem is that even the best instruments tend to have one or more idiosyncratic compromised notes which are weaker in quality and /or accuracy.

One cause may be that joints, bends and valves create irregularities in the tubing. If these occur at a node or antinode (an acoustic pressure point) for a particular note's wave length, that note will be affected. Often such factors actually improve notes. Minute changes at a nodal point have been said "magically" to solve compromised notes. However finding each pitch's nodal point and making the correct adjustment is an inaccurate science to date. Successful designs over the last 180 years have been those with the best sound and the least compromised notes and have been arrived at by experience, common sense and luck. Thus "identical" instruments from the same maker can exhibit different compromised notes – if the interior profile is compromised at a node through inconsistent or bad workmanship.

A second cause may be the so-called "Venturi" effect. This Italian physicist discovered that the narrowing of a tube increased the energy within water or air passing through it but before and after that restriction the flow remained the same. This has been applied to sudden changes in bore within instruments, especially immediately at the end of the mouthpiece shank. Adding or removing such steps in the tubing is claimed again "magically' to solve compromised notes. But again serendipity rather than science rules.

The fourth major problem is the variety of similar instruments modern conditions require and the tendency to use two or three instruments concurrently.

This is controlled by the keys of the work, timbre required or players' particular preferences. Sometimes, within one work, merely because of the sound required, a tubist or trumpet player will prefer his B flat instrument for one passage and his C for another. Horn players are really doing this constantly as they play alternatively on the B flat and F sides of their double horns.

The fifth major problem is the weight, fragility and costs of brass instruments.

To overcome these problems, the present invention proposes the use of a valve with, if desired, not two but three routes and two bores. In all cases, although the invention may be placed before or after the standard valves, when the invention is placed after them, if any of the other valves are opened the air will also go through the loop or loops of the valve or valves used.

The present invention proposes that the air column has three separate routes dictated by the invention. The first route is via the "cul de sac" - this is an ascending valve with its return within the valve barrel. It is the shortest and goes through the top tier of the valves into the valve and then straight out of the "cul de sac" to the bell. This would be as default a euphonium/ French c tuba or f descant horn, alto trombone or c piccolo trumpet.

The second route is via the mid-range or middle tier – this uses the same route through the valves and then is directed by the invention back along its own middle tier route through the valve block and then along a conical tube back to the invention's wider bore port serving the bell. This instrument's default would be bass tuba or B flat horn or tenor trombone or B flat piccolo trumpet.
The third route is via the lowest range or lowest tier - this uses the first route through the valves and then is directed by the invention back along its own lowest tier route through the valve block. It then travels along the longest conical tube back to the wider bore invention port serving the bell. This would be as default contrabass tuba, bass trombone, F horn or flugel or standard B flat trumpet

To overcome the first aspect of the first problem - that is the imperfection of valves' intonation - the present invention proposes the use of a valve with not two but three routes. The three alternative routes geometrically increase the number of alternative fingerings – ie harmonic series - for any compromised note.

To overcome the second aspect of the first problem - that is the imperfection of valves in their corruption of an appropriate conical bore profile - the present invention proposes the use of a three way valve with two widely different bores. Rather than merely adding cylindrical tubing, it can switch between two conical profiles of different pitches. A far greater proportion of the tubing added is conical and tapered to a profile appropriate to the entire instrument. Tubas can have quasi-tenor (euphonium), bass and contrabass bore sections. French horns can vary bore between F, B-flat and descant. Slide trombones with a thumb valve are also assisted as wider bore bass trombone tubing may be added.

Both the above first and second aspects of the first problem also overcome the problems of the profile of compensating systems when this valve is used as the compensating valve.

To overcome the second problem of incompatibility of modern instruments with historic scores the proposed invention uniquely allows considerable lengths of the correct bore and profile to be added or subtracted and a built-in ascending valve. This enables natural and safe performances on an appropriately configured instrument. Thus, with the proposed invention as a single "switch" valve between them, one instrument has three sections – with, as desired, entirely different conical and fully tuned pitches and functions. These may be a high, middle and lower tuning of that instrument - permitting, for example, a euphonium (tenor), bass and contrabass tuba; a quasi-alto, narrow and wide bore trombone; a four (not five) valve triple French horn or a piccolo with standard triple trumpet.

