ASD TR 7-904 (III)

ASD INTERIM REPORT 7-904(III)
March 1962

STRUCTURAL FABRIC PROGRAM

J. O. Miller
E. Bilsky

GOODYEAR AIRCRAFT CORPORATION
AKRON 15, OHIO

Contract: AF33(600)43036
ASD Project: 7-904

Interim Technical Progress Report
1 January 1962 - 31 March 1962

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METHODS AND MATERIALS DIVISION
MANUFACTURING METHODS DIVISION

Aeronautical Systems Division
United States Air Force
Wright-Patterson Air Force Base, Ohio

GOODYEAR AIRCRAFT CORPORATION
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62-3-1

ABSTRACT - Summary
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The aforementioned efforts are directed toward the development of a loom procurement specification and the actual procurement of a loom capable of producing a low density AIRMAT in the order of 10 to 20 feet wide with a maximum depth of eight (8) feet.

* Trademark - Goodyear Tire and Rubber Company, Akron, Ohio.

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FOREWORD

This Interim Technical Progress Report covers the work performed under Contract AF33(600)43036 from 1 January 1962 to 31 March 1962. It is published for technical information only and does not necessarily represent the recommendations, conclusions, or approval of the Air Force.

This contract with Goodyear Aircraft Corporation was initiated under ASD Manufacturing Methods Project 7-904 "Structural Fabric Program". It is administered under the direction of Mr. J. O. Snyder, ASRCFT, of Methods and Materials Division, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. This report is the third in a series to be published quarterly for the duration of the contract.

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SECTION I - INTRODUCTION

The glide re-entry vehicles presently being designed require large low-density structures. The use of fabrics for the structural material not only answers this requirement but provides the advantage of being packageable in a small volume for ease of storage and handling on the ground with the additional advantages of maximum utilization of missile payload volume and minimum effect on the aerodynamic performance of the missile during ascent. The rapid pace of development in the astronautics field imposes the requirement that facilities capable of producing quantities of fabrics for re-entry applications be available in the near future. Goodyear Aircraft Corporation (GAC) is now engaged in a program under Contract Number AF33(600)43036 to develop a loom and associated machinery and processes capable of producing metallic AIRMAT fabrics of such size, quality and shape as required for re-entry vehicle applications. This report concerns itself with the effort during the third quarterly period under Contract Number AF33(600)43036.

The ultimate objective of this program is a loom having the capabilities of weaving large AIRMAT structures. These capabilities will be demonstrated by weaving AIRMAT specimens in two (2) categories.

1. Rene' 41 AIRMAT, 20 feet wide, 8 feet thick and 35 feet long, 200 by 200 yarns per inch.

2. Type 304 stainless steel AIRMAT, 11 feet wide and 35 feet long with a cross section along the 11 foot fill direction consisting of 4 foot straight AIRMAT, 4 feet deep with the remaining 7 feet tapering to 6 inches in depth. The specimen will have a 20% taper along the 35 foot length. The specimen will have 100 by 100 yarns per inch.

It is also intended that the loom will have the capability of weaving shapes such as open end tubes, cones of different angles and curved surfaces of different radii of curvature such as ellipses, parabolas, etc.

The effort during the third quarter was devoted primarily to further investigation into a feasible method of drop yarn extension. The sample weaving program which was initiated during the second quarter was continued and expanded in an attempt to prove the feasibility of the intra-weave system. At the conclusion of the sample weaving program, the intra-weave system was abandoned due to excessive drop yarn entanglement during expansion of the AIRMAT sample. An investigation of new methods for producing 8 foot AIRMAT brought to light a mechanical drop yarn extension system which showed great promise. Further investigation of this method proved its feasibility and a decision was made to proceed with the loom design incorporating this method of producing AIRMAT.

To aid in understanding the textile terms used throughout the various issues of this report, a glossary of terms has been added (See Appendix A). This glossary will be amended and added to, if the need arises, in subsequent Interim Technical Reports.

SECTION II - DISCUSSION

A. Work Completed During the Third Quarter

1. Prototype Evaluation Program

As a result of the unsuccessful attempt to expand the prototype AIRMAT sample (See ASD TR 7-904 II), an extensive sample weaving program was initiated to further explore the feasibility of the intra-weave method of producing AIRMAT. The prototype model loom was used to conduct this program. The decision to weave additional samples was based on the assumption that the failure of one sample was not conclusive since other factors could contribute to the problem of drop yarn entanglement, such as yarn diameter, yarn type and configuration, cold working of yarns, type of lubrication or coating, and drop yarn density. The sample weaving program was initiated to investigate these factors in an attempt to isolate the cause of the sample failure.

Sample Structure

Each intra-weave sample woven during the sample weaving program contained the following elements:

warp construction	- 200 ends per inch per fabric
warp material	- .0016" dia. Rene' 41 wire
filling construction	- 200 picks per inch per fabric
filling material	- .0016" dia. Rene' 41 wire
drop yarn height woven	- 19.20"
fabric width	- 2"

In weaving the various samples, intra warp and intra weft wires were used in making the samples but were removed prior to attempting to expand the samples.

Sample Descriptions

a. Sample No. 1 - This sample was woven using 3 drops for the drop yarn, in place of the 5 drops as woven in the prototype sample "A" (See ASD TR 7-904 II). It was felt that reducing the density of the drop yarns, although reducing the expanded drop yarn height, might reduce the tendency of the drop yarns to entangle. The weaving conditions encountered in making this 3-drop sample were the same as those in weaving the 5-drop Sample A.

It was again found difficult to overcome the drop yarn tension build-up when the drop yarn crossed from one warp sheet to the other. High tension on the drop yarns were generated. This was due to the drag of the yarn through the heddle eyes and the long travel of the drop yarn heddles. Since the intra-wefts in this sample were woven into the warp sheets, the excessive drop yarn tension caused the warp sheets to deflect toward the center of the fabric, decreasing the 19.2" intended woven height to about 18.75". Some improvement in maintaining the proper weaving height between fabrics was obtained by controlling the drop yarn tension. It was necessary to increase the drop yarn tension when weaving the fabric portion between drop yarn crossovers to minimize yarn entangling and to reduce the drop yarn tension when the crossovers were to occur.

Because of drag of the drop yarn through the heddle eyes, the Jacquard heddles and their lingo weights were pulled forward 2 or 3 inches when the reed was beating up the drop threads. This drag through the flat type drop yarn heddle eyes caused the Rene'41 drop yarn to be curled or cold worked.

Bronze wire .013" diameter was used for the intra-weft. It was found that this relatively stiff wire was required because the tension of the drop yarns tended to pull either Alginate and nylon when used as intra-wefts through adjacent warp ends causing uneven drop yarn lengths. If the Alginate or nylon or equivalent could be kept under sufficient tension, then this material might resist the tension of the drop threads.

Sample Descriptions - Continued

a. Sample No. 1 - (Continued)

Again, when weaving drop threads, the intra-weft which was being beat-up into the fabric had a tendency to slide back from the beat-up point when the reed was returning to the back position. Subsequent beat-ups would finally place the intra-warp into the woven fabric, but not without disturbing the alternate Rene' 41 permanent wefts.

Also it was observed that at least one-half inch of woven fabric is required to sufficiently lock in the drop threads. This lack of bind is probably inherent in the fine wire weaving and is probably not detrimental if the warp sheets are to be coated. The lack of bind was also noticed in the warp ends.

Sample No. 1 (which was 1" long warpwise) failed to expand 57.75" (3 x 19.2"). The drop yarns became entangled in the manner of Sample A when the warp sheets were pulled apart after removal of the intra-picks. The distance between fabrics attained was approximately 36".

b. Sample No. 2 - This sample was used to determine the effect of round heddle eyes on the cold working of Rene' 41 yarn. It was felt that the round heddle eyes would reduce cold working by rounding the sharp edge of the heddle eye over which the yarn must travel. The heddle eyes were made from 1/16" diameter steel wire and were 1/8" wide by 5/16" high inside. All the conditions as described for Sample No. 1 were encountered in weaving this sample except as follows:

(1) The curling or cold working of drop yarns through their heddle eyes seem to be less severe.

(2) The 1/4" wide heddle eyes chafed adjacent warp ends when the eyes traveled up and down through the warp sheds. In other words, the over-all width of the heddle eye should be held to a minimum so as not to disturb other yarns in the sheds.

Sample Descriptions - Continued

b. Sample No. 2 - (Continued)

Sample No. 2 failed to expand; the drop yarns entangling as experienced on previous samples. The drop yarn length attained was 42" instead of the required 96" (5 x 19.2").

c. Sample No. 3 - This sample was woven to determine the effect of increasing the intra-warp weave angle. The intra-picks were held against the permanent warp sheets by the intra-warp, as originally outlined for the intra-weave method. The intra-warp weave angles were increased from 2.75° to 8.5°. It was felt that this increase in angle would be sufficient to show if there was an advantage in weaving with a greater angle, and with the reed in the model loom it was still possible to maintain the 19.2" woven height. The disadvantage of weaving at greater warp angles is a necessary increase in drop yarn heddle travel from 31" to 35 1/2".

The greater angle of weave was an improvement in holding the required drop yarn lengths between warp fabrics. One side of the upper fabric did fall away about 1/4" from the upper weaving gage angle, but this was due to slack intra-warps at that point.

Since the intra-picks are not woven into the fabric, but lay between the woven warp sheet and the intra-warps, the intra-picks had a tendency to slide back 1/2" from the beat-up point. Four selvage wires were used on each end of the fabrics and threaded through heddle wires on the permanent warp harnesses. This arrangement allowed the intra-picks to be tied into the weave by the selvage wires only.

The intra-weft slide-back was held to 1/2" by manipulating the vertical position of the drop yarn heddles in relationship to the reed, so that the feed-off of the subsequent drop yarn length occurred when the reed was at or near beat-up position. The operation was possible in this hand operated model loom, but may be impossible or awkward in the 252" wide loom.

Sample Descriptions - Continued

c. Sample No. 3 - (Continued)

It was again necessary to remove the creel weights from the drop yarns when weaving drop threads and to replace them when weaving the fabric between adjacent drop thread groups. But a difference was noted. If the tension weights were left on the creel yarn while weaving drop threads, the intra-warps were not pulled toward the center of the shed (as in previous samples) due to the improved weave angles. The tension weights did pull out the last placed intra-pick from its beat-up position about 3 or 4 inches. Thus the drop threads were woven without tension weights. This sample also failed to expand to 96" due to entanglement. The drop yarn length attained was 38 inches.

d. Sample No. 4 - This sample was woven using 220 denier Dacron* drop yarn to determine if the previous failures were due exclusively to the Rene' 41 wire yarn or if the intra-weave technique itself was at fault.

