**T.C.**
**BALIKESİR ÜNİVERSİTESİ**
**FEN BİLİMLERİ ENSTİTÜSÜ**
**MAKİNE MÜHENDİSLİĞİ ANABİLİM DALI**

# HELEZON ELEVATÖRLERİN HELİSEL YAPRAKLARININ SOĞUK ÇEKME İLE İMALATI VE ANALİZİ

**YÜKSEK LİSANS TEZİ**

**Mak.Müh. Kubilay TURAN**

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**Tez Danışmanı : Yard.Doç.Dr.Semin KAYA**

**Sınav Tarihi: 16/07/2010**

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**Yard.Doç.Dr.Ziya AKSOY (BAÜ)**

**Balıkesir, Temmuz-2010**

# ÖZET


**HELEZON ELEVATÖRLERİN HELİSEL YAPRAKLARININ SOĞUK ÇEKME İLE İMALATI VE ANALİZİ**



**Kubilay TURAN**

**Balıkesir Üniversitesi, Fen Bilimleri Enstitüsü**
**Makine Mühendisliği Anabilim Dalı**



**(Yüksek Lisans Tezi / Tez Danışmanı: Yrd. Doç.Dr.Semin KAYA)**

**Balıkesir, 2010**

Bu çalışmada tahıl transportasyonu, silolara malzeme yüklenmesi gibi birçok zirai ve ticari kullanım alanına sahip olan helezonların üretimini gerçekleştiren makinelerin ilk örnekleri, çalışma prensipleri ve bu makinelerde soğuk çekme yöntemi ile çelik bir saçın helisoide dönüştürülmesi esnasında, çelik sacda oluşan deformasyonu incelemek için yapılan analiz konu alınmıştır. Bu incelemeler yapılırken "Sonlu Elemanlar Yöntemi"ni esas alan bir saç şekillendirme analiz ve mühendislik programından faydalanılmıştır.

Analiz sonuçlarının daha gerçekçi olabilmesi açısından sonlu elemanlar ağ yapısının daha sık modellenmesi, daha farklı ve detaylı bir mühendislik programı kullanılması önemlidir. Ancak bu parametreler analiz süresini oldukça uzatacaktır.

Sonuç olarak önerilir ki; Eklerde verilen patentlerde mucitlerin, makinelerin çalışma prensipleri hakkındaki savları ile bu çalışmada belirlediğimiz parametrelerin ve boyutların dikkate alınması ile yapılacak analizler makinenin tasarımı bakımından faydalı olacaktır.



**ANAHTAR KELİMELER:** helezon / konveyör / sonlu elemanlar yöntemi / elevatör / soğuk çekme

# ABSTRACT


**THE PRODUCING SPIRAL ELEVATORS' HELICOID FLIGHTS BY COLD FORMİNG AND ANALYSIS OF THİS PROCESS**



**Kubilay TURAN**

**Balıkesir University, Institute of Science**
**Department of Mechanical Engineering**

**(M. Sc. Thesis / Supervisor: Assist. Prof. Dr. Semin KAYA)**

**Balıkesir, 2010**



In this study, the analysis of the stress distrubution in the steel plate that being created during the cold forming process of the screw conveyors which have many cases of useage like loading the materials to the scilos,transporting the bulk materials..etc.; early models of this machines and their working fundamentals are being examined. This review is being done by an analysis and advanced engineering applications program that's benefiting from "Finite Element Method".

Modeling more fine mesh, using different and beter engineering programmes are important to have more realistic analysis results. but these parameters make the analysis process longer.

Finally it's suggested that; it will be useful for conception of the machine, to take into consideration the thesis of the inventors' in the patents that is given at the end of this study, and the parameters and dimensions that we decided for this study.



