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ARMSTRONG LABORATORY

ERGONOMIC SURVEY
HILL AFB UT

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13. ABSTRACT *(Maximum 200 words)* At the request of Hill AFB Hospital Commander, the AFOEHL in conjunction with the National Institute for Occupational Safety and Health conducted an ergonomics assessment at Hill AFB from 29 Oct - 2 Nov 90. The survey was conducted at preselected industrial shops that had demonstrated a high occupational illness rate for cumulative trauma disorders or back injuries. Recommendations were made to correct bad postures; awkward work practices; inappropriate glove use; tool design; fixture design; and manual lifting practices.

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I. INTRODUCTION

Over the previous 18 months Hill AFB had experienced an increase in the diagnosed number of cumulative trauma disorders. As a result, on 3 Oct 1990, USAF Hospital Hill, Hill AFB UT requested that the Air Force Occupational and Environmental Health Laboratory (AFOEHL) perform an ergonomic assessment of selected workplaces on their base. In order to assure the quality of the information obtained from the survey, an arrangement was made for a joint Health Hazard Evaluation with the National Institute for Occupational Safety and Health, Division of Safety Research (NIOSH/DSR).

The AFOEHL, in conjunction with personnel from NIOSH, performed an ergonomic assessment of selected industrial areas on Hill AFB from 29 Oct to 2 Nov 90. The areas were selected based on the incidence of cumulative trauma disorders (CTD) and on the results of a presurvey conducted by CAPT Roger Jensen from NIOSH.

The following industrial areas were assessed:

a. Building 507, Landing Gear

b. Building 225, Station 12 Sheetmetal

c. Building 265, Bonding and Honeycombing

d. Building 849, Heavy Crating

e. Fuels Control

f. Building 900, Freight Terminal

The team consisted of the following members:

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NOTE: This report was accomplished by the Air Force Occupational and Environmental Health Laboratory (AFOEHL), which is now the Armstrong Laboratory, Occupational and Environmental Health Directorate.

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II. DISCUSSION

A. Ergonomics is a much neglected study in the United States. Its importance has only recently been appreciated. Given the seemingly simple nature of some of the suggested changes in this report, the impression may be created that people in charge should have recognized these problems and corrected them. This is not the case. This is a way of thinking new to our industries. It is a unique body of knowledge that is just now being emphasized in the Air Force.

1. While ergonomics has obvious pertinence with regard to humane treatment of workers and can make significant inroads into occupational illness and injury rates, its greatest economic consequence is in the arena of productivity. Relatively simple and inexpensive equipment and adjustments have increased productivity 20% - 30%. We will make some recommendations in this report which may have this much impact. In assessing the payback time of new suggested equipment, this should be kept in mind.

2. The success of an ergonomics program requires incorporation of ergonomic design early in the planning process for an operation. This means that present operations must be thoroughly studied for needed improvements and the resulting requirements must be part of the five year plan. Information must be gathered from the worker level as to the appropriate way to conduct an operation. Early and continuing involvement of design engineers is a must. When a specific device or protective measure is adopted, coordination with

procurement must be close and ongoing to avoid the inappropriate substitution of a similar device that to the unknowing eye of the purchasing agent appears to be the same but cheaper. As with all such programs, ongoing top level management support is necessary for success. This support in combination with ongoing feedback among the involved operations at all levels of concern will assure the program's success. Anything less than this will lead to a program failure.

B. During this assessment it was observed that there were no tool counterbalance devices in any of the areas visited. Many of the tools in use weighed seven to ten pounds. The speed and efficiency of the operations would be improved by the placement of tool counterbalances. These devices support the weight of the tool, leaving the operator free to direct the tool with increased speed and accuracy usually resulting in increased productivity and decreased body strain. Tool counterbalancing devices are of several types. The most common is the take-up reel. These devices are commonly seen in shops specializing in rapid auto lubrication and oil change. They are relatively inexpensive with $35.00 representing a usual cost. They may be selected from the GSA catalog or purchased locally. Payback time on these devices is commonly less than a week. In addition to increasing ease of tool use they serve as a storage device for the tool when not in use and will keep both the tool and the accompanying airline out of the way of the worker and off the floor and thus improve safety. Specific locations for these devices are indicated in the discussion below.

1. Chairs and stools for relief from standing on hard floors need to be more widely distributed. Many of those already present on the floor are in poor repair with protruding springs and broken frames.

2. The types of gloves in general use are for the most part inappropriate. The majority are cotton gloves without special gripping surfaces. These gloves have a slippery working surface with a low coefficient of friction (COF). The worker must compensate for about 25% loss of grip by increasing the force of the grip. This leads to early fatigue with increased risk of injury and decreased productivity.

3. In general, the tools observed were of poor ergonomic design. While there may be some, we did not see any that allowed the type or position of the tool grip to be varied so that appropriate wrist and body posture could be maintained. Most of the tools in use produced high amplitude vibrations of various frequencies as well as substantial torques, yet none were vibration isolated. Polysorbethane pads can easily be added to most available tools. These improve purchase, decrease vibration and fatigue and prevent chronic injury. Care must be exercised not to increase the size of the grip too much for appropriate purchase. For the worst vibration problems, tools are available with gas and metal spring counterweights which will practically eliminate vibration. Careful assessment of work stations will reveal where it is appropriate to consider use of these relatively expensive tools. Keep in mind that the cost is only relatively expensive and not absolutely expensive in terms of injuries prevented and productivity increase.

C. Lifting is a general problem in the areas observed. The following discussion is generated in order to foster some appreciation of the moments involved in lifting. The term forces will be used though some feel this is technically incorrect. In determining the acceptability of a weight to be lifted, the position relative to the spine must be considered. This discussion assumes an erect posture. The position of the center of rotation at the base of the spine creates lever arms which amplify the force applied to the spine by significant factors. A weight held in the extended hand exerts five times the force of the same weight held at the abdominal wall and has a leverage of 60 to one compared to a load directly over the spine. Thus, the force generated by a five pound weight in the hand is equivalent to 300 pounds at the spine. With the elbow flexed and at the side, the leverage is 30 to one and the force is 150 pounds. Even when held at the abdominal wall the force is 60 pounds. When the increase in force generated by acceleration is considered and added to the above the force can be quite dramatic. If odd postures are introduced and rotational motions are applied, the resulting interaction can be devastating. It is the accumulation of these forces that allows the seemingly simple task of picking up a relatively light object to be the final straw in a resulting back injury. When a lifting task is being described, these figures should be kept in mind.

D. As with many job analyses conducted at a single worksite, the biomechanical problems identified and the corrective measures suggested for one work area may apply to similar jobs in other areas. Because this is so, reference may be made to earlier comments or recommendations in the report in order to avoid redundancy in later segments when a similar activity or procedure is addressed.

III. SUMMARY OF ERGONOMIC ASSESSMENTS BY BUILDING

Directly quoted paragraphs from Vern Putz-Anderson, NIOSH, have been included in this report. His quotes are noted in italic type.

A. Building 507, Landing Gear: Only a small area of this very large shop could be adequately observed in the time available. Three areas were observed; machine shop, landing gear grinding, and vertical turret lathe.

Machine Shop: Lifting, Assembly

CAUSE OF PROBLEM	SOLUTION
The tool tray attached to the front of the conveyor increases worker's reach distance.	Remove tool tray; install tool balancers.
Conveyor height is not adjustable, causing the worker to lean over the work surface.	Replace conveyor with adjustable table/conveyor where height can be customized.
Hex wrench used for breaking bolts with impact wrench is too small and short.	Tool handle should be lengthened and diameter increased and padded.

The first station of the production line where breakdown of the wheels begins offers many opportunities for improvement. The tool tray in front of the worker impedes access to work by increasing the necessary reach by four to eight inches. It can be removed and the small hand tools used by the worker can be carried on a personal equipment belt. The air driven impact wrenches should be placed on overhead returns in order to both remove them from the work area when not in use and improve ease of handling when in use. The worker should be instructed to move the pieces as close to the edge of the conveyer as possible in order to limit reach. The height of the conveyer is inappropriate for the current worker and needs to be elevated. Small conveyer sections on hydraulics are available so that height can be customized as needed. This will substantially eliminate back fatigue and increase speed and productivity. The purchase of tools with interchangeable grips will allow choice of the appropriate handle for the current task position and substantially decrease poor wrist posture with its resulting fatigue and risk of cumulative trauma. The gloves in use are the cotton type with poor purchase qualities. This slippery surface increases the force required to hold the tool while in use, thus increasing fatigue, decreasing productivity and increasing injury risk. The hex wrench held in the operator's left hand when breaking bolts with the impact wrench is far too small and too short. She is suffering repeated, high force, rapid onset, torques. The tool handle should be lengthened and its diameter increased and padded to improve her leverage and isolate vibration. An automatic breaking torque wrench might be investigated for use to prevent some of the highest accelerations.

A female worker was observed using an overhead hoist mounted on a crane to transport a wheel housing to a conveyer work area where she proceeded to disassemble parts from the wheel housing. There are a number of ergonomic problems associated with her job. First, she was observed bending or leaning over the edge of the conveyer while elevating her shoulders to reach the center section of the wheel housing that she was working on. An adjustable conveyer or work table is needed here that can be lowered to reduce the stress on her shoulders and provide her with greater mechanical advantage. The table also could be tilted slightly towards her so that the work piece would be as close to her as possible. Second, an overhead tool balancer should be installed to hold the tools in place for her. This would reduce the need for the tray or tool trough, which was attached to the front of the conveyer. This tray should be removed because it increases her reach distance by at least 6 inches.

Landing Gear: Lifting, Grinding.

CAUSE OF PROBLEM	SOLUTION
Booth designed so that worker had to use an excessive reach distance to be able to work on the part.	Booth enclosure should wrap around worker--concave a section of the work surface to allow worker to get closer to the job.
Lifting wheel into the booth required worker to reach, lift and turn to push the wheel through the side opening.	Use of a push bar from the side of the booth so that the wheel can be pushed into place from the conveyor.

The sanding booths at the end of the stripping process were assessed for lifting, vibration, ventilation, and respiratory protection. Ventilation is adequate and respiratory protection appropriate. The small grinding/sanding tools used to remove rough edges and burrs create significant high frequency vibration. Use of vibration isolation pads should be considered.

The lifting required to place the part in the sanding booth is deceptively risky. The requirement to reach, lift and turn produces significant torsional stress on the spine with a fairly substantial risk for cumulative injury. It seems possible to eliminate most of this awkwardness by using a pusher bar from the side of the conveyer opposite the opening into the booth. Suggest this possibility be investigated.

This operation involved grinding and sanding wheel housings. The worker pushed a wheel housing through the side port of the ventilation booth where a sander was used to clean and prepare the surface. When completed the wheel housing was pushed out the other side through a small port. The booth was designed to control the dust from the sanding operation. Because of the nature of the enclosure, the worker had to lean into the booth using one hand to position the wheel housing and the other to guide the sander, causing shoulder, neck and back flexion. A smaller worker in another booth was observed sitting on the ledge of the booth while using a stool to balance herself. Such constrained postures put pressure on the thigh and can easily cut off blood circulation. To reduce what appeared to be an excessive reach distance, the enclosure should wrap around the workers in a circular fashion, allowing the workers to keep the work piece close to their body. It may be possible to simply cut out a concave section of the work surface in the booth to allow the worker to reduce the reach distance and still contain the dust exposure.

