

Design and development of a foot pedal operated ‘Center Close Shed- Horizontal Lever Electronic Dobby’ for weaving all-over and brick motif fabrics

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The present research has addressed the limitations faced by woven fabric designers in developing a wide range of all-over and intricate brick motif fabric samples by manipulating the drafting in healds and heald lifting plans. Multi-treadles with tumbler levers and mechanical vertical hook dobbie are the only two shedding devices available to weave all-over and intricate brick motif fabrics. These traditional shedding devices have proven impractical due to the cumbersome operation of multi-treadles in proper sequence. In vertical hook dobbie shedding, a larger number of pegged lattices is required to lift the healds. Hence, this research focuses on designing and developing a new ‘Center Close Shed – Horizontal Lever (CCS-HL) Electronic Dobby’ shedding device with ‘Horizontal Levers’ that can be used in place of treadles in the existing multi-treadle handloom to form a ‘Center Close Shed’ with tumbler lever reversing motion. The dobbie is designed with two horizontal levers to lift or lower each heald. The selection of levers in the required sequence is done by the ‘Solenoid Electronic System’ instead of treadle operation in different sequences or huge pegged lattice selection. The electronic system is operated by inputting the digital lifting plan prepared from any open-source Paint software. This dobbie can be used in the existing multi-heald handloom with a tumbler lever reversing motion by replacing the treadles. A diamond brick motif fabric sample is developed using the new dobbie to operate eight healds. The possibilities of weaving different brick motif samples by keeping the same draft but changing the heald lifting plans are explored. A foot pedal is used to operate the dobbie. Hence, the time required for sample development decreases from 25 % to 33 % compared to the multi-treadle operation. Using this dobbie, the designers could develop different all-over and brick motif fabrics by changing the lifting plan and setting the loom with a definite drafting order. Handloom, Textile, and Fashion Technology Institutes can use this dobbie in Weaving and Fabric Analysis Laboratories to weave and learn the different woven fabric structures effectively. It is also handy for textile research centers and weaving mills to develop innovative, diversified fabric samples for R&D activities and get the sample approvals fast before going for bulk production.

Keywords: Brick motif, Center close shed, Digital peg-plan, Electronic dobbie, Horizontal levers, Solenoids

1 Introduction

In the weaving industry, three different varieties of woven fabric structures are produced using simple weaves like plain, twill, sateen, honeycomb, huck-a-back, etc., and compound weaves like Bedford cord, extra warp, extra weft, terry pile, etc.¹. They are:

- All over single weave fabrics – These fabrics are woven using only one weave to produce a similar appearance throughout the fabric surface. Two to twelve healds control the ends in a definite order (draft) to weave this variety of fabrics. Figure 1(a) is an all-over single-weave fabric woven with honeycomb weave.
- Geometric-brick motif fabrics - These fabrics are produced by combining two opposite weaves derived

from one weave². Each weave alternately repeats for a group of ends and picks to produce simple figures in geometric-brick forms³. For weaving this variety, two to twelve healds control the ends in the group draft, and two to twelve treadles operate the healds to weave picks in the group. Figure 1(b) is a brick motif fabric woven by combining two colour effects of warp rib weave.

- Figured motif fabrics - These fabrics are woven by combining two or more weaves to produce distinct ground and figure parts of the curved motifs. For weaving the figured fabrics, a jacquard shedding device is used by operating the ends individually through harnesses to form the interlacement as per the figure to be formed⁴. Figure 1(c) is the figured floral motif fabric that combines warp face and weft face weaves.

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The following are the shedding devices^{5,6} used in the handloom to operate the healds or harnesses for producing the above three varieties of fabrics:

- **Multi-treadle:** The multi-treadle shedding set-up operates up to 12 healds carrying ends to weave all over single weave fabrics and brick motif fabrics. The loom is called the countermarch loom. With roller reversing motion or tumbler lever reversing motion, it forms the centre closed shed. In this set-up, the healds are operated by the treadles. As per the lifting plan of the weave, a tie-up connection is made between the healds and treadles. Weaver operates the multi-treadle in the required sequence with his two feet. Figure 2(a) shows a frame handloom set with the tumbler reversing motion to lift four healds.
- **Horizontal Lever Dobby:** The horizontal lever dobbie shedding device operates up to 48 harnesses, carrying extra warp ends with two healds carrying ground ends for weaving figured extra warp fabrics. Harnesses are lifted by the light wooden horizontal levers in the dobbie. The levers are selected directly through the pegged lattices. The pegging is done as per the figure graph prepared. Two treadles operated by the feet of
- the weaver lift the levers along with the healds. With the lingo reversing motion, it forms the open shed. A horizontal lever dobbie mounted on a handloom is shown in Figure 2(b).
- **Vertical Hook Dobby:** The vertical hook dobbie shedding operates up to 12 healds carrying ends to weave all over single weave fabrics and brick motif fabrics. Healds are lifted by the heavy iron vertical hooks in the dobbie. The hooks are selected directly through pegged lattices or needles and punched cards. The pegging or punching is done as per the lifting plan of the weave or brick motif to be produced. Hooks are lifted by a single treadle operated by the foot of the weaver. With Spring reversing motion, it forms the bottom close shed. The top of Figure 2(c) shows a vertical hook dobbie, and the bottom shows the pegged lattices used to select the hooks.
- **Mechanical Jacquard:** The vertical hook jacquard shedding device operates up to 600 harnesses carrying ends to weave all figured fabrics. In the jacquard, the light iron vertical hooks lift the harnesses. Punched cards select the hooks through needles. The cards are punched as per the figure graph prepared. Hooks are lifted by a single treadle

