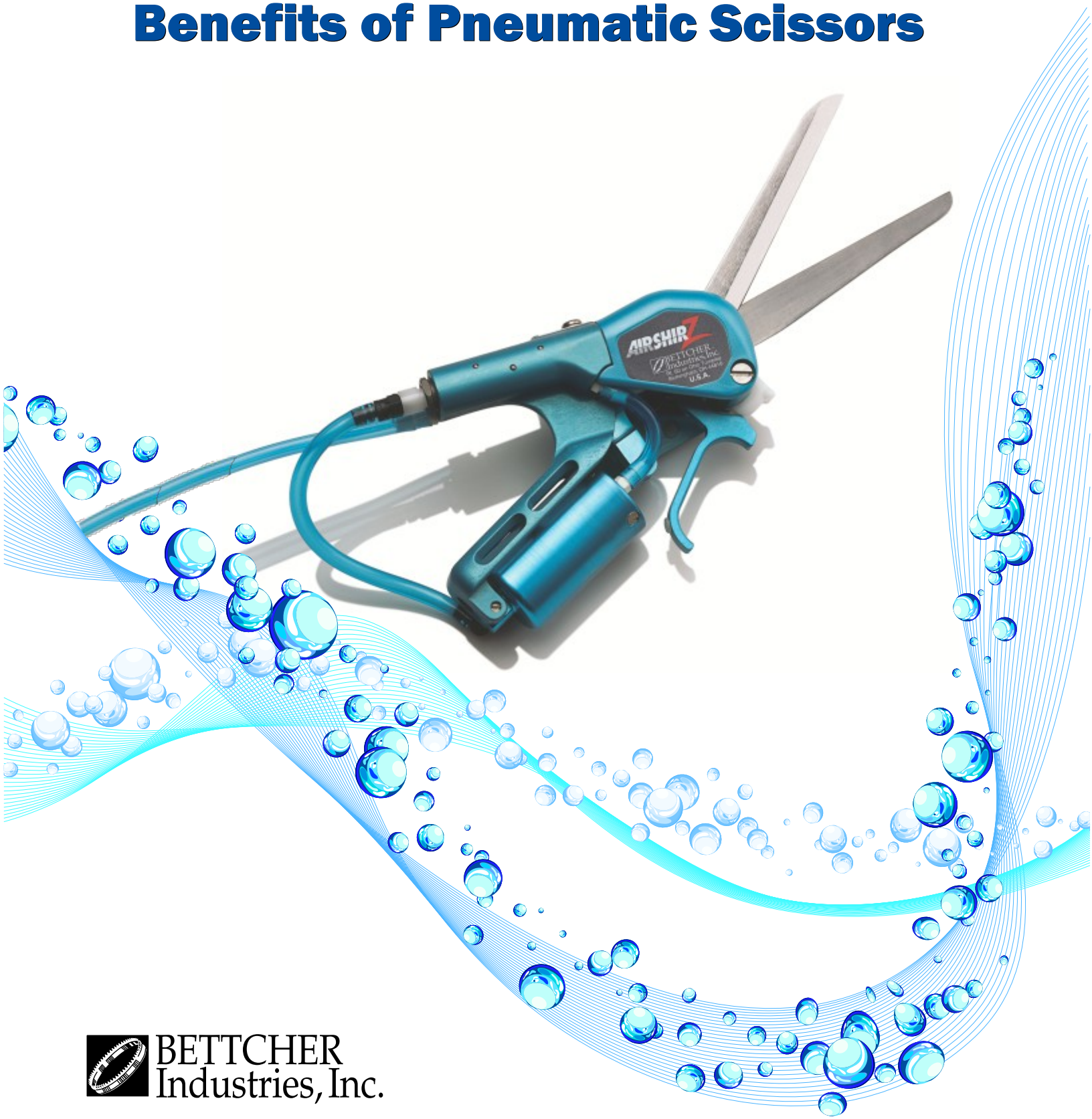
Advanced Ergonomic Benefits of Pneumatic Scissors



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Abstract

While a certain of automation within the poultry industry has been reached, there will always be an interaction between the product, individual, and tools. Variability in the product will always limit the amount of automation that can be used in certain applications. Therefore, hand tools, individuals, and the work place environment pose an ergonomic challenge. The hand tool that is predominantly used in the poultry industry is scissors (poultry shears). High forces, repetition, and other risk factors associated with hand tools have contributed to the high incident rate of cumulative trauma disorders in the poultry industry.