Dacron yarn was easier to handle in the weaving process due to its yarn size and tensile properties. A 220 denier Dacron yarn has an approximate diameter of .006 in. The intra-weft slide-back was no more than when weaving Rene' 41 drop threads without the tension weights. Probably due to the larger size of the Dacron, some of the tension was consumed to overcome drag through the shed and the creels. But the drop yarn tension did cause a definite uneven spacing of the woven Rene' 41 wefts.

Upon attempting to expand this sample by allowing the intra-weft and intra-warp wires to be displaced toward center of fabric while pulling the woven warp sheets apart, the sample pulled apart to about 40", whereupon the drop yarns were beginning to bind when passing over intra-wefts. The intra-wefts had to be removed and the sample then pulled out to 79". One portion of about 20 drop yarns became knotted in the center of the span. The knots were cut out and the remaining drop threads extended to 94 3/4" between warp sheets. This is a loss of 1 1/4" in drop yarn length from the intended 96". Definite kinks were

* Trademark - E.I. duPont de Nemours and Company

Sample Descriptions - (Continued)

d. Sample No. 4 - (Continued)

apparent in each drop yarn at points where intra-picks were located in the woven sample.

A partial success was attained in expanding this Dacron drop thread sample; to do so, however, required combing and untangling of some ends in the process. In a specimen of considerably greater size, this type of handling of the threads to facilitate expansion would not be feasible.

e. Sample No. 5 - This sample was to have been woven using monofilament Rene' 41 .0016" diameter drop yarn coated with Teflon*. The sample was delayed due to inability to procure the coating material on time and was subsequently cancelled since Sample No. 11 was considered to be sufficient evidence of the results of Teflon coating.

f. Sample No. 6 - This sample was woven using stranded Rene' 41 wire (7 x .0016" diameter) for drop yarn to determine if the stranded Rene' 41 wire would be less susceptible to cold working.

As in Sample No. 4 the tension on the drop yarns caused a disturbance or uneven grouping of the wefts in the woven warp sheets. Apparently, there was not sufficient locking between the Rene' 41 wefts and warps, possibly due to the grouping of the warp ends.

The sample was expanded to 38" where it became completely entangled. No improvement over monofilament was apparent.

g. Sample No. 7 - This sample was woven without crossing the drop yarns to determine if the crossover of drop yarns contributed to the entanglement.

The simulated Jacquard mechanism on the model loom was altered to allow all the drop ends to travel together instead of one half of the ends being opposite to the remaining half, as in all previously woven samples.

*Trademark - E.I. duPont de Nemours and Company

Sample Descriptions - Continued

g. Sample No. 7 - (Continued)

The density of the drop threads was maintained at 55.5 drop threads per square inch. The last intra-pick of a group of five fell back more than experienced with cross-over samples, because in this sample all the drop ends were pulling on each intra-weft.

The sample failed to expand; the drop threads becoming hopelessly entangled as experienced on previous samples and a height of 36" was attained instead of the intended 96".

h. Sample No. 8 - This sample was woven without drop yarn crossover using 220 denier Dacron drop yarn. The same weaving conditions were used as in Sample No. 7. Three or four Rene' 41 permanent wefts were required to be beat into fabric before last intra-wefts would remain in the beat-up position.

The sample expanded to 60" where drop threads became permanently entangled. Comparing the results to Sample No. 4 where the Dacron drop threads were woven with a crossover, Sample No. 8 without crossover was definitely no improvement. The expansion results of Samples No. 7 and No. 8 indicate that weaving without drop thread cross-over hinders the weaving process and does not improve expansion.

i. Sample No. 9 - This sample was woven with a decrease in the number of drop yarns per square inch to determine if the reduction would improve the expansion characteristics.

The loom Jacquard was again set to weave crossover drop threads, but with a drop thread density of 8.33 drop threads per inch.

The face fabrics had a much improved appearance due to the fact that less drop threads were pulling against the Rene' 41 wefts. Also, due to less drop threads the intra-wefts remained more readily in their beat-up position.

Sample Descriptions - Continued

i. Sample No. 9 - (Continued)

When expanded the Rene' 41 drop threads pulled out to 48" where they entangled as before. The 85% reduction in Rene' 41 drop thread density did not improve the expansion results.

j. Sample No. 10 - This sample was woven with the same configuration as Sample No. 9 except that drop yarns of nylon coated wire were used. The drop yarns were 7 x .004 diameter stranded stainless steel with .032" diameter nylon (Stranded Diameter - .012"). The drop yarn density was 8.33 ends per inch. The .032" diameter nylon coated cable was the smallest commercially available size and obviously is too large for making a suitable fabric, but other than size, the test did show whether the nylon coating is an advantage in weaving or expanding AIRMAT.

Because of the relatively large size of the coated drop ends, the yarn had no bind in the warp sheets and pulled the intra-wefts out from beat-up position.

The sample did expand 97 1/2" but the ends entangled during the expansion process and had to be individually untangled by hand. The results of this test indicate that a plastic coated drop yarn may be an advantage in facilitating expansion and subsequent packing of the fabric specimen.

k. Sample No. 11 - This sample was woven with the same configuration as Samples No. 9 and 10 except that Teflon lubricated stranded yarn was used. The drop yarns were stranded Rene' 41 wire (7 x .0016" diameter).

This drop yarn apparently caused less drag, than bare wire, through the drop yarn heddles. The heddles were not pulled forward as with Rene' 41 monofilament or stranded drop yarn. The intra-wefts did not have a great

Sample Descriptions - Continued

k. Sample No. 11 - (Continued)

tendency to pull out of their beat-up position. The last intra-weft remained in position after the next Rene' 41 weft was woven in. Entanglement occurred during expansion but the fabric did pull out to 60".

Although the sample failed, the Teflon lubrication of the yarn reduced drop yarn drag and tension in the weaving process.

l. Sample No. 12 - This test was established to determine the value of using a plied yarn composed of .0016" diameter Rene' 41 and 150 denier Fortisan* yarn as the drop yarn to reduce cold working. The test was cancelled because it was felt that no great improvement would result from this test based on the experience from the other test samples.

In addition to weaving the various test samples by changes in drop yarn materials and/or weaving methods, a program was initiated whereby various techniques were used to determine if a method for expanding the samples could be developed that would eliminate the drop yarn entanglement problem. This program included immersing the AIRMAT samples into highly viscous materials in order to orientate the drop yarn and provide lubricity. These materials included gear oil, gelatin, paraffin and foam. None of these methods resulted in any improvement for expanding the AIRMAT samples.

As summarized in Table I, page 12 none of the attempts to weave AIRMAT using the intra-weave method proved successful and it was decided that the yarn tangling was caused primarily by the lack of orientation during the weaving process. The cold working of the yarn, as it passes through the heddle eyes, contributed to the yarn

*Trademark - Celanese Corporation of America

TABLE I

SAMPLE WEAVING PROGRAM SUMMARY
INTRA-WEAVE METHOD

Sample Identification	Description	Results
A (Initial demonstration sample 10" long)	.0016" diameter Rene' 41 (5 drop)	Entangled after expanding to 36".
1	.0016" diameter Rene' 41 (3 drop)	No improvement.
2	.0016" diameter Rene' 41 (5 drop) Round heddle wires	Cold working appeared reduced. Entangled after expanding to 42".
3	Same as 2 except increased angle of intra-warp (8.5^{o} vs. 2.75^{o})	Entangled after 38".
4	Same as 2 except 220 denier Dacron drop yarn	Expanded to approximately 95" with difficulty. Entanglement existed.
5	Coated .0016" diameter monofilament yarn	Test deleted.
6	Same as 3 except used stranded Rene' 41 wire for drop yarn (7 x .0016" diameter)	No improvement over Sample 3.
7	Same as 2 except no drop yarn crossovers	Entangled after 36".

Table continued on next page.

TABLE I

SAMPLE WEAVING PROGRAM SUMMARY
INTRA-WEAVE METHOD
(Continued)

Sample Identification	Description	Results
8	Same as 7 except use Dacron drop yarn	Entangled after 60".
9	Same as 2 except reduce drop yarn density (8 per in^2 vs 55 per in^2)	Entangled after 48".
10	Same as 9 except use Nylon coated wire	Expanded to 97" with great difficulty - knots and tangles removed by hand.
11	Same as 9 except use Teflon lubricated stranded Rene' 41 (7 x .0016" diameter)	Expanded to 60" with the same difficulty experienced in sample 10.
12	Same as 9 except use plied yarn of .0016" diameter Rene' 41 and Fortisan	Test deleted.

Sample Descriptions - Continued

1. Sample No. 12 - (Continued)

entanglement but it is felt that even though cold working can be reduced through the use of coated yarns and round type heddle eyes the intra-weave method is still not considered feasible.

At this point, it was felt that, to successfully produce the desired sizes and shapes of AIRMAT, another method must be devised. In view of this a number of alternate methods were proposed and evaluated.

(1) Fabrication - This method consists of weaving AIRMAT in flat or tapered sections at a maximum thickness of 12 inches. These sections would be bonded together in layers to form the required thicknesses and configurations. (See Figures 1 and 2.) This method was determined to be feasible but of questionable value due to added fabric weight and cost of weaving and assembling. However, it was felt that this technique might be usable if no better method could be found.

(2) Weaving and Sewing - This method consists of pre-weaving the outside AIRMAT fabrics and drop fabric in flat sheets (See Figure 3). The drop fabric would be of open mesh to reduce weight. The two layers of outside fabric would be fed from two warp beams located outside of the AIRMAT structure and at right angles to it. The drop fabric would be fed from a third beam on the center line behind the AIRMAT structure. The drop fabric would pass over a combination of rollers and sewing head which would permit sewing the drop fabric to one warp fabric after which it would traverse the required drop distance to the other warp fabric where the sewing operation would be repeated. This would result in loose partitions between the warp fabrics, positioned in the fill direction. Other techniques in this category were explored such as seam welding