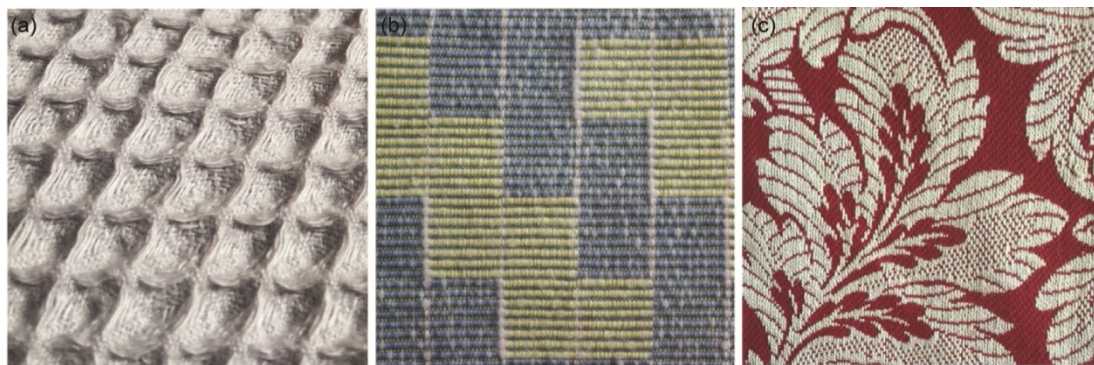


Fig. 1 — Varieties of woven fabric structures (a) all-over single-weave fabric with honeycomb weave, (b) brick motif fabric with dual colour warp rib weave, and (c) figured floral motif fabric combining warp face and weft face weaves

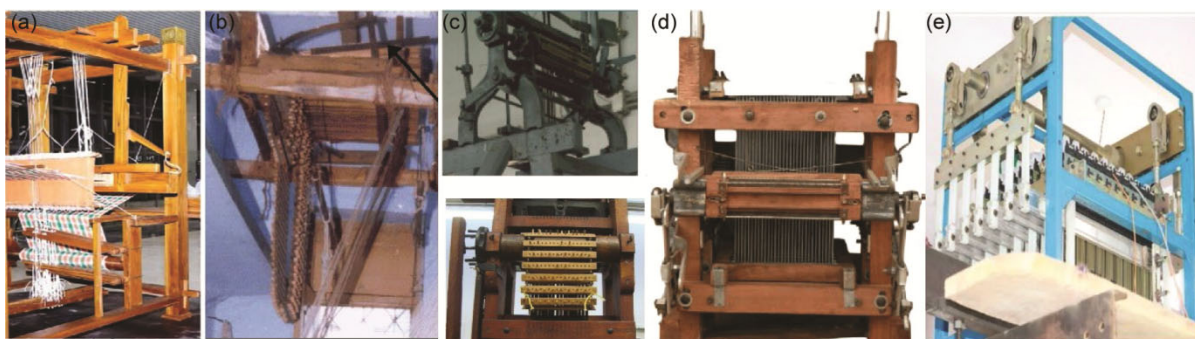


Fig. 2 — Traditional handloom shedding devices (a) frame handloom with tumbler reversing motion for four healds, (b) horizontal lever dobbie mounted on the handloom, (c) vertical hook dobbie (top) and associated pegged lattices (bottom), (d) mechanical jacquard with wooden frames, and (e) electronic jacquard

operated by the foot of the weaver. With a lingo-reversing motion, it forms the bottom close shed. A jacquard with wooden frames is shown in Figure 2(d).

- Electronic jacquard: During recent years, considerable research has been done on loom shedding mechanisms. Shedding systems have been suitably modified so that it has become possible now to weave fabrics with varied profiles to suit specific technical applications^{7,8}. Later, the intermittently operated ‘Electronic jacquard’ was introduced gradually to replace the above-mentioned mechanical jacquard⁹. The Electromagnetic (solenoids) principle is used instead of needles and cards to operate the hooks. The selection of solenoids is directly done by the digital figured graph design prepared in the computer¹⁰. Hence, preparing the figured graph manually and punching the cards from the graph are eliminated. In the handloom, the electronic jacquard is operated by changing the lifting mechanism to work intermittently through the ‘pedal switch’ operated by the foot of the weaver. The use of 480 and 960 hook capacity electronic jacquards is significantly increasing day by day in handlooms. A double-shaft cam shedding was also experimented with¹¹. Figure 2(e) shows an electronic jacquard used on the handloom.

Table 1 compares the shedding devices used by the designers to develop all-over and brick motif fabric varieties. The merits of each shedding device are highlighted in green, and the demerits of each shedding device are highlighted in red. The following observations are made concerning the shedding devices used for weaving the all-over and brick motif fabric varieties.

- Multi-treadle and mechanical vertical hook dobbie are the only two shedding devices available in handloom for operating multi-healds to produce all-over and brick motif fabrics using group drafting in healds and group sequence of treadling order.
- In multi-treadle shedding, the young weavers find it cumbersome to operate multi-treadles with proper sequence,
- In vertical hook dobbie shedding, a larger number of pegged lattices are required to weave brick motif fabrics, which makes this dobbie commercially non-viable.
- The centre close shed formed by the tumbler lever reversing motion in multi-treadle shedding is more advantageous than the bottom close shed formed by the spring reversing motion in vertical hook dobbie shedding.
- The digital heald lifting plan is more advantageous than the cumbersome operation of multi-treadles or the huge number of pegged lattices.
- The use of electronic jacquard for handlooms is significantly increasing to produce elaborately figured fabrics. Meanwhile, the use of electronic dobbie in handlooms is found to be insignificant.

With these observations, the research focused on designing and developing a new shedding device that can replace treadles in the existing multi-treadle handloom to form a ‘Center Close Shed’ with tumbler lever reversing motion. The dobbie is designed with two horizontal levers to lift or lower each heald. The horizontal levers are operated by the solenoids¹², micro controller¹³, and proximity sensors¹⁴. The electronic system is operated by

Table 1 — Merits and demerits of shedding devices for weaving all-over and brick motif fabrics

Shedding device	Multi treadle	Horizontal lever dobbie	Vertical hook dobbie	Mechanical hook jacquard	Electronic jacquard	New electronic dobbie
Carrying part of ends	Healds	Harnesses	Healds	Harnesses	Harnesses	Healds
Reversing motion used	Tumbler lever	Lingo	Spring	Lingo	Lingo / Spring	Tumbler lever
Shed formed	Center close	Open	Bottom close	Bottom close	Open	Center close
Lifting part of carrying part	Treadles	Horizontal levers	Vertical hooks	Vertical hooks	Vertical hooks	Horizontal levers
Selecting part of lifting part	Tie-up	Pegged lattices	Pegged lattices or Needles and Punched cards	Needles and Punched cards	Electromagnet-solenoid	Electromagnet-solenoids
Designing of selecting part	Lifting plan of the weave	Figured graph	Lifting plan of the weave	Figured graph	Digital figured graph in computer	Digital lifting plan in computer
Operating part	Multi treadles	Single treadle	Single treadle	Single treadle	Pedal switch	Pedal switch
Power imparted by	Foot of the weaver	Foot of the weaver	Foot of the weaver	Foot of the weaver	Foot of the weaver	Foot of the weaver
Fabric variety produced	All over and brick motif	Extra warp-figured motif	All over and brick motif	Figured motif	Figured motif	All over and brick motif

inputting the digital lifting plan prepared from any open-source Paint software¹⁵. Therefore, the new shedding device developed in the research for weaving all-over and brick motif fabrics is named as the ‘Center Close Shed – Horizontal Lever (CCS-HL) Electronic Dobby’.

