TECHNOLOGIES OF FORMING THE LOCKSTITCH TYPE 301 AND THEIR DEMERITS

The author of the article, Ph.D. Zarif Sharifovich Tadjibaev, Director of ZARIF Sewing Machine Co., Ltd. (www.zarif.uz), who in **1994** invented the world's first **ZARIF technology of forming the double thread chain stitch of the new type 401 using a rotary looper**, for which **US Patent No. 6095069** was issued in 2000.

Also, Ph.D. Zarif Sharifovich Tadjibaev in **2016 and 2019**, through the improvement of ZARIF double thread chain stitch technology from 1994, invented **new ZARIF double thread chain stitch technologies**, which are **the most advanced for sewing various materials and automation of sewing.**

The structure of lockstitch type 301.

As know the lockstitch type 301 consists of the top thread 1 (needle thread) and the bottom thread 2 (hook thread) (see Fig.1).

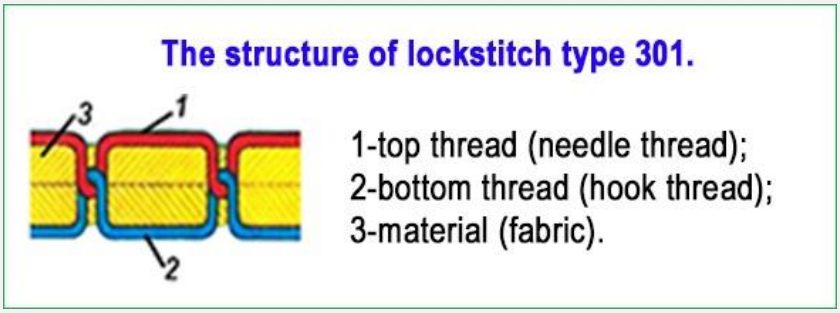

Fig.1.

To get the lockstitch type 301 structure for joining material 3, need to perform the following actions on the threads 1 and 2 (see Fig.1):

1. The loop from the top thread 1 is conducted through the material 3 (in all stitch forming technology this process is carried out using a needle).
2. One branch of the bottom thread 2 is passed through the loop of the top thread 1.
3. The loop of the top thread 1 is tightened to the middle of the material 3, taking one branch of the bottom thread 2 to the middle of the material 3.
4. Material 3 is feed to the stitch length and, all actions over the threads 1 and 2 are repeated.

The demerits of the above stages of action on the threads 1 and 2 (see Fig.1):

1. In the second stage, it is necessary to pass one branch of the bottom thread 2 through the loop of the top thread 1, this can be done only if the whole bobbin with the bottom thread 2 is passed through the loop of the top thread 1.

That is, it is technically impossible to pass one branch of the bottom thread 2 from the big spool with portions through the loop of the top thread 1, as is done with the top thread 1, it is required to pass the whole bobbin with the bottom thread 2 through the loop of the top thread 1.

2. For high-quality performance of the third stage, i.e. threads 1 and 2 interlacing in the middle of the material 3, to ensure a tight joining of various materials with different thicknesses, densities, stiffness's, to ensure the joining of light materials without wrinkles, to ensure the elasticity of the joining of elastic materials, based on the ability of the lockstitch type 301, more precise adjustments of the tension of threads 1 and 2 are required.

Advantages and demerits of lockstitch type 301.

Advantages of lockstitch type 301 (see Fig.1):

- The upper and lower sides of the stitch have the same appearance;

- The upper and lower sides of the stitch do not create a thickening on the surfaces of the material 3, since, on the surfaces of the material 3 lies one branch of the thread, therefore, the upper and lower sides of the stitch are more resistant to wear;
- The stitch does not unravel if the stitch threads 1 and 2 are interlacing in the middle of the material 3.
- Relatively low consumption of threads 1 and 2 per stitch.

Demerits of lockstitch type (see Fig.1):
- The stitch is relatively low elongation under the action of the load along the stitch, because of the small stock of threads in stitch.
- The stitch has a relatively low strength under the action of large loads and cyclically (often) operating small loads directed across the stitch, because one branch of the bottom thread 2 is passed through the loop of the top thread 1.

Technologies of forming the lockstitch type 301 and their demerits.