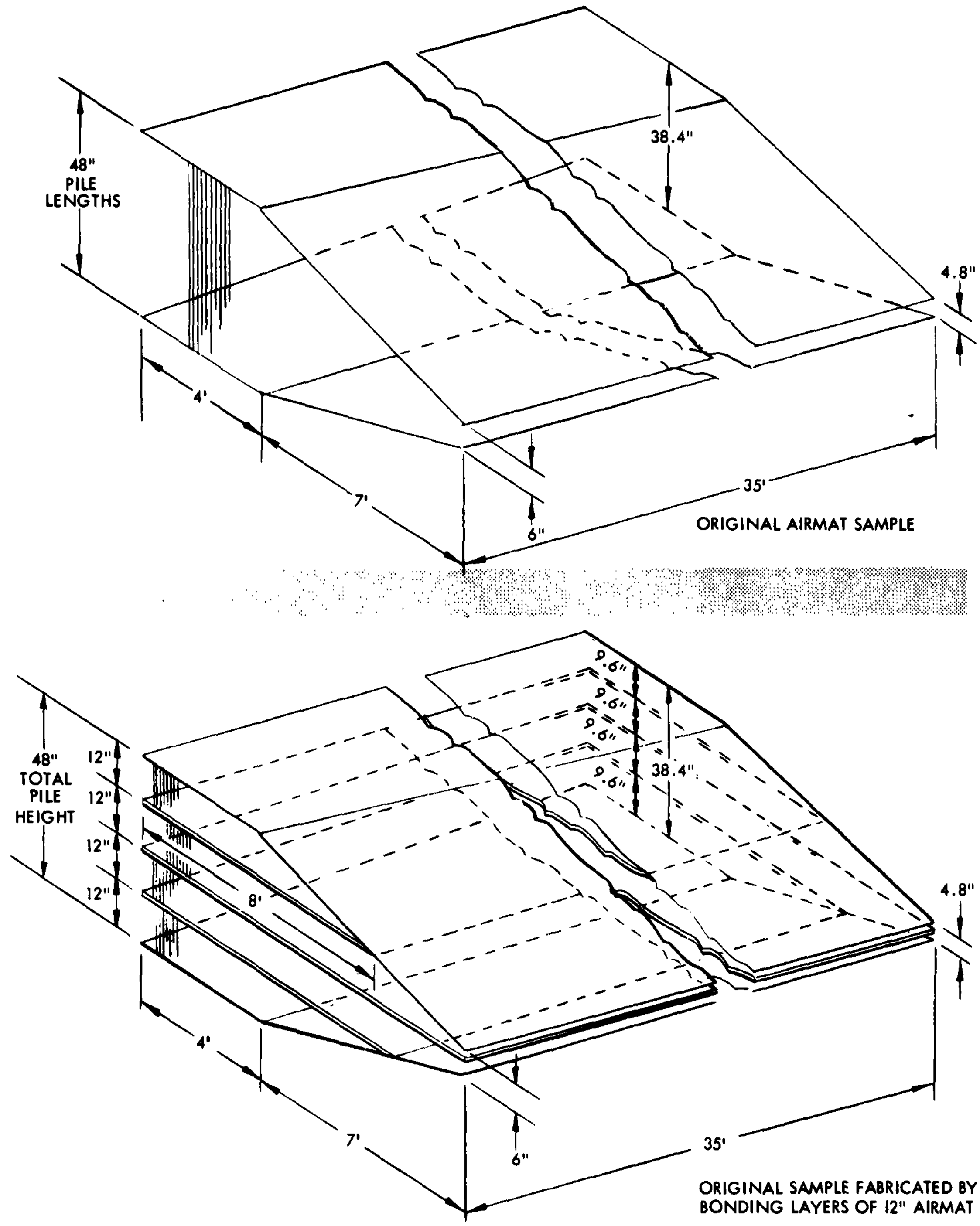

48"
PILE
LENGTHS
38.4"
4.8"
4'
7'
6"
35'
ORIGINAL AIRMAT SAMPLE
48"
TOTAL
PILE
HEIGHT
12"
12"
12"
12"
8'
9.6"
9.6"
9.6"
9.6"
38.4"
4.8"
4'
7'
6"
35'
ORIGINAL SAMPLE FABRICATED BY
BONDING LAYERS OF 12" AIRMAT

Figure 1

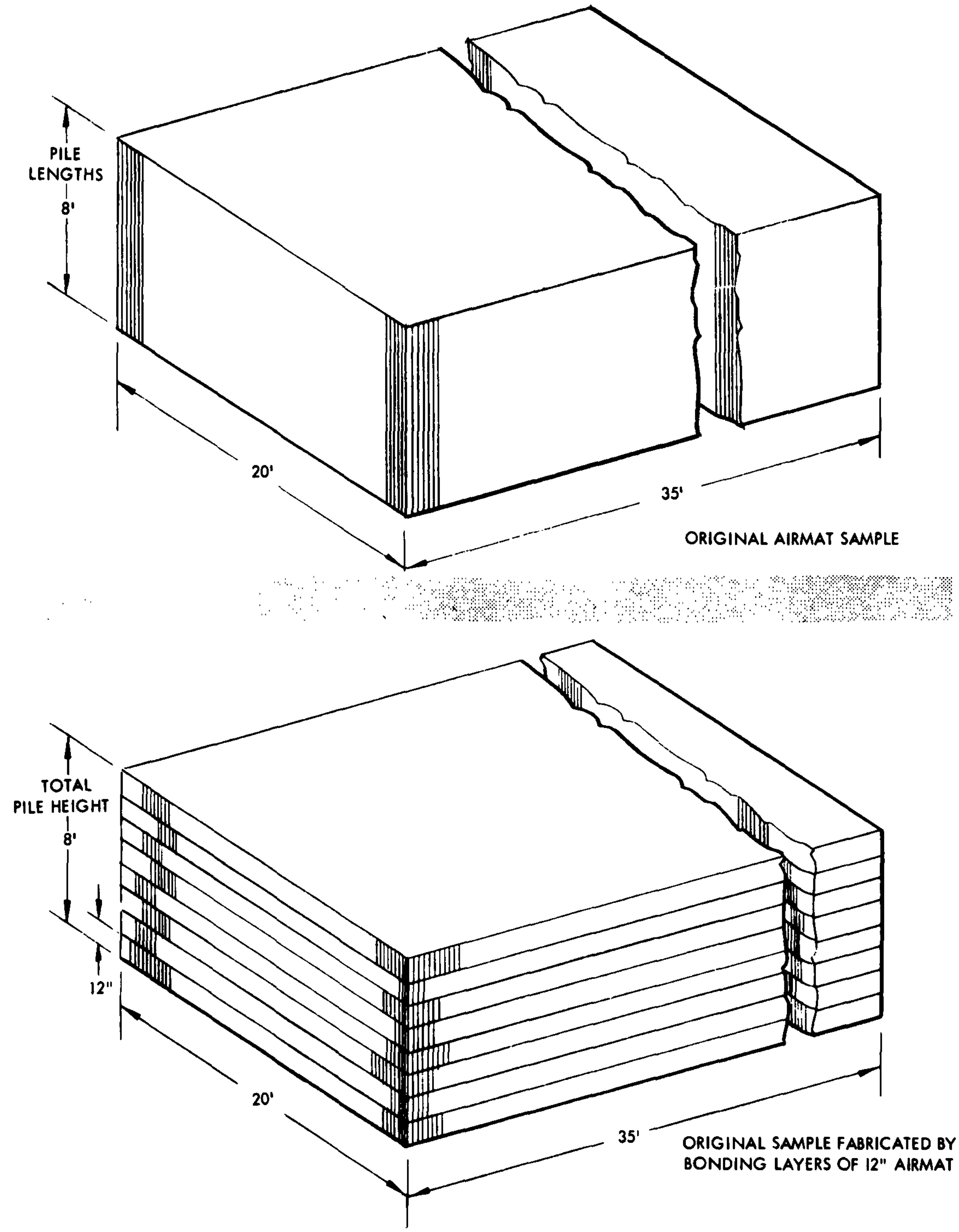

PILE
LENGTHS
8'
20'
35'
ORIGINAL AIRMAT SAMPLE
TOTAL
PILE HEIGHT
8'
12"
20'
35'
ORIGINAL SAMPLE FABRICATED BY
BONDING LAYERS OF 12" AIRMAT

Figure 2

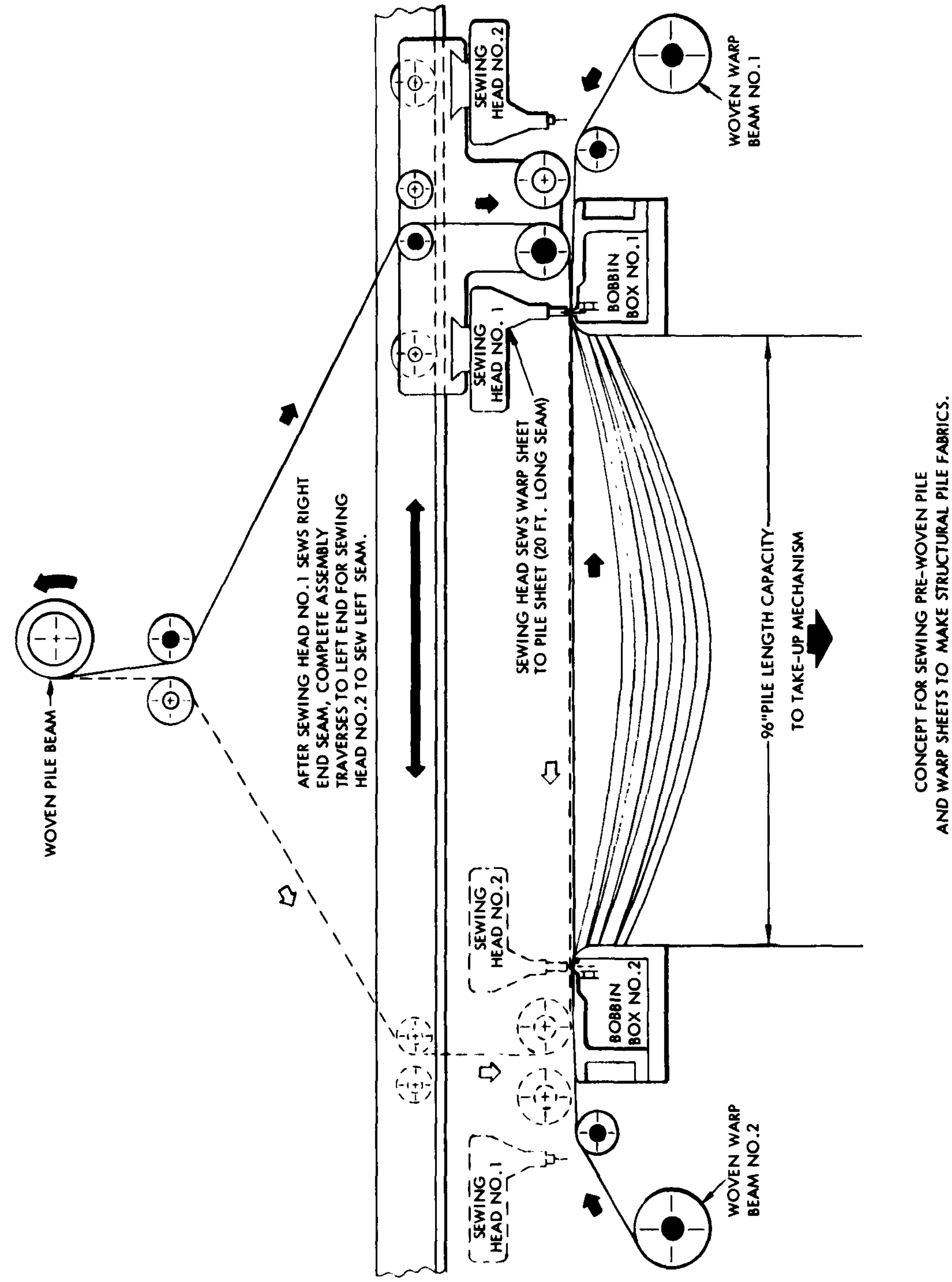

WOVEN PILE BEAM
AFTER SEWING HEAD NO.1 SEWS RIGHT END SEAM, COMPLETE ASSEMBLY TRAVERSES TO LEFT END FOR SEWING HEAD NO.2 TO SEW LEFT SEAM.
SEWING HEAD NO.2
SEWING HEAD NO. 1
SEWING HEAD NO.2
SEWING HEAD NO.1
SEWING HEAD SEWS WARP SHEET TO PILE SHEET (20 FT. LONG SEAM)
BOBBIN BOX NO.1
BOBBIN BOX NO.2
WOVEN WARP BEAM NO.1
WOVEN WARP BEAM NO.2
96"PILE LENGTH CAPACITY
TO TAKE-UP MECHANISM
CONCEPT FOR SEWING PRE-WOVEN PILE AND WARP SHEETS TO MAKE STRUCTURAL PILE FABRICS.