To overcome the third problem of compromised notes the proposed invention is excellent at providing numerous extra alternative fingerings. First, by using an entirely different total length of appropriately profiled tubing, the player will move the nodal points away from any irregularity or Venturi step. Secondly, a traditionally stuffy note can be made into an open bugle note or a different harmonic. If a note is required to be particularly rich and centred, then by altering the tube lengths it may be made into a bugle note on one "side" of the instrument. One of the three lengths of the instrument provided by the invention can be simply so adjusted that a weak note is now produced as a powerful open note for that length. For example F sharp for Bb instruments. In essence it provides a very wide set of alternative fingerings to improve response as well as tuning.

To overcome the fourth problem of the variety of similar instruments modern conditions require, the proposed invention allows one instrument to be configured to an individual’s wishes. Then each of the three sides will accord with his favoured specifications for the majority of requirements. For example, a CC / BB flat tuba with an ascending BB natural valve. This solves many tuning problems with a single valve and allows the player to switch between the two common contrabass tubas. Equally an F/ E flat and CC tuba would allow a bass tuba to tackle lower parts with the CC tuba’s clearer contrabass voice. However that CC tuba would be of slimmer overall bore than if it were the default version of the instrument. Similarly a piccolo c’ and b’ flat trumpet with a lower pitch of choice would allow altissimo passages to be switched to as a piccolo. Lower passages could have the richer sound of the Bb standard trumpet.

To overcome the fifth problem of fragility, costs and weight, the proposed invention envisages both the valves and/or the instruments built of carbon fibre or other new non-metallic substances. This allows for lighter and more durable parts. This would be particularly important for triple valve versions. In addition carbon fibre may be spun into parts controlled by three dimensional computer modelling. This would allow the creation of the precise configurations with far less hard engineering than brass. The appearance may be maintained by metallic colouring. The weight would be one third.

Advantages of Invention:

A three way, two bore brass instrument valve has the advantages that it looks and is manipulated basically like a traditional valve. The instrument looks like the traditional models. It allows every note to be played powerfully and in tune whilst creating full sounding and safe altissimo notes and resounding lowest notes. It adds both conical or cylindrical tubing allowing the natural sound and nature of each genre of the instrument to remain unaltered. It allows the same resistance or feel for valved and unvalved notes. Scientifically it avoids intrinsic problems rather than trying to solve those created by the laws of Physics in that it maintains the inner-integrity of the tubing, ensures that the molecules of air through which the sound wave is traveling are kept within a coherent environment and ensures that added tubing becomes part of a new and coordinated profile for the entire instrument. It adds or subtracts lengths of tubing as a descending and ascending valve thereby creating innumerable new valve combinations to assist tuning and fingering. It can cope, if desired, with very large differences in bore for conical instruments permitting three routes for the sound wave. Each creates a different total length and profile allowing a choice of either a descant high range, a mid-range and a low range or a specialized route to assist awkward fingering or tuning problems or a route to assist a particular effect or feature. The prototype is in brass but experimental versions are built of carbon fibre (and/or impregnated with metal) for additional speed and lightness. It creates lighter and more versatile instruments and avoids historical limitations. It operates in a rotary or piston form on all brass instruments.

Preferably the invention will be made of carbon fibre treated to look exactly like a metal of choice or a similar material and/or of metal or alloys.

Drawings:

An example of the invention will now be described by referring to the accompanying schematic drawings. They are not intending as detailed scaled plans nor in proportion. Certain features are drawn deliberately to show only the configuration and not as an instrument might be actually designed.