To address this situation, an engineering solution was developed to replace standard scissors, reduce risk factors associated with CTDs, and improve workers' efficiency and product quality. The AirShirz pneumatic scissors allows the worker to perform a task in less time while reducing the amount of physical exertion. Spending less effort on portions of the total job and reducing the amount of time to do them is a “win-win” situation for everyone.

Introduction

In 1990, the Poultry Industry Joint Safety and Health Committee along with the National Turkey Federation requested that Bettcher Industries develop a pneumatic scissors. These organizations were sensitive to the problem that scissors operations were contributing to the high rates of CTDs. The request of the Committee was to manufacture a tool that would meet specific criteria. The design criteria for the AirShirz took into account identifiable risk variables that have been associated with CTDs. The AirShirz® needed to:

1) function like manual scissors
2) incorporate sound ergonomic principles
3) reduce physical demands
4) improve efficiency
5) improve psychophysical interaction to the job

Functions like Scissors

If a tool is not user friendly, it probably won't be used, and may even lead to more problems. One of the most important functions of the AirShirz is to perform like a scissors. Think about the first time you ever used manual scissors. When cutting through thick material, the blades needed not only to be closed but pulled against each other by applying force to the fingers. Even at an early age, one could testify about the pain that scissors cause to the hand.

The AirShirz blades were designed to be activated and fully controlled by the finger loop. When the safety latch is off, the finger loop is kept open by a small return spring. The return spring keeps the finger loop open when the safety is off. This accomplishes two goals:

1) if the tool is dropped, the blades will not automatically close, *and*
2) the fingers are not required to open the blades as with conventional scissors.

This eliminates the need for the fingers to work in opening the blades, unlike conventional scissors. To close the blades, the finger(s) gently squeeze the finger loop to overcome the return spring. The blades mirror the movement of the finger loop.

Blade speed and position are fully controllable, like scissors, for precision cutting.

The Integration of Sound Ergonomic Principles

Scissors are probably the most common household item utilized for many non-repetitive tasks around the home. The non-repetitive nature of the home tasks does not pose a high risk to hand problems, unlike the heavy industrial utilization of scissors. From the human factor perspective, scissors are *not well designed for continual, heavy use.* As described below, three factors are important in designing any hand tool are:

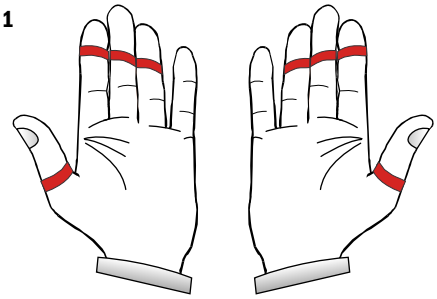
1) weight
2) pressure points
3) surface contact

Weight and Balance

Weight of a hand tool is coupled with the movement that is necessary to perform each task. Not only does a worker have to balance the tool's weight, but also activate the tool and perform the movements necessary to complete the job. The standard scissors used in the poultry industry weighs 0.5 pounds and is balanced on 5.13 square inches of the hand using a 50th percentile male hand *(Figure 1)*. (The amount of force that is required to perform cutting tasks is discussed in the Reduce Physical Demands Section.)

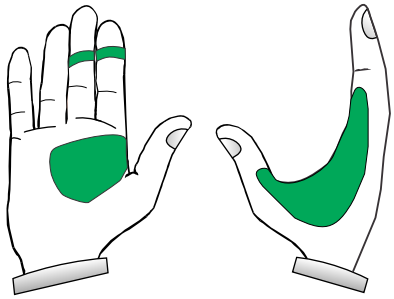
The AirShirz® unit weighs approximately 1.28 pounds but is balanced on the adductor pollicis, flexor brevis pollicis, and abductor pollicus between the index finger and the thumb. Again, using the same 50th percentile male hand, this weight is balanced on 13.48 square inches of the hand *(Figure 2)*.