Figure 3

Sample Descriptions - Continued

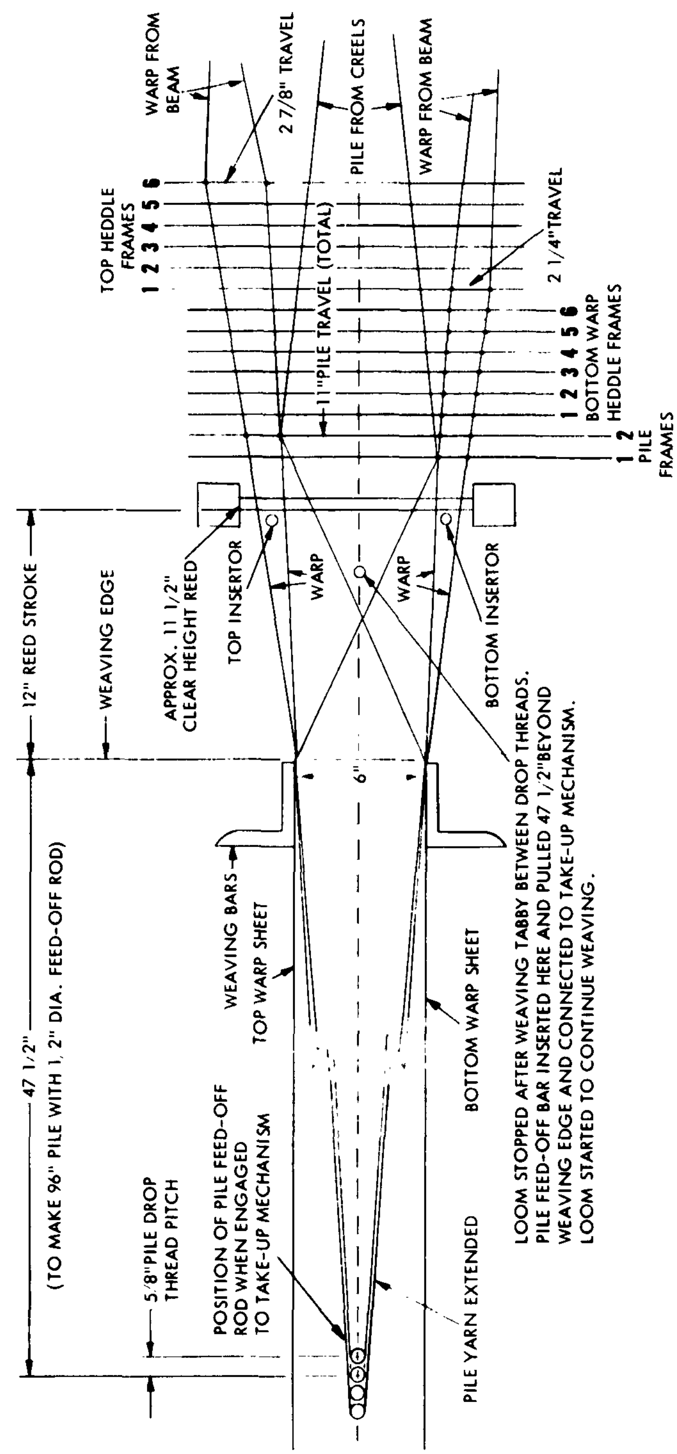
(2) Weaving and Sewing - (Continued)

drop fabric to the upper and lower cloth, sewing the individual drop yarns and welding the individual drop yarns. It appeared that any of these methods might be feasible but were undesirable because of high fabricating costs and the possibility of weak spots in the AIRMAT due to the chance of failure of individual drop yarns at the tie-in point.

(3) Mechanical Drop Yarn Extension- This method would utilize a mechanical system to engage the drop yarns at crossover and pull them away from the weaving edge into the take-off area. By pulling the drop yarns out to a predetermined distance in a straight line parallel to the weaving edge, flat AIRMAT can be produced. In addition, by varying the distance of the pull out in either a straight line on contoured configuration, contoured AIRMAT can be produced in both the warp and pulling directions. It was decided that this method showed the most promise and should be given further consideration.

2. Development of Mechanical Drop Yarn Extension Technique

As previously mentioned, a program was initiated to further investigate the possibilities of mechanically extending the drop yarns to facilitate weaving AIRMAT. The prototype loom was utilized by Lansco to weave three new samples using this method. To accomplish this, it was not necessary to modify the prototype loom except to add a means of supporting the extended drop yarns during the weaving process. (See Figure 4, Page 19) The top and bottom cloth configuration was woven the same for these samples as for the previous samples except for the elimination of the intra-warp and intra-picks.

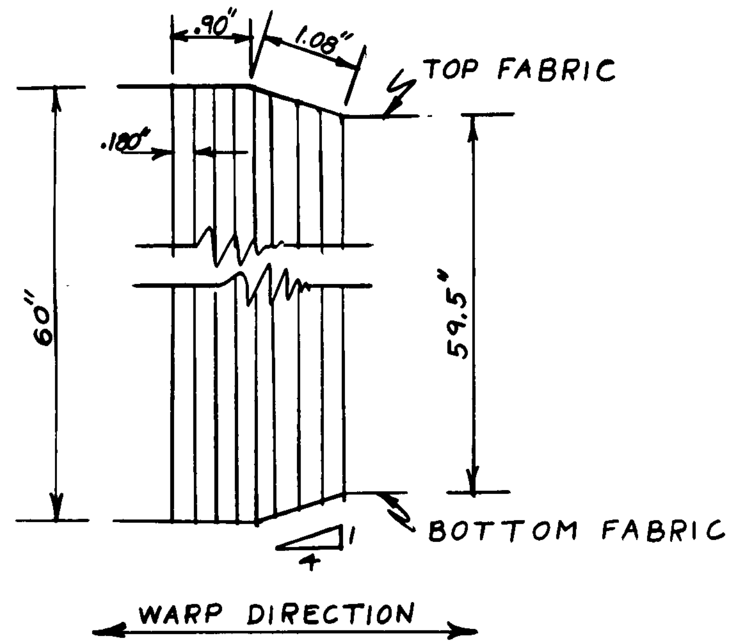


MECHANICAL EXTENSION METHOD FOR MAKING AIRMAT FABRIC

Figure 4

2. Development of Mechanical Drop Yarn Extension Technique - Continued

a. Sample No. 13 - This sample contained stranded Rene' 41 (7 strands x .0016" diameter) drop yarns with a drop yarn density of 55.5 ends per inch, and was woven to be 60 inches high when expanded with a one to four sloped section reducing to 59 1/2 inches as shown below:



For making the 5 feet high straight portion of the sample, the drop yarn feed-off rods were inserted at the drop yarn crossover point in front of reed, pulled straight forward and inserted into the take-up mechanism at a calculated distance of 28 3/8" from the weaving edge to form 60" long drop threads. To form the tapered section, where the drop yarns reduce in length, each rod was placed progressively closer to the weaving edge.

The sample was expanded to 60" and was folded successfully several times. The drop yarn feed-off rods also served to orient the drop threads during the expansion process and to assist in folding and packaging.

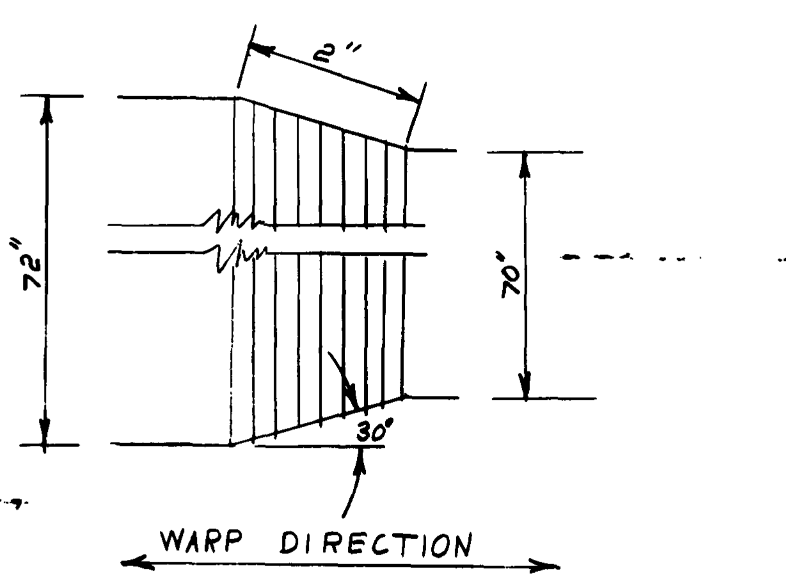
2. Development of Mechanical Drop Yarn Extension Technique - Continued

b. Sample No. 14 - This sample contained monofilament Rene' 41 (.0016") drop yarns with a drop yarn density of 55.5 drop yarns per square inch and woven flat with a planned expanded height of 72 inches. The drop yarn pulled back the weft shots, but not as much as in Sample No. 13. Where nearly full spools of Rene' 41 were used on the creels the pull back of the weft was more noticeable than where nearly empty spools were used, since the rotation of heavy spools during the feed-off process causes more tension on the drop yarn.

The sample was expanded successfully to the 6 foot intended height (See Figure 5, Page 22).

c. Sample No. 15 - This sample also contained the same elements as Sample No. 14 but was woven to be 72 inches maximum expanded height with a slope of 30 degrees full width (See Figure 5, Page 22). The weaving procedure was the same as with Sample No. 14.

The sample was successfully expanded to 75 inches and assumed its planned configuration as shown below.