Currently, in order to pass a whole bobbin (spool) of the bottom (under) thread through the loop of the top (needle) thread, they use technologies forming the lockstitch type 301, invented in the 19th century, using various types hooks (shuttles), inside of which there is a small bobbin (spool) with the bottom (under) thread, which is located inside the fixed bobbin (spool) case, where the bottom (under) thread from the bobbin (spool) is supplied by a certain tension, where the hooks (shuttles) can make an oscillatory or rotary movements.

A rotary hook, in which the hook rotates in a full circle around a stationary bobbin (spool) case. In this system, the shuttle hook catches the top (needle) thread when the needle is going back up through the fabric and the hook then carries the top (needle) thread around the bobbin (spool) case to form the stitch, going all the way around the bobbin (spool) case.

Rotary hook sewing machines have tight thread tolerances. In other words, they work well with threads of specific, recommended sizes but can be unforgiving outside of their range.

A sewing machine with a rotary hook runs smoother at higher speeds (no vibrating), is quieter and has less frequent thread jams than machines with oscillating hooks.

Oscillating hook sewing machines have a hook that, instead of rotating in a full circle, oscillates back and forth. In this system, the hook picks up the top thread from the needle and carries it down around the bottom of the bobbin (spool) case. Once it has done this, the hook reverses its direction and returns to its original location.

Oscillating hook sewing machines have simpler mechanics, than rotary hook machines. Since oscillating hook machines have looser tolerances than the precise rotary hooks, oscillating hook machines can sew heavier threads in smaller machines. The drawbacks to oscillating hook machines are that they are louder and are generally not as fast.

Thus, in formation the lockstitch type 301, with rotary and oscillating hooks (shuttles), a whole bobbin is passed through the loop of the top thread, is getting the loop of the top thread to go round the bobbin (spool) case.

Lockstitch technologies of type 301 for rotary hooks with horizontal axis (see Fig.2):
- The needle is inserted into the material (see Fig.2, a).
- As the needle moves upward from its lowest position, the needle thread forms a loop which is caught by the point of the hook (see Fig.2, b).
- The hook enlarges the needle thread loop (see Fig.2, c).
- The needle thread loop is guided around the bottom thread spool (see Fig.2, d).
- Interlacing begins (see Fig.2, e).
- The take-up lever tightens the stitch into the material. The material is feed forward by the length of the stitch until the next needle puncture material (see Fig.2, f).