Figure 1



Surface contact with conventional scissors

Figure 2



Surface contact with AirShirz

Relief of Pressure Points

Some areas of the body are more sensitive than others because tendons, nerves and blood vessels are located close to surface and underlying bones, sides of fingers, back of fingers, and palm of fingers [1]. The points in Figure 3 show where the fingers come in contact with the conventional scissors. The surfaces of the finger loops are hard and smooth with causes more control problems when the hand becomes covered with moisture and fatty tissues from the product.

The pressure points on the AirShirz® are illustrated in Figure 4. The surfaces of the AirShirz® unit are smooth and the finger loop allows all fingers to come in contact with its surface. Another benefit is that the thumb is not used to operate the AirShirz®. The design of the AirShirz® unit allows the thumb to "rest" comfortably in a neutral position against the side of the unit, thus eliminating a pressure point. These pressure points allow one to now examine the contact stress of the tissues in the hand.

Figure 3

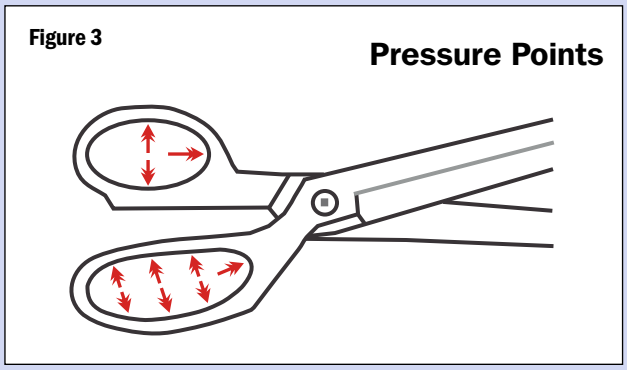
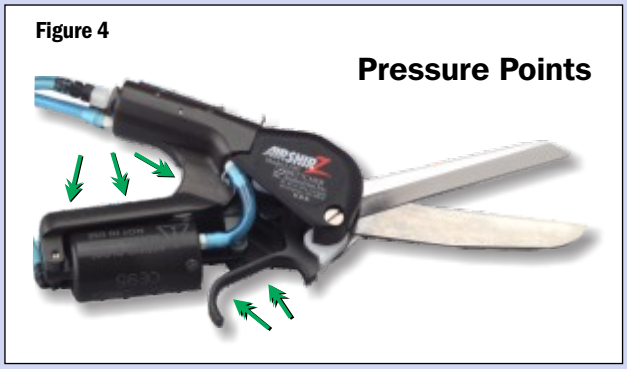


Figure 4



Contact Stress

Contact stress is related to the location and area of contact[2]. Some areas of the body are better suited for bearing contact stress than others. The skin on the back of the hand and sides of the fingers, for instance, is much thinner than the palmar side, and less suited for exerting loads[3]. Mechanical tissue stresses produced in the area of contact with an external object [4] is calculated as follows:

$$\text{Stress} = \text{Force} / \text{Area}$$

$$s = F / A$$

In a laboratory environment where standardized materials were cut, the force required by the operator using manual scissors was 5 pounds, while the force required to perform the same cut using AirShirz® was only 0.72 pounds.

Conventional Scissors

$$s = 5 \text{ lbf} / 5.13 \text{ in}^2 = 0.975 \text{ psi}$$

AirShirz® Pneumatic Scissors

$$s = 0.72 \text{ lbf} / 13.48 \text{ in}^2 = 0.053 \text{ psi}$$

Another point to note is that there is *no force required to open the blades of the AirShirz.* The tool was designed so that the blades remain open with the finger loop is spring loaded to the open position to eliminate the added pressure of opening blades as with conventional scissors.

With conventional scissors, in order to open the blades, the very thin layer of skin and tissue on the back of the hands are exposed to high levels of contact stress.

These levels of contact stress, pressure points, and weight are directly related to the physical demands placed on the worker. The muscle activity while operating both tools has been quantified.

Cutting with conventional scissors for long periods of time stresses fingers, hands and forearms.