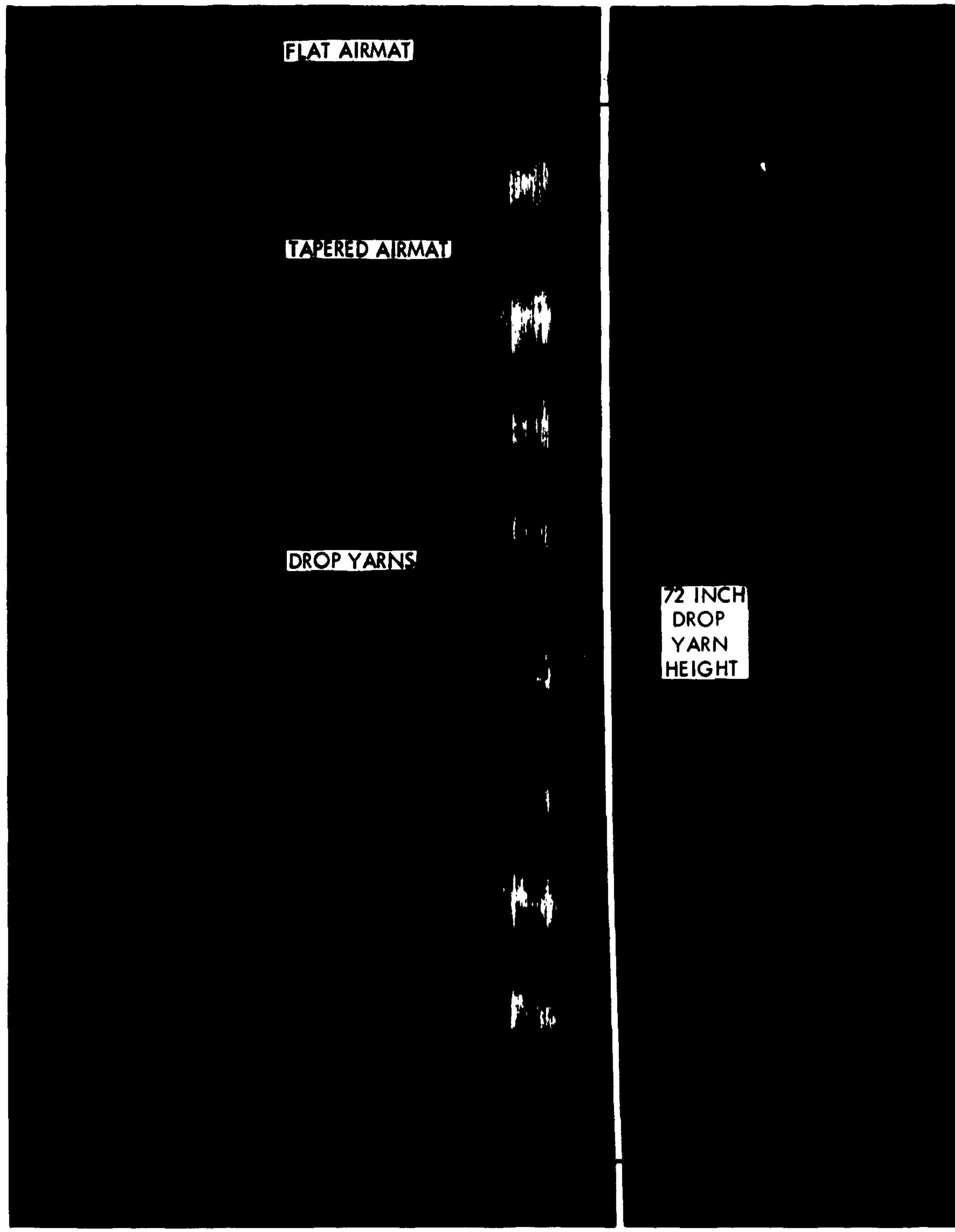


Figure 5
RENE' 41 AIRMAT SAMPLES

2. Development of Mechanical Drop Yarn Extension Technique (Continued)

As a result of the successful attempts to weave AIRMAT samples on the prototype loom, Lansco proposed an adaptation of this method for the full size loom. This was based upon inserting a drop yarn feed-off bar or wire just in front of the reed (in rear position) but back of the drop threads to be metered. The feed-off bar would be pulled forward to a metered distance ahead of the weaving edge and connected to the take-off mechanism. When the inserted feed-off bars were moved forward at right angle to the edge of the fabric, flat AIRMAT would be produced. If the bars were canted at some angle other than 90°, tapered AIRMAT would be produced. Since this method was based on a straight rod or wire under tension, only flat surfaces could be woven. In order to weave the samples required by contract, the 35' sample length would require 35' loom width to permit straight line generation.

Although it was believed that this approach would have proved feasible for weaving the two contract samples, it would limit the loom to straight line contours in the weft direction and would require excessive draw-in times since the extra 15 foot width of the loom would require a 75% increase in the number of ends to be drawn-in.

Concurrently with Lansco's sample weaving program as outlined above, GAC conducted an investigation of the mechanical drop yarn extension technique utilizing the GAC plush loom. A flat Dacron sample, 2 inches wide by 4 feet long by 41 inches high was woven and successfully expanded (See Figure 6, Page 24). In weaving this sample, the drop yarns were pulled out of the weaving area of the loom by inserting a one-inch diameter steel pipe parallel to the drop yarn crossover point in the shed and displacing the drop yarns horizontally away from the weaving edge. When the desired extension was reached, the loom was started, the drop yarns woven in and a piece of heavy wire was inserted to retain the drop yarns prior to removal of the piece of pipe. The first flat AIRMAT sample produced using this method was quite crude since no means was provided to accurately gauge the drop yarn lengths. However

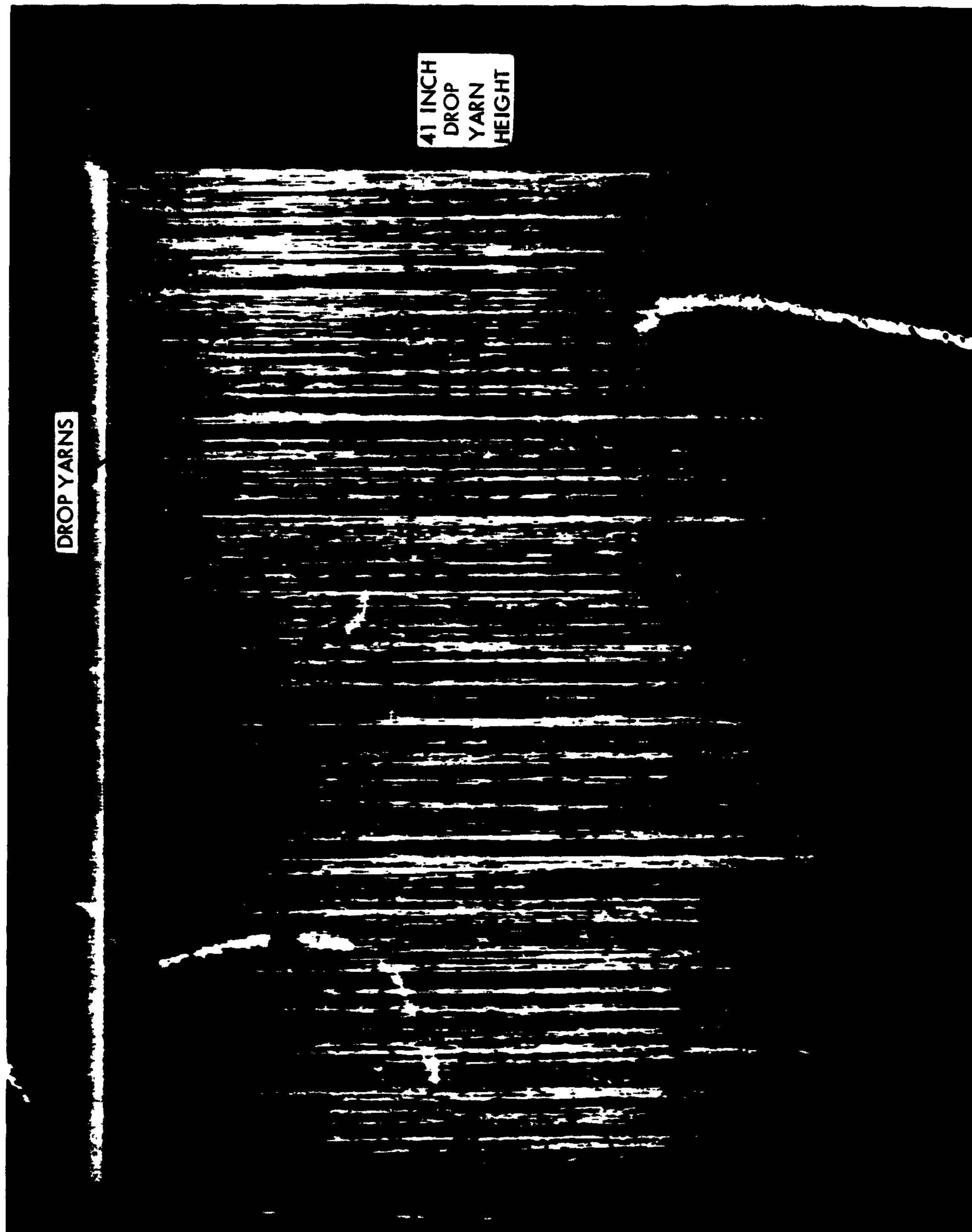


Figure 6
41" DACRON AIRMAT SAMPLE

2. Development of Mechanical Drop Yarn Extension Technique (Continued)

it was of great value in proving the feasibility of the method on a 60" loom. The second sample (tapered) produced on the GAC loom was made using the same one inch diameter steel pipe, however, in producing this sample the pipe was pulled out at an angle to the weaving edge (See Figure 7, Pg. 26). This sample was also successfully demonstrated.

As a result of the success of the various samples, utilizing the mechanical extension technique, a concerted effort was made at GAC and Lansco to establish design parameters for the loom incorporating a mechanical drop yarn extension mechanism. Two methods of drop yarn extension were proposed.

a. Single Bar Extension Method - This method utilizes a straight or formed bar, depending on the requirement for flat or contoured AIRMAT, to extend the drop yarn the required distance from the weaving edge (See Figures 8 and 9, Page 27 and 28). This is basically the method used to produce all of the mechanical extension samples to date. (See Figure 10, Page 29)

b. Multiple Hook Extension Method - This method utilizes multiple hooks (or similar catching devices) lying in the warpwise direction between the two fabrics which engage a filling wire (placed in front of the drop yarn) pulling the drop yarns the required distance from the weaving edge. (See Figure 11, Page 30)

Since both of these methods show great promise, it remains to determine which method is the most feasible and provides the greatest weaving capability for producing AIRMAT in various sizes and configurations.

