WORKING DRAWINGS, SCHEDULES, AND AN EXPLANATION OF SCENERY CONSTRUCTION TECHNIQUES FOR KANSAS STATE UNIVERSITY'S PRODUCTION OF MOZART'S THE MAGIC FLUTE

by

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INTRODUCTION

On March 2, 1978 Kansas State University's Departments of Speech and Music, and the KSU Opera Theatre opened their production of Wolfgang Amadeus Mozart's The Magic Flute. The audience was presented with a spectacle of grand dimensions. Great colored mobiles turned slowly above a cast arrayed in beautiful costumes, as they sang their story to the accompaniment of an excellent orchestra. The action took place on a large unit set with the look of a sun burst about it. Several of the sun's rays were suspended in air over the orchestra pit. The center of this set was a large raked octagon with the capability of disgorging characters through a trap door in its center. The magical air of the opera was further enhanced by mysterious fog, swings that appeared out of nowhere, and huge abstract pictures cast on the blue cyclorama that provided the backdrop for the production.

To me fell the task of creating this scenic illusion envisioned by the director and the designer. I agreed to be the technical director for this production in partial fulfillment of my Plan B Master's Project. The production was an excellent opportunity for me to try complex problem solving on a practical, rather than theoretical, basis. This job was a chance for me to apply basic scene construction and drafting techniques that I already had learned to a full scale production, while allowing me to learn new practices in both areas. My responsibilities included:

1) preparing all working drawings for the set,
2) ordering all materials required to complete the production within a stated budget of $3,200.00,
3) keeping a budget sheet showing all expenditures,

4) preparing and maintaining an overall building schedule to complete the construction in six weeks time,
5) supervising a building crew of nine people,
6) organizing and supervising set in of the scenery,
7) supervising a running crew of fifteen people,
8) preparing an overall strike schedule, and
9) supervising strike.

APPROACH

My overall approach involved discovering what the total project demanded, breaking the design down into construction units, and finally completing all detail work involved with each of these units.

After looking at both the designer's drawings and his model of the set, I began to plan the various work stages. This was accomplished by making a list of the working drawings that would be required to complete the set. I then ranked the drawings in a priority system by considering three things:

1) the amount of time I felt the project would take to complete, including how many workers would be available at what times;
2) the availability of the materials needed to complete the job, and
3) which projects could not be started until some other project was completed.

Once I had the ranked list of drawings needed (which also determined building order in the shop) I began checking over the list for important materials that would have to be ordered from sources outside Manhattan, i.e. the fog machine, roto-locks, and pneumatic staples, and gave a list of these items to the departmental technical director so they could be ordered immediately. I then figured the lumber order for the first several projects, and placed this order locally.

THE WORKING DRAWINGS

Standard Platforming

After making arrangements for the materials needed, I began the actual drafting process. The first drawing was a platform lay-out (which did not include either the center rake or the cantilevers) that showed how many platforms could be pulled from stock and how many would have to be built. As I divided the set into individual platform units, I also indicated the placement and length of the legs for each platform. I felt this was necessary, as many of the units included several different length legs because the platforms rested one on top of another to produce the layered look of the set. My crew was mostly inexperienced help from outside the department; and I felt these specific instructions to be more helpful than simple, overall platform height designations. I also assigned each unit a code number which I used on the detail drawings of each unit in order to provide a reference system among the various drawings.

I followed this drawing with a working drawing of Kansas State University's version of a standard platform. In many shops this simple drawing might have been considered superfluous as the shop crew would have been well trained in all standard building procedures. However, the inexperience of my crew again dictated that I provide them with a little extra information. I also used this drawing to provide a list of exactly which units would be constructed and which could simply be pulled from stock.

Non-Standard Platforming

The initial platform lay-out showed that several non-standard platforms would have to be constructed in order to complete the basic floor plan as designed. I devoted the next two drawings to the construction procedures for these eight units. I included leg placement, but not leg length, on these detail drawings. The leg length could be determined by referring back to the first drawing.

Raked Platform - Overall Problems

Having dealt with those platforms that required only standard construction techniques, I proceeded to the working drawing of the center portion of the set. This section presented several interesting construction problems. To begin with, the total unit would have been too large to fit through the doors between the shop and the stage, but the sections had to be easily put together and taken apart to allow for painting, for rehearsals, and for the construction of the trap door. This problem was solved by building three permanent sections of easily handled dimensions (the center section had to be large enough to include the trap door) and connecting these sections with two by fours placed in joist hangers. This kept the rigid sections a reasonable size, while allowing us to quickly set up and strike the entire unit. The support beams were constructed of two by six to allow the use of fewer legs on each beam. The connecting beams were all two by four as the spans between the support beams were only four feet, and two by four provided all the support that was necessary in these areas.