AirShirz is like power steering... just a light squeeze of the trigger is the only effort required, plus the blades open automatically when pressure on the trigger is released.

Reduce Physical Demands

A pilot study [5] conducted with several medical doctors incorporated electromyography and a Jamar grip strength dynamometer to identify the benefits of using the AirShirz instead of conventional scissors. The pilot study was performed at a work rehabilitation center and used non-poultry workers as volunteer subjects.

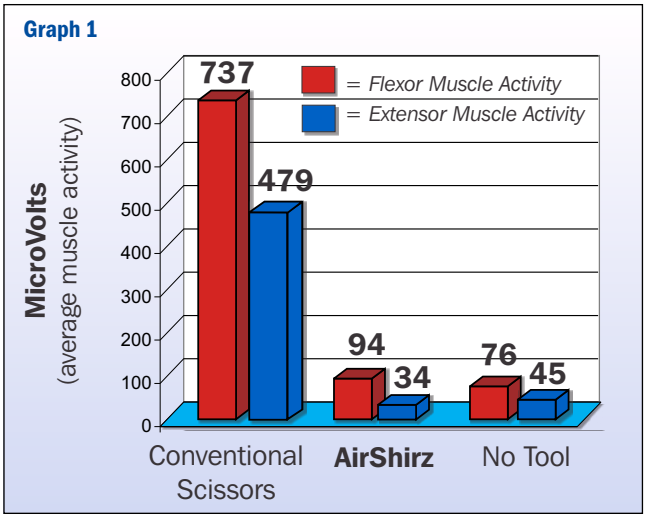
Muscle activity was measured with a Cadwell 5200A and a Fasstech InSight Muscle Fatigue Instrument, both measuring muscle activity in millivolts (mvolts). A Jamar grip strength dynamometer which measures peak grip strength was used pre- and post- cutting with both tools. A total of seven subjects (six female and one male) ranging in age from 30-58 comprised the study. Each subject was seated in a metal folding chair and instructed to cut ½-inch marked strips from a 3-inch wide piece of cardboard. The forearm was kept at a 90 degree angle to the body. The task was performed for 5 minutes with each tool randomly selected in order of cutting.

Lightweight yet powerful, AirShirz® provides clean, accurate cutting, snipping and trimming resulting in less waste and a better looking finished product.

Muscle Actvity (EMG)

Two muscle groups were tested: extensor carpi radialis and flexor carpi radialis. The extensor muscle which opens the fingers and allows the hand to move back had a gross average of 470 mvolts using conventional scissors, 34 mvolts using AirShirz, and 45 mvolts while opening and closing the hand. The flexor muscle, responsible for closing the fingers and gripping, had a gross average muscle activity of 737 mvolts using conventional scissors, 94 mvolts using AirShirz, and 76 mvolts opening and closing the hand. *See Graph 1.*

Graph 1

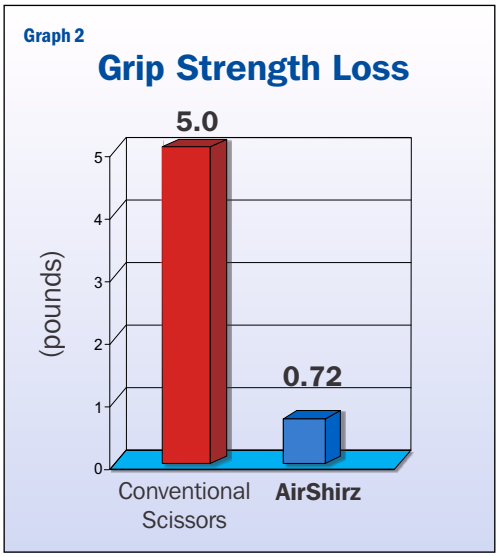


Peak Grip Strength (Force)

In determining the amount of force that is applied to the fingers, load cells could be placed on the finger to determine the amount of force that is applied. Unfortunately, the amount of slippage and small areas of contact does not allow these load cells to be used in this pilot study.