Vertical turret lathe: This operation needs immediate attention.

CAUSE OF PROBLEM	SOLUTION
Loading 37 lb. wheels requires having to step into the lathe machine and place the part on the center spindle.	Install a jib crane or floor mounted knuckle crane to load the wheels.

Loading requires climbing, stepping over a barrier and leaning into the machine in a very awkward manner. The operator did this task in the best possible way, but because of the many obstructions and reaches required, maximum permissible lifting weights are exceeded with even very light weights. The overhead cranes used for loading large drums are too few in number for the number of machines in operation and thus are under-utilized for the lifting task. Consideration should be given to increasing their number or designing and installing an appropriate lifting mechanism for operator use. The drums are brought on a fork lift and deposited on the floor on a pallet. The operator must stoop and lift the drums from the pallet. Placing the drums on an elevated surface will increase efficiency and decrease risk of injury. Adjustable benches may be the answer here. If the work is piled high at times, it may be necessary to consider a platform which sinks below ground level when loaded. Similar platforms are in use in the air freight terminal. The keyboard on the controller for the lathe is vertical. If this is extensively used, it will cause elbow and shoulder problems. If use is intermittent, this is not a problem. If use is frequent the design needs to be changed.

A male worker was observed lifting a section of wheel housing weighing about 37 lbs and placing the part in a large milling machine.

Because of the configuration of the milling machine, the worker had to actually climb into the machine to load the part on the center spindle of the machine. This lift poses a risk for shoulder, knee, and low back injury because of the excessive reach distance between the front of the machine and the center of the machine. The distance between the front of the machine and the location of the center spindle where the part had to be loaded was approximately 30 inches, which exceeds the 25 inch maximum allowed by the revised lifting equation NIOSH (1990). The simplest and only solution for this lifting job is to install and use a jib crane or floor-mounted knuckle crane to load the wheel housings into the machine.

B. Building 225, Station 12: It performs specialized sheet metal work for parts of the F-4 tail section.

CAUSE OF PROBLEM	SOLUTION
Rivet guns are not available with different grips to allow for position changes.	Purchase riveters that have both inline and pistol grip handles.
Jigs for holding various parts are not available, causing workers to improvise positioning parts.	Jigs should be designed to hold parts in appropriate positions so workers do not have to bend, kneel or lean into position to work on the part.
Bucking bars are poorly designed, creating pressure on palms of the hand when used.	Design a better bucking bar and use bucking gloves that have polysorbethane pads to help absorb shock.
Table heights were not adjustable.	Table heights should be adjustable.
Overhead tool balancers were not available.	Install tool balancers at each station.

The work requires the assumption of many poor postures and involves the use of high force, rapid onset, and vibrations from rivet guns. The bucking bars necessary to obtain access to the confined spaces within the tail section are small, poorly designed and have been a significant contributory cause of numerous cases of median nerve damage in personnel in this area. The rivet guns are not ergonomically designed. There is no provision for changing grips in order to minimize poor wrist, arm and body positioning while working. There is a definite need for appropriate jigs to hold parts in position while being worked on. Some workers were observed placing parts on the floor and sitting astride them while holding arms and bodies in extremely awkward postures in order to accomplish the required tasks. If appropriate design cannot be accomplished locally, there are many companies which specialize in solving such problems. Even though the task performed may be slated for termination in the not too distant future, properly designed jigs can be transferred to other tasks in other locations. There are no take-up reels or other tool balancing devices available. These would be an immense help in this shop.

Bucking bars, in general, are not well designed. There is a need for such design. Perhaps local design engineers could collaborate with local medical personnel to design ones better suited to the human hand than those available on the market. While looking into that possibility, we recommend the purchase of bucking gloves with polysorbethane pads. While it is true no good study addresses the use of these gloves in riveting, they have been adequately studied in other uses. These studies show quite clearly that these pads are very good at transferring loads to broad areas from small impact points. They are also quite good at transferring vertical force to the horizontal plane. It is therefore reasonable to assume that they would be effective in translating the point forces generated by the bucking bars to a broader area of the hand and in dissipating the force horizontally. In our opinion, it is reasonably medically certain that the bucking bars have been a major contributor to the very high rate of operative median nerve damage in this unit and that use of the glove will be of significant benefit in reducing this injury. The cotton gloves in use in this section are inappropriate. They have a slick surface and require the operator to exert increased force to grip the tool, thus increasing fatigue, decreasing productivity and increasing the risk of injury. Appropriate gloves with gripping surfaces are available. The tools themselves should be slated for replacement with appropriate tools with vibration dampeners. Since this is a long range goal, appropriate dampening material should be placed on current tools.

During the repair process, workers were observed standing on a work table to flatten a piece of sheet metal. With the metal so flattened, they bent over and used a scribe to mark the surface of the metal for cutting and drilling. Once appropriately marked and cut they once again mounted the table to hold the metal with their weight while bending over to drill holes for the rivets. This operation is totally unnecessary. The use of appropriately designed jigs and clamps will accomplish this task with far greater speed and efficiency and far less fatigue and risk of injury.

Workers were observed riveting and de-riveting small sections of the aircraft in the shape of cones. The problems of awkward hand and shoulder postures, exposure to vibration, the use of forceful hand motions observed here were similar to the ergonomic problems observed in workers doing similar jobs identified in Bldg 265. The recommendations also are similar: (1) install overhead tool balancers to suspend the tools to reduce the fatigue associated with holding the tool, (2) consider the use of specialized work fixtures and/or adjustable lift tables to properly position and secure the work pieces, and (3) purchase some vibration absorbing gloves that provide sufficient friction to hold the tools without the need to increase grip force to compensate for the gloves. You may have to consult with a design engineer and with the employees to ascertain what would be the most versatile and suitable fixtures to hold the work pieces that are normally repaired.

C. Building 265, Bonding and Honeycombing Sheetmetal Shop: It has many of the same problems that Station 12 has.

CAUSE OF PROBLEM	SOLUTION
Problem/Solutions from the previous section (Station 12) also apply here.	
Jigs for large parts are moveable, however, they are rarely adjusted because of the complexity and time required.	Make large jigs more easily adjustable.
Some stations use plywood platforms that are not adjustable and have no jigs available.	Replace platforms with adjustable lift tables. Construct jigs for parts.

The remarks above regarding tools, postures, gloves, and jigs are all applicable in this area. To some extent, some of the poor postures are worse in this shop due to the immobility of the large parts being worked. The jigs are movable but are rarely moved because it requires the use of the overhead crane to change position of the part. Some of the work stations do not have jigs but use plywood platforms which cannot be adjusted. The poor postures, high impacts and repeated actions involved in this work have resulted in an unusual number of cumulative trauma injuries. In general the corrective actions suggested above will be applicable here as well.

The following statements follow in sequence the NIOSH videotape taken during the survey:

The first worker observed was subjected to a series of awkward and static postures while grinding rivets off a large flat section of the aircraft, which is resting on a pair of saw horses. Observed postures included squatting, extreme flexion at the waist, wrist extension, and neck flexion. This is an example of the worker adapting to the constraints imposed by the work materials and job task. The usual solution to this problem is to use a mobile and articulated fixture to hold the material in various positions to allow the worker to assume a more normal and upright posture. A pedestal vacuum-style of industrial manipulator. which is available commercially from a number of companies specializing in manual handling devices, would provide the most complete solution. Industrial manipulators can be used to hold and position a variety of materials of different shapes and weights. Although these devices tend to be expensive, they are by design more generic in their application; therefore, are more adapted to low-volume custom work where individual material holding fixtures might be too restrictive or simply impractical.

Another problem is that the worker observed was using cotton gloves that provide a low coefficient of friction (COF). Workers who used cotton gloves must compensate for about a 25% loss of grip strength; and consequently, cotton gloves often require the workers to apply excessive manual force to maintain control of their work tools. I recommend the use of a glove with a higher COF, such as a leather glove with rubberize finger strips and some form of vibration absorbing qualities. Raynaud's disease is common among grinders. A number of anti-vibration gloves are available on the market. You may have to purchase samples from different vendors and have the workers select and use those work gloves that best fit their needs.

The second worker shown in the video tape was drilling out rivets on a large aircraft section that was held in a vertical position by a large fixture. It is apparent that a high level of manual force is required for this drilling operation. This is a case in which the tool appears to be ill-suited for the job. One solution is to provide a heavier and larger power drill that is suspended overhead by a tool balancer. With a larger and heavier tool that is also suspended, less manual force should be required to perform this type of job. In addition, the worker's drill bits need to be inspected and sharpened on a regular basis. Applied force can be reduced if the worker has access to, and uses, sharper drill bits made of high grade steel. Ultimately, the solution to the biomechanical stresses imposed by the difficult job of de-riveting is to find a better tool or system for removing rivets. Identifying such tools should be a high priority.

The fourth worker shown in the video tape appeared to have developed his own de-riveting device. He used this custom tool as a "horizontal drill press" to increase his leverage as he drilled out the rivets in the aircraft panel. Despite the worker's use of his customized leverage tool, the worker was observed leaning into the tool using his body weight to force the drill bit through the rivet head. I was surprised he wasn't breaking drill bits. It is evident from this worker's custom drill holder, and the stressful body postures exhibited involving extensive and forceful shoulder extensions and wrist extensions, that these de-riveting jobs need to be redesigned. A priority, noted above, is the need to identify and implement a less stressful method for removing rivets. I consider these de-riveting jobs highly stressful for even the strong young men who were observed performing these jobs. Based on my experience, these jobs will lead to musculoskeletal symptoms characterized by overexertion involving the workers' hands, shoulders and low backs.

In the next work sequence, two men were filmed working together riveting what appeared to be a tail section of an aircraft. This job also involved significant manual forces to hold a "bucking bar" in place and to position the riveting gun. Overhead tool balancers could be installed to suspend the tools at the proper height and reduce the fatigue required to hold the tools. Again, some awkward postures were evident here that could be reduced with appropriate fixtures or industrial manipulators. Such fixtures would allow the work piece to be positioned closer to waist level rather than having the workers stand on boxes and work with their arms elevated. Working postures involving elevated arms and forceful activities are associated with a number of chronic shoulder complaints. See Table 1, p. 22 in Putz-Anderson manual on cumulative trauma disorders (1988).(Appendix E)

Another worker was filmed in a seated posture using a drill to remove rivets from a small aircraft panel. Many of the previous comments apply here. Obviously, the workstation and chair used here are inappropriate for this job. Again, an articulated manipulator or fixture could be used to hold and position the work piece to reduce the awkward hand and arm postures used in this drilling operation. Rather than being able to position the material, the worker was seen drilling underneath from the bottom up, which is mechanically unsound and potentially dangerous. A fixture also is needed to hold the material in place to allow the worker to assume less stressful work postures. Again, an overhead tool balancer should be installed.