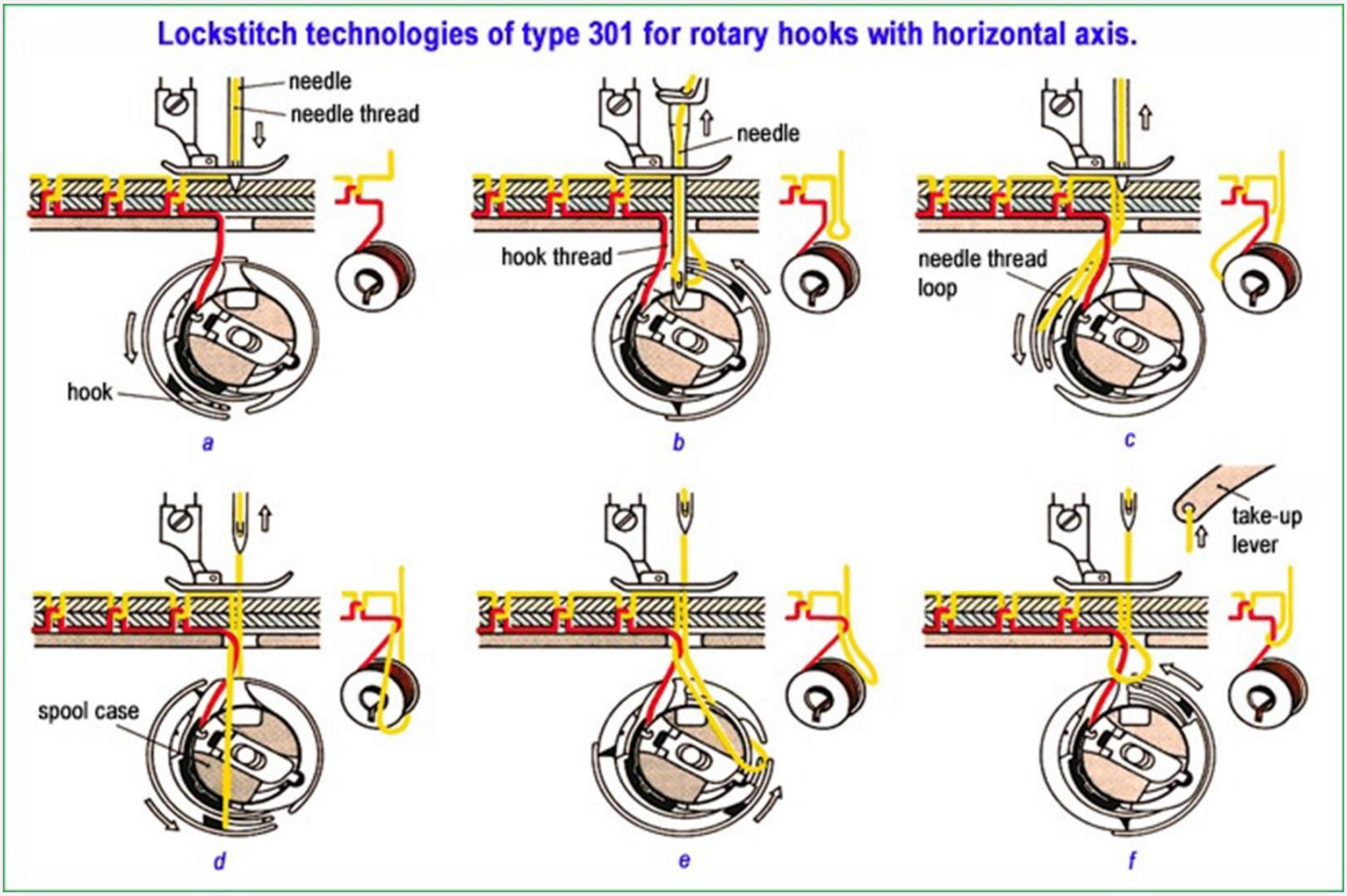

Fig.2.

For various lockstitch technologies, different types of hooks (shuttles) are used with and without the bobbin case opener (see Fig.3).

Fig.3.

The regular cleaning of the lockstitch sewing machines prolongs the service life of the components, improves the sewing performances, reduces the lockstitch sewing machine downtime and reduces the maintenance costs. It is therefore a good rule, at least at the end of every working shift, to remove the bobbin case and to clean (e.g. with compressed air) the hook and the surrounding area and to clean delicately the bobbin case underneath the tension spring (e.g. by blowing air).

If in the course of sewing the thread gets caught in the raceway of rotary hook, then the hook becomes wedged, then have to remove or dismantle the hook.

Needle is attached to the top of needle bar and is one of the most important parts to sew materials.
If needle is not good, it will be the cause of various troubles such as thread breakage, material breakage, puckering (wrinkle by sewing), etc.

If there is any problem related to the sewing, it is general to check whether threading is proper, then to check whether needle is defective.

Hook point, when passing the needle, should be set so that there is a clearance between them of **0.05-0.10 mm.**

Any interference with the formation of the needle thread loop will result in faulty stitch formation. One of the most common conditions is that the material stitched is not held firmly by the presser foot at the point where the needle passes through, allowing the material to flag, or move up with the needle as it rises. Either no loop is formed at all, or the loop is formed too late. This will result in skipped or broken stitches. You should always refer to the needle, fabric and thread chart to make sure the right size needle is being used.

All types of hooks (shuttles) have needle guide of hook.
Needle guide is attached to hook excluding exception. Needle guide is the most important part to protect blade point of hook and keep hook from damage, and also plays a role of protecting needle breakage.

The momentum of needle bar is not one kind since the sewing machine sews cloths of various thicknesses. There are three kinds (for heavy-weight, medium-weight and light-weight materials) of momentum for needle lockstitch machine. When the needle bar stroke is large, there are such merits as penetrating force is improved, distance from throat plate to upper dead point of needle tip becomes larger and thick material is easily entered, etc. Demerits are inertia force is increased and vibration or noise is likely to occur, mechanical load is increased and it is not fit to high speed, needle heat rises, etc.

Lubrication systems for high-speed rotary hooks with horizontal and vertical axis (see Fig.4).