3. Loom Specification

As a result of the decision to proceed with the mechanical extension technique, the loom design parameters were firmed up sufficiently to permit completing the Specification Control Drawing which is approximately 90% complete at this writing.

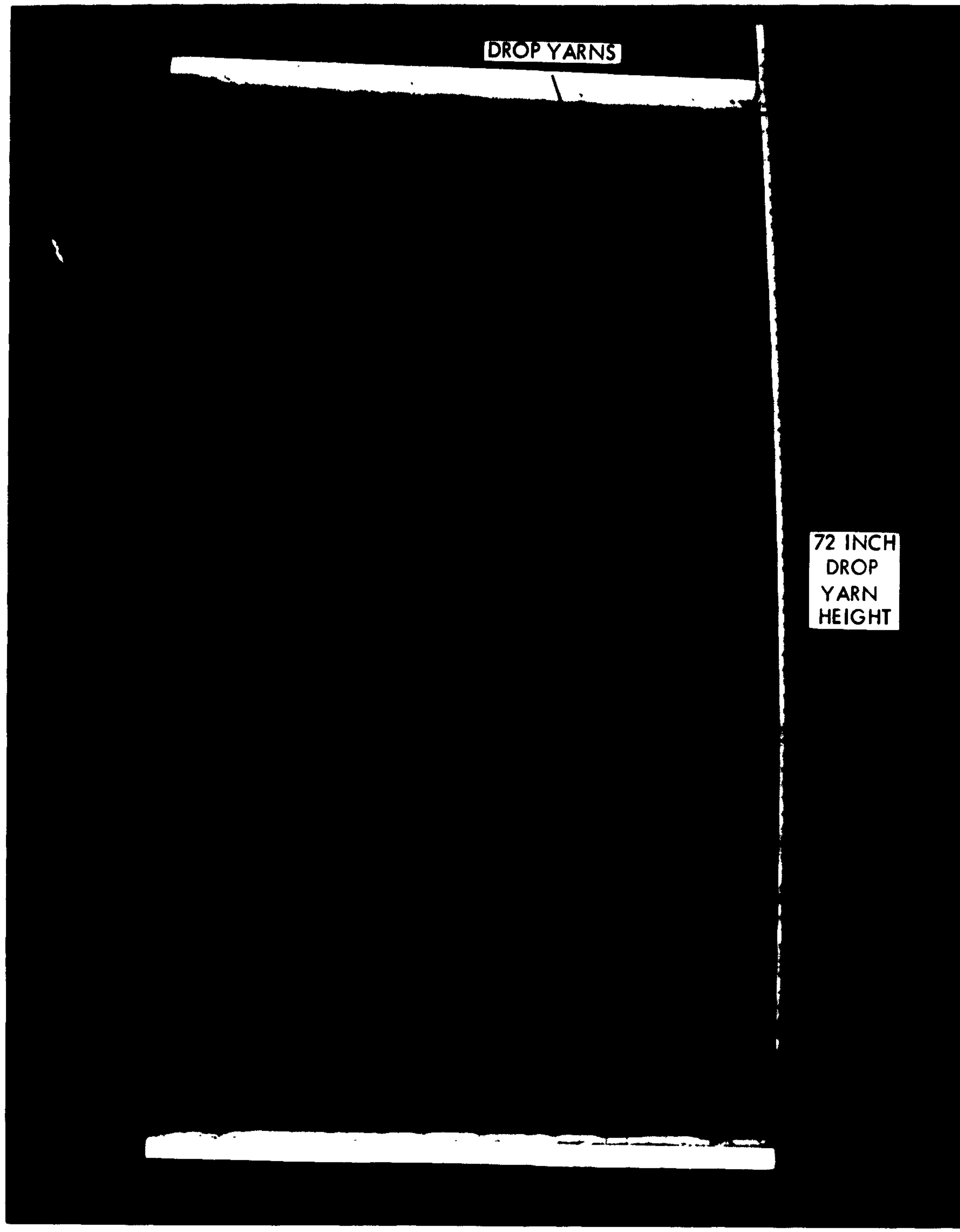
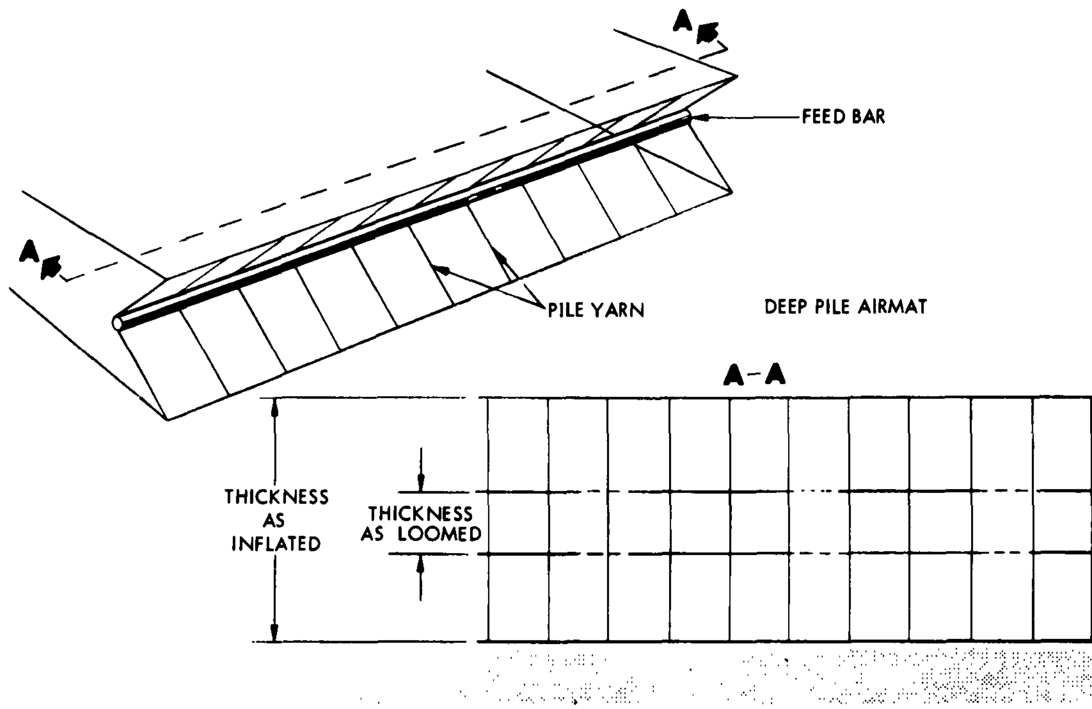
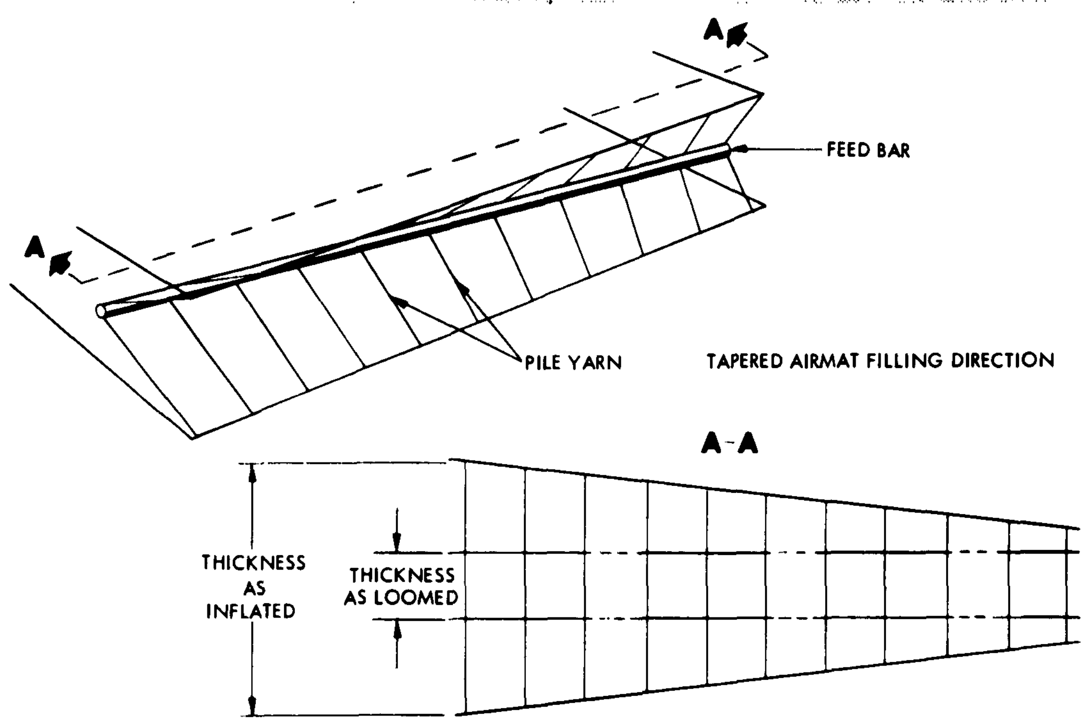