Figures 1 and 2 show the principles of operation and the appearance.
Figures 3 explain the principles of the acoustics.
Figures 4 show the configurations that might be used on the tuba.
Figures 5 show the configurations that might be used on the trombone.
Figures 6 show the configurations that might be used on the standard and piccolo trumpets.
Figures 7 show the configurations that might be used on the flugel horn and piccolo trumpet.
Figures 8 illustrates the Blaikley compensation system as prior art and with the invention as a conical compensating valve.
Figure 9 shows diagrammatically how the invention as the single switch valve with only three standard valves might readily be used for a triple horn or tuba.
Figure 10 shows the two way conical piston version.

In Figures 1 views are provided of the appearance of the inner barrel (1.1, 1.2 and 1.3). It may be seen that two tunnels one (a) above the other (b) transverse one vertical cross section of the barrel, whilst the opposite face has a deep elliptical chamber (c) scalloped from it with an ovoid cross section ("the cul de sac"). The upper arch (d) of the cul de sac is exactly the size of the diameter of the upper tunnel (a). The lower inverted arch (e) of the cul de sac is exactly the size of the diameter of the lower tunnel (b).

Figure 1.4 is a cross section showing the tubing serving the valve when the barrel is in the cul de sac position – the most innovative use of the invention. The sound waves from the mouthpipe pass through the standard valve section and then enter the tube (f) which directs the sound waves to the upper half the cul de sac. The wave is reflected and refracted down within the cul de sac and it emerges directly into the tubing leading to the conical tubing leading to the bell (g). It may be seen that the upper tubing (f) may have a bore of half of that of the lower tubing (g) to gain the greatest comicality. The cul de sac has an inner profile that preserves the integrity of the sound waves. Figures 3 deal with this in detail.

Figure 1.5 shows the invention serving a cylindrical instrument of the proportionate size of a trumpet. The tunnels (k) and (l) are identical and the cul de sac (j) is a regular ovoid and not elliptical.

Figure 1.6 shows the invention sized as configured for a bass trombone.

In Figures 2 views are provided of operation of the invention and three routes available.

Figures 2.1 shows the barrel (h) as it fits into the casing (i) within which it revolves. In this cul de sac position as Figure 1.4 above the sound enters at (a) is deflected within the cul de sac and leaves to the bell via (b). The alternative routes (c) to (d) or (e) to (f) are not used. Figure 2.2 shows the wave flow from above.

Figure 2.3 shows the cross section of the same illustrating a ball joint linkage (j) that would join the two way mechanism (k) and (l) to traditional valve paddles or triggers. The valve would float between contoured plates (m) and is centred as traditionally by a shaft and end plate (n).

Figures 2.4, 2.5 and 2.6 show the same pattern but for a route through the length of conical tubing serving outlet (e). This might be the default setting of the instrument when the invention would be at its normal open position. The tubing would be configured to the requirements of a standard instrument of that pitch. The section between (e) and (f) would blend perfectly with the entire profile.

Figures 2.7, 2.8 and 2.9 show the alternative route through perhaps a shorter length of conical tubing. This would run from (c) to (d).

Figures 3 show the way that the cul de sac preserves acoustic integrity.

Figure 3.1 shows an ideally bent u-tube and how it correlates to a cylindrical version of the invention. The end of the straight tubes (a) protrude into the volume of the foreshortened turning chamber (d) and the inner profile at (b) is removed. Thus reverberation mass is both lost and gained.

Figure 3.2 shows the conical version with the tubes (f) and (g) protruding into the chamber's volume (h) at (a). The area (b) is however gained.

Figure 3.3 shows this chamber flattened as in (j). The profile (i) is corrected to (j) to avoid too expansive a space (k).

Figure 3.4 shows the inner profile cross section at (X) modifying as the chamber is foreshortened. Figure 3.4 (l), (m) and (n) show the progressive change in the inner profile of ideally bent u-tubing as the cross section is foreshortened through (n) to (m) to (l). However in the invention this area (Y), as seen in Figures 3.5 and 3.6 is replaced by the inner rounded profile (p) of the casing. At (m) the (X) cross section would be round whereas at (Y) the cross section has a flattened face. This causes no problems in clarity or intonation and is less significant than the corruption caused by standard valves.