For high speed types hooks, there are two kinds of lubricating systems, one is semi-automatic lubricating system, which has a structure sucking up some of oil applied to the lower shaft metal, and another is full-automatic lubricating system, which is designed to lubricate automatically through a central hole of the hook shaft. As to the full-automatic lubricating system, there are two types for the path of lubricant-closed type and open type. A vertical axis hook is designed to suck up oil from an oil tank of sewing machine through the shaft.

To judge lubricating condition into automatic lubricating type hooks, put test paper below hook while idling and check oil flow into the hook by oil mark on the paper.

The oil marks on the testing papers show the state of lubrication in a rotating hook. Adequate lubrication is 1 Omg/min at minimum and 20-30mg/min generally, though it depends on the speed of the sewing machine.

When thick thread or hard-to-slide thread is used, thread tightness is improved when increasing the amount of lubrication to such an extent that oil is not attached to the sewing products.

When thin thread or especially, synthetic thread is used, it is better to decrease amount of lubrication to such an extent that hook is not seized. However, seizure of race surface occurs if amount of oil is excessively decreased. As a result, motion of inner hook is deteriorated, and hook noise or hook temperature is increased. Also, dirt of needle thread (thread gets dark) may occur.

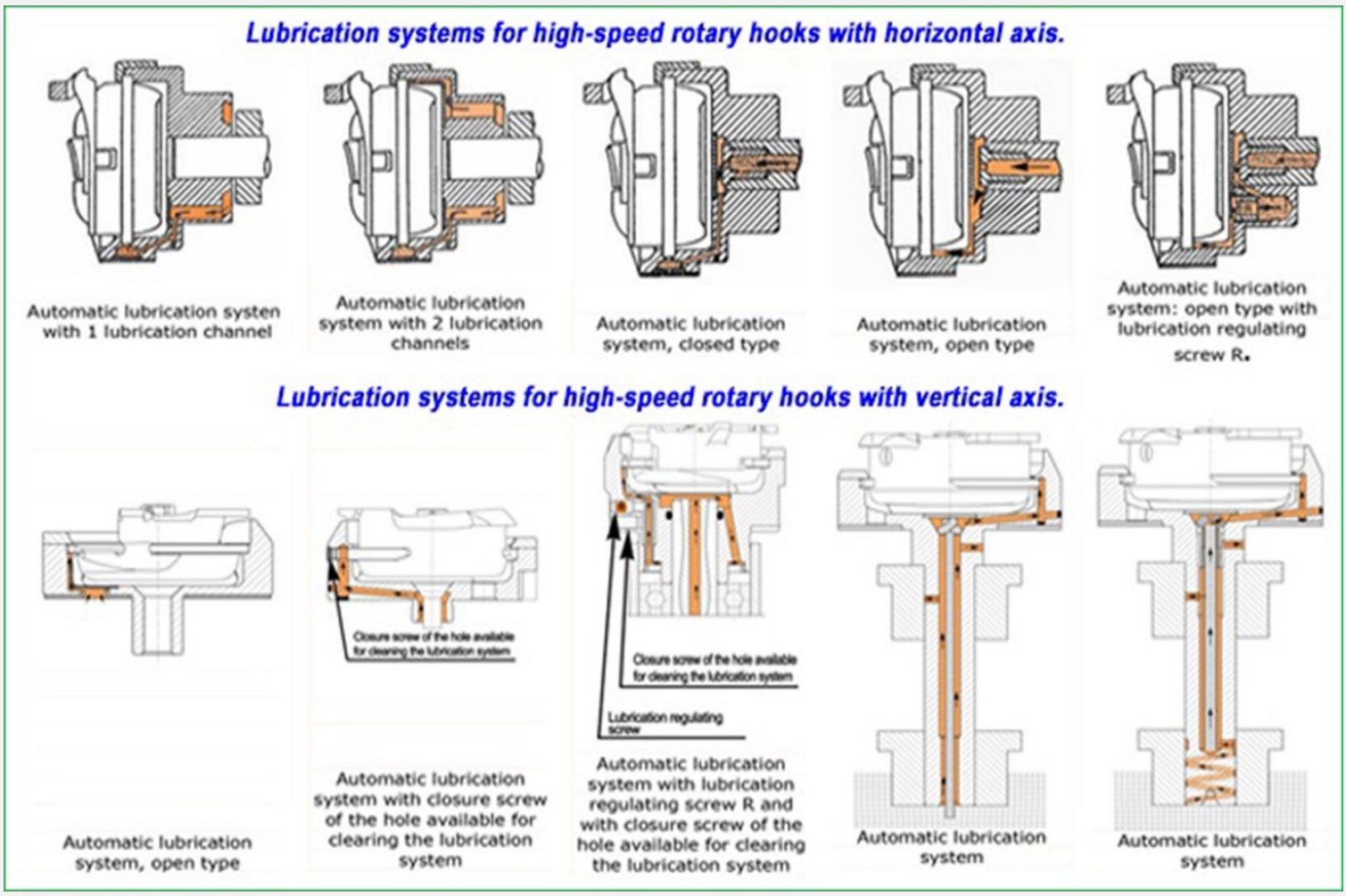

Fig.4.

Temperature of hook which rotates at high speed rises, however, the extent of rise of temperature varies in accordance with number of revolutions, continuous rotating time and amount of lubrication.
Rise of hook temperature should not be worried except for abnormal cases. However, it should be careful about the lubricating condition.

There are also oil-free hooks (plastic coated race way), but their use limits the sewing speed to **4,000 stitches/min**.

The advantages of oil-free hooks:

- Keeps sewing material & thread being no stain from oil.
- Smooth & noise-less running.
- Steel bobbin case base protect damage from needle hitting.
- Effective for thin material (lingeriess etc.).

Function of thread take-up lever:

1. Provides needle with top thread.
2. Supplies necessary amount of thread so that hook can scoop upper thread and so that the top thread can pass through inner hook.
3. Lifts top thread quickly when top thread passes through inner hook.
4. Feeds out top thread to be consumed for stitches together with feed dog.
5. Performs thread-tightening and wind the next portion of the upper thread from the coil.

Types of thread take-up levers used in lockstitch sewing machines (see Fig.5).

1. Cam type thread take-up lever.
Thread take-up lever moves up and down by means of cam fixed on main shaft. Thread tightening is very finely performed, and this type is largely used for leather and heavy-weight materials. This is used for the old home-use sewing machines. In addition, this is not suitable for high-speed.