**KEYWORDS :** helicoid / conveyor / finite element method / elevator / cold forming

**İÇİNDEKİLER**

# SEMBOL LİSTESİ

| **Simge** | **Simge Adı** | **Birimi** |
|---|---|---|
| u | Ek sistemin fonksiyonu | |
| r | Konum vektörü. | |
| D(r )v | Sistemin konuma bağlı katsayıları | |
| B(r )v | Sistemin konuma bağlı katsayıları | |
| q(r )r | Sistemin konuma bağlı kaynak terimi. | |
| u(r )r | Sistemin hesaplanacak olan fonksiyonu. | |
| $\hat{n}$ | Sistemden dışarı doğru ve sınır yüzeyine dik birim vektör | |
| $S_b$ | Sistemin, geri yansımanın olmadığı(boşluk) bölge ile sınır yüzeyi | |
| $S_y$ | Sistemin simetri yüzeyi (yansımanın olduğu yüzey) | |
| a | Sabit bir katsayı. | |
| $c_i$ | Ritz katsayıları (bilinmeyen parametre) | |
| $u_{yak}(r)$ | $u(r\,)^r$ fonksiyonuna getirilen yaklaşım temsili | |
| Si(r) | Şekil fonksiyonları | |
| K | Dağınık(sparse) yapıda simetrik bir matris | |
| L | Lineer diferansiyel operator | |
| W | Ağırlık foksiyonu | |
| $q_{yak}$ | Ek sistemin kaynak fonksiyonu yaklaşımı | |
| B | Ana Hadde genişliği | mm |
| A | Ana Hadde Alt genişliği | mm |
| r | Ana Hadde Yuvarlatma Yarıçapı | mm |
| θ | Hadde Eğim Açısı | drg[º] |
| H | Ana Haddeler Arası Mesafe | mm |
| R | Ana Hadde Yarıçapı | mm |
| W | Yanal Hadde Genişliği | mm |
| a | Yanal Hadde Alt Genişliği | mm |
| $r_{1,2}$ | Yanal Hadde Yuvarlatma Yarıçapları | mm |
| R | Yanal Hadde Yarıçapı | mm |

## ŞEKİLLER LİSTESİ

**<u>Şekil No</u>** **<u>Şekil Adı</u>** **<u>Sayfa No</u>**

**<u>Şekil No</u>** **<u>Şekil Adı</u>** **<u>Sayfa No</u>**

# ÖNSÖZ

Öncelikle çalışmamın daha sonra yapılacak araştırma ve çalışmalara katkıda bulunmasını temenni eder, sonra bu çalışmada bana her türlü desteği veren ve tecrübeleri ile bana yol gösteren bu günlere gelmemde büyük emek ve payları olan başta aileme, danışmanım Yard.Doç.Dr. Semin KAYA ve Yrd.Doç.Dr.İlker EREN'e, Prof.Dr. Bedri YÜKSEL, Prof.Dr.İrfan AY ve tüm değerli hocalarıma; yine yardımlarını esirgemeyen arkdaşlarım Gülenay Alevay KILIÇ, Tayfur Kerem DEMİRCİOĞLU ve Meltem KORALAY'a teşekkür ve şükranlarımı bir borç bilirim.

Temmuz, 2010 Kubilay TURAN

# 1 GİRİŞ

Gün geçtikçe hızla artan insan nüfusunun beslenme ihtiyacının en temel ayaklarından biri şüphesiz karbonhidrat deposu olan tahıllardır. Tahıl üretim ve tüketiminde meydana gelen artış, bu sektörde yeni teknolojiler ve yeni makinelerin kullanılmasını gerektirmekte, bu nedenle insanlar yeni arayışlar içine girmektedirler. Bu arayışlar 1800lerin başlarında oldukça sıklaşmış ve yeni makineler icat edilmeye başlanmıştır. Bunların en başında tahıl transportunda büyük önem taşıyan *" Helezon Konveyörler"* gelmektedir.

Helezon iletici bundan yaklaşık 2214 yıl önce Archimedes tarafından tarlaların sulanması için bir çeşit pompa olarak geliştirilmiş en eski bir sürekli ileticidir. O yıllardan 1800'lerin başlarına kadar kendisine geniş bir kullanım alanı bulamamış dolayısıyla da pek bir gelişme gösterememiştir [1].

Ancak 1800lerin sonlarına doğru yavaş yavaş gelişme göstermeye başlamış olan helezon konveyörler, düzenli olarak artan Amerikan nüfusunun ihtiyaçlarını karşılayabilmek için gittikçe artan yem ve tahıl üretiminde bir araç olarak kendisine farklı bir kullanım alanı bulmuştur [1].

## 1.1 Daha Önce Yapılmış Çalışmalar

William C. MARR ve arkadaşları 1888 yılında 27 Kasım günü,bir yılı aşkın bir süredir üzerinde çalıştıkları ve *"Machine For Twisting Metal and Forming Spiral Conveyers"* (Metal Bükme ve Spiral Konveyör Şekli Verme Makinesi) adını verdikleri çalışmalarının patentini aldılar. Bu makine bir manivela kolu vasıtasıyla insan gücü ile tahrik edilen,karşılıklı çalışan dört adet dişliye bağlı şaft ve uçlarındaki koniklerin arasından sacın geçirilmesi prensibine dayalı olarak çalışan ve bu alanda tasarlanan makinelerin ilk örneklerinden biriydi [2].

Franc C. CALDWELL ve arkadaşları (1896) *“Spiral Conveyer Flight and Apparatus For Making Same”* (Spiral Konveyör Kanadı ve Bunu Yapan Makine/Aparat) adını verdikleri çalışmalarını 1898 yılında tamamlayarak aynı yılın 29 Martında çalışmaya ait patenti almışlardır. Bu çalışmalarında Caldwell ve arkadaşları, dikey ve birbirlerine açılı bir biçimde konumlandırılmış ve motordan direk tahrik edilen millerin ucunda bulunan koniklerin arasından saç metal şeritin geçirilmesi ile sürekli spiral konveyör kanadı üretmeyi konu almış ve başarmışlardır [3].

Charles O. GUSTAVSEN ve arkadaşları 1903 yılının temmuzunda başladıkları ve *“Machine For Rolling Helicoids or Spiral Conveyer”* (Spiral Konveyör ve ya Helezon Yapma Makinesi) adlı çalışmalarını 1904 yılında tamamlamaları ile aynı yılın mayıs ayında Amerikan Patent Ofisi’nden patentlerini almışlardır. Bu çalışmada tek elektrik motoru tarafından tahrik edilen dişli bir çark ve bu çark tarafından tahrik edilen eş büyüklükteki başka bir çark ve bunlara bağlı ters yönde dönen koniklerin arasından geçirilen sacın spiral konveyör kanadı halini alması konu alınmıştır [4].

Yine Charles O. GUSTASEN ve arkadaşları bu kez aynı isimli çalışmalarında bazı değişiklikler yapıp 1909 yılında yeni bir patent almışlardır. Temelde yapılan en büyük değişiklik sacın, aralarından geçtiği koniklerin kademeli hale getirilmesi idi [5].

Hiram O. FULSON ve arkdaşları 1938 yılının Kasım ayında başladıkları ve *”Apparatus For Rolling Helicoid Conveyer Flight”* (Helezon Konveyör Kanadı Yapma Makinesi/Aparatı) adını verdikleri çalışmayı 1941 yılında tamamlayarak aynı yılın 11 Kasım’ında sekiz sayfadan oluşan Patentini Amerikan Patent Ofisi (United States Patent Office)’nden almışlarıdr. Ortaya çıkan makine ; Eş zamanlı olarak çalışan iki adet elektrik motoru tarafından ; bir ucunda dişli çark öteki ucunda ise konik hadde elemanları bulunan iki şaftın tahrik edilmesi ile bu koniklerin arasından metal sacın geçirilerek sürekli helezon konveyör kanadı üretilmesi prensibine dayalı çalışmaktadır [6].

Joseph O. BAILEY ve arkadaşları 13 Nisan 1926 tarihinde patentini aldıkları çalışmanın adını *"Machine and Process For Making Continious Helicoids or Conveyers"* (Sürekli Helezon veya Konveyör Yapma Proses ve Makinesi ) olarak belirlediler. Bu çalışma daha önceki çalışmalara göre çok daha modern ve komplike bir tasarıma sahip bir makine olarak dikkat çekiyordu. Daha önceki çalışmaların temel prensiplerinden bazılarını birleştirerek daha karmaşık ve yenilikçi bir tasarım oluşturmuşlardı. Dikey ve açılı konumlandırılmış şaftlar, bunların bir ucundaki konik elemanlar, öteki ucunda bulunan ve yine konik bir yapıya sahip olan dişli çarklar bu makinenin en dikkat çeken özellikleri idi [7].

Luigi DANIELI ve arkdaşları, 1965 yılında patent aldıkları *"Apparatus For Machining Variable Pitch Helicoid Grooves in Rolling Mill Rolls"* isimli çalışmalarında, farklı hatve ve ebatlarda ayarlanabilen spiral konveyör kanadı üretmeyi başarmışlarıdır. Tahmin edilebileceği gibi İtalyan mucit bunu yaparken konik elemanlar ve kademeli dişlilerden faydalanmıştır [8].

## 1.2 Çalışmanın Amacı

Bu çalışmanın amacı, çalışma prensibi aslında çok basit olan sürekli helezon konveyör kanadı çekme makinesinin ticari kaygılar nedeni ile sır gibi saklanan tasarımının, daha önceden yapılmış çalışmalar ve alınan patentlerden yola çıkarak, yeni yapılacak olan çalışmalara ışık tutması açısından incelenmesi, tasarım parametrelerinin ortaya konması ve düz bir metal sacdan helezon konveyör kanadı oluşturmak için gerekli çalışma bölgesinin tasarımını bilgisayar destekli modelleme programında oluşturmaktır.

# 2 KONVEYÖRLER

Taşıma, tanım olarak hammaddenin özünde ve niteliğinde herhangi bir değişiklik yapmadan, dayandığı yüzeyden alınıp, sonradan kullanılabilmek için bir başka yere götürülmesi işlemidir. İletim ise, materyalin niteliğinde değişmenin yapılmasından sonra taşındığı işlemler zincirini kapsar [9].

Konveyörler malzemeyi iki nokta arasında tek yönlü hareketle sürekli veya kesikli olarak taşıyan sabit veya portatif araçlardır [9].

Genel olarak konveyörleri aşağıdaki gibi gruplandırmak mümkündür;

- Bantlı konveyörler
- Zincirli konveyörler
- Elevatörler
- Hidrolik konveyörler
- Pnömatik konveyörler
- Helezon konveyörler

## 2.1 Konveyör Türleri

### 2.1.1 Bantlı Konveyörler

Taşıma gücü plastik veya benzeri maddelerden yapılmış esnek bir bandı tahrik eden elektrik motorundan gelir. Bandın altında aşağıya doğru esnemeyi engelleyen ve sürtünmeyi azaltan silindirler mevcuttur. Taşınacak malzemenin cinsine göre bandın profili düz veya V şeklinde olabilir. Bantlı konveyörlerde taşıma uzaklığı için limit yoktur. Birkaç metreden kilometrelerce uzunluğa kadar iletme yapabilirler. Hız için maksimum limitler bulunmakla beraber, belirli sınırlar içinde değiştirilme olanağı vardır. Özellikle montaj bantlarında hızın ayarlanabilir olması üretim kontrolü açısından büyük avantaj sağlar.

Bantlı konveyörler, sabit ve hareketli olmak üzere iki tipte imal edilirler. Sabit bantlı konveyörlerin bütün yapılış şekilleri, kullanılma müddetince sabit kalacak şekildedir. Bunlar öyle dizayn edilirler ki başka bir yerde tekrar monte edilebilmesi için, kolaylıkla sökülebilmeli ve taşınabilmelidirler [9].

**Şekil 2.1** Bantlı konveyör

### 2.1.2 Zincirli Konveyörler

Taşıma aracı, bir motorla tahrik edilen sonsuz zincirden ibarettir. Bu tip konveyörler bantlılara kıyasla iki avantaja sahiptirler:

1. Doğrudan mekanik tahrik nedeniyle sürtünme kayıpları azdır.
2. Zincire takılacak çeşitli elemanlarla çok değişik malzeme taşıma olanağı vardır.

Zincir hem esnek hem de sağlam olduğundan, yatay, dikey ve de eğimli taşımaların aynı sistemle bir arada yapılması mümkündür.


**Şekil 2.2** Zincirli Konveyör

### 2.1.3 Elevatörler

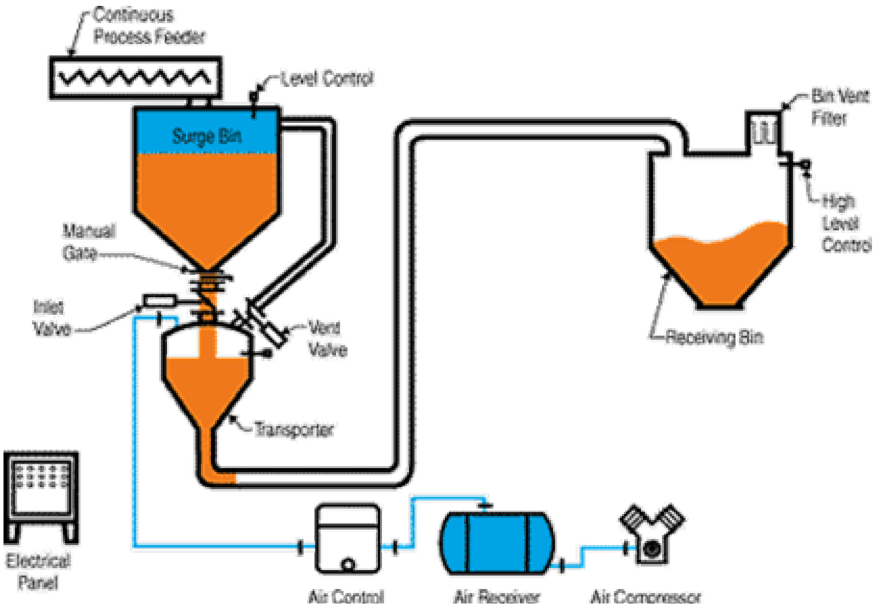
Elevatörler, bilhassa tane halindeki malları (kum, hububat, kömür vs.) iletirler. Bantlı elevatörler ile büyük kaldırma yükseklikleri düşey-veya yalnız düşeye nazaran az bir eğimli- aşılabilirler. Bunların avantajları yalnız küçük bir taban yüzeyine ihtiyaç göstermeleridir.

Bantlı elevatörlerin zincirli elevatörlere nazaran avantajları ;

1. Sakin gürültüsüz hareket etmesi,
2. Toza karşı koyması,
3. Daha büyük aşınma mukavemeti,
4. Daha cüzi hareket direnci,
5. Daha yüksek hıza sahip olması [9].

### 2.1.4 Pnömatik konveyörler

Çevreye toz, buhar ve başka yollarla zarar verebilecek maddelerin taşınmasında kullanılırlar. Toz, tane veya ufak paketler şeklindeki malzeme, kapalı bir sistem (boru gibi) içerisinde güçlü bir vantilatör tarafından oluşturulan hava basıncı ile istenilen noktaya doğru sürüklenerek taşınır




**Şekil 2.3** Pnömatik Konveyörler

Pnömatik konveyörlerin; Dizayn güçlüğü, yüksek maliyet, taşınacak malzeme cinsinin sınırlı oluşu, enerji kaybı dolayısıyla düşük verimlilik gibi sakıncaları vardır.

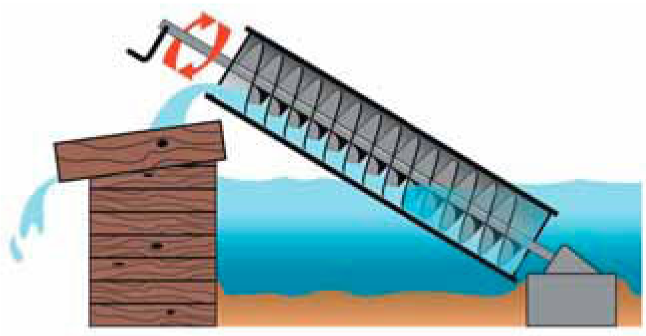
Buna karşılık avantajları ise:

- Çevre kirlenmesine engel olurlar,
- Değişik ve köşeli rotalar izleyebilirler,
- Gereğinde tavandan, duvar kenarından ve zemin altından geçebilmeleri sayesinde yer tasarrufu sağlarlar,
- Dökülüp saçılma yüzünden malzeme kayıpları bulunmaz,
- Bozulabilir malzemeyi dış etkenlerden korurlar,

- Kullanma kolaylığı,
- Tamir-Bakım masraflarının düşüklüğü,
- Standart parçalardan oluşmaları [9].

## 2.2 Helezon Konveyörler

Helezon iletici bundan yaklaşık 2200 yıl önce Archimedes tarafından tarlaların sulanması, gemilerin içinde biriken suyun dışarı atılması gibi işlerde bir çeşit pompa olarak geliştirilmiş en eski bir sürekli ileticidir [11].



**Şekil 2.4** Archimedes'in gemilerden su tahliyesi için icat ettiği ilk konveyör

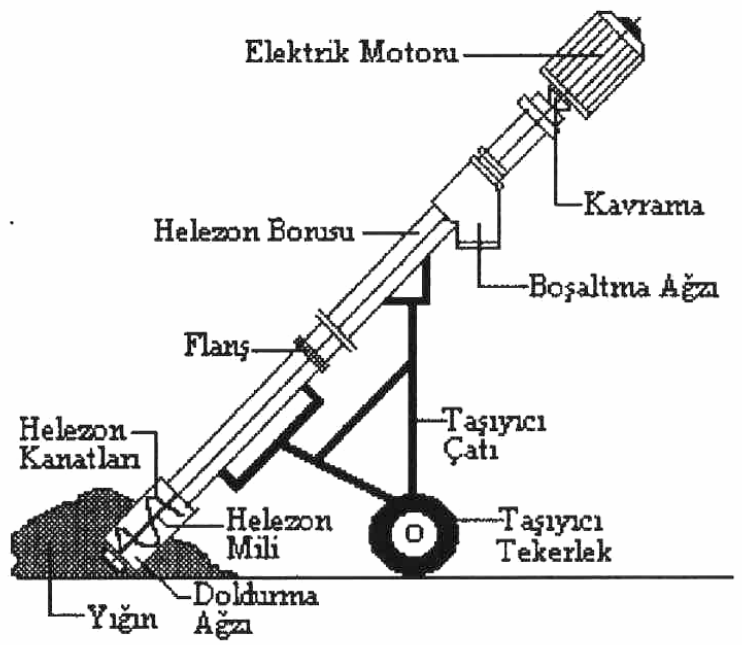
1800lerin sonlarına doğru yavaş yavaş gelişme göstermeye başlamış olan helezon konveyörler, düzenli olarak artan Amerikan nüfusunun ihtiyaçlarını karşılayabilmek için gittikçe artan yem ve tahıl üretiminde bir araç olarak kendisine farklı bir kullanım alanı bulmuştur. İlk yem öğüten değirmenler, proseslerinde helezon konveyörleri kullanmışlardır. Bugün bile en modern değirmenlerde, tahıl işleme endüstrisinde yer alan fabrikalarda a' dan z' ye tüm taneli materyallerin iletiminde geniş bir kullanım alanına sahiplerdir [1].

### 2.2.1 Tanımlama

DIN 15201'e göre, döner vida şeklindeki sürekli veya kesikli helezon, malı bir oluk veya boru içinde yatay, dikey veya eğik olarak iterek dökme malların naklini sağlar. Kısa iletme mesafelerinde, küçük iletme kapasitelerinde, toz halinden küçük parçalı iletme mallarına kadar, bütün endüstri dallarında kullanılmaktadırlar. Ayrıca eleme, yıkama, karıştırma, soğutma, ısıtma ve sıkıştırma elemanı olarak da kullanılmaktadırlar. Helezon götürücüler, masuralı ve titreşimli götürücüler gibi bükülebilir bir çekme elemanının bulunmamasıyla diğer götürücü türlerinden ayrılır [9].

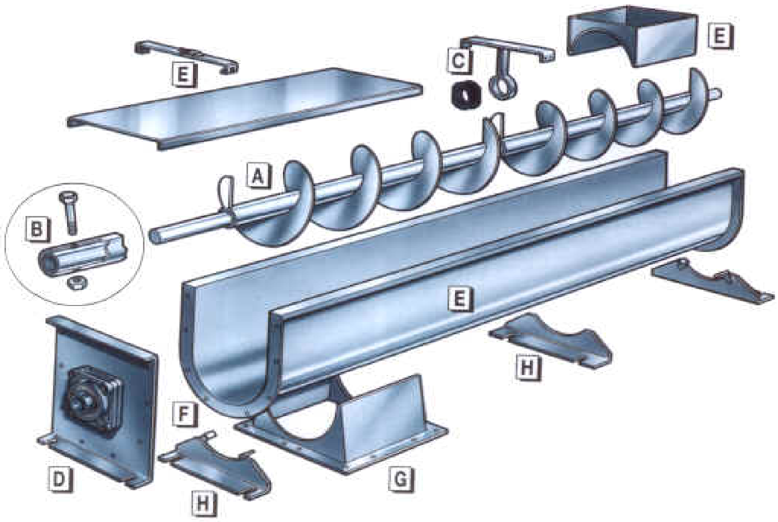
### 2.2.2 Helezon Konveyörlerin Genel Yapısı

Helezon konveyör (götürücü), genellikle bir tekne içinde, dönen bir mile takılmış helezon ile bu mili hareket ettiren bir çalıştırma biriminden meydana gelir.




**Şekil 2.5** Helezon Konveyörün genel yapısı [9]

Mil döndükçe malzeme helisin (ya da kanatların da denilebilir) eksenel etkisiyle götürücüye beslenir. Mil ve helezon U biçimindeki tekneye yataklanmış olan milin çevresinde dönerler. Taşınacak malzeme götürücüye bir yada daha fazla sayıda besleme oluğundan doldurulur. Malzemenin tekne boyunca kayma ilkesi, dönmesine engel olunan bir somun içindeki vidanın döndükçe yaptığı öteleme hareketinin benzeridir. Yük, malzemenin ağırlığı ve tekne duvarları arasındaki sürtünme nedeniyle vida (helezon) ile birlikte dönmez. Böylece öteleme hareketi yapan malzeme, teknenin diğer ucundan yada teknenin alt kısmından açılmış deliklerden boşaltılır. Boşaltma olukları bu deliklerin altına yerleştirilirler. Ara boşaltma delikleri ise kapaklı olup, bu noktalarda boşaltma yapmak istendiğinde açılırlar [9].




**Şekil 2.6** Helezon Konveyörün Parçaları

- A: İletme vidası ve ortasından geçen mil
- B: Sabitleyici pim
- C: Orta yatak
- D: Ana yatak
- E: Oluk (tekne),boşaltma ağzı ve kapakları
- F,G,H: Taşıyıcı ayaklar (çelik konstrüksiyon)

### 2.2.3 Kullanım Alanları

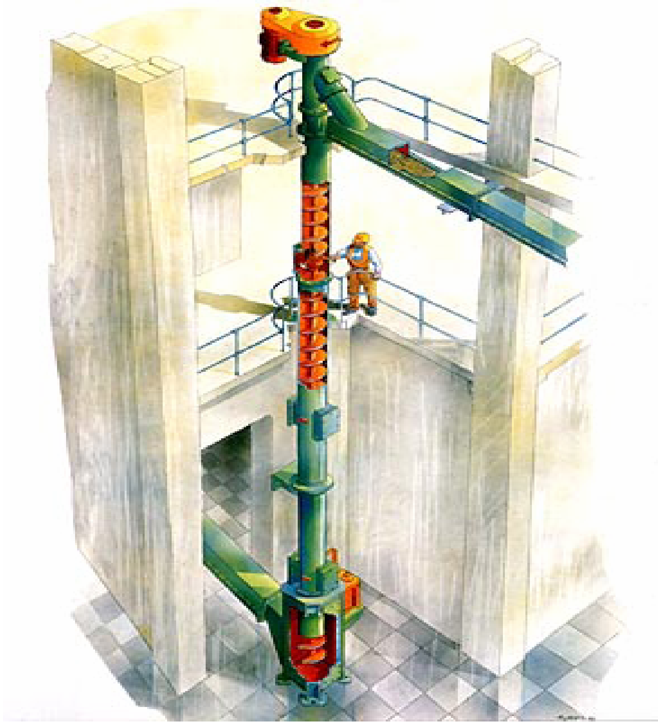
DIN 15201'e göre döner vida şeklindeki sürekli veya kesikli helezon, malı bir oluk içerisinde yatay, düşey ya da eğik olarak iterek dökme mallarının naklini sağlar [9].

Helezon ileticiler bütün endüstri dallarında (çimento, kireç, şeker, bira fabrikalarında, tahıl ve un değirmenlerinde, şekerleme endüstrisinde v. s.), özellikle kimya endüstrisinde ve proses tekniğinde kısa iletim uzunluklarında ve küçük iletim miktarlarında sıkça kullanılmaktadır.[1] Ayrıca eleme, yıkama, karıştırma, soğutma, ısıtma ve sıkıştırma elemanı olarak da kullanılmaktadır[9].

Helezon konveyörler (götürücüler), özellikle granül materyallerin taşınabilmeleri için uygun tasarımlar olmaları nedeniyle, gerek tarım sektöründe gerekse de sanayi sektöründe yaygın olarak kullanılmaktadır. Sanayide özellikle kimya endüstrisinde kısa taşıma uzunlukları için en fazla 400 ton/saat kapasiteli aletlerin kullanıldığı görülmektedir [9].

Bunlara karşılık helezon ileticiler için keskin köşeli, aşırı aşındıran, sert kırılgan yığın ya da parça mallar uygun değildir [1].

Kısa taşıma uzunlukları için tasarlanan helezon götürücülerin performansları yüksek olduğu gibi maliyetleri de düşük olmaktadır. Yatay iletim hattında bulunan bir götürücünün performansı ise, aynı ölçülerde ve aynı tip materyal iletimi için düşey konumda çalışan bir götürücünün sahip olabileceği performanstan oldukça fazladır [9].



**Şekil 2.7** Düşey olarak çalışan bir konveyörün şematik gösterimi [10]

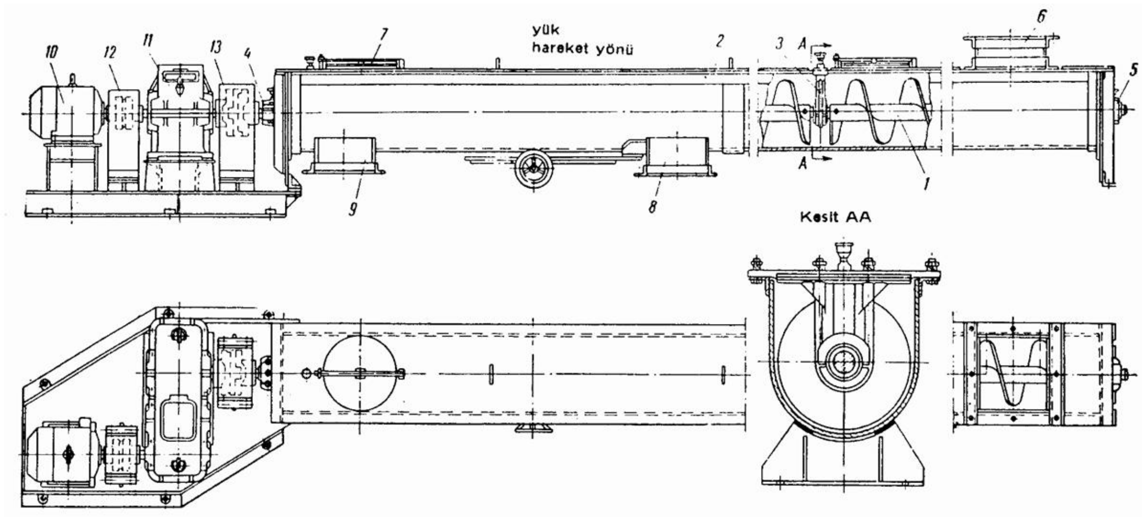
Helezon konveyörler tarımda çiftlik içi ve tarla ortamında yükleme - boşaltma işlemlerinin kolayca yapılmasına olanak sağlayan ekipmanlar olarak karşımıza çıkmaktadırlar. Bu yüzden biçerdöver gibi bazı gelişmiş tarım makinelerinde de helezon götürücülerin uygulamalarını bulmak mümkündür [1].

Silolardan ya da ambarlardan römork ya da başka araçlara hububat yüklemesinde, çiftlik gübresinin taşınmasında, siloların doldurulmasında, soğutucu ve ısıtıcı akışkanların iletilmesinde ise eşanjör olarak kullanılan helezon götürücülerin görüldüğü gibi tarım alanında kullanım alanı oldukça geniştir**.**

Helezon konveyörün tasarımı basit, bakımı kolay ve genişliği az olup malzemenin çeşitli noktalarda boşaltılmasına izin verir (bu özelliğin tozlu ve sıcak malzemelerle, kötü kokulu malzemeler için özel önemi vardır) ve bu durumda tekne, toz geçirmez biçimde yapılmıştır. Bu tür konveyörler, malzeme ile helezon ve tekne arasındaki sürtünmenin oluşturduğu yüksek güç tüketimi, malzemenin kırılması ve konveyör parçalarındaki önemli ölçüde aşınma nedenleriyle her zaman elverişli olmayabilir.