An airpowered reverberating sander was demonstrated for our viewing by a worker who noted the excessive hand vibration associated with the use of this tool. Some form of vibration-absorbing glove is recommended here. As I understand, this sanding job is performed only intermittently by the workers. Total exposure time to vibration should be monitored to ensure that it does not exceed the limits recommended in the recent NIOSH Criteria Document on Hand-Arm Vibration.

A worker was observed and filmed stripping the metal skin from a section of the aircraft. A small scoring tool with a rotating disc was used to cut a channel in the skin. A chisel was then used to lift the edge of the metal skin. Once an edge was exposed, a long bar was used to roll up the skin, like opening a sardine can. Although this job requires some forceful arm and wrist motion, the use of the long stripping bar provides a good mechanical advantage. To secure the work piece on the bench, a large cylindrical object in the shape of a coffee can, acting as a counter weight, was placed on the work piece. This is a potential safety hazard. If the worker applies too much downward force, the counter weight could easily be catapulted off the bench, striking the worker. This example represents yet another job where a fixture should be used to secure and position the work piece to allow the worker to adjust the work piece to provide more bio-mechanically sound work postures.

D. Building 849: Heavy crating

CAUSE OF PROBLEM	SOLUTION
Table heights were not adjustable and were too wide.	Convert existing tables to ones that adjust and are narrower.
Tool balancers were not available for nailers that weigh 6.5-7.5 lbs.	Install balancers for each station.

Workers manually handle lumber, cut it on power saws, and construct crates using nail and staple guns and hammers. Body part discomfort forms were completed on 17 workers in the shop. On a scale from 1 to 10, no discomfort to maximum discomfort, body parts were assessed by each individual at the beginning of the shift (0700), midday (1200), and the end of shift (1430). Of the 17 workers, 7 constructed crates, 6 cut soft blocking (foam, cardboard) and 4 cut wood. (Appendix C)

Very little discomfort was noted by workers on the initial body part discomfort form completed at 0700. By 1200 hours the right wrist, hand, mid to lower back and right and left lower legs/feet were marked by several workers as experiencing weak to moderate discomfort. On the end of shift form the areas just cited increased in discomfort and the right and left shoulders also increased. It should be noted that by the end of shift the mid to lower back and both lower legs and feet were giving 13 out of 17 workers some discomfort. See Appendix C. Discomfort ratings were totaled for each body part by time of day.

Table heights ranged between 30 and 34 inches and were not adjustable. Nail guns weighed 6.5 to 7.5 pounds depending on the size nail in use.

Counter weights for tool suspension were not in use. Gloves available for use were made of cotton or suede, materials that are not appropriate for handling tools. Table heights should be adjustable so varying heights of workers can be accommodated. Using platforms for the shorter workers would be acceptable as long as they were large enough to allow movement and not contribute to falls. Power tools, nail and staple guns, should be suspended on counter weights to allow all weight to be supported. This will prevent workers from having to support these heavy tools during use. Having the tools suspended will also keep them in reach and out of the way. Gloves should be made of materials that have a gripping surface on the palms and fingers. Smooth gloves prevent a good grip and cause the worker to increase the force applied.

In this work area, female workers were engaged in constructing crates for shipping. Air powered nailers weighing between 6.5 lbs. and 7.5 lbs. were used to assemble the crates on large tables, 34.5 in. high and approximately 60 in. wide. In addition to the observed trunk flexion, excessive shoulder flexion and abduction was observed. The weight of the tool also contributed to high levels of applied grip force, accelerating arm fatigue and hand tendonitis. All of the jobs in the heavy crating operation could benefit from the use of overhead tool balancers. For the majority of the carpentry jobs observed, the work table was too high. Adjustable work tables (commercially available and labeled as "lift tables") are needed. These tables can be readily lowered and raised by the worker as required. Moreover, the work tables were too wide for the jobs observed, resulting in workers having to lean over the table or walk around to the other side of the table to complete the operation. Rotating table tops, such as a "lazy susan" that allow the work material to be positioned in front of the worker would reduce some of the leaning, bending, and walking required to do the job. Workers were observed nailing from underneath the material, pointing the nailer upwards towards their face. This is a potential safety hazard that could be remedied with a mercury switch that would disengage the trigger mechanism when the nailer is tilted upside down. The manufacturer of the nailer (SENCO) should be consulted about installing a safety device in the nailer gun to prevent the tool from operating in this position.

E. Building 900: Freight Terminal

CAUSE OF PROBLEM	SOLUTION
Manual lifting required to load pallets can cause workers to handle items up to 70 lbs and tires up to 250 lbs.	Lifting assist devices should be installed to handle items over 50 lbs.

Pallet loading performed here requires substantial manual lifting. During our observations the terminal was not busy and therefore the pace for loading was relaxed. On the conveyer side of the terminal most of the large items are loaded with fork lifts. The majority of the boxes weighed 25 pounds or less. Occasionally boxes weigh up to 70 pounds. Tires for varying aircraft could weigh up to 250 pounds and are difficult to handle. There is tire/wheel handling equipment available on the market. (Appendix B)

A worker was observed building a pallet for air transport. During our period of observation, the worker was able to load the pallet in a leisurely manner. All packages that were carried were less than 25 lbs, well within the NIOSH (1981, 1990) guidelines for manual lifting. The conveyer system, however, is capable of handling loads up to 75 lbs. Loads that exceed 50 lbs should be prominently labeled with a warning sticker identifying the requirement to use automated lifting-assist devices, such as overhead hoists mounted on a small mobile gantry or use of a jib crane.

F. Fuels Control:

CAUSE OF PROBLEM	SOLUTION
Hose on the R-9 truck would jam while being extended.	Uptake reel is too narrow for size of hose; reel should be widened.

The hose on the R-9 truck would jam while operators were pulling the hose out causing them to be jerked off their feet. The uptake reel is too narrow to wind the hose properly and it backlashes suddenly when being pulled out. It has pulled two operators off their feet as they were unreeling the hose. The solution to this problem is to widen the reel, thus permitting the hose to be rewound without overlapping itself.

The injury rate in this shop is 16.67 back injuries per 100 employees per year. This is twice the national average rate for all injuries per 100 employees. Because of this rate, LVRS at Maxwell was contacted by phone in November 1990. According to LVRS no other bases are having problems with injuries and the R-9. This lack of reported injuries is most likely a reporting problem rather than a true absence of injuries because LVRS stated that other bases have attempted to modify the reel on their own. This means that others are having some form of trouble which made them look at modification.

The seriousness of this injury rate warrants an investigation of the design. Careful equipment design, not employee training, must be the first line in preventing injuries.

IV. MEDICAL RECORDS REVIEW: LCDR Patricia Schnitzer was provided a current listing (October 1988-October 1990) of the CTD cases from the PHOENIX data base for review. There were a total of 79 cases. Medical records of 16 cases reported from workers in the four areas that were surveyed during the visit were reviewed: station 12 sheet metal (Building 225), heavy crating (Building 849), bonding/honeycombing and stabilators (Building 265).

A. *Of the 16 medical records, all workers had been referred to or from a private physician though it was not always possible to ascertain the sequence of events. It appears that these workers received the majority of their treatment and diagnostic procedures from private physicians. As a result, the clinic medical record did not always have detailed chronology of the worker's clinical course. In addition, it is possible that results of diagnostic procedures may not have been sent to the clinic and are therefore not available in the medical record.*

B. Limited or light duty was prescribed for all 16 workers. One worker was on light duty for 1 month with resolution of the problem, but typically these workers were unable to perform their normal duties for periods of 4-15 months. Five workers changed jobs permanently and two others were recommended for a permanent job change by the physician.

C. Five of the 16 workers had CTD's which required surgical intervention within 2-10 months of initial presentation to the occupational medicine clinic. Two of these workers underwent bilateral carpal tunnel release surgery. Results of EMG and/or nerve conduction studies were present in 7 of the 16 charts.

D. Based on the medical record review, LCDR Schnitzer's impression is that the PHOENIX surveillance system identifies the more severe CTD cases. It is likely that these cases merely reflect the tip of the iceberg in terms of CTD prevalence at Hill AFB. A survey might be considered to establish prevalence of CTD symptoms in the workers at Hill AFB. A survey would serve two purposes. It would identify work zones with the highest prevalence of CTD symptoms in workers, and identify risk factors for CTD's. Expected outcomes of a survey include the ability to effectively target high-risk jobs for intervention strategies and establishing baseline prevalence to which post-intervention prevalence can be compared. This comparison would allow for effective evaluation of intervention strategies.

E. In lieu of a large scale study, it might be more feasible to initiate a screening program for CTD symptoms among workers in high risk work zones. Such routine screening programs currently exist at Hill AFB for monitoring hearing capability among workers in noisy work zones. In fact, during the walk through workplace inspections, it was noted that many of the workers exposed to repetitive manual tasks were also exposed to noise. This observation was confirmed during the medical record review as most of the records I reviewed contained reports of annual audiometric testing. Thus, the cost of a CTD symptom monitoring program could be minimized by obtaining the CTD symptom information at the time of the worker's audiometric test. Early identification of workers with CTD symptoms would allow for the implementation of non-invasive interventions which, in turn, may prevent progression of the condition.

V. COMMENTS: The following comments are from Roger C. Jensen, Ph.D., Division of Safety Research, NIOSH. His statements are based on a solution priority going from elimination to substitution to control.

A. *Elimination: The first comment concerns the handling of brake drums. As the process is understood, brake drums are rebuilt in Building 507 and manually placed in a large wooden crate. The crate is then transported to Building 849 for temporary storage. Eventually, someone with the Distribution Division in Building 849 manually lifts the brake drums out of the wooden crate and puts them in smaller containers for shipping. It should be possible to eliminate the manual load handling task in the Distribution Center by having someone in Building 507 put the brake drums into smaller containers instead of into large wooden crates. This approach--elimination of a hazardous operation--is the preferred approach.*

B. *Substitution:* If elimination is not a realistic option, the substitution approach should be considered. An application of this approach may be in the air freight terminal where pallets are loaded for shipment. The items to be loaded are delivered to the loading area on roller conveyers. Workers pick up the items at a fixed height from the conveyer, carry it to the pallet, and place it on the pallet. The work rule is that items weighing up to 70 pounds may be lifted by one worker. The risk of back injury can be reduced by changing this rule to 50 pounds and using materials handling equipment for items over 50 pounds. Two possibilities for materials handling equipment are suggested for consideration by the Hill AFB engineers. The first would be a portable chute to allow items to be slid downward from the conveyer onto the pallet. The essence of this approach would be the substitution of gravity for human back muscles as the source of power for the transfer. It would not need to be any more sophisticated than a typical slippery-slide found on a children's play ground. It would, of course, need some sort of hooks to attach to the edge of the conveyer or be self supporting. The second possibility would be to install a chain hoist for each pallet loading platform with suspension extending over each platform and the adjacent section of the roller conveyer. If either of these can be accomplished, establishment of a work rule that equipment be used for any item weighing over 50 pounds is recommended.