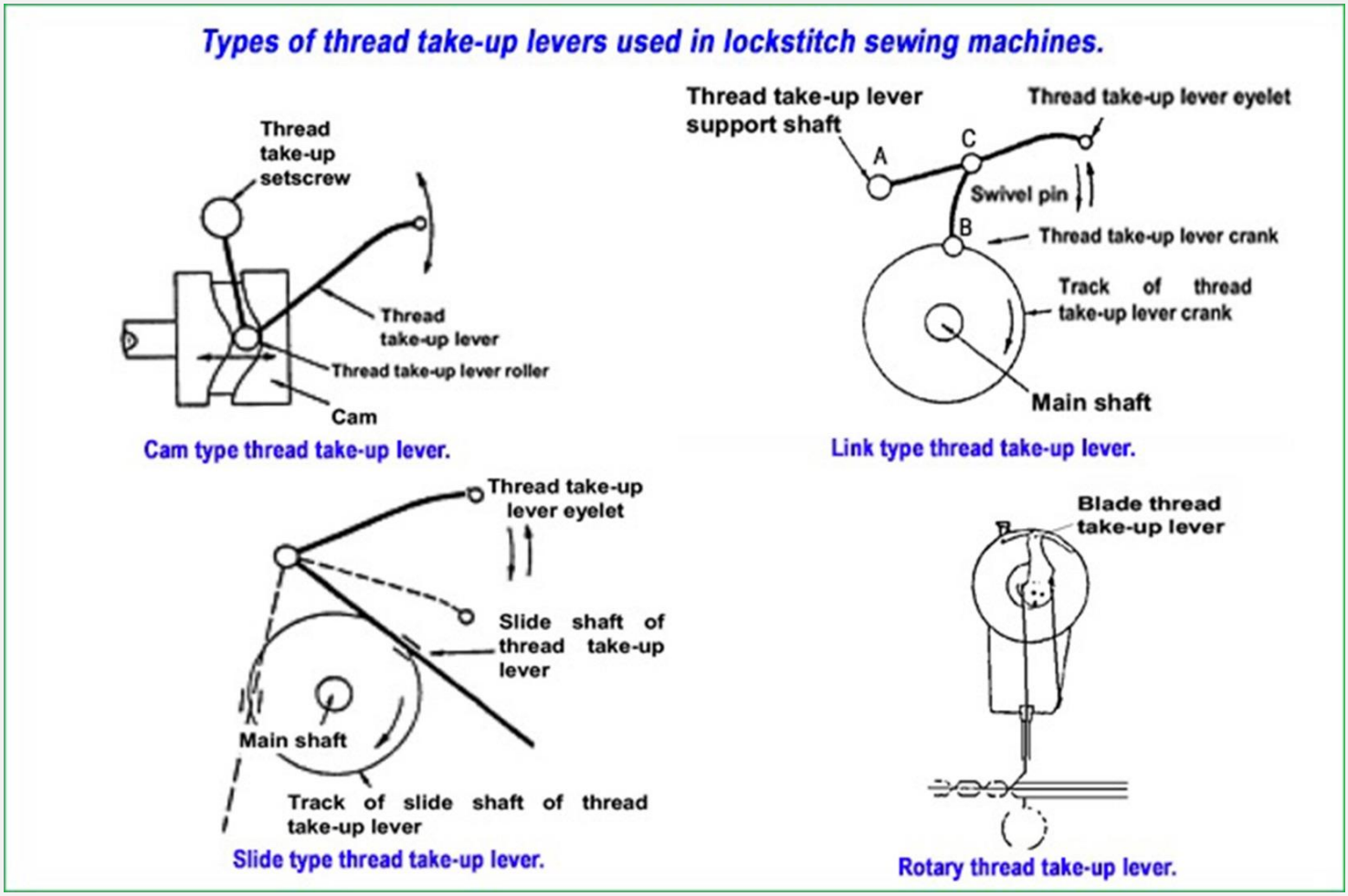

Fig.5.

2. Link type thread take-up lever.
Thread take-up lever crank is rotated by means of rotary motion of main shaft and thread take-up lever moves up and down the connecting rod curve. This type is used the most for general lockstitch sewing machines.

3. Slide type thread take-up lever.
Slide shaft of thread take-up lever is rotated by means of rotary motion of main shaft and thread take-up lever moves up and down. This makes good thread tightening and is used with vertical hook for heavy-weight materials. However, this is not suitable for high-speed. (Approx. up to **3,500 spm**).

4. Rotary thread take-up lever.
Blade-like thread take-up lever is rotated by means of rotation of counter weight mounted to main shaft and loosening and lifting of upper thread can be performed. This makes good-looking stitch tightness and is used largely for zigzag stitching (foundation).

Thus, different types of thread take-up levers are used to form the lockstitch and, all of them tighten the top (needle) thread unevenly, i.e. not smooth.

In lockstitch technologies, it is impossible to smoothly tighten the top (needle) thread, since the time for tightening the loop of the top (needle) thread is small, and the size of the loop of the top (needle) thread is large enough.

The reduction of the mechanical strength of the top (needle) thread after sewing in the technologies of forming the lockstitch.

Since, in all technologies of forming the shuttle stitch, with the help of a rotary or oscillating hook (shuttle), the loop of the top (needle) thread will be circled around the fixed bobbin case, inside which the bobbin with the bottom thread is located, the hook (shuttle) consumes a rather large length of the top (needle) thread, to form the lockstitch.

As mentioned above, the thread consumption for forming the lockstitch type 301 is the smallest, while the consumption of the top and bottom threads per stitch is equal if the threads are interlacing in the middle of the material being sewn.

Threads consumption per stitch depends on the stitch length, on the thickness of the material being sewn and on the degree of tightening of the stitch threads.

Since, the hook (shuttle) consumed a sufficiently large length of the top (needle) thread, i.e. a sufficiently large length of the top thread was passed through the material downwards, only a small length of the top thread, after the stitch was formed, will be on the stitch, the lagging majority of the top thread returns above the material with the help of a thread take-up lever.

As a result, any place of the top thread, before being on the stitch, will be many times passed down and up through the hook, material, eye of the needle, thread guides, and eye of the take-up lever.

The number of repeated movements of the top thread up and down increase with a decrease in the thickness of the sewn materials and stitch length, as the consumption of the top thread on the stitch is reduced, in addition, with an increase in the size of the bobbin of the bottom thread, which will increase the size of the loop of the top thread.

The greater the number of repeated movements of the top thread, as well as the sewing speed, the greater the wear rate of the top thread during the sewing process and, accordingly, the top thread more lose their mechanical strength after sewing.