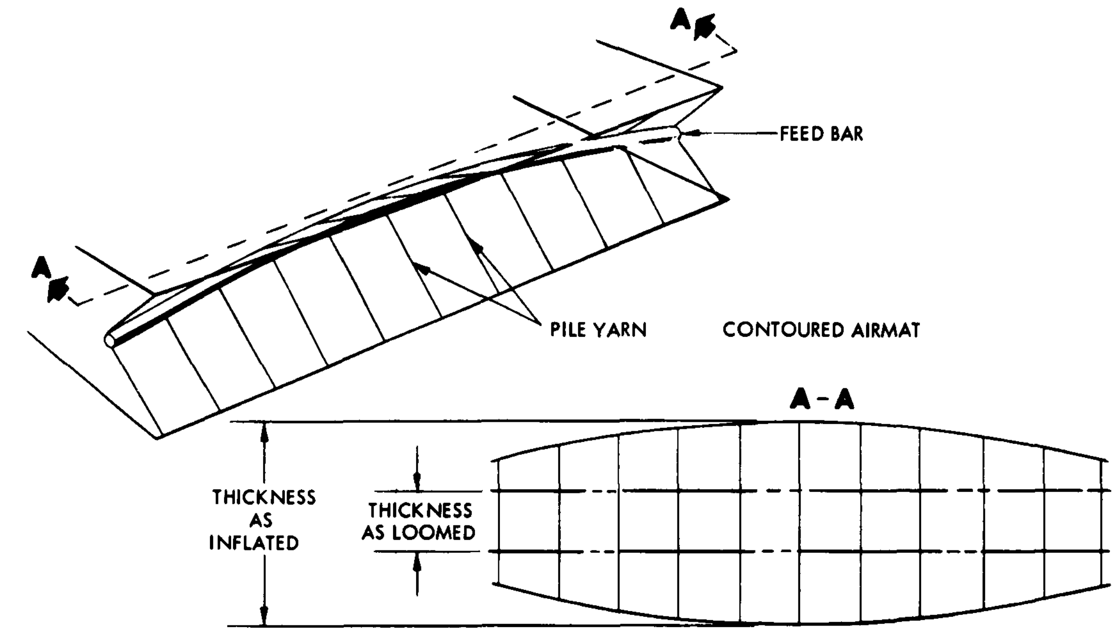
Figure 7
72" DACRON AIRMAT SAMPLE

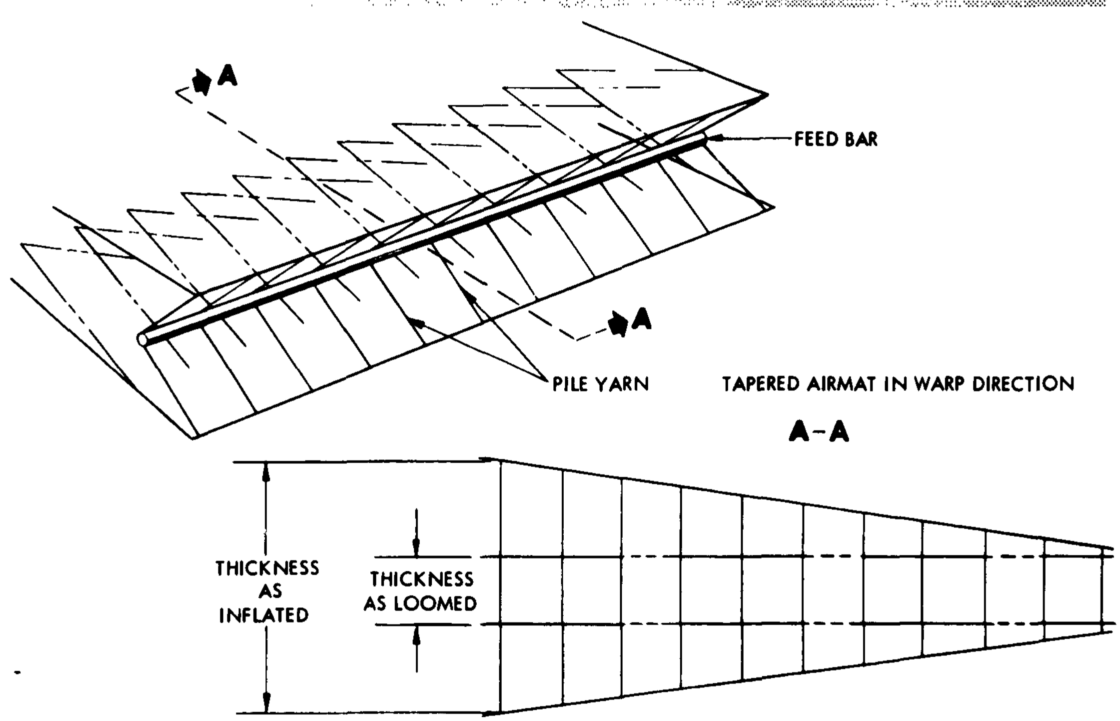




SAMPLE AIRMAT SHAPES -- SINGLE BAR MECHANICAL EXTENSION METHOD

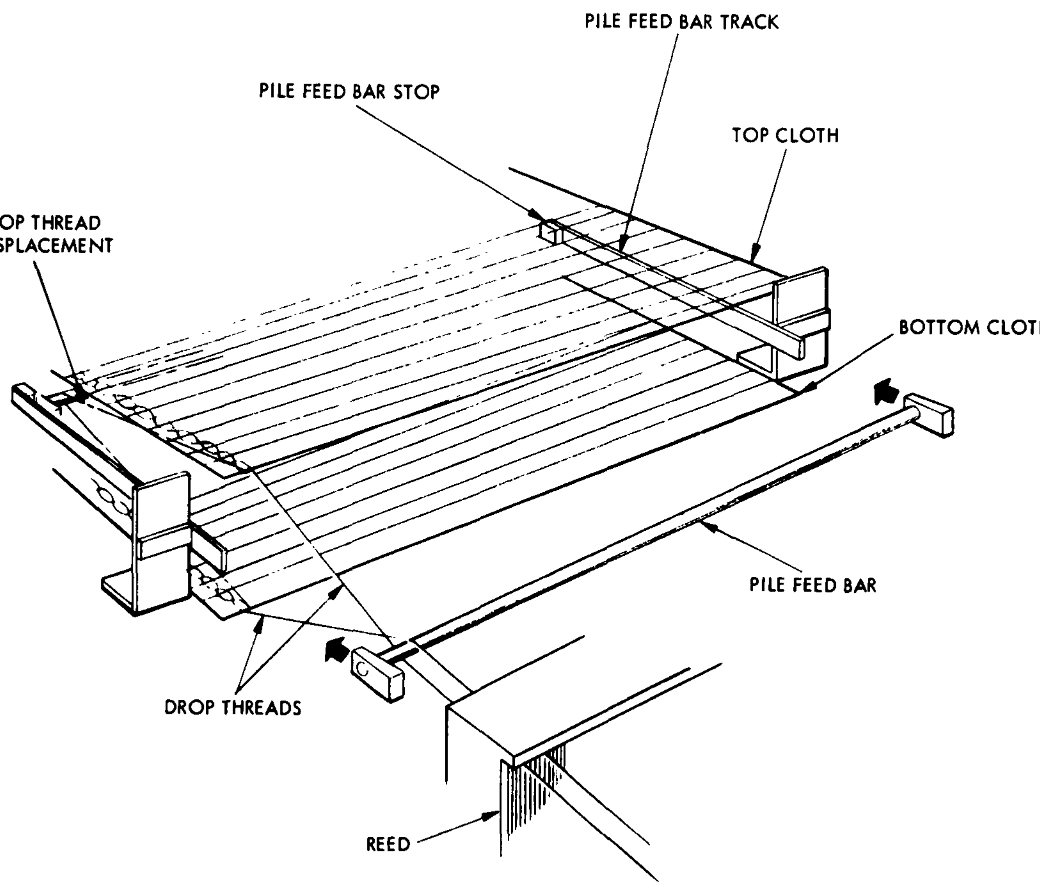
Figure 8





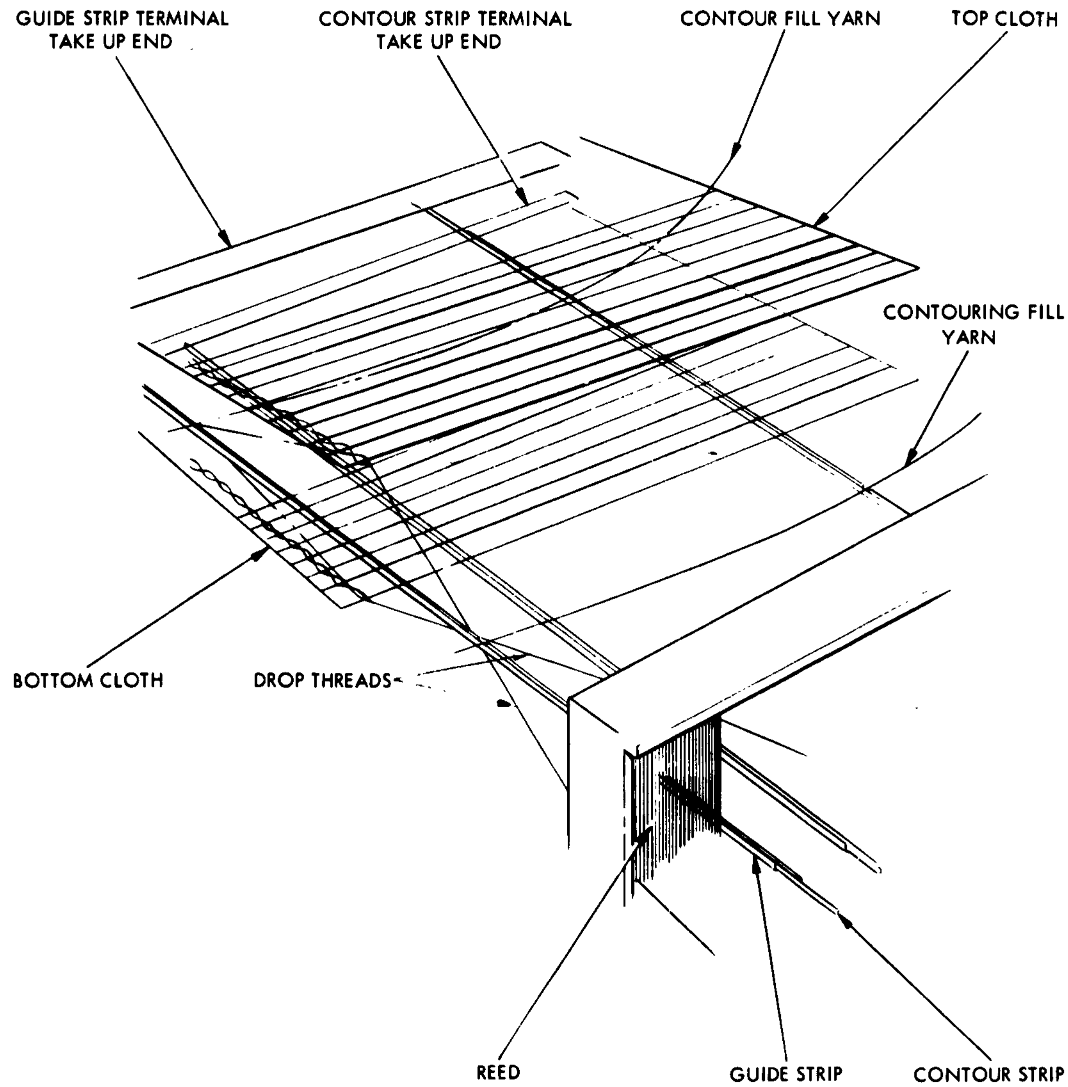
SAMPLE AIRMAT SHAPES—SINGLE BAR MECHANICAL EXTENSION METHOD

Figure 9



SINGLE BAR MECHANICAL EXTENSION METHOD

Figure 10



MULTIPLE HOOK EXTENSION METHOD

Figure 11

B. Program for Next Quarter - April 1962 through June 30, 1962

The anticipated effort for the next quarter will consist of the following:

1. Mechanical Extension Technique

Based on design and evaluation studies to be conducted on the GAC's 60" loom, a decision will be made on the method of mechanical extension to be used. Assembly layouts will then be made and the detail design effort will be started.

2. Loom Design and Fabrication Program

The assembly layouts will be completed and manufacturing drawings will be produced. Procurement of materials and parts will commence.