2 Motif, Weave, Draft, Treadle Tie-up, and Lifting Plan of a Brick Motif

The top of Figure 3 shows one repeat, and four repeats of the diamond brick motif formed based on the 1 up 5 down twill motif (6 groups), in the extra weft

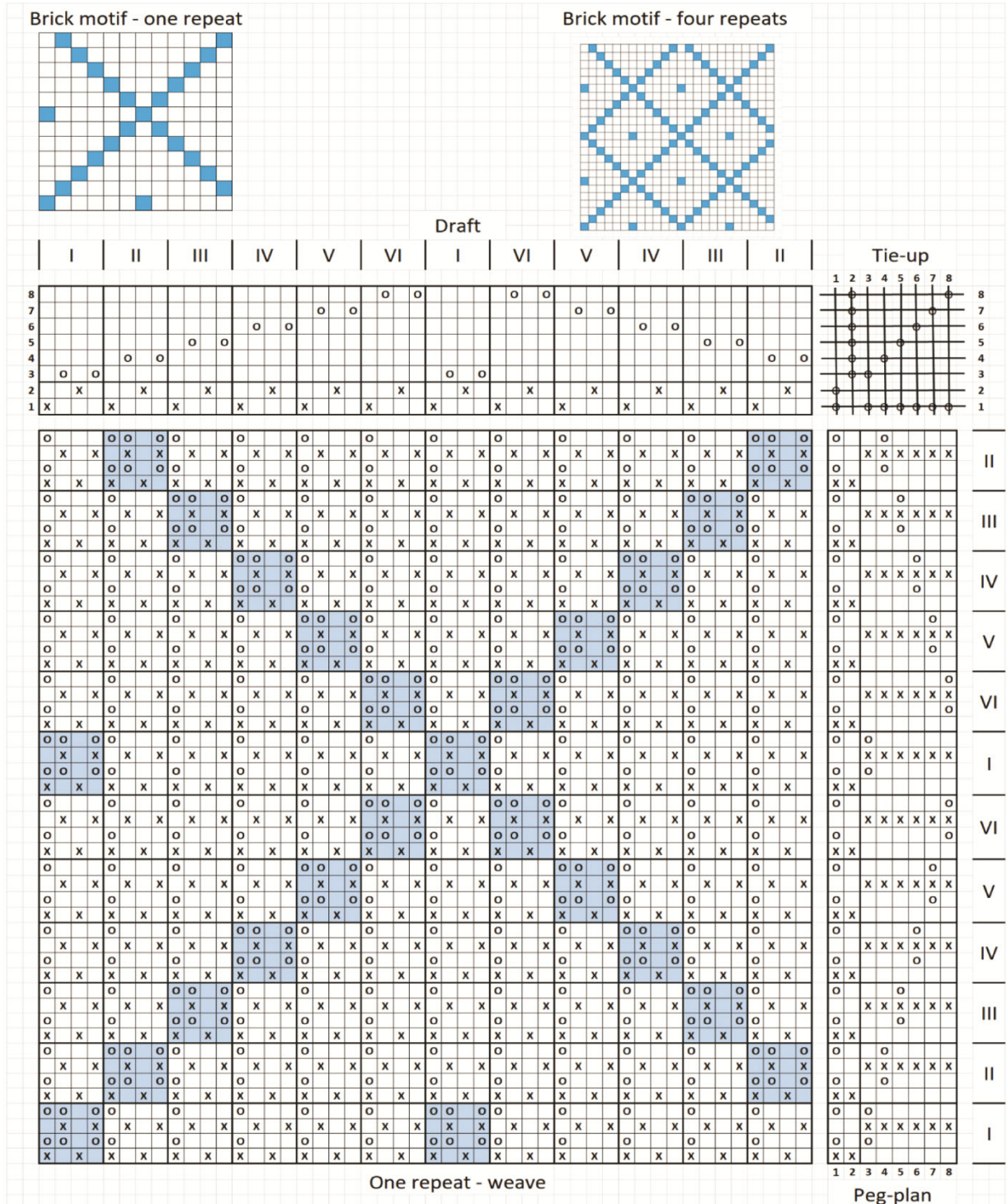


Fig. 3 — One and four repeats of the diamond brick motif woven using the extra weft principle; shown with weave structure, group draft plan, peg-plan, and tie-up

principle, taken as an example for weaving. On the face of the fabric, the Extra weft up forms the brick motif figure, and the extra weft down (plain fabric) forms the ground. However, while weaving, the extra weft down (plain fabric) forms the brick motif figure, and the extra weft up forms the ground. The consolidated weave of one repeat of the brick motif is shown along with the group draft plan, the heald lifting plan, and the tie-up of the weave are also given in Figure 3. Table 2 shows the fabric quality particulars. The table also shows the details of the draft plan for drafting 288 ends in eight healds and the treadling order of eight treadles used for weaving 288 picks if the fabric is woven using the multi-treadle loom. By going through the treadling order given in Table 2, it is understood how difficult it is to remember the treadling sequence and operate it in the given sequence and number of times. Figure 4 shows the monochrome bitmap digital peg-plan prepared in 8 ends (healds) x 288 picks using MS Paint. It is transferred to the design control unit of the new CCS-HL electronic dobby through a pen drive. The design is saved in the internal memory of the design control unit.

3 Different parts of the new dobby and their function

Figure 5 shows the left-side and front view of a frame handloom. Fig. 5(a) shows the newly developed CCS-HLE Dobby (1), along with the motor control unit (2) placed below the warp sheet. The warp sheet is drawn in eight healds (3) as per the draft order. The healds are serially assumed as numbers – H1 to H8. The bottom of heald is connected to the short lamms (4) placed below the warp sheet. The top of each heald is connected to the outer side of the tumbler

levers (5), and the inside of the tumbler levers is connected to the long lamms (6) placed below the short lamms. The healds and lamms are levelled to keep the warp sheet at the centre of the reed to form a centre close shed. Fig. 5(b) shows the foot pedal switch (7), which operates the motor control unit (2), which is placed below the weaver's seat to operate conveniently by the weaver's foot. The design control unit (8) with the electronic processor and internal memory, is placed on the right side of the weaver's seat. The power supply for the processor is from the AC-DC converter (9). From the processor, the electronic signals are transferred to the relay unit (10) with eight relay channels and optocouplers. Each channel relay controls a solenoid.