A second problem arose in trying to achieve the desired rake for this platform. Before actually calculating the angle of the rake, I had to reach a decision about how the legs would be attached to the two by six support beams.

I rejected the traditional method of lap joints with carriage bolts as too time consuming and complicated. Instead, I chose to use butt joints, twelve inch by twelve inch upsom board corner blocks, and one inch long pneumatic staples. This method had proven to be a quick and stable way of legging platforms in a previous K-State production. Staple legging had several advantages. First, it allowed for a simple way of determining the angle to be cut for each leg; second, it cut down on construction time considerably; and third, it was a method that would work well on the center section of the set, as this section would be firmly held in place from all sides.

Several problems had to be dealt with before this method could be considered completely safe. While this method of legging allows good strength when the pressure is straight down, side to side motion can cause legs to break off. This problem was taken care of by attaching considerable one by three angle bracing to the legs and by firmly bolting the rake to surrounding platforms when it was finally assembled on stage. Another pitfall that had to be avoided was using too much pressure when shooting in the staples. If the bar of the staple broke the surface of the upsom board, its strength was greatly reduced. To combat this problem, the air compressor was run at low pressure, and the staple gun was held slightly away from the surface as the corner blocks were applied.

To calculate the actual angle of each support beam, I drew a side elevation of the rake from which I took the front and rear height of the beam. To determine leg placement, I first measured the exact placement of the stage traps that would be open and then drew these traps on the ground plan. From this, and from the consideration of the weight-bearing capabilities of two by six, I calculated where to place legs so they would bear their share of the total load and still not be placed where they would rest in the open trap area. I included these calculations on the working drawing of the rake by drawing each support beam in side view, showing the angle of the beam, height of the legs, and placement of the legs.

<u>Raked Platform - Construction</u>

To build the rake in the shop the crew had to:

1) leg each support beam,
2) clamp all the beams together to test the correctness of the rake,
3) nail in, or insert, two by four joists,
4) cut the support beams to form the octagon shape,
5) nail the three permanent sections together,
6) measure, cut, and nail the coverings of the three permanent sections in place, and
7) measure, cut, and nail temporarily in place the coverings for the two other sections.

To achieve the first step, a straight line was chalked on the floor of the shop. Perpendicular to this line measurements were made that corresponded with the front and rear heights of the support beam as shown on the drawing. These measurements were marked on the floor. The beam was then laid on the floor so it intersected these marks. Then the two by six was marked to show the correct positioning of the legs; and the two by fours were laid in place, marked, cut, and stapled. When all the support beams had been legged, all the vertical supports were clamped together, and adjustments were made in leg length to ensure the rake was consistant across its total width. Several inconsistencies were discovered and corrected during this process. Unfortunately, incorrect legs had to be removed, re-cut, and re-stapled, a very frustrating process. The vertical beams were then connected with two by four joists, first in three separate sections, and finally, after the joist hangers had been put in place, as a total unit.

The next step involved adding the support beams that formed the angled sides of the octagon. At first, I tried to accomplish this by chalking the true shape of the octagon on the floor, turning the whole unit upside down, and marking and cutting the angles in this position. This approach did not work because all the joints ended up being cut square to the floor instead of at the correct angle to the floor caused by the raking of the beams. I finally solved this problem by turning the unit right side up, and marking and cutting the boards in their actual positions. This problem cost a whole day of construction time because many of the support beams had to be totally replaced as the previous cutting had made them too short for their intended use. This replacement process also involved re-legging the new beams. After the internal framing was squared and nailed in place, the correct position of the angle pieces was determined by laying out a continuous piece of string, in the shape of an octagon, on top of the unit. The string was wrapped around a nail at each corner of the rake. Measurements and adjustments were then made on the string until each side of the octagon was the proper length. This insured that the unit would fit exactly within the rest of the set. When the correct positions and angles had been determined, the angle beams were marked, cut, and nailed in place.

The final job to be completed was covering the frame with three - quarter inch plywood and one-eighth inch masonite. The masonite was used to provide a reasonable dance surface on the rake and was placed rough side up for better traction. Both the plywood and the masonite were fastened firmly in place on the three permanent sections. Finally, the joining sections were fitted with covers and were nailed temporarily in place. In this form the unit was used for one rehearsal period (to give the actors a feel for working on an incline), and the unit was painted. After the rake had been constructed, tested, and painted, the pieces were carefully coded as to position, and the unit was struck to its component parts. These pieces were then stored in the trap room to clear badly needed space in the shop. The center section of the rake was later returned to the shop to allow the trap door to be fitted and installed. When the unit was finally placed on the stage, all temporary joints were nailed into place, and the covering was permanently attached over the whole surface.