Therefore, sewing machines with large hooks (shuttles), compared to sewing machines with standard hooks (shuttles), cannot sew at high speeds due to the large number of repeated movements of the top thread.

Thus, the currently used technologies of forming the lockstitch type 301, which were invented in the 19th century, are not perfect technologies for sewing various materials and automation of sewing, because:

1. Frequent changer of the bobbin of the hook (shuttle), does not allow long stitching without stopping in automated sewing systems.

The use of various automatic devices bobbin changer in automated sewing systems, complicates their design and increases their cost (see **Patents:** EP0953665A2, EP2369047A2, CN104264386A, CN105755693A, CN106222901A, CN107541868A, CN108221203A, CN108642739A, CN108691104A, CN203683887U, CN204000237U, CN204959271U, CN206916410U, EP1751339B1, JP6148699B2, JP2004275781A, JP2007117703A, US5769343, US6994040, US7614354).

2. Sewing of various materials, can be realized:

- With the help of one sewing machine, where the needle bar stroke is regulated, by changing the needle bar stroke, followed by setting the needle and the hook (Example**: PFAFF 2081**-High flexibility due to the adjustable needle bar stroke **30** to **36 mm**, one machine for all material thicknesses).
- With the help of several sewing machines, with different needle bar strokes, with a small needle bar stroke for sewing light materials, and a large needle bar stroke for sewing heavy materials (Example: **JUKI DDL-5550A** (**29 mm**), **JUKI DDL-5550** (**30.5 mm**), **JUKI DDL-5550H** (**35 mm**), «**A**» type for light-weight materials, «**H**» type for heavy-weight materials).

3. For high-quality sewing various materials, it is necessary to adjust the tension of the threads so that the top and bottom threads of the lockstitch type 301 are interwoven in the middle of the stitched materials, and the stitch provides a tight join of medium and heavy materials, smooth stitching on light and ultra-light materials.

4. It is very difficult to implement automatic adjustment of threads tension in automated sewing systems, not only when changing the thickness, but also the density and stiffness of the sewn materials, using devices for electronic regulation of the tension of the top (needle) thread (needle-thread active tension) and the tension of the bottom thread the hook (shuttle) bobbin (see Patents: JP5059389B2, JP2008119078A, CN101798730A).

5. For sewing various materials, i.e. from heavy materials to ultra-light materials, needles from **No. 130** to **No. 60** are usually used, when switching to various materials, besides the correct installation of the needle into the needle bar, the hook with respect to the needle must also be adjusted, due to the maximum allowable clearance between the point of the hook and needle equal to **0.15 mm**.

6. For sewing materials from different thicknesses with sewing threads having different thicknesses, various rotary or oscillating hooks (shuttles) are used, differing in designs and sizes.

7. When sewing various materials, in order to increase the reliability of caught the point of the hook the loop-overlap of the top thread formed by the needle, while lifting of the needle from the lowest position, it is necessary to adjust the lifting height of the needle from the lowest position depending on the thickness of the materials.

8. For sewing materials from different thicknesses, different types of thread take-up levers are used, which tighten the top (needle) thread unevenly, it is impossible to develop for the technology of forming a lockstitch type 301 of one type of thread take-up lever for sewing materials from different thicknesses, which provides a smooth tightening of the top (needle) thread.

9. Sewing various materials, sewing a combination of different materials, especially when sewing through thicker seams, stitch skipping may occur, i.e. technologies of forming the lockstitch type 301 cannot guarantee sewing without skipping a stitch.

10. When sewing various materials, especially when sewing at high speeds can occur in breaks in the threads, i.e. technology, the formation of a lockstitch type 301 is not able to guarantee sewing without breakage of threads, which will lead to a sudden interruption of the sewing process automatic mode in automatic sewing systems.

11. A slight deflection of the needle, when passing the needle through thick, rigid, dense materials can cause the needle to collide with the needle plate or with the hook (shuttle), which may result in needle breakage or deformation of the needle tip, which will lead to a sudden interruption of the sewing process automatic mode in automatic sewing systems.

12. It is necessary to constantly clean the hook (shuttle) from dirt released from the stitched materials, from sewing threads, and if the sewing thread gets into the raceway, the hook may become jammed, which will lead to a sudden interruption of the sewing process automatic mode in automatic sewing systems.