The diagram and the pictures in Figure 6 show the different parts of the newly designed CCS-HL electronic dobby. The frame of the dobby measures 22" in length, 18" in width, and 16" in height. The diagram in Figure 6(a) and the picture in Figure 6 (b) show the levers of the dobby designed and developed to operate eight healds. To operate 8 healds, there are sixteen levers (11) of 18" in length, kept horizontally in a line over ball bearings arranged in a shaft. The first two levers form one set, and sixteen levers total eight sets (assumed serially as numbers, I set to VIII set). Thus, the eight sets of sixteen levers are named in the order of Ia-Ib, IIa-IIb, IIIa-IIIb, IVa-IVb, Va-Vb, VIa-VIb, VIIa-VIIb, and VIIIa-VIIIb.

The diagram given in Figure 6(c) and the picture in Figure 6 (d) show a set of heald levers (Ia – Ib) and their related parts. In between this set of two heald levers, a vertical 'heald lever selector' (12) of 7" length is placed at the centre of the heald levers. On top, this

Table 2 — Specifications of diamond brick motif fabric and weaving details

Parameter	Drafting order – 8 healds 1, 2 – stitching; 3, 4, 5, 6, 7, 8 (6 healds) – design for 6 groups				Treadling order – 8 treadles 1, 2 – plain picks; 3, 4, 5, 6, 7, 8 (6 treadles) – EW design for 6 groups			
	Warp count = 2/20 ^S (blue)	I	1, 3, 2, 3	6 times	24 ends	1, 3, 2, 3	6 times	24 picks
Ground weft count = 10 ^S (blue)	II	1, 4, 2, 4	6 times	24 ends	1, 4, 2, 4	6 times	24 picks	
Extra weft count = 10 ^S (brown)	III	1, 5, 2, 5	6 times	24 ends	1, 5, 2, 5	6 times	24 picks	
Ends per inch in reed = 48	IV	1, 6, 2, 6	6 times	24 ends	1, 6, 2, 6	6 times	24 picks	
Ground picks per inch (GR) = 24	V	1, 7, 2, 7	6 times	24 ends	1, 7, 2, 7	6 times	24 picks	
Extra weft picks per inch (EW) = 24	VI	1, 8, 2, 8	6 times	24 ends	1, 8, 2, 8	6 times	24 picks	
Ratio of GR: EW picks = 1: 1	I	1, 3, 2, 3	6 times	24 ends	1, 3, 2, 3	6 times	24 picks	
Total ends per repeat (24 x 12) = 288, Width of repeat (288/48) = 6"	VI	1, 8, 2, 8	6 times	24 ends	1, 8, 2, 8	6 times	24 picks	
	V	1, 7, 2, 7	6 times	24 ends	1, 7, 2, 7	6 times	24 picks	
	IV	1, 6, 2, 6	6 times	24 ends	1, 6, 2, 6	6 times	24 picks	
Total picks per repeat (24 x 12) = 288, Length of repeat (288/48) = 6"	III	1, 5, 2, 5	6 times	24 ends	1, 5, 2, 5	6 times	24 picks	
	II	1, 4, 2, 4	6 times	24 ends	1, 4, 2, 4	6 times	24 picks	
Repeat size of the brick motif = 6" x 6"				288 ends			288 picks	

selector has a double nose, one on each side. Inside each set of heald levers, a small peg (13) is fixed facing each other. One peg is fixed inside the heald lever Ia, on the right side, facing the right nose of the selector, and another peg is fixed inside the heald lever Ib, on the left side, facing the left nose of the selector. When the dobby is inoperative, all the left-side noses of selectors rest over the left-side pegs fixed inside the heald lever Ib. Each selector lever, in its middle, is connected to a solenoid (14). The 230-volt electromagnet solenoid has a capacity of 0.5 kg and a 10 mm displacement. When the solenoid gets magnetised, the core is dragged backwards (right side) and the selector backwards. Hence, the selector's nose gets locked with the right-side peg fixed in the heald lever Ia. At its bottom, each selector lever is connected to a horizontal power lever (15). In dobby, there are eight sets of heald lifting levers, eight selectors, eight

solenoids, and eight power levers. All eight power levers are connected and made into one power lever assembly (16).

The diagram given in Figure 6(e) and the picture in Figure 6 (f) show the connection diagram between the motor and the power lever. The AC induction motor (17) of 0.25 hp runs at 1440 rpm. Through the pulley-belt drive (18) and sprocket chain drive (19), the motor drives the power shaft (20). The belt drive and chain drive are set together to reduce the 1440 rpm of the motor to 60 rpm on the power shaft. The power shaft rotates the cam (21). Through the cam follower (22), the cam rotation operates the power lever assembly (16) up and down and, in turn, all the selectors. Figure 6(f) shows three proximity sensors (23, 24, and 25) fixed over a shaft. Two metal pieces (26a and 26b) are fixed in the power shaft in line with the first sensor. One is fixed at 0 degrees and the other