Figures 4 show different configurations of the tuba.

Figures 4.1, 2 and 3 are the same instrument. Figure 4.1 shows the default position. Figure 4.2 shows that the F or E flat default section is replaced by a far longer conical section creating a narrow bore contrabass tuba. This is shown in CC or BBb but simultaneously to assist compromised notes and tuning on an E flat tuba a contrabass pitched in AA might be chosen. If built as a contrabass BBb default then the lowest section might similarly be pitched in EEE – in the full carbon fibre tuba version where weight would not be a problem. This is a conical compensating system in effect. Figure 4.3 shows the cul de sac used for compromised notes as an ascending valve. The valves are not tuned to this position.

Figure 4.4 depicts a full 6/4 bore contrabass tuba using the invention (I) to have a compensating CC/ BB flat instrument with a cul de sac section (D) for compromised notes. If this were in D then it would provide the often difficult second and third valve upper F sharp. Along the emboldened route the sound waves travel through the standard valves tuned to CC into the invention (I) then through a short tube(BBb1) back through the standard valves at a second level which add sufficient compensating tubing to be tuned to BB flat then through a conical section back to the invention which then diverts back to the bugle to the bell. The section of tubing immediately above the invention (CC) is the alternative to the emboldened route having traversed the CC upper level of the valves the invention then takes the CC sound wave straight to the rest of the bugle and the bell. This can be built in keys of choice and applied to the French horn.

Figure 4.5 shows a fully double bass tuba with an E flat section (Eb) and a separate contrabass (CC) section. The cul de sac is here in G rendering the often difficult second and third valve upper b natural. This can be built in keys of choice and applied to the French horn.

Figures 5 show the invention with the trombone. Note the wider bore default bass trombone of Figure 5.1 with its even larger F section, the tenor of Figure 5.2 and the smaller jazz soloist version of Figure 5.3.

Figures 6 show how the invention can create a light triple trumpet. This is a standard Bflat with two piccolo sides b flat and c.

Figures 7.1 shows how the invention would allow a flugelhorn to have an altissimo section (b’b), as well a “alto” side in F which would allow jazz players to use the “pedals” from f below middle c down. Figure 7.2 shows a piccolo trumpet in c and b’ flat with a standard B flat section.

Figures 8 shows the invention used as part of a Blaikley compensating system, the critical point being that from the valve block (a) to the invention (b) the compensating tubing is conical.

Figure 9 shows diagrammatically how the invention with only three standard valves might readily be used for a triple horn or tuba with a descant side (f) a conical B flat side (Bb) and a conical low F side (F).

Figure 10 shows diagrammatically the two way conical piston version.

Claims:

1. A valve for any brass instrument comprising an inner barrel within an outer casing with if desired not two but three routes and two bores for which the air column has in the three way version three separate routes determined by the position of the inner barrel.

2. A valve according to claim 1 which in the rotary conical three route version has two tunnels one above the other transversing one vertical cross section of the barrel which in each position direct the air column around a separate length of if desired conical tubing, whilst the opposite cross section has in the conical version a deep elliptical chamber scalloped from it with an ovoid vertical cross section ("the cul de sac").

3. A valve according to claim 1 which in the rotary cylindrical three route version has two tunnels one above the other transversing one vertical cross section of the barrel which in each position direct the air column around a separate length of cylindrical tubing, whilst the opposite cross section has in the cylindrical version a deep regular ovoid chamber scalloped from it with an ovoid vertical cross section ("the cul de sac").

4. A valve according to the above claims which in the piston three route version has three positions the upper directing the air column around one length of if desired conical tubing, the middle tunnel ("the straight-through tunnel") cutting straight through the piston as an ascending valve and the third directing the air column around a second length of if desired conical tubing.

5. A valve according to the above claims which is operated by the traditional springs, ball joint linkages, struts and levers which may be set to operate the three way version to three positions or solely to two positions at preference thereby using the three way version as a two way version for teaching or temporarily to remove one stretch of tubing to lighten the instrument.