Cantilevered Platforms

Having decided how I would approach the problems of the center rake, I began to consider how I would deal with the two platforms suspended in air over the orchestra pit. Both the designer and the conductor were adamant that no visible means of support were to be used. It seemed to me that the easiest way to deal with these platforms was to cantilever them.

In order to ensure the total safety of both actors and orchestra members, I began my calculations by questioning the director about the amount of use the units would receive. We discussed both the maximum weight the units would be expected to bear at any one time, and the type of activity that would take place on this part of the set. Together we estimated the weights of the individual actors who would be positioned on the cantilevers, and then I added a ten per-cent safety factor to the figure. I was also assured that no violent physical activity would take place on either platform.

With this information in hand, I was able to make a decision about what materials I would employ to construct the units. I realized it would be very convenient to use two by twelve for the outside frames and the center braces, as its eleven and one-quarter inch width would allow for the three-quarter inch plywood top to be attached without exceeding the specified one foot platform height. At the same time all necessity for legging the platforms would be eliminated. With the help of the departmental technical director I figured out the load capacity of the amount of two by twelve I would be using and found that it far exceeded the total weight it would have to bear, including the ten percent safety factor I had already allowed.

The next consideration was how long to make the beams of two by twelve that would support the platforms. The optimum length would have been the same length as the platforms themselves. This proved impossible for two reasons. First, beams that long would have interfered with the open traps in the stage floor and made entrances and exits through the trap door in the set impossible. Second, the two platforms were set at such an angle to one another that the beams would intersect. Therefore, I decided to make the support beams on the longer of the two platforms as long as possible without interfering with the trap area and bolt the beams of the shorter platform to them.

Having determined these lumber lengths, I placed a special lumber order and proceeded with drawing and building the units. It seemed wise to use smaller dimension lumber for the internal bracing and angle pieces, to reduce the overall weight of the units. I designated two by four for the internal bracing as it did not have to bear weight and two by six for the angle pieces to provide adequate surface for attaching facings. The larger of the two units was built in two sections along the center seam, with the two center beams being nailed together when all other framing was complete. The smaller unit was built using standard platform construction techniques. Once the frames were finished, the platforms were covered with three-quarter inch plywood, padded, covered, painted, and stored in the trap room until set in.

While the wooden frames were being constructed, one of my crew members was preparing the metal plates that would be used for bolting the units to one another and for bolting the units to the floor. The specifications for these plates were included on the drawing of the cantilever platforms. These plates were necessary as a safety factor. Without them the bolts could concievably pull through the two by twelve, and the platforms would then have no form of support.

These cantilevered units were positioned and bolted in place very early in the set in process to avoid having to have the crew crawl under the entire set to drill bolt holes and fasten the platforms down.

The longer of the two platforms did have some give in it, causing it to sink somewhat under a full load of actors. This sinking was caused by the unevenness of the stage floor and proved not to be dangerous. Once the actors and director realized the unit only sank a few inches and was perfectly safe, this small problem became negligible.

Trap Door

The trap door was an intregal part of the design and had to fulfill several functions. It was meant to be used as an alternate entrance and exit, especially for the Queen of the Night, but also for her Three Ladies, and for the dancers. In addition, the director wished the door to be capable of opening to several intermediate positions, providing varying emphasis for the actors standing on it. This feature of the trap door was to be used primarily during scenes when both chorus members and principals were on stage.

K-State had a hand-operated winch that had been built for a previous production, so opening and closing the trap door for entrances and exits became a simple matter. Building it to bear weight in several partially open positions, however, was not such a simple matter. The problem was so closely related to that of the platforms suspended over the orchestra pit that I reached the same solution about the basic approach; the trap door would be cantilevered.

I again consulted with the director to determine how much weight would have to be supported, and what kind of activity would be taking place in this area. Having reached a total weight figure and adding a safety factor of ten percent, I began considering the type of materials I wanted to use. The actual door was framed in two by four and covered with three-quarter inch plywood and one-eighth inch masonite.

Obviously, this type of construction would not stand up to the forces exerted on a cantilever under these conditions. Therefore, I designed a metal frame that would be bolted firmly to the wooden frame of the trap door, to bear the weight of the actors and the strain of the downward pull of the winch.