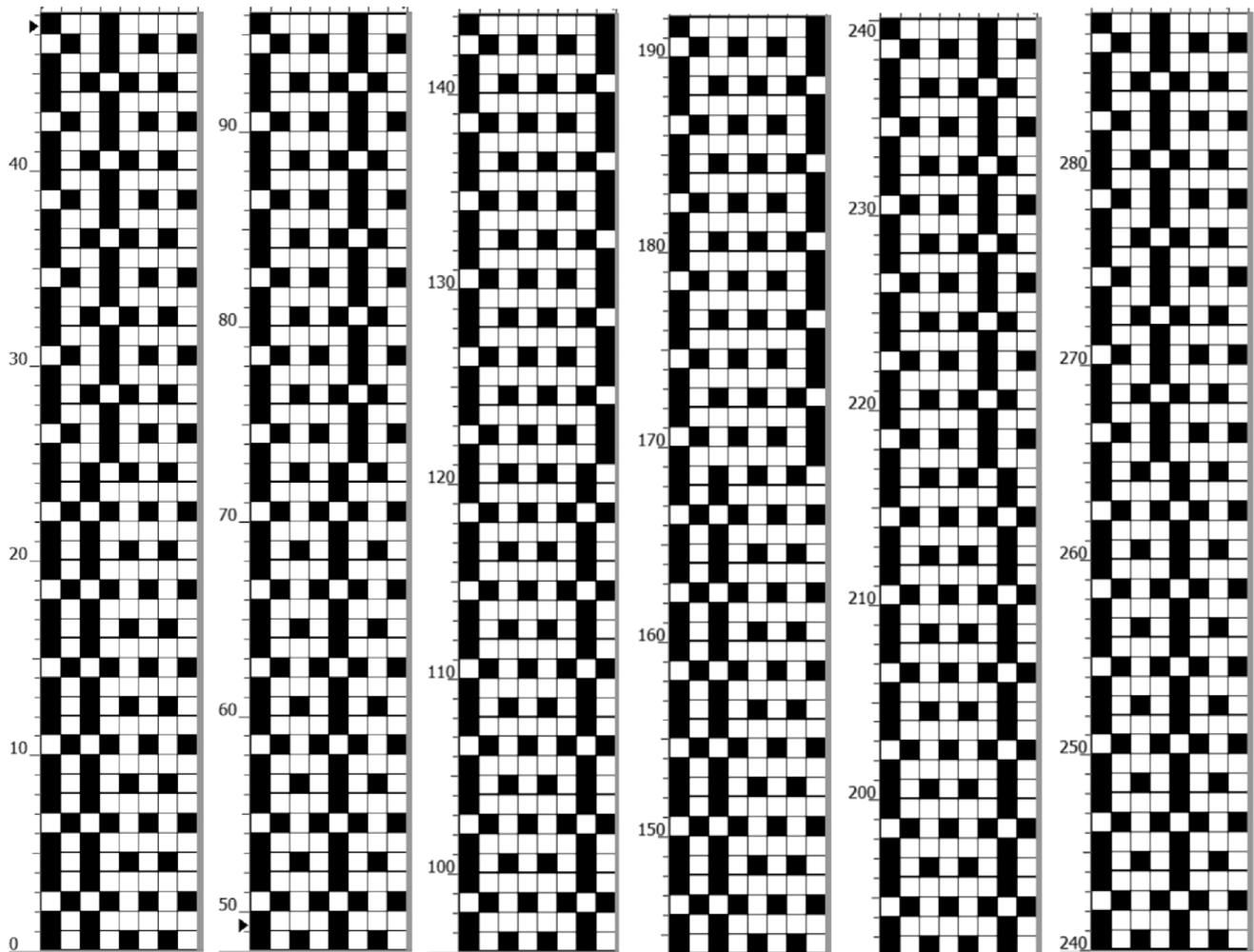


Fig. 4 — Monochrome bitmap digital peg-plan prepared in 8 ends (healds) x 288 picks using MS Paint for input to the CCS-HL electronic dobby's design control unit

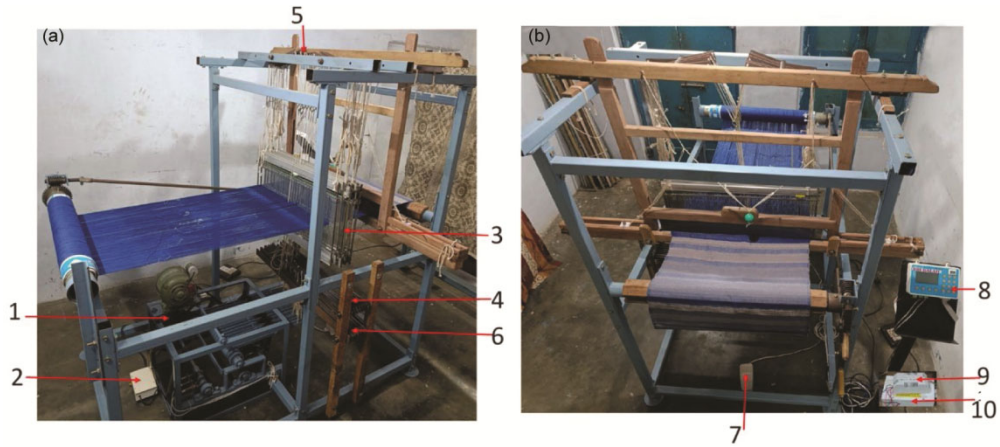


Fig. 5 — Frame handloom fitted with CCS-HL electronic dobby (1) CCS-H dobby, (2) motor control unit, (3) eight healds, (4) short lamms, (5) tumbler levers, (6) long lamms, (7) foot pedal switch, (8) design control unit, (9) AC-DC converter, and (10) relay unit