3. Specification Control Drawing (SCD)

The SCD will be issued for approval on or about 5 April 1962.

4. Miscellaneous

GAC will continue to monitor Lansco's effort.

Continuing coordination will be maintained with Mr. E. B. Grover the Textile Consultant.

APPENDIX A

GLOSSARY

GLOSSARY

AIRMAT	A Goodyear Aircraft Corporation (GAC) trademark denoting a type of double-woven fabric containing interconnecting drop threads. AIRMAT samples produced with the two fabrics parallel are referred to as Flat AIRMAT. Where the samples have a curved or tapered shape in either the warp or filling direction, or both, it is referred to as contoured AIRMAT.
ALGINATE	A water soluble textile yarn. Made in England.
BEATING UP	One of the basic motions in weaving. It consists of forcing the filling - which the shuttle has inserted in the shed-up to the fell of the cloth. This is accomplished by the lay.
BEAMING	The process by which the warp yarns are wound onto beams. Sometimes referred to as warping.
BOBBIN	A package on which yarn is wound. Bobbins are used for both the filling yarn and drop yarn supply.
CLOTH	The structure resulting from the crosswise interlacing of two groups of yarns. It includes any pliant fabric formed of any textile fiber, wire, or other material.
COMBER BOARD	A long narrow board extending across the full width of the warp and located beneath the Jacquard machine. It contains many small holes and serves to keep the Jacquard harness cords in order, one cord passing through each hole.
CREEL	A framework arranged especially to hold the various packages from which the yarn is drawn to supply a given machine. The drop yarn is drawn from a creel.

GLOSSARY
(Continued)

DENT	An opening in the reed through which the ends of the warp and pile are threaded. The dents per inch determine the ends per inch in fabric.
DOBBY	A mechanism attached to a loom for controlling the operation of the harnesses. Dobbies are made so that they can operate up to 25 harnesses. The action of the dobby is controlled by an endless chain set with small iron pegs which program the lifting of the harnesses and determines the fabric weave.
DOUBLE END	A defect in plain woven fabrics caused by two adjacent ends un-intentionally weaving alike. Also called a flat.
DOUBLE PICK	A fabric defect caused by having two picks un-intentionally in the same shed in the filling direction.
DOUBLE-WOVEN PILE FABRIC	A kind of pile cloth woven as two fabrics, one above the other, with interlacing ends joining the two fabrics that are later cut to form the pile.
DRAWING-IN	The operation of entering the warp ends from the warp beam through the eyes of the correct heddles on the respective harnesses.
DROP YARN	The interconnecting yarn between the two cloths of an AIRMAT fabric. Sometimes referred to as pile yarn.
DROP YARN DENSITY	The number of drop yarns per square inch of fabric.
DROP YARN HEIGHT	The distance between the top and bottom AIRMAT fabrics. If fabric is contoured, this dimension will be variable to form the contour.

GLOSSARY
(Continued)

DROP WIRE	A thin flat metal strip used in certain warp stop motions. It has an eye through which a warp thread passes. If the warp thread breaks, the drop wire is released making an electrical contact and stops the loom.
END	One thread of the warp, either before weaving, or in the cloth.
FABRIC	A collective term applied to cloth no matter how constructed or manufactured and regardless of the kind of fiber from which made. In the commonest sense, it refers to a cloth made by weaving.
FABRIC CONSTRUCTION	The essential details about a fabric. This usually includes width, ends per inch, picks per inch, weight, and yarn size.
FABRIC COUNT	The actual number of ends and picks per inch in any woven cloth, Sometimes referred to as thread count.
FALSE PICK	In an AIRMAT fabric, a pick woven on the face of the fabric over which the drop yarns are woven. Upon removal of the false pick, the drop yarns held by this pick are released allowing the AIRMAT fabric to increase in depth. This is a limited technique for producing higher pile AIRMAT than the loom is otherwise capable of doing.
FELL (of cloth)	The edge of the cloth which is nearest to the reed while being woven.
FILLING	The yarn which interlaces with the warp yarn to weave a woven fabric. The filling runs from selvage to selvage at right angles to the warp. Also known as a fill, pick or weft.

GLOSSARY
(Continued)

FILLING STOP MOTION	A mechanism applied to a loom designed to stop the loom in case the filling breaks or the shuttle becomes empty.
HARNESS	The frame containing the heddles through which the warp threads are drawn prior to weaving.
HARNESS CORD	A long cord, usually of linen, fastened to the lower end of a Jacquard machine. The harness cords are threaded through the comber board and at their lower ends are attached the Jacquard heddles and lingoes.
HEDDLE	The part of a loom harness having a small opening near its center through which one or more threads of warp or drop yarn are threaded. Heddles are attached to the harness frames.
INTRA-WEAVE	A method similar to the false pick method for producing high pile AIRMAT. This system employs the use of additional warps and filling referred to as intra-warp and intra-pick, respectively. These yarns are not woven into the AIRMAT sample but provide a means for weaving with the pile yarns and upon removal of the intra-weave yarns allows the AIRMAT fabric to increase in pile height.
JACQUARD	A shedding mechanism, located above the loom, by which a large number of warp ends may be individually controlled. Programming of the weave is accomplished from pre-punched cards which control the raising and lowering of the Jacquard heddles through which the warp or drop yarns are threaded. Elaborate fabric weaves can be accomplished with this mechanism which are beyond the scope of a Dobby mechanism.
JACQUARD TIE	The manner in which the harness cords are connected to the Jacquard machine and threaded through the comber board.

GLOSSARY
(Continued)

LAY	The term given to the collective parts of a loom which oscillate to perform the operation of beating up. The most important parts of the lay are the lay swords, reed, and reed cap.
LAY SWORD	The legs or support for the lay of a loom. There are two swords, one on each side of the loom.
LEASE	The method of arranging the threads of a warp in an orderly fashion so they will maintain the same relative position with respect to one another. It is done by passing the threads over and under lease rods, alternating odd and even numbered ends or in some similar manner.
LEASE RODS	Rods inserted between the warp yarns to prevent them from clinging together and crossing each other.
LET-OFF MOTION	The mechanism on a loom for regulating the delivery of the warp yarn from the warp beam and for maintaining the desired tension on the warp.
LINGOE	A slender metal weight attached to the bottom of each harness cord in a Jacquard. Its function is to pull down the harness cords and connecting parts during the operation of the Jacquard.
LOOM	A machine for weaving fabrics by interlacing two series of yarns at right angles to each other.
MECHANICAL DROP YARN EXTENSION	A method for producing flat or contoured AIRMAT to any desired pile height or shape. This technique employs a straight or contoured bar that is inserted across the warp, near the fell of the cloth, at the position where the drop yarns are placed into the fabrics. This bar is horizontally moved against the drop yarns which are displaced to the desired length.

GLOSSARY
(Continued)

MISPICK	A defect in the woven fabric caused by a pick of filling failing to interlace in the desired sequence.
PATTERN CARD	Any of the pre-punched cards used in the Jacquard to program the lifting of the Jacquard heddles.
PICK	One thread of filling placed between the warp threads in one passage of the shuttle through the shed, at right angle to the warp.
PICK GEAR	One of the gears in the train that operates the take-up motion on a loom. When changing fabric construction (picks/inch), this gear is changed.
PILE	The interconnecting yarns between the two cloths in AIRMAT fabric. Also known as drop yarns.
PLAIN WEAVE	The simplest of the fundamental weaves. Each filling yarn passes alternately over and under the warp yarns.
REED	A closed metal comb fixed in a frame, keeping the warp (and pile) ends evenly spaced. It forms a guide for the back of the filling inserter mechanism and beats up the filling. Also determines the ends per inch in the fabric.
REED MARKS	Uneven warp yarn spacing in the cloth usually caused by a faulty reed condition.
RENE' 41	A nickel-cobalt super alloy developed by General Electric. Has a maximum useful temperature of 1800°F and is not easily oxidized. Can be welded, sewed or woven.

GLOSSARY
(Continued)

SATIN WEAVE	A weave consisting almost entirely of warp or filling floats, as in the repeat of the weave each thread of one system passes over all but one thread of the other system. The intersection points do not fall in regular lines but are separated from one another in a regular or irregular manner.
SELVAGE	The lengthwise woven edge of a fabric.
SHED	The opening formed when some of the warp yarns are raised by their harnesses while others are left down. Forming the shed is the first action in weaving.
SHEDDING	The operation of forming a shed. The lifting of the harnesses may be controlled by cams, a dobby, or a Jacquard.
SHUTTLE	The implement that carries the filling through the shed during weaving.
SHUTTLE MARK	Streaks or marks on the warp threads, caused by a dirty or greasy shuttle, as it passes through the shed.
SMASH	A major fabric defect where the warp yarns have been ruptured by breaking a group of yarns, caused most commonly by the shuttle being trapped in the shed during beat-up.
SMASH PROTECTOR	A mechanism designed to prevent the shuttle from being trapped in the shed as the reed beats up. It consists of a series of micro-switches or solenoids which will stop the loom if the shuttle is not in the shuttle box at beat-up.
SLEY	The number of ends per inch in a cloth.

GLOSSARY
(Continued)

START-UP MARK	A fabric defect consisting of a fillingwise streak extending clear across the cloth, usually occuring when a loom has been stopped. Also called a set mark.
TABBY	Another name for plain weave.
TAKE-UP MOTION	A mechanism on a loom for taking up the cloth as it is woven. The number of picks per inch determines the rate of take-up.
TEMPLE	A device on a loom located near the fell of the cloth, one on each side, the function of which is to hold the cloth out as wide as possible during beat-up.
TWILL WEAVE	In a twill weave, each end floats over or under at least two consecutive picks and the points of intersection move one outward and one upward (or downward) on succeeding picks. This causes the formation of diagonal lines in the cloth.
TYING-IN	The process of joining the threads of a new warp to those of a former warp by knotting together the end of a new thread with an old thread. This saves drawing-in and reeding the new warp, but it can be done only when the two warps are alike.
WARP	The yarns that run lengthwise in a woven fabric.
WARP BEAM	The large spool-like device upon which the warp yarn is wound, and is fitted in the loom at the back.
WEAVE	The programmed interlacing of warp and filling yarns with each other to form a cloth. Plain, twill and satin weaves are the three main types.
WEFT	Same as Filling.

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31 March 1962
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(ASD TR 7-904 (III)
Contract AF33(600)-43036

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1. Looms
2. Textiles
3. Metallic Cloth
4. AIRMAT

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49 pp. (Project 7-904)

(ASD TR 7-904 (III)
Contract AF33(600)-43036

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*TM Goodyear Tire & Rubber Co., Akron, Ohio

1. Looms
2. Textiles
3. Metallic Cloth
4. AIRMAT

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III. Goodyear Aircraft Corporation
IV. Contract AF 33(600)43036
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