This frame consisted of two pieces of four inch channel iron that fit just outside the bracing members of the wooden frame, two pieces of three inch channel iron welded at right angles to these two pieces, at the juncture of the trap and the rake, to clear the framing members of the door and the platform; and two more pieces of four inch channel iron, welded, at right angles, to the bottom of the three inch channel iron, to provide the leverage needed to raise the trap with the winch. These levers were designed to be as long as possible and still clear the opening in the stage floor, as the winch was to be placed in the trap room. The only other parts to this simple frame served to keep the trap level as it was raised and lowered. They consisted of two pieces of two inch by two inch angle iron, one welded to each of the pieces of four inch channel iron within the wooden frame, and bolted to the outside member of the wooden trap, and a piece of three inch channel iron welded across the top of the two levers.

Three jobs still remained to make the planning for this unit complete. The first was to specify the manner of hinging the trap door to the rake platform. For this I chose two ten inch strap hinges to be bolted through the rake and through the two pieces of three inch channel iron that were to be bolted to the framing of the rake. Each corner of the framing of the rake directly behind the trap was to be re-inforced with two inch by two inch angle iron, bolted in place, with a metal plate to serve as a washer at each corner. In this way I made certain the strain on the trap would neither tear the hinges loose nor tear the center section of the rake apart.

The winch was to serve both to open and close the trap door and to keep it open at various angles while it was being used for a platform. A method of securing the winch in place was needed, so the weight of the actors on the trap door did not pick up the winch and shut the trap. The auditorium stage manager would not allow me to bolt the machine to the floor of the trap room. This project probably would have been costly in both time and money anyway, as the floor is concrete. After consulting with the departmental technical director, I decided it would be possible to build a frame of pipe and roto-locks that would hang from the steel work that formed the stage trap, and to fasten the winch to this pipe frame.

I specified that a lip of one inch by one inch angle iron be attached around the hole for the trap door, in the center portion of the rake, where the two by four framing of the trap door would rest on it when the door was fully closed. This was done to prevent the door from falling into the trap room if the hinges somehow ripped loose.

The only problem encountered with the trap door assembly was the stretching of the cable running from the winch to the cantilever. This stretching only

only became evident when actors stepped onto the slightly open trap door. The door would close an inch or two when this happened, but it was not obvious or bothersome, so we did not try to correct the problem.

Stairways and Ramps

After I completed all the planning for the platforming of the set, I began to work on the stairs and ramps that would provide access to the set. Three of the seven stairways needed were pulled from stock. The others had to be constructed in the shop. I provided a drawing of a standard stair unit since this was another building practice which my inexperienced crew was not familiar with.

I also provided a sketch drawing of the ramp that was to be the main exit stage right. This ramp had a slight angle to it, and had to be legged on lines parallel to this angle so it would rest evenly on the floor at its lowest end. The sketch included the framing of the irregular platform that made up this angle, and what platforms would be pulled from stock to form the rest of the unit. When I drew the final drawing of this unit, some time after the production, I included the specifications for another ramp that was added to the design during dress rehearsals. The costume worn by the Queen of the Night not only made it impossible for her to negotiate the trap door entrance, but also made it impossible for her to go up and down steps. A ramp was constructed and placed off the lowest platform stage left to provide a reasonable entrance and exit for this character.

Mobiles

The three giant mobiles required a good deal of planning. There were several difficult design considerations to be met, as well as, numerous safety precautions to be taken.

Each mobile consisted of one large hexagonal unit and three smaller hexagonal units to balance it. The design showed the individual units divided into three sections, with a space between each section. The designer did not want the connections between sections to be visible to the audience. I was aware, from previous work on our stage, that metal in thicknesses of one inch or less becomes virtually invisible when used as a part of a setting in McCain Auditorium. I began thinking about metal connections between sections, and it occurred to me I might be able to use a metal frame for each unit. This seemed an ideal approach as it would solve some of the safety problems I was concerned about. Metal frames would guarantee a solid connection between the sections, and they would not be likely to pull apart under the strain of gravity when suspended in air. However, the use of metal frames alone would have caused two problems. First, the units were to create a stained glass window effect, and the frames had to be stretched with the muslin that would later be dyed to attain this effect. Attaching muslin to metal would have been time consuming and difficult. Second, the entire frame would have disappeared when covered with muslin. This would not have been acceptable to the designer. He wished the framing of each section to be very visible. Both of these problems could be easily solved by framing each section as an irregular flat and then stretching the muslin and stapling it to the wooden frame. In order to ensure a solid unit, each joint would have to be half-lapped, glued, and stapled together with pneumatic staples. If such a framing technique were used, the metal frame could be bolted to the back of the wooden frame with stove bolts. This approach seemed to solve all the problems I could foresee, and nothing remained to be done except choosing the type of metal I wanted to use and actually designing the metal frames.