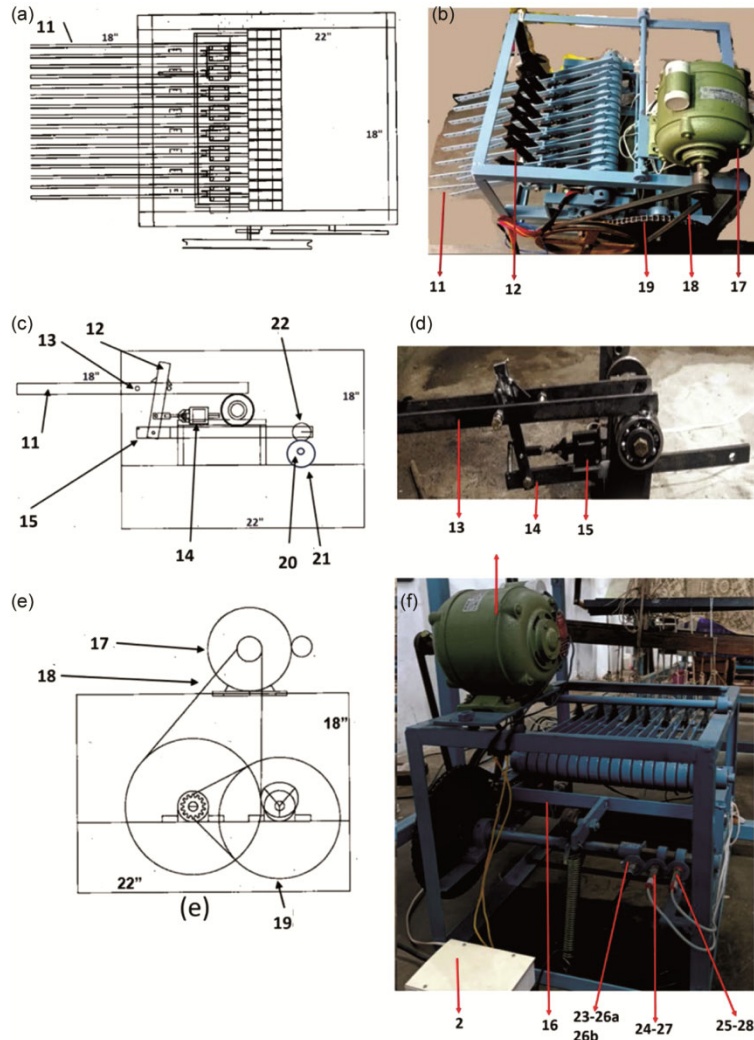


Fig. 6 — Parts of the CCS-HL electronic dobby (a, b) sixteen heald levers, (c-d) heald levers set and related parts, (e-f) motor-power lever connection diagram. Labels: Sixteen levers (11), (12) heald lever selector, (13) a small peg, (14) solenoid, (15) horizontal power lever, (16) power lever assembly, (17) AC induction motor, (18) pulley-belt drive, (19) sprocket chain drive, (20) power shaft, (21) cam, (22) cam follower, (23-25) three proximity sensors, (26a-26b) two metal pieces and (27-28) metal pieces

is 180 degrees. One more metal piece (27) is fixed in the power shaft at 0 degrees, in line with the second sensor (24), and one more metal piece (28) is fixed in the power shaft at 340 degrees, in line with the third sensor (25). The first proximity sensor with metal pieces (23-26a, 26b) controls the motor through the motor control unit. It gives the signal to run or to stop the motor at 0 degrees and 180 degrees of the power shaft's rotation. The second proximity sensor with the metal piece (24-27) controls the solenoid through the design control unit. It gives the signal to read the pixels in the next row of the design and activates the solenoids at 0 degrees of the power shaft's rotation. The third proximity sensor with the metal piece (25-28) also controls the solenoids through the design control unit. It signals to deactivate the solenoid through the design control unit at 340 degrees of the power shaft's rotation. Figure 6 (f) also shows the motor control unit (2) having a solid-state relay connected to the motor.

The diagram of the back-side view of the loom is given at the top of Figure 7. The line diagram on the top shows the connections between heald lever selectors, heald levers, and healds. There are sixteen levers to operate 8 healds (11). The first two levers together form one set, and sixteen levers total eight sets (assumed serially as numbers, from set I to set VIII). Thus, the eight sets of sixteen levers are named in the order of Ia-Ib, IIa-IIb, IIIa-IIIb, IVa-IVb, Va-Vb, VIa-VIb, VIIa-VIIb, and VIIIa-VIIIb. Each set of two levers operates one heald (3). The first heald lever of the first set (Ia) is connected to the top of the heald H1 (3) through the long lamm I (6) and tumbler lever I (5). When this heald lever Ia moves down, it lifts the heald H1 from the center to the top. Hence, it is named a 'heald lifting lever' (Ia). The second 'heald lever' of the first set (Ib) is connected to the bottom of the heald H1 (3), directly through the short lamm I (4). When this heald lever Ib moves down, it lowers the heald H1 from the centre to the bottom. Hence, it is named as 'heald lowering lever' (Ib). Similarly, out of sixteen heald levers, the odd levers (Ia, IIa, IIIa, IVa, Va, VIa, VIIa, and VIIIa) are connected serially to the long lamms I to VIII and thus become heald lifting levers of eight healds. Again, out of sixteen heald levers, the even levers (Ib, IIb, IIIb, IVb, Vb, VIb, VIIb, and VIIIb) are connected serially to the short lamms I and VIII and thus become heald lowering levers of eight healds.

The flow diagram at the bottom of Figure 7 shows the connections between different control units of the

new doobby. In the flow diagram, the yellow shaded boxes show the connections from the foot pedal switch to the power lever assembly of heald lever selectors. The green shaded boxes show the connections from the foot pedal switch to the electronic solenoid selection of heald lever selectors. i) The connections between the pedal switch and power lever assembly of heald lever selectors are: Pedal switch (7) - motor control box (2) - motor (17) - belt drive (18) - chain drive (19) - power shaft (20) - cam (21) - cam follower (22) - power lever assembly (16). Again, Power shaft (20) - proximity sensor (23-26a, 26b) - motor control unit (2). ii) The connections between the foot pedal switch and solenoid selection of heald lever selectors are: Pedal switch (7) - motor control box (2) - motor (17) - belt drive (18) - chain drive (19) - power shaft (20) - proximity sensors (24-27) and (25-28) - Design control unit/processor (8) - eight-channel relay unit (10) - eight solenoids (12). iii) The connections between solenoids/power levers and healds are: Solenoid /power lever (14, 15) - peg (13) heald lever selector (12) - heald lifting lever/heald lowering lever (11) - long lamm (6) / short lamm (4) and tumbler lever (5) - healds (3).

4 Working Principle of the New Dobby to Form Center Close Shed

First, the lifting plan of the brick motif design is prepared on the computer using graph designing software like MS Paint, as shown in Figure 4. The black colour pixel in the lifting plan indicates heald up, and the white colour pixel in the lifting plan indicates heald down. The lifting plan is prepared in monochrome bitmap form and transferred to the design control unit through a pen drive. The design is saved in the internal memory of the design control unit. The power of the motor control unit, AC-DC converter, and eight-channel relay unit is switched on. From the AC-DC converter, the design control unit gets the DC supply, and it reads the black and white pixels in the first row (first pick) of the design. For the first pick, we must lift the first four healds (H1, H2, H3, and H4) and lower the next four healds (H5, H6, H7, and H8). For this, the first row of the design is prepared to have the first four pixels (1, 2, 3, and 4) in black and the next four pixels (5, 6, 7, and 8) in white. The signals from the design control unit get transferred to the eight-channel relay unit. Thus, the relay unit sets the power supply to the solenoids S1, S2, S3, and S4 and magnetizes them. The cores of