6. A valve according to the above claims from which the valve tubing may be removed temporarily to remove one stretch of tubing to lighten the instrument and in the appropriate configuration render it into a single pitch with an ascending valve.

7. A valve according to the above claims which may be placed before or after the standard valves and when the invention is placed after them, if any of the other valves are opened the sound waves will also go through the loop or loops of the standard valve or valves used.

8. A valve according to the above claims which may be placed after the standard valves and when the invention is placed after them, if any of the other valves are opened the sound waves will also go through the loop or loops of the standard valve or valves used this also overcome the problems of the non-conical profile of prior art compensating systems when this valve is used as the compensating valve

9. A valve according to the above claims for which the air column has three separate routes dictated by the invention: The first route being the "cul de sac" –a simple ascending valve with its return within the valve barrel by use of an elliptical or ovoid chamber connecting the upper and lower levels: The second route being a mid-range or middle tier routed through the valves and then directed by the invention back along its own middle tier route through the valve block and then along a conical tube back to the invention's wider bore port serving the bell: The third route being the lowest range or lowest tier using the first or second route through the valves and then is

directed by the invention back along its own lowest tier route through the valve block then traveling along the longest conical tube back to the wider bore invention port serving the bell.

10. A valve according to the above claims when used for cylindrical instruments the width of the cul de sac is exactly the size of the diameter of the tunnels.

11. A valve according to the above claims when used for conical instruments the diameter of the upper arch of the cul de sac is the same size as the upper tunnel's diameter and the lower inverted arch of the cul de sac is exactly the size of the diameter of the lower tunnel .

12. A valve according to the above claims which when the barrel is in the cul de sac position the sound waves from the mouthpipe pass through the standard valve section and then enter the upper incoming port which directs the sound waves to the upper half of the cul de sac after which the wave is reflected and refracted down within the cul de sac and emerges directly into the tubing leading to the conical tubing leading to the bell .

13. A valve according to the above claims in which the cul de sac has an inner profile that preserves the integrity of the sound waves because the inner profile cross section modifies as the chamber is foreshortened.

14. A valve according to the above claims in which the cul de sac has an inner profile that preserves the integrity of the sound waves by using the inner concave rounded profile of the casing as a flattened continuum of its inner profile.

15. A valve for any brass instrument according to the above claims being a two way version not a three way version and therefore comprising a inner barrel within an outer casing with two routes of two bores for which the air column has in the two way version two separate conical routes determined by the position of the inner barrel the operation and application of which is identical with the above claims for the three way version except the rotary cul de sac chamber or the piston straight-through tunnel are not present and therefore not available but this two way version more particularly providing a conical compensating system when this valve is used as the compensating valve.

16. A valve according to the above claims which uses traditional springs, ball joint linkages, struts and levers that would join the mechanism to traditional valve tops, paddles or triggers.

17. A valve according to the above claims would be built in carbon fibre or otherwise or in a metal or substance of choice.

18. A valve according to the above claims would be built in an instrument built of carbon fibre or otherwise or in a metal or substance of choice.

Abstract:

A three-way, double-bore valve for brass musical instruments.

Figures 2.1 and 2.2 to accompany the abstract.

SCHEDULE ONE

The Valve System:

Description:

Valves change the basic length of an instrument by adding or subtracting extra loops of tubing. For about 150 years players have been able to choose in an instant that length which best produces the note required. By convention instruments are normally made with three basic valves – adding one tone, half a tone and one and a half tones respectively. Tubas, French horns and piccolo trumpets can have several more.

The Laws of Physics dictate that to lower a tube by one tone one must add one eighth of its original length.

A trumpet pitched in C is approximately 4 feet long. A good player can produce some ten to twenty open bugle notes (harmonics) all in the key of C.