When I began working on these jobs, I realized the units would have to be finished on both sides, because all sides of each unit would eventually become visible to the audience as the mobiles rotated in the air. This meant the metal frames would have to be sandwiched between the wooden frames. For this reason I chose the flattest metal I could think of that would provide the structural strength I needed, one eighth inch strap iron. The designer pointed out to me that I might want to use styrofoam to frame one side of each unit, as it did not have to bear weight or hold any fabric. I took his excellent suggestion, because styrofoam would also reduce the weight of the mobiles and reduce by half the time needed to half-lap the joints.

Having determined all the materials I would use and the building approach I would take, I began designing the metal frames. For those units that would be hung between two other units, I designed a rectangular frame for the center section, with a set of arms welded on each side to be bolted to the side sections. The top and bottom were to be two inch wide strap iron with a loop welded on each for attaching the cable. The sides and arms were to be three-quarters inch wide strap iron. It did not seem necessary to totally frame the side sections in metal as they were not to bear weight. Those units which had nothing hanging below them were to be framed somewhat differently. The center section was to be framed only across the top and down both sides only as far as the bottom set of arms. All the joints on all the units were to be welded on both sides.

Hanging and balancing the mobiles, once they were constructed, could have been a real problem. To forestall the worst of these problems, I specified one-eighth inch aircraft cable for all the lines, and to insure maximum safety for everyone working underneath the mobiles, I specified two Crosby Clips to be used anywhere the aircraft cable had to be tied off. In order to allow the greatest possible flexibility in balancing the mobiles, I designed pivot points of short pipe and roto-locks at each joint. In this way each side of the mobile could be adjusted along the main section of pipe until perfect balance was reached, while the whole mobile hung free in the air.

When the mobiles had been rigged according to the original design, the designer found that they did not fill the space as he had expected. He went to work with the rigging crew, and together they created a new configuration that was acceptable to both the designer and the director.

The Swing and The Rumble Pots

The last two drawings in this project were completed only after The Magic Flute had closed and the set had been struck. Advance planning for rigging the swing was impossible beyond generalities, until it could be determined if part of the rigging could be fastened to the orchestra ceiling. The rumble pots became the special project of two of my crew members, under the supervision of the departmental technical director. I had no idea how the machines had been built until I examined them closely after the production. It was from this examination that I gained enough information to include a construction drawing with this project.

The rigging of the swing presented many interesting problems. The designer had designated its path on a diagonal line to the proscenium arch, so the lines could not merely be tied to a stabilized batten. The director wanted the swing to be in evidence only for one short scene, so it could not be dead-hung from the grid.

Finally, an elaborate system was devised to provide a disappearing swing that moved on a diagonal path. Once again roto-locks became a useful tool. A piece of one and one half inch pipe the width of the swing was roto-locked to a convenient batten at the required angle to the procenium arch. A three-quarter inch hemp rope was then tied to each end of this pipe. In order to stabilize the batten against the motion of the moving swing, two pipe fittings were devised. The first was merely a two inch section of inch and a half pipe welded vertically to a metal plate. This plate was then clamped to the edge of the orchestra ceiling where the down-stage rope would pass directly through it. The second fitting was more complicated. To begin with, another two inch section of pipe had to be welded vertically across the end of a twelve foot long section of pipe. The longer pipe was then carefully positioned so that the up-stage rope would pass directly through the vertical section and clamped securely to the orchestra ceiling. The ropes were then measured to the exact length required by the director, cut off, and the ends carefully taped to prevent raveling.

During rehearsal the director and the designer decided it would be best if the existence of the swing were hidden from the audience until the moment Papagena began swinging on it. This could not be accomplished by merely flying the swing in, because the noise of the moving batten immediately drew attention to the swing's existence. A way of camouflaging the swing ropes was needed. This was accomplished by flying in a whole series of ropes, including the swing ropes, for Papageno's suicide aria, which took place right before the scene requiring the swing. The swing board was smuggled on by Papagena when she entered and was tied on the ropes by the Three Spirits, while they hid Papagena from Papageno. The other ropes were flown out just as Papagena began swinging. The swing worked perfectly for all rehearsals and performances.

The two rumble pots produced dry ice fog during the Trial by Fire and Water. They were constructed of fifty-five gallon oil drums. Each drum was