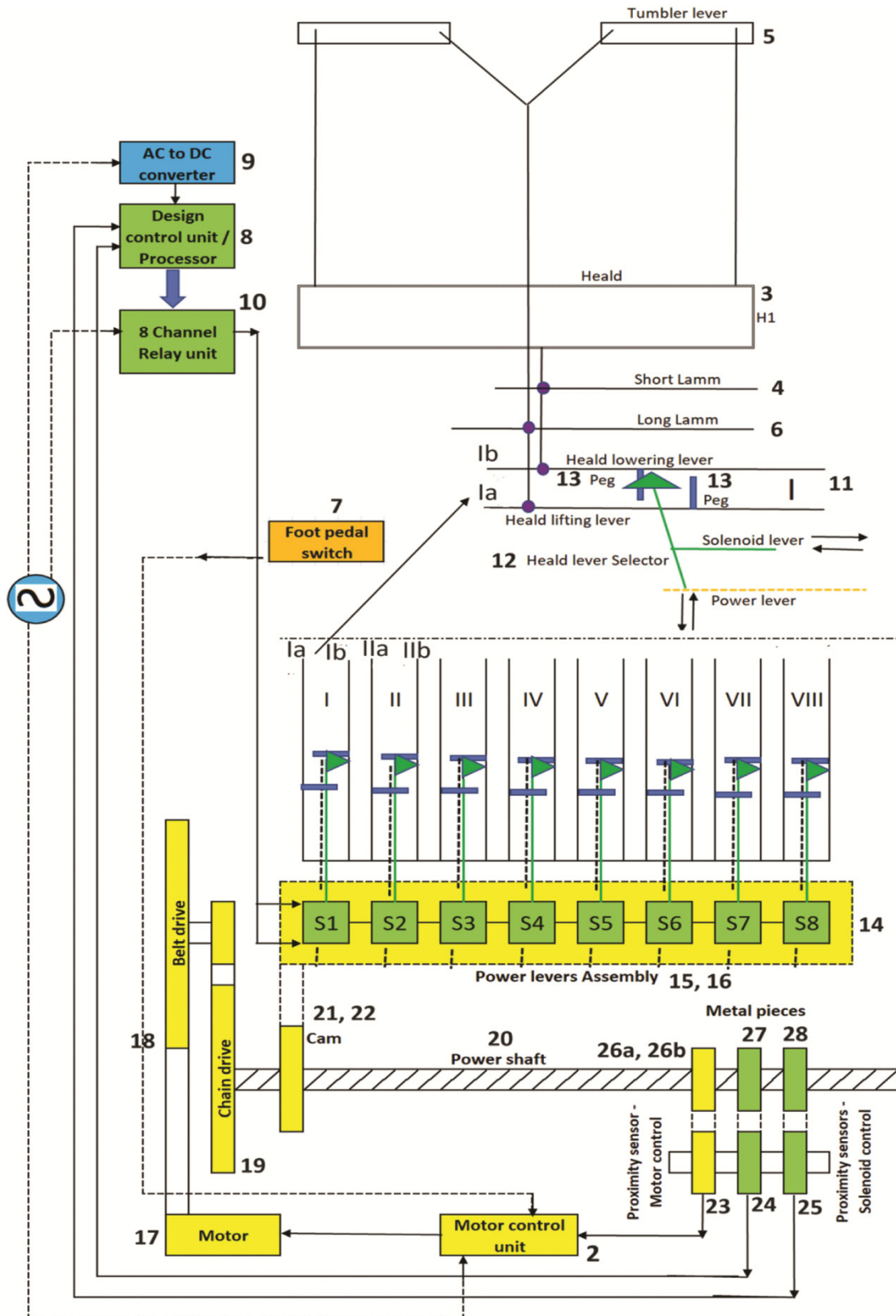


Fig. 7 — Top: Line diagram showing connections from lever selectors to healds. Bottom: Flow diagram showing interconnections among the dobby's control units

these solenoids move backwards (right side), and the noses of selectors I, II, III, and IV get locked with the right-side pegs fixed in the heald lifting levers Ia, IIa, IIIa, and IVa. At the same time, the solenoids S5, S6, S7, and S8 remain inoperative, leaving the noses of these selectors to remain locked with the left-side pegs fixed in the heald lowering levers Vb, VIb, VIIb, and VIIIb.

Now, the weaver taps the pedal switch down with his foot. By doing so, the power lever assembly moves down by the rotation of the cam (through the motor control unit, motor, pulley drive, chain drive, power shaft, and cam follower) and brings down all the selectors through the power levers. The selectors I, II, III, and IV bring down the heald lifting levers Ia, IIa, IIIa, and IVa (because they are locked) and thus lift the healds H1, H2, H3, and H4 from centre to top. At the same time, the selectors V, VI, VII, and VIII bring down the heald lowering levers Vb, VIb, VIIb, and VIIIb (because they are locked) and thereby bring down the healds H5, H6, H7, and H8 from center to bottom. Thus, the shed is opened from the center of the reed. When the power lever assembly moves to the maximum down position, the first set of proximity sensors sends the signal to the motor control unit and turns off the motor. By doing so, the power assembly remains at the bottom and keeps the shed open. Now, the pick is inserted in the shed and beat it to the fell of the cloth.

After completing the picking and beating, the weaver taps the pedal switch with his foot. By doing so, the power lever assembly moves up by the rotation of the cam and reversing spring (through the motor control

unit, motor, pulley drive, chain drive, power shaft, and cam follower) and brings up all the selectors and all the heald lifting levers to their original positions. Thereby, all the healds get levelled and bring the warp layers to the centre of the reed. At the same time, all the selectors, which were dragged backwards for the previous selection, move forward and get locked with the left side pegs due to the reversing spring action of the solenoid cores. Now, the second set of proximity sensors sends the signal to the design control box and changes the processors to read the black and white pixels in the second row (second pick) of the design. Magnetising of the solenoids, moving of the selectors, and locking of the heald levers take place according to the black and white pixels in the second row. The third set of position sensors decides the duration of activation time between each change in reading each row of the design. By the next tapping of the pedal switch, the power lever assembly moves down with the locked heald levers as per the second row of pixels. The second shed is formed by lifting and lowering the healds to insert the second pick. After picking and beating, by tapping the pedal switch again, the power lever assembly moves up. Thus, the weaving is continued by simply tapping the pedal switch with the foot and carrying the picking and beating with the hands.