C. *Control:* The third general approach is to control the level of hazardous energy experienced by the worker. An opportunity for application of this approach was observed in the container fabrication area of Building 849. Two workers were building panels for wooden crates. Both stood on the same side of a large table. They had to reach 36 inches in front of their body to shoot fasteners into one side of the panel. It would be helpful to have a table 36 inches wide in the work area. Then the two workers could stand on opposite sides of a panel. Each would be able to easily reach across half the panel for shooting fasteners. This would reduce the level of biomechanical stress in the back and shoulders, and reduce risk of developing a cumulative trauma disorder. It would also be helpful if the work tables were adjustable in height.

The use of gloves is also an application of the control approach. In Building 265, a hand-held powered rotary sander is used to smooth wing flaps, ailerons, and other components of wings and stabilizers. One hand holds the handle and trigger while the second hand applies pressure to the sander. A vibration damping glove on the second hand would help control the level of vibration energy reaching the hand.

Gloves with impact attenuation pads in the palm are strongly recommended for holding the bucking bar in the riveting operations performed in Building 225, Sheetmetal Station 12. Numerous other riveters would probably benefit from gloves, but other riveting operations were not observed closely. It may be appropriate for some riveters to use different types of gloves on their two hands, e.g., a leather glove to hold the riveting gun and a glove with impact attenuation pads in the palm for the hand that holds the bucking bar. It might be useful to provide several glove models for workers to try out. They would probably be the most effective judges of which type glove would best suit their needs.

D. In addition to the above suggestions, research literature citations are provided at Appendix D and may be consulted for more information.

VI. CONCLUSIONS

This ergonomic survey was a large step forward in establishing a comprehensive ergonomics program at Hill AFB. Although only a relatively few job practices were reviewed during this survey, the recommendations in this report have validity at many other work areas on Hill AFB and other Air Force installations.

APPENDIX A

Request for Ergonomic Survey

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DEPARTMENT OF THE AIR FORCE
UNITED STATES AIR FORCE HOSPITAL HILL (AFLC)
HILL AIR FORCE BASE, UTAH 84056-5300

03 OCT 1990

REPLY TO ATTN OF: SGPM

SUBJECT: Request for Ergonomic Assessment at Hill AFB

TO: AFOEHL/CC

1. Over the past 18 months Hill AFB has been experiencing an increase in the number of upper extremity cumulative trauma disorders with 38 such conditions diagnosed since Jan 90. Although we reduced our back injuries by 30% during FY90 (263 in FY89 vs 175 in FY90) through extensive training and the use of back belts, we fully recognize that if we are to make additional gains in this area, sound ergonomic principles must be applied to job design.

2. Because of our lack of expertise in ergonomics, we previously requested that the NIOSH Division of Safety Research (DSR) perform an Ergonomic Health Hazard Evaluation (HHE) at Hill AFB. During July, Dr Rodger Jensen of DSR visited our installation and performed a pre-survey. He was given an extensive tour of the work areas where we are experiencing the majority of our ergonomic disorders.

3. We were recently informed by DSR that they are not certain that they will be able to perform the HHE due to funding constraints. In light of this, our occupational health working group and the Installation Occupational Health and Safety Council have decided that we can wait no longer for the assistance of NIOSH as we are anxious to find solutions to our problems. I am aware that a number of AFOEHL personnel have recently received extensive ergonomic training. Because of this, I am requesting that AFOEHL perform an ergonomic assessment to include a number of selected workplaces at Hill AFB. The tasks associated with the ergonomic disorders primarily involve riveting, grinding, sanding, hammering and lifting. Dr Jensen of DSR told us that there may be sufficient funds available for NIOSH to provide some technical consultants at the time of your evaluation, therefore I suggest that you contact him for this purpose. In addition, if you can obtain a report of the pre-survey that Dr Jensen performed, it should help direct your efforts here at Hill. His address and phone number are as follows:

Centers for Disease Control
National Institute for Occupational Health
ALOSH/DSR (Attn: Dr Rodger Jensen)
944 Chestnut Ridge Rd.
Morgantown, WV 26505-2888
(304)-291-4809

AFLC COMBAT STRENGTH THROUGH LOGISTICS

4. My point of contact for the evaluation is Lt Col Craig Postlewaite, Chief of Environmental Health Services. He can be reached at AV 458-1166.

KENNETH KLINT, Col, USAF, MC
Commander

APPENDIX B

Tool Design Information

ANTIVIBRATION GLOVE MANUFACTURERS

VISCOLAS Glove Material
Mr Steve Coakley
GENCO Glove Co.
P.O. Box 231
Chattanooga, TN 37401

800-233-7551

SORBOTHANE Glove Material
Mr Harry Lewis
Sager Glove Co.
65 E. Palatine Road
Prospect Heights, IL 60070

312-541-1361

PORON Glove Material
Mr Dan Pouba
Shelby Glove Co
P.O. Box 8735
Grand Rapids MI 49518

800-253-3598

Mr D.J. Stanley
Guard Line Inc
P.O. Box 919
Atlanta TX 75551

800-527-8822

Mr R. Smith
Steel Grip Safety Apparel Co
P.O. Box 747
Danville IL 61832

217-442-6240

ERGONOMIC HAND TOOLS

The following tools have features which would appear from their design to reduce workplace stressors in some jobs.

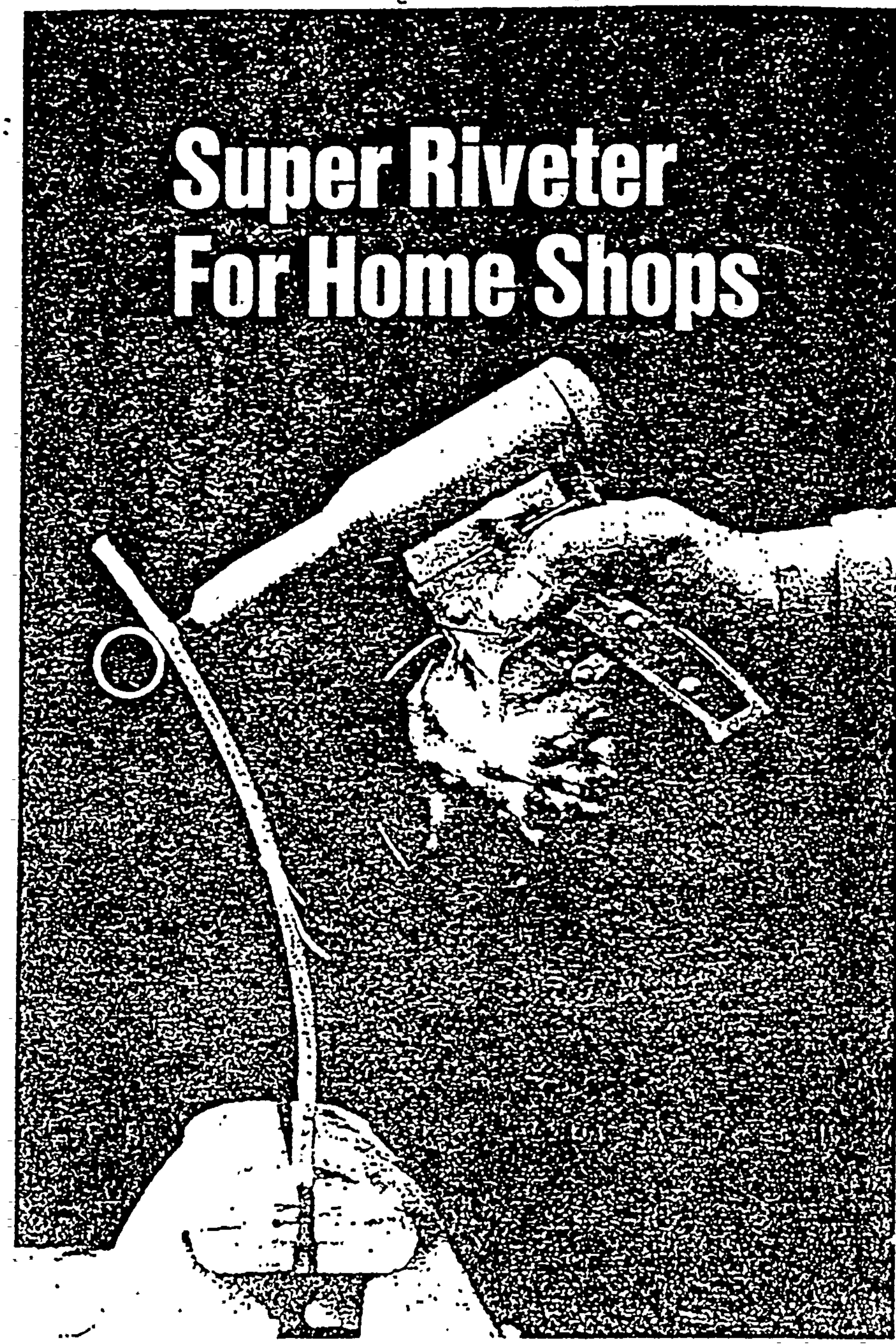
Electronic Assembly Tools

Tool	Feature	Model	Manufacturer
1. Sidecutters, Benders, Swagers, Pliers	Reduced grasp span, comfort grip	• Magic Line BH Series	EREM Inc., Torrence, Calif.
	Comfort grip	• Standard 8000 • Micro Series 3000	Lindstrom Eskilstuna, Sweden (Techni-tool Plymouth Meeting, PA)
	Comfort grip	• Micro Series 400	Utica Tool Co. Inc., Orangeburg, SC
2. Pneumatic Cutters, Benders	Small, lightweight	• Magic 1500	EREM Inc., Torrence, Calif.
	Small, lightweight	• Jim Dandy MM1, single jaw • Squeeze Eze MSP1, multiple jaws	Simonds Inc., Southbridge, Mass.
	Small, lightweight	• UA 100	Utica Tool Co. Inc., Orangeburg, SC

Maintenance, Construction Tools

Tools	Feature	Model	Manufacturer
1. Scaling Hammer, Pneumatic	Reduced noise and vibration, long life chisel tip	• 8316	ARO Corp., Bryan, OH
		• RVM 06	Atlas Copco Farmington Hills, MI
2. Chipping Hammer, Pneumatic	Reduced noise	• RRD 37,57	Atlas Copco Farmington Hills, MI
3. Riveting Hammer, Pneumatic	Reduced noise and vibration	• RRH 10P,105	Atlas Copco Farmington Hills, MI
4. Pop Riveter, Hydraulic	Lower forces, reduced grasp span, one handed use	• Trojan HR 77	Parker Mfg. Co., Worchester, Mass.
5. Die Grinder, Pneumatic	Reduced noise and vibration	• LSF 16/LSV 16	Atlas Copco Farmington Hills, MI
6. Offset Handle Drill	In-line handle grasp	• LBB 11,22,33	Atlas Copco Farmington Hills, MI
7. Screwdriver	High torque, triangular shape handles	• "Power Grip", Model STD	Snap-on Tools, Kenosha, Wisc.
	High torque, racheting spherical handle	• "Easy Driver"	Creative Tools Inc., Burlington, VT
8. Ratchet Driver	Improved grasp, restricted space	• Palm Style F 714	Snap-on Tools, Kenosha, Wisc.
9. Hammers, Claw and Ball Peen	Reduced hand deviation	• "Hand Tastic" Style	Sears Roebuck Co., Chicago, IL

Super Riveter For Home Shops



A SERIES of gentle squeezes on the trigger is all that's needed to operate Trojan's hydraulic riveter. Tool's jaws grip mandrel until rivet is expanded and fully set.

WHEN a riveter for the home shop can be used to do a job of joinery in less time and with less effort than with other riveters, it is a tool worth examining. Which is what we did. We tried a new heavy-duty *hydraulic* riveter.

The hydraulic feature is what makes this super riveter different from other home riveters, which are manual only. In appearance, it is also different, having a large cylinder over the squeeze handle and a likness to an early Buck Rogers ray gun. You won't be able to death-ray anyone with this new riveter but you sure can do a quicker and more convenient job of applying cold rivets for things you want to fasten together.

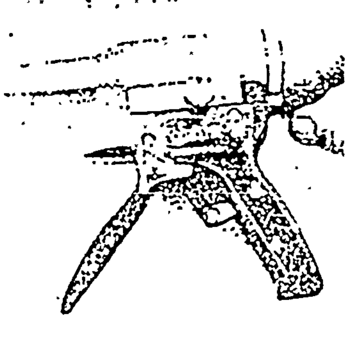
We've done many riveting jobs with the other manual rivet tools (which are good and also get the job done), but after setting the first rivet with the Troian HR 77 Hydraulic Riveter, we knew there was a better way.

We tried the gun on some typical riveting chores around the house and shop, including open and blind riveting (where access to only one side of the work is possible), and were impressed. The expanded, set rivet was no different from the work of any other riveter but the means to setting the rivet is where the tool shines.

The Trojan can be operated with one hand (others need two), gets the job done quicker and requires minimal effort only to pull a rivet. And, just as important, its nose gets into spaces where other riveters can't.

The tool also is nicely balanced and has a comfortable grip. The hydraulic pressure system results in a mechanical advantage which reduces the amount of muscle power required to pull the rivet. Relatively gentle squeezes on the trigger are all that's required to drive

AFTER the rivet has been set, the spent mandrel is expelled by simply pressing the release button with your thumb.



TWO nosepieces accommodate 1/8-, 5/32- and 3/16-in-diameter rivets. The extra fitting is stored at back of handle.

HYDRAULIC riveter can be operated conveniently with one hand. Other models sometimes require two-hand operation.

Super Riveter

a rivet home, fully secured.

The jaws of the Trojan grip the rivet mandrel continuously and keep the grip until the rivet is completely expanded and set—and the mandrel breaks off. Repositioning, to advance the grip on the mandrel (as with a conventional home riveter) is unnecessary.

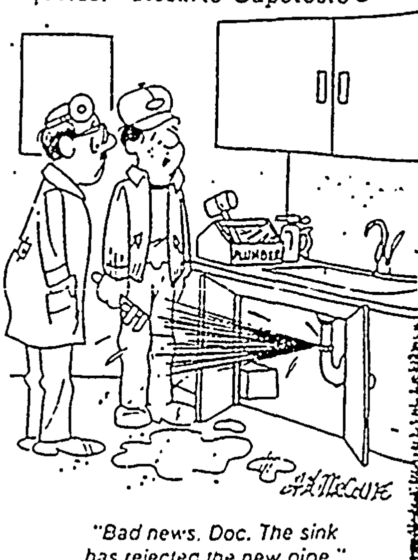
A conveniently located release button, pressed by the thumb, ejects the unused portion of the mandrel and the gun is ready to receive another rivet. If the gun is used in the left hand, the button can be pressed with the side of the index finger.

The pistol shape of the riveter enables it to get into confined areas. Joining or repairing small assemblies (sheet metal or electronics projects) is a piece of cake for the barrellike nose. This is not possible with the other riveters.

The gun is well-built with heavy parts. The manufacturer recommends a cleaning of the jaws after heavy use to remove accumulated mandrel particles which could prevent proper gripping. And, after prolonged use, you may have to replenish the hydraulic oil. Conventinal No. 10 oil or 3-in-1 Oil can be used for hydraulic fluid.

The Trojan comes with two nosepieces. One is for use with 1/8-in. rivets, the other for 5/32-in.- and 3/16-in.-diameter rivets. Rivets are also available in aluminum or steel for regular work and in white aluminum to match with white aluminum siding, gutters and downspouts, storm windows and storm doors.

The HR 77 is made by Parker Mfg. Co., 149 Washington St., Worcester, Mass. 01613. The price is $39.45.—*Rosario Capotosto*



"Bad news, Doc. The sink has rejected the new pipe."

Riveting hammers

Atlas Copco
Farmington Hills
MI

New, patented design giving revolutionary ergonomical advantages.

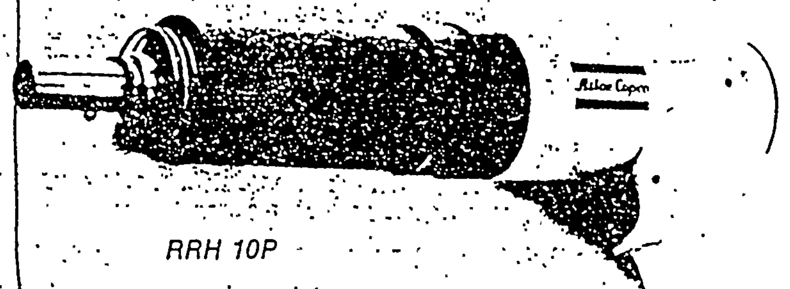
Vibration level extremely low due to unique damping system that isolates the handle from the percussion mechanism.

Reduction in the noise level.

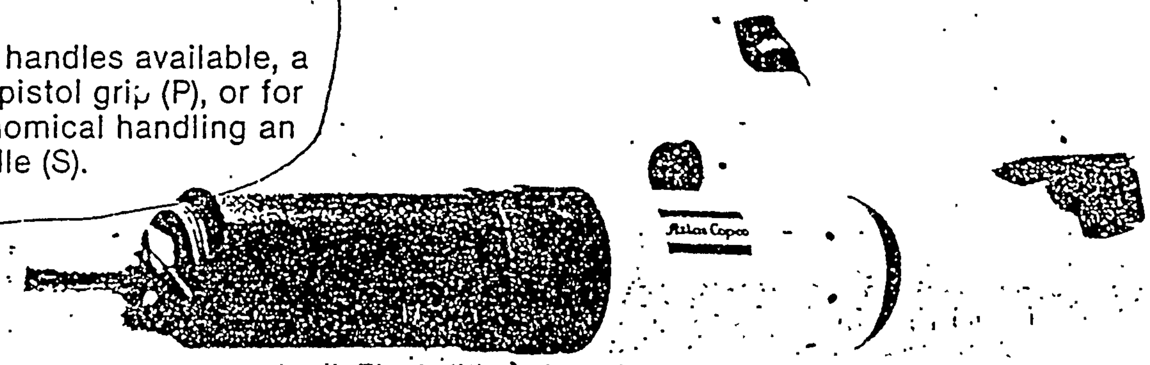
High impact force-to-weight ratio.

Built-in power regulator for exact adjustment to different rivet materials and sizes.

Two different handles available, a conventional pistol grip (P), or for optimal ergonomical handling an "in-line" handle (S).



RRH 10P



RRH 10S

Standard equipment

Spring retainer.
Rivet set, blank

Specifications

Model	Ordering No	Max rivet dia. Dural in	Dural mm	Steel in	Steel mm	Bore in	Bore mm	Stroke in	Stroke mm	Blows per min.	Weight lb	Weight kg	Length, incl. retainer in	Length, incl. retainer mm	Hose size in	Hose size mm	Air consumption cfm	Air consumption l/s
RRH 10P	8426 1110 20	0.39	10	0.31	8	0.75	19	4.65	118	1550	4.4	2.02	10.87	276	3/8	10	23	11
RRH 10S	8426 1110 38	0.39	10	0.31	8	0.75	19	4.65	118	1550	4.2	1.95	11.1	282	3/8	10	23	11

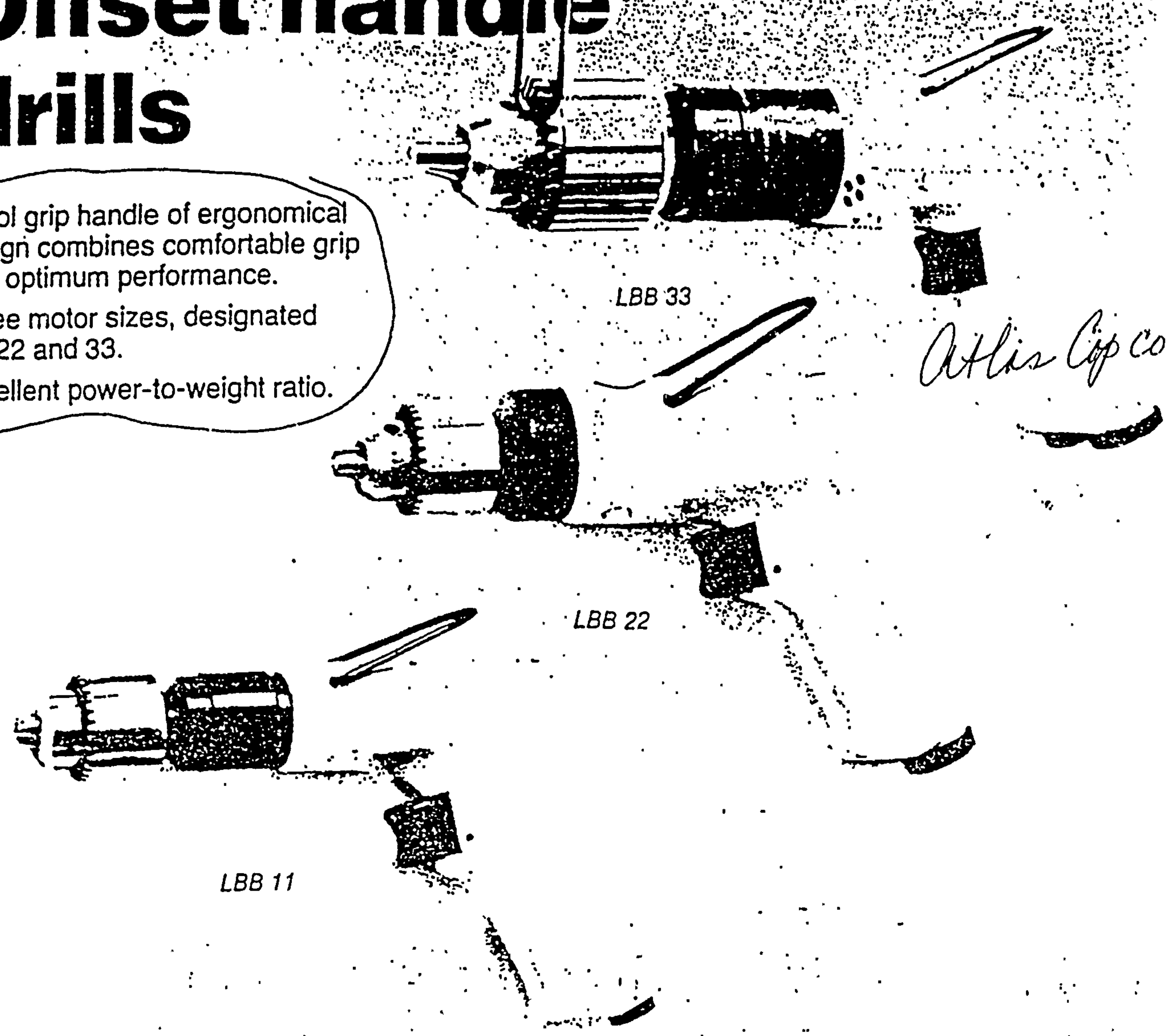
Performance figures are at 6 bar (87 psi) air pressure
Hose fitting thread ¼"
Shank size .498 rivet set.

Offset handle drills

Pistol grip handle of ergonomical design combines comfortable grip with optimum performance.

Three motor sizes, designated 11, 22 and 33.

Excellent power-to-weight ratio.



Specifications

Model	Ordering No.	Standard chuck capacity in	Standard chuck capacity mm	Max output hp	Max output kw	Free speed rpm	Weight, incl. chuck lb	Weight, incl. chuck kg	Side to center distance in	Side to center distance mm	Length, incl. chuck in	Length, incl. chuck mm	Hose fitting thread	Hose size in	Hose size mm	Air consumption cfm	Air consumption l/s
LBB 11 H048	8421 0101 36	¼	6.5	0.16	0.12	4800	1.4	0.6	0.6	15	7.7	196	⅛	3/16	5	6.3	3.0
LBB 11 H029	8421 0101 28	¼	6.5	0.16	0.12	2900	1.4	0.6	0.6	15	7.7	196	⅛	3/16	5	6.3	3.0
LBB 22 H220	8421 0201 50	¼	6.5	0.25	0.19	22000	1.8	0.8	0.75	19	7.0	177	¼	¼	6.3	11.6	5.5
LBB 22 H049	8421 0201 43	¼	6.5	0.25	0.19	4900	1.8	0.8	0.75	19	7.3	186	¼	¼	6.3	11.6	5.5
LBB 22 H022	8421 0201 35	¼	6.5	0.25	0.19	2200	1.8	0.8	0.75	19	7.3	186	¼	¼	6.3	11.6	5.5
LBB 22 H011	8421 0201 21	5/16	8.0	0.25	0.19	1100	2.2	1.0	0.75	19	9.0	228	¼	¼	6.3	11.6	5.5
LBB 33 H060	8421 0301 42	5/16	8.0	0.44	0.33	6000	2.4	1.1	0.9	23	7.6	193	¼	⅜	10	16.0	7.5
LBB 33 H033	8421 0301 34	5/16	8.0	0.44	0.33	3300	2.4	1.1	0.9	23	7.6	193	¼	⅜	10	16.0	7.5
LBB 33 H026	8421 0301 26	⅜	10.0	0.44	0.33	2600	2.8	1.3	0.9	23	7.8	199	¼	⅜	10	16.0	7.5
LBB 33 H013	8421 0301 18	⅜	10.0	0.44	0.33	1300	3.3	1.5	0.9	23	9.1	232	¼	⅜	10	16.0	7.5
LBB 33 H007*	8421 0301 00	½	13.0	0.44	0.33	700	3.5	1.6	0.9	23	9.4	238	¼	⅜	10	16.0	7.5

Performance figures are at 6 bar (87psi) air pressure.
*Supplied with dead handle.

Standard equipment

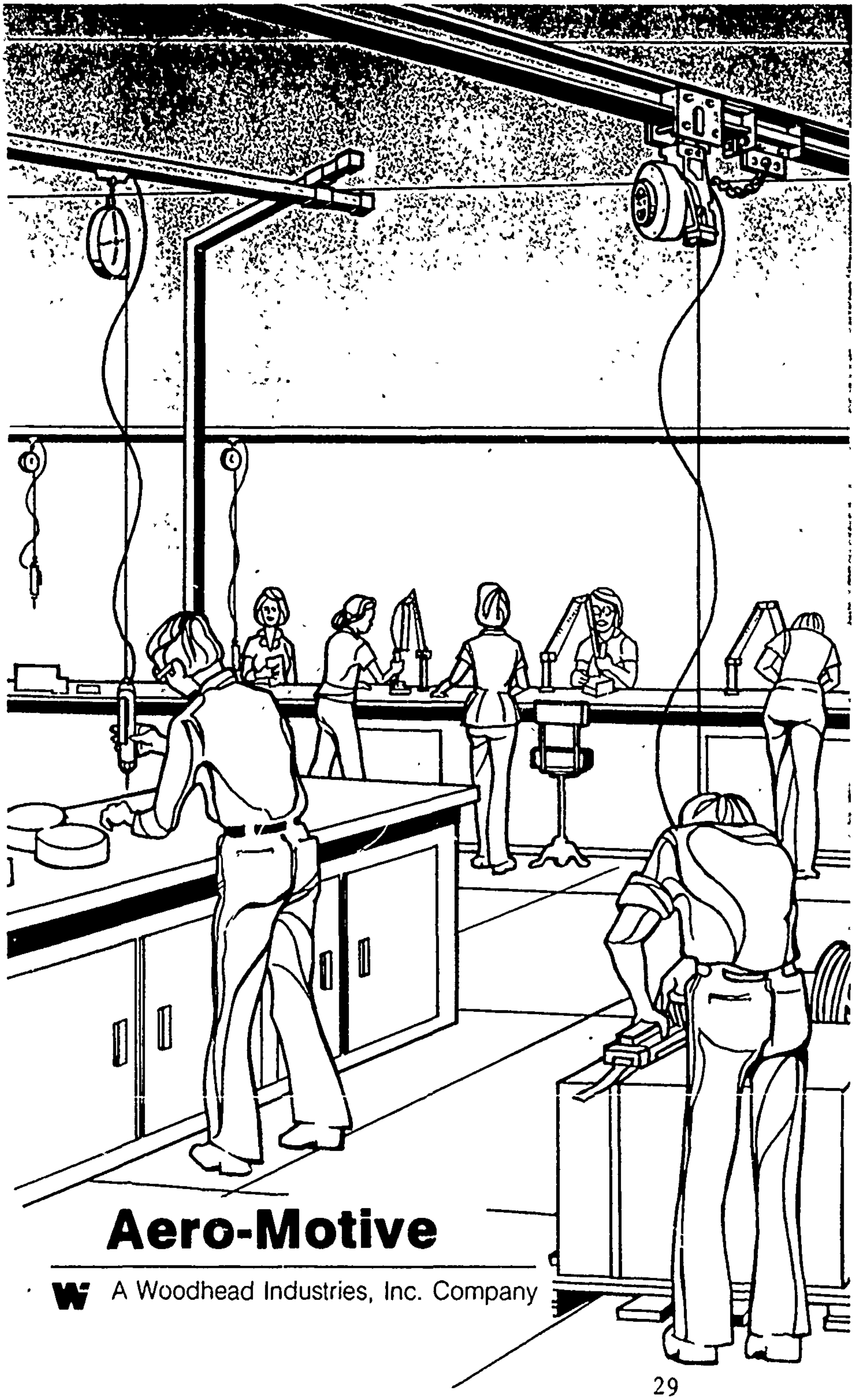
Drill chuck.
Chuck key.

Optional equipment

See page 65 for Jacob's chucks, keyless chucks, collet holders and collets, support handle.

BALANCERS DB-89

and work station systems



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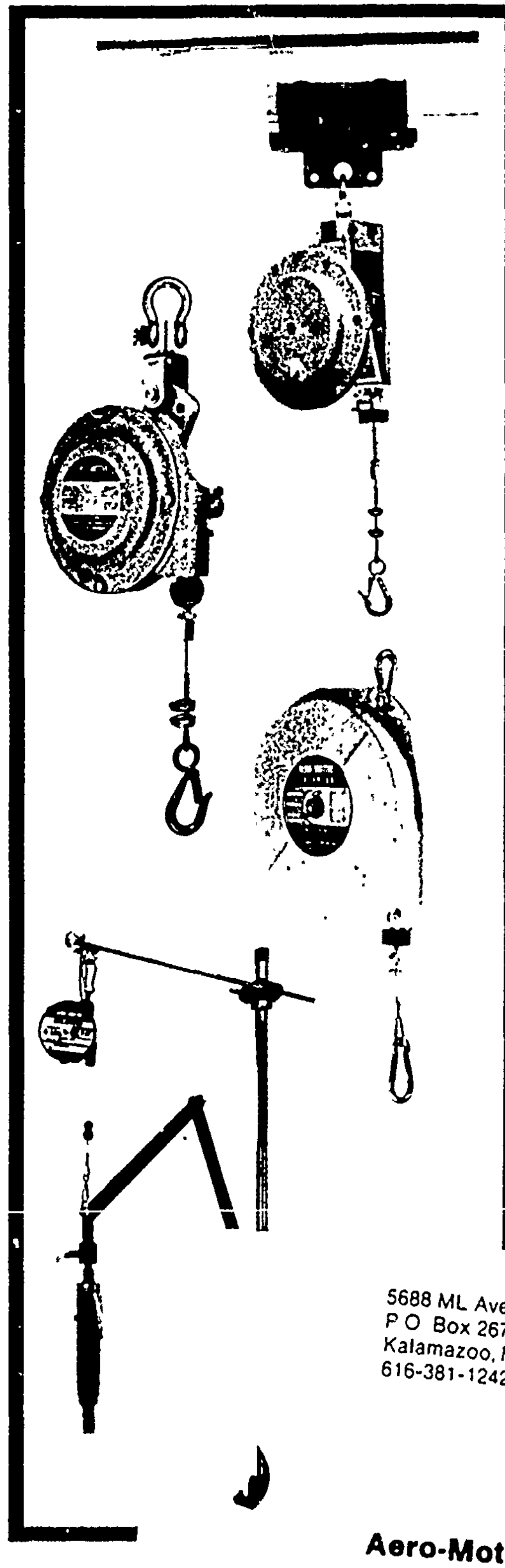

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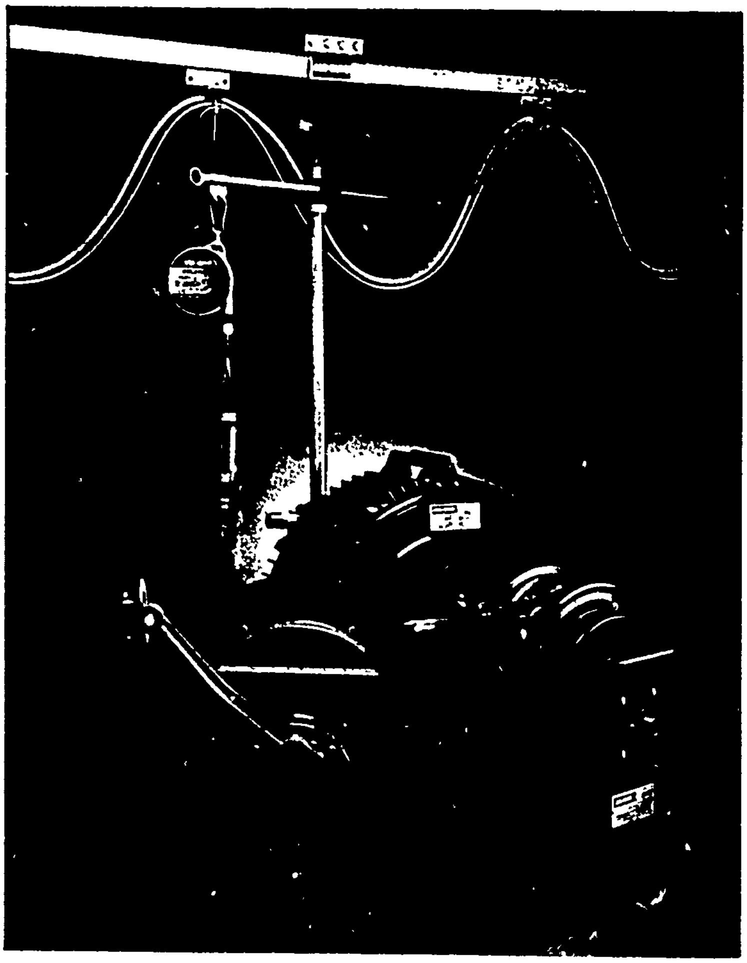
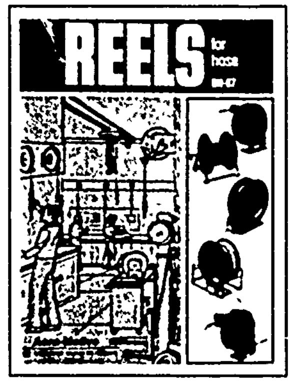
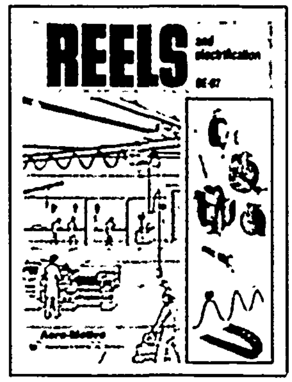




HOSE REELS

Hose Reels for a wide range of applications from standard industrial to specialized hydraulic and pneumatic equipment.



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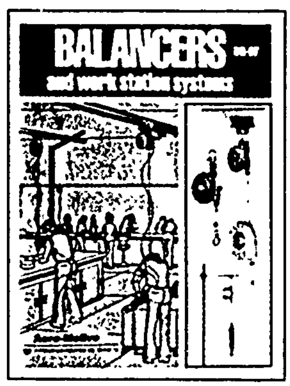

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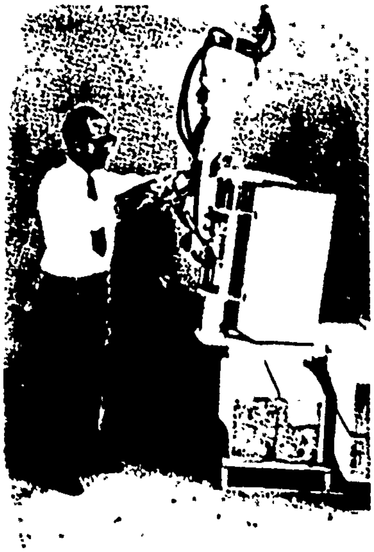
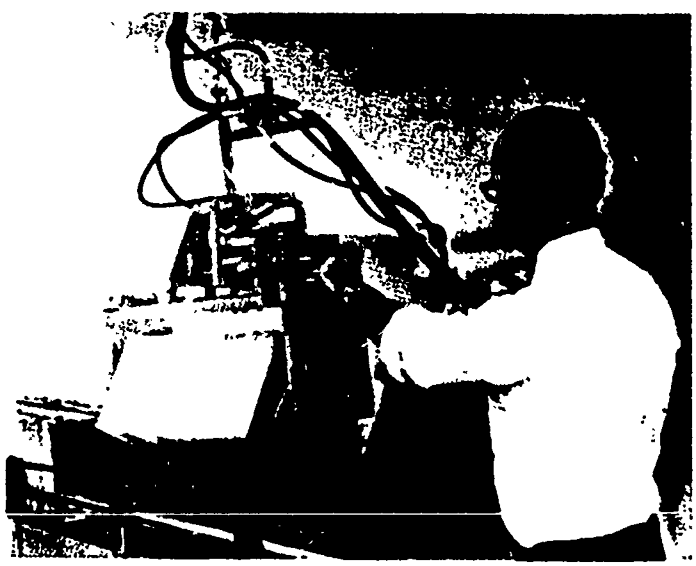


180 degree manual rotate

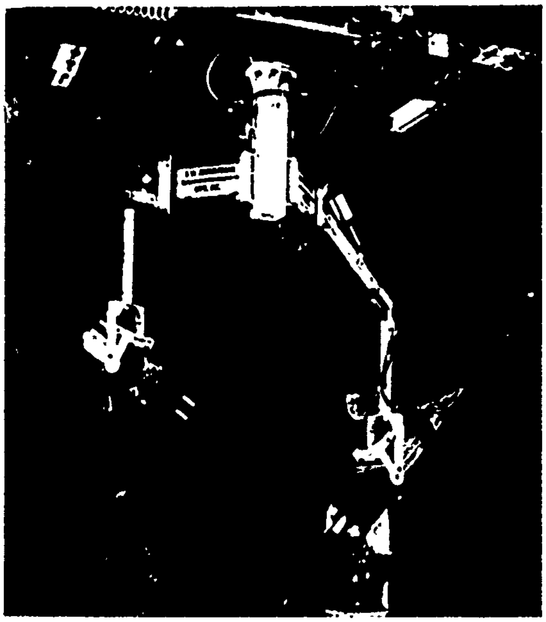
:nd cylinder clamp for straight transfer

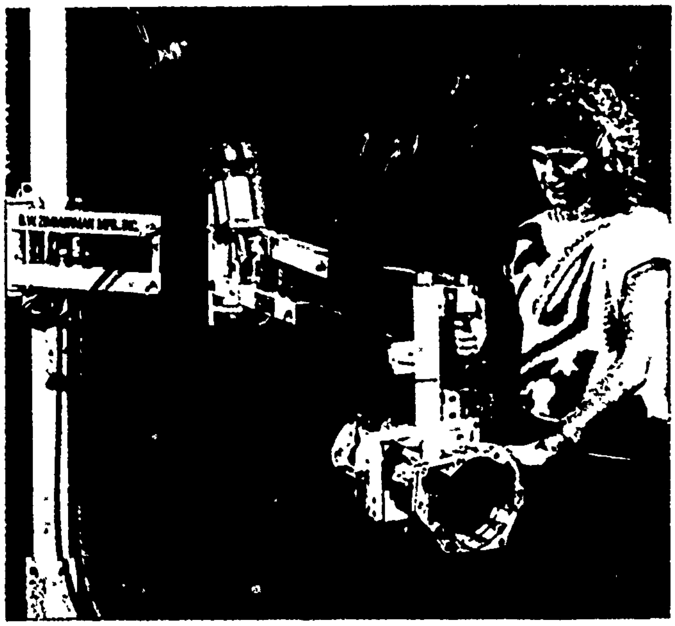
90 degree manual tilt

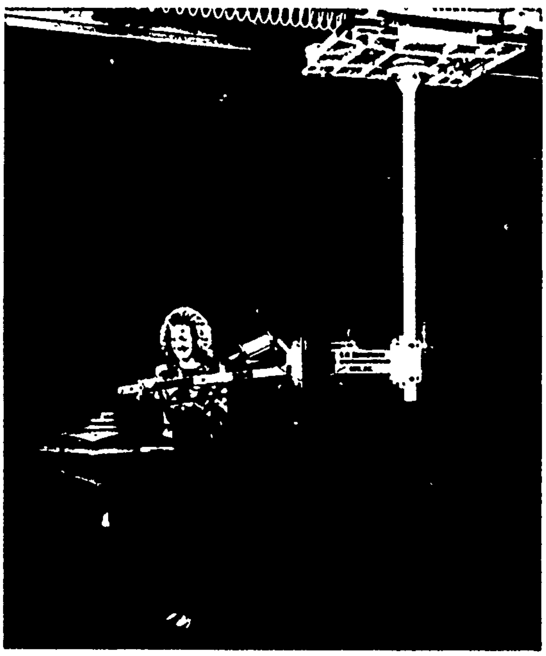
Fork-type vertical stacker unloader



180 degree gravity rotate







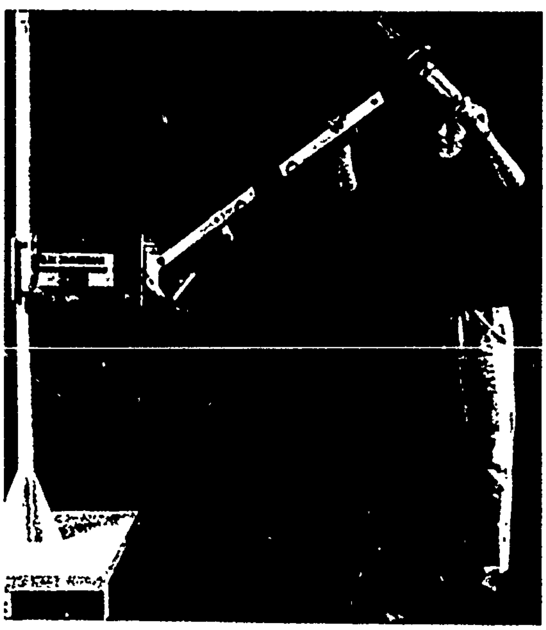
The Zimmerman Series 400 Manipulators are pneumatic, ergonomically designed, articulated arms used for the pickup, orientation, transfer and precision positioning of parts or for the float-action balancing and suspension of tooling in manufacturing and assembly operations.

The Series 400 provides the operator with excellent positioning flexibility, provides protection from fatigue and injury and also protects product and tooling from damage.

Depending on the model, the Series 400 can handle loads up to 100 pounds (45 kg.), offers up to 84 inches (2139 mm) of horizontal reach, up to 46 inches (1168 mm) of vertical travel and provides extensive radial coverage.

Extended horizontal reach and vertical travel flexibility are achieved through modular design which incorporates three adjustable arm sections having one-inch incremental settings. Three or four trolley (360° Rotation) overhead carriage, stationary pedestal, portable pallet base and wall mounting options further expand the versatility of the Series 400 Manipulators.

The Series 400 Manipulator models can be combined with custom engineered end effectors or tool holders to meet customer requirements for handling specific parts. The tool holders can be sized to fit customer-specified air tools.



ZIMMERMAN®
SERIES 400
MANIPULATORS

APPENDIX C

Body Part Discomfort Questionnaire Analysis

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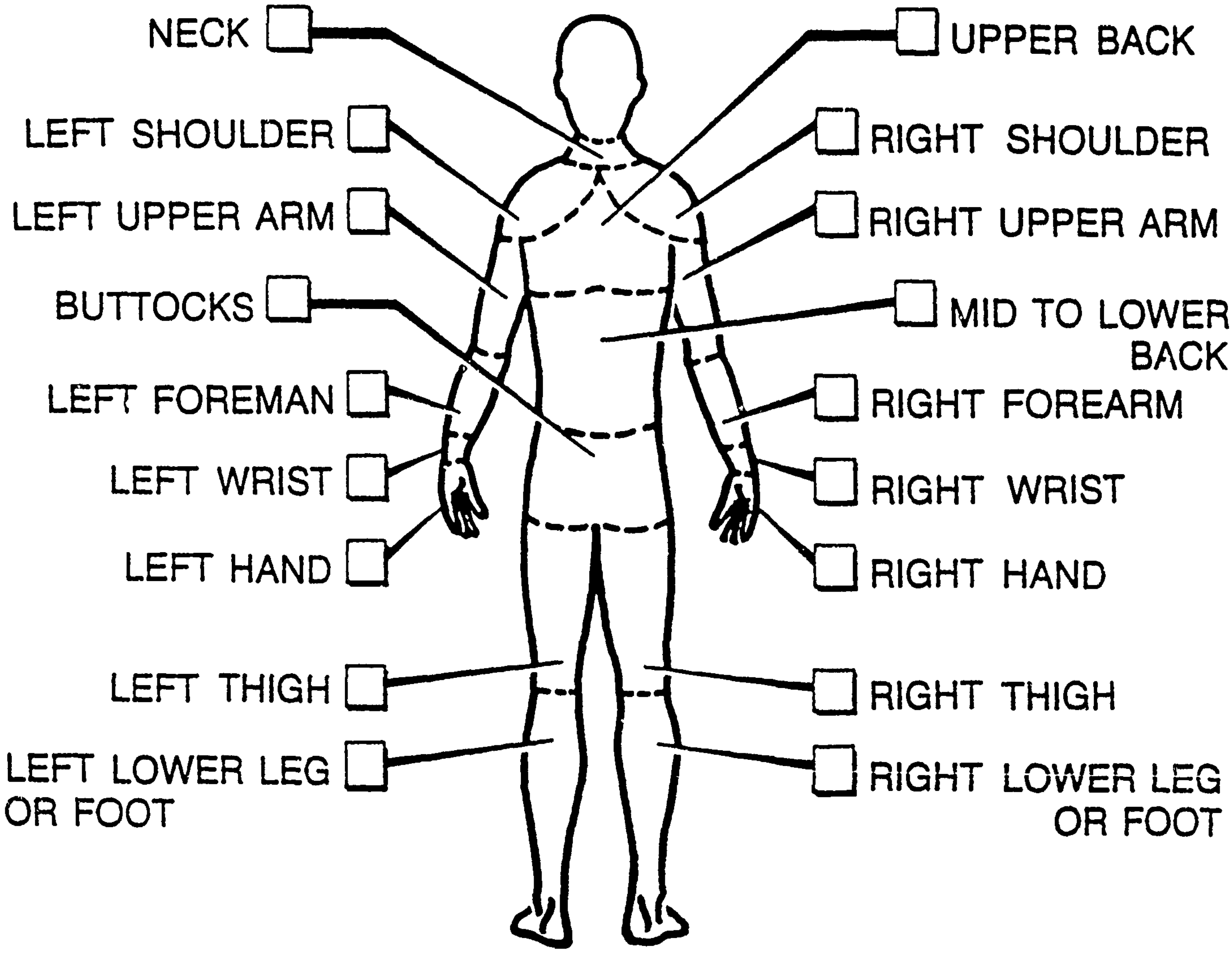
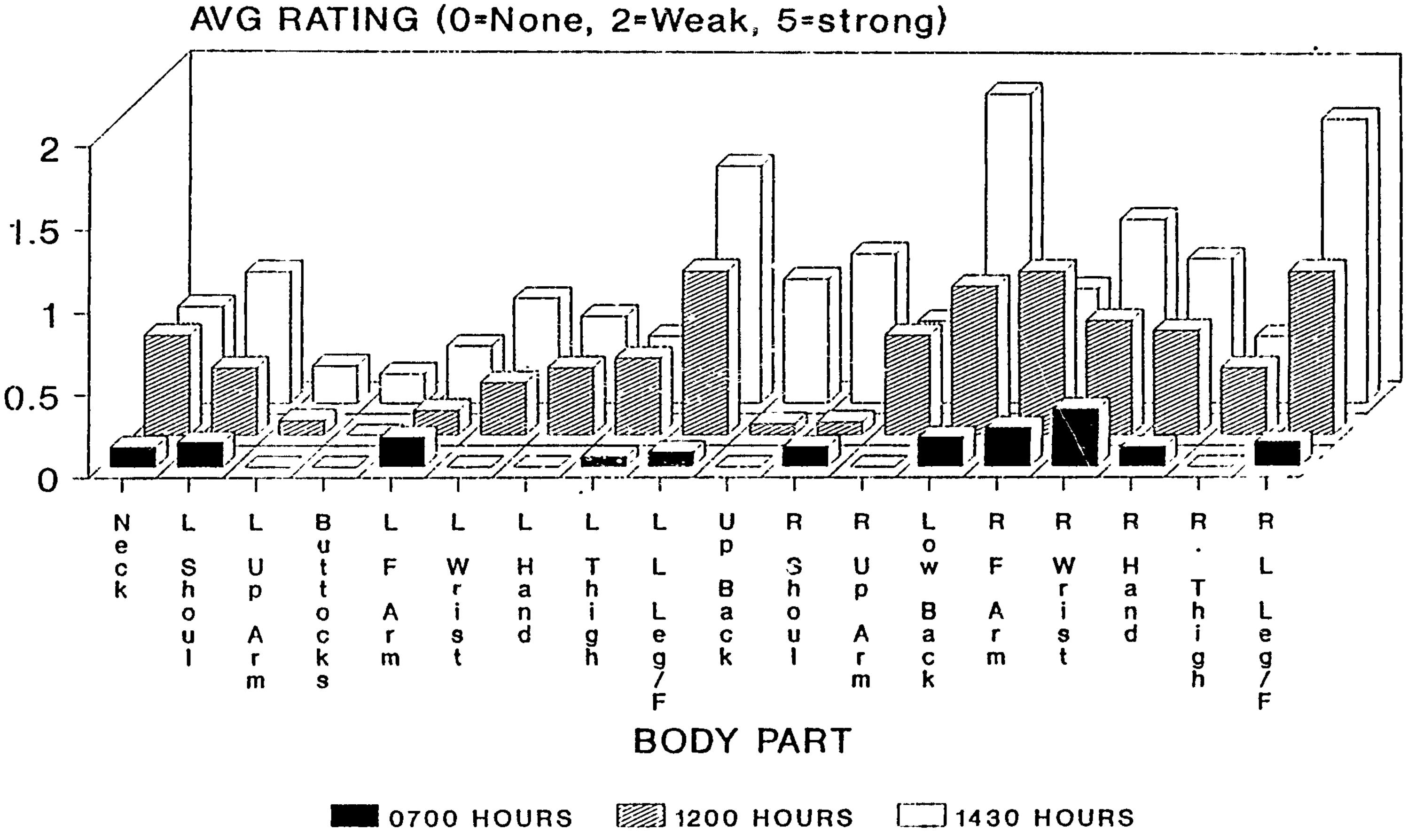


DISCOMFORT RATING SCALE

0	Nothing at all
0.5	Very, very weak
1	Very weak
2	Weak
3	Moderate
4	Somewhat strong
5	Strong
6	
7	Very strong
8	
9	
10	Very, very strong Maximal

Body Part Discomfort Questionnaire

Heavy Crating - Hill AFB - 29 Oct 90



AFOEHL Ergonomics Working Group

APPENDIX D

Literature Citations and Bibliography

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Appendix D

RESEARCH LITERATURE CITATIONS

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APPENDIX E

Table 1, Cumulative Trauma Disorders

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Table 1. Job, identified disorder, and occupational risk factors

Type of job	Disorder	Occupational factors
1. Buffing/grinding	Tenosynovitis Thoracic outlet Carpal tunnel De Quervain's Pronator teres	Repetitive wrist motions, prolonged flexed shoulders, vibration, forceful ulnar deviation, repetitive forearm pronation.
2. Punch press operators	Tendinitis of wrist and shoulder	Repetitive forceful wrist extension/flexion, repetitive shoulder abduction/flexion, forearm supination.
	De Quervain's	Repetitive ulnar deviation in pushing controls.
3. Overhead assembly (welders, painters, auto repair)	Thoracic outlet Shoulder tendinitis	Sustained hyperextension of arms. Hands above shoulders.
4. Belt conveyor assembly	Tendinitis of shoulder and wrist Carpal tunnel Thoracic outlet	Arms extended, abducted, or flexed more than 60 degrees, repetitive, forceful wrist motions.
5. Typing, keypunch, cashier	Tension neck Thoracic outlet Carpal tunnel	Static, restricted posture, arms abducted/flexed high speed finger movement, palmar base pressure, ulnar deviation.
6. Sewers and cutters	Thoracic outlet	Repetitive shoulder flexion, repetitive ulnar deviation.
	De Quervain's Carpal tunnel	Repetitive wrist flexion/extension, palmar base pressure.
7. Small parts assembly (wiring, bandage wrap)	Tension neck Thoracic outlet Wrist tendinitis Epicondylitis	Prolonged restricted posture, forceful ulnar deviation and thumb pressure, repetitive wrist motion, forceful wrist extension and pronation.
8. Musicians	Wrist tendinitis Carpal tunnel Epicondylitis Thoracic outlet	Repetitive forceful wrist motions, palmar base pressure, prolonged shoulder abduction/flexion, forceful wrist extension with forearm pronation.
9. Bench work (glass cutters, phone operators)	Ulnar nerve entrapment	Sustained elbow flexion with pressure on ulnar groove.
10. Operating room personnel	Thoracic outlet Carpal tunnel De Quervain's	Prolonged shoulder flexion, repetitive wrist flexion, ulnar deviation (holding retractors).
11. Packing	Tendinitis of shoulder and wrist Tension neck Carpal tunnel De Quervain's	Prolonged load on shoulders, repetitive wrist motions, over-exertion, forceful ulnar deviation.
12. Truck driver	Thoracic outlet	Prolonged shoulder abduction and flexion.
13. Core making	Tendinitis of the wrist	Repetitive wrist motions.
14. Housekeeping, cooks	De Quervain's Carpal tunnel	Scrubbing, washing, rapid wrist rotational movements.
15. Carpenters, bricklayers	Carpal tunnel Guyon tunnel	Hammering, pressure on palmar base.
16. Stockroom, shipping	Thoracic outlet Shoulder-tendinitis	Reaching overhead. Prolonged load on shoulder in unnatural position.
17. Material handling	Thoracic outlet Shoulder-tendinitis	Carrying heavy load on shoulders.
18. Lumber/construction	Shoulder-tendinitis Epicondylitis	Repetitive throwing of heavy load.
19. Butcher/ meat packing	De Quervain's Carpal tunnel	Ulnar deviation, flexed wrist with exertion.
20. Letter carriers	Shoulder problems Thoracic outlet	Carrying heavy load with shoulder strap.

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