> Valve One adds its own separate loop of tubing one eighth (6”) of the bugle - lowering it one whole tone to the pitch of B flat (“Bb”) allowing all harmonics in Bb.
> Valve Two adds one sixteenth (3”) to the bugle - lowering it half a tone - to the pitch of B. This allows a new set of harmonics being some ten to twenty bugle notes in the key of B.
> The third valve adding three eighths (9”) lowers it to A.

The trumpet can now play many notes. Four harmonic series are available - C (open bugle), B, Bb, and A. These include nearly all the following notes within its higher range – A, B, Bb, C, D, E, F, G. However many of the half steps between these – (Ab, Cb, Db, Eb et al) and some lower notes are missing.

To produce these, two or three valves must be pressed simultaneously. Valves 2 and 3 together will lower the trumpet two tones to Ab; valves 1 and 3 two and one half tones to G; valves 1,2 and 3 - three tones to F#. Now, there are eight available harmonic series – valve combinations 0, 1, 2, 3, 12, 23, 13, and 123.

These are sufficient to enable a full chromatic scale - by selecting notes from one or another of the harmonic series available.

The Major Problems

Intonation:

As mentioned, the Laws of Physics dictate that to lower a tube by one tone one must add one eighth of its original length. The vital phrase is “of its original length.”

Suppose that we hold down the third valve. We have lengthened that C trumpet by 9 inches. We, in effect, now have an A trumpet.

Now we wish to play G - one whole tone lower. Can we merely press down the first valve?

Critically, our trumpet is no longer 4 feet but, with the third valve down, 4 feet (the open bugle) plus 9 inches (the third valve loop) – 4 feet 9 inches.

We should add one eighth - not of the original trumpet of 4 feet - but one eighth of 4 feet 9 inches – that is not 6 inches but 7.125 inches. Thus our 6 inch first valve loop is too short for our “A trumpet” and the G we play is sharp.

One or so inches are not so noticeable and easily corrected by the player’s lips. However on a huge contrabass tuba the discrepancies can be 12 inches or more and are very obvious.

Solutions:

Extra Valves:
One solution is to add the required extra tubing with extra valves. However, they reduce the clarity of sound, general resonance and add weight.

Compensating Systems:
Between 1874 and 1930 an ingenious “compensating” system was developed and patented. It rode on the back of many inventions - especially for French horns. This automatically adds extra loops of tubing without extra valves. However, the larger valves and the greater lengths of non-uniform tubing of non-conical nature create further problems. This again can reduce clarity and speed, adds weight and leaves several important lowest notes out of tune.

When the patent expired numerous parties copied the system. Some improved it somewhat by widening the bore of the longer valve loops. However, instruments without this system still play more freely and are far lighter in weight.

Double and Triple Instruments:
This is normal in French horns. They have two or three complete sets of valve tubing and two or three tier valves – each tier serving separately a different set of tubing. The player must use one or two switch valves to change between them. This method is practically impossible for the tuba as the weight and interference with the clarity of tone is greatly compounded and unacceptable. The conical nature of the tubing is severely compromised as is the beauty and clarity of sound. The very best horns are however brilliant engineering achievements.

Slides:
Tubas, trumpets and cornets especially are often fitted with easily moved valve slides to add temporarily the “missing” lengths of tubing. These are moved manually as required. Even with springs and levers, they are inconvenient compared to valves.

Using longer instruments:
Since the worst intonation problems are in the lowest register - which uses numerous valves - the traditional solution is to build a longer, lower pitched instrument for lower parts. These low notes will fall within that longer instrument’s middle range, require few valves and be in tune. Such “families” of saxhorns and other instruments were very popular in 1850s. However this has created over-specialised larger instruments or strict restrictions on writing parts.

SCHEDULE TWO

Three valves have eight possible combinations. (0;1;2;3;12;13;23;123) Four have an additional eight (4;14;24;34;124;234;134;1234). Every fingering has 15 to twenty harmonics. Any particular note on a brass instrument may be fingered as, for example, the 6^{th} harmonic of one fingering, or the 7th of a second fingering or the tenth of yet another. A note out of tune in one fingering may well be in tune in another. However clarity and sound quality usually suffers.