4.1 Samples Development Using the New Dobby

Figure 8 shows the brick motif fabric sample developed using the new CCS-HL Electronic dobby as per the weave and draft shown in Figure 3 and Table 2, and the digital heald lifting plan shown in

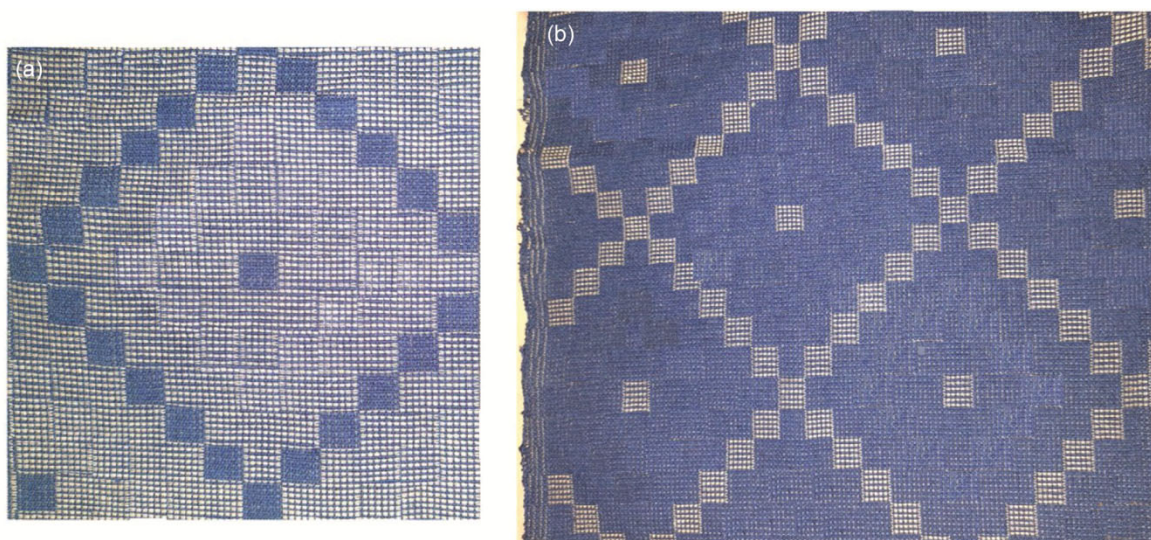


Fig. 8 — Fabric developed using the CCS-HL dobby: (a) single repeat corresponding to a motif in Fig. 3, and (b) fabric face showing multiple diamond brick repeats

Figure 4. Figure 8(a) shows one repeat of the fabric corresponding to the motif and weave shown in Figure 3. Figure 8(b) shows the face side of the fabric sample with multiple repeats forming the diamond.

Figures 9 (a) – (d) show the diamond brick motifs that can be woven using the same draft shown in Table 2,

but changing only the heald lifting plans. The diamond brick motif shown in Fig. 9 (a) is developed on the 2 up 4 twill base, and the diamond brick motif shown in Fig. 9 (b) is developed on the 3 up 3 twill base. The wavy twill across brick motif shown in Fig. 9 (c) is developed on the 2 up 4 twill base, and the wavy twill



Fig. 9 — Brick motif variations using the same draft (Table 2) but altered lifting plans: (a–d) diamond motifs, (e) oblong diamond motif, and (f) circular brick motif

across brick motif shown in Fig. 9 (d) is developed on the 3 up 3 twill base. Fig. 9 (e) shows the oblong diamond brick motif that can be woven using the same draft shown in Table 2, but in the lifting plan, the number of picks in each group is varied to obtain the oblong diamond. Figure 9(f) shows the circle brick motif that can be woven by combining the drafting plan, in which the number of ends in each group is varied, and the lifting plan, in which the number of picks in each group is also varied.

4.2 Merits of the CCS-HLE Dobby

The new Center Close Shed - Horizontal Lever Electronic Dobby has the following merits.

- The new dobbie can be used in the existing multi-head handloom with a tumbler lever reversing motion by replacing the treadles.
- The dobbie can be used to weave all-over single-weave fabrics of any weave and brick motif fabrics of any size.
- It produces a centre close shed. Hence, all the advantages of the centre close shed are derived, like high production, low power consumption, low wear and tear of loom parts, less time consumption, and equal tension on both the top and bottom warp lines.
- The lifting plan can be prepared on the computer using simple graph designing software like MS Paint and fed through the design control unit. The lifting plan of any number of picks (hundreds and thousands) can be used to weave brick motif fabrics, repeating in large sizes.
- A single pedal operates the dobbie. Hence, the speed increases from 25 % to 33 % compared to the multi-treadle operation. This, in turn, decreases the time required to develop a new sample.
- Suitable for weaving finer and coarser-weft intricate fabric varieties, which is the strength of handloom weaving.
- Handloom, Textile, and Fashion Technology Institutes can use this dobbie in Weaving and Fabric Analysis Laboratories to weave and learn the different fabric structures effectively.
- It is also handy for the Textile Research Centres and Weaving Mills to develop innovative, diversified fabric samples quickly for R&D activities and get the sample approvals within the given short time before going for bulk production.

5 Conclusion

This research has identified critical limitations in the currently available handloom shedding systems—

namely, the multi-treadle mechanism with tumbler levers and the mechanical vertical hook dobbie—for producing all-over and intricate brick motif fabrics. The operational complexity of coordinating multiple treadles and the requirement for a large number of pegged lattices in vertical hook dobbies have rendered both systems inefficient and impractical for intricate sample development. Hence, a new shedding device, ‘Center Close Shed – Horizontal Lever (CCS-HL) Electronic Dobby’, has been designed and developed. This dobbie replaces traditional treadles with electronically controlled horizontal levers operated by solenoids, forming a centre close shed compatible with the existing tumbler lever reversing motion. The electronic system is operated by inputting the digital lifting plan prepared from any open-source Paint software. A diamond brick motif fabric sample is developed using the new dobbie to operate eight healds. The possibilities of weaving different brick motif samples by keeping the same draft but changing the heald lifting plans are explored. The new dobbie has the merits of developing different all-over and brick motif fabrics by changing the lifting plan by setting the loom with a definite drafting order. Handloom, Textile, and Fashion Technology Institutes can use this dobbie in Weaving and Fabric Analysis Laboratories to weave and learn the different woven fabric structures effectively. It is also handy for textile research centres and weaving mills to develop innovative, diversified fabric samples quickly for R&D activities and get the sample approvals in a short time, before going for bulk production.

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