The Jamar hand dynamometer measures the amount of

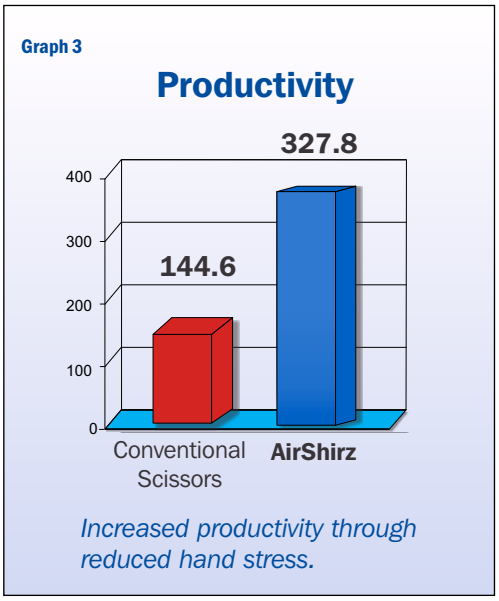
peak grip strength (PGS) of the hand in pounds. PGS was recorded before and after the use of each tool. The average grip strength loss after using the conventional scissors was 5.0 lbs and 0.72 lbs after using the AirShirz®. *(See Graph 2.)*



Efficiency

Cardboard strips were used as a constant medium that could be replicated throughout the experiment. Each 3-inch wide piece of cardboard was segmented in ½-inch strips. The subjects were required to possess some type of eye-hand coordination that would be representative in an actual working environment. The subjects were instructed to cut as many pieces during 5 minutes as they could. Subjects were not distracted as they sat facing a wall, isolated from the others.

After each tool was used, the number of pieces cut was counted and recorded. This set the criteria of establishing production rates and then coupling those results with the reduced amount of muscle activity and fatigue that resulted in the improved efficiency. As Graph 3 shows, the increase in productivity was 127%. (Of course, one could always increase productivity, but the importance is being able to increase *and* maintain productivity without depleting the input or worker.)



Increased productivity through reduced hand stress.

Psychophysical Factors

A hand tool can be perfectly designed to accommodate the human body and perform the intended task, but if the operator does not feel comfortable with the tool, then the improvements are not seen. Psychophysical factors (how a worker perceives the physical requirements of the job) play an important part in designing and implementing a new tool. Unlike the other tests that were performed by machines, psychophysical testing is subjective.

In this case, a Likert scale was used to determine the perception of the physical requirements when cutting using both the manual scissors and the AirShirz®. A Likert scale test assesses attitudes by asking a series of questions that are constructed to be clearly favorable for half of the questions, and clearly unfavorable for the other half. A 20-statement questionnaire was filled out by the subjects immediately after the testing was completed.

Conclusion

The human body is designed to move and work! As with all machines, proper care and maintenance are necessary in order for the human body to perform effectively. In order to perform jobs correctly, humans need tools that are designed to optimize productivity and minimize wear on the body. Many criteria have to be examined before a hand tool is made.

In the case of the AirShirz®, a need for an improved type of scissors was identified in the poultry industry. The conventional scissors had been associated with CTDs of the hands and wrists.

Five criteria were established for the AirShirz® unit:

1. Function like scissors
2. Incorporate sound ergonomic principles
3. Reduce physical demands
4. Improve efficiency
5. Improve psychophysical interaction

AirShirz® scissors are also highly effective for repetitive cutting activities involving non-food items such as upholstery, wire mesh, rubber, Kevlar® and similar engineered fabrics

Through a series of medical, engineering, and psychophysical tests, all five criteria were met with dramatic results. By utilizing engineering principles and incorporating human-factor research, a solution was created for all repetitive cutting jobs that require the use of manual scissors. The AirShirz® pneumatic scissors was systematically developed by utilizing many engineering disciplines. The final product met the demands of the customers and, more importantly, provided a solution to the Cumulative Trauma Disorders long associated with conventional hand scissors.

References

This white paper was written by Dr. John E. Johnson a Certified Professional Ergonomist and expert on product design features and worker safety.

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[5] Johnson, J.E.; Huff, C.W.; Bingham, R.C. "AirShirz® Pilot Study". December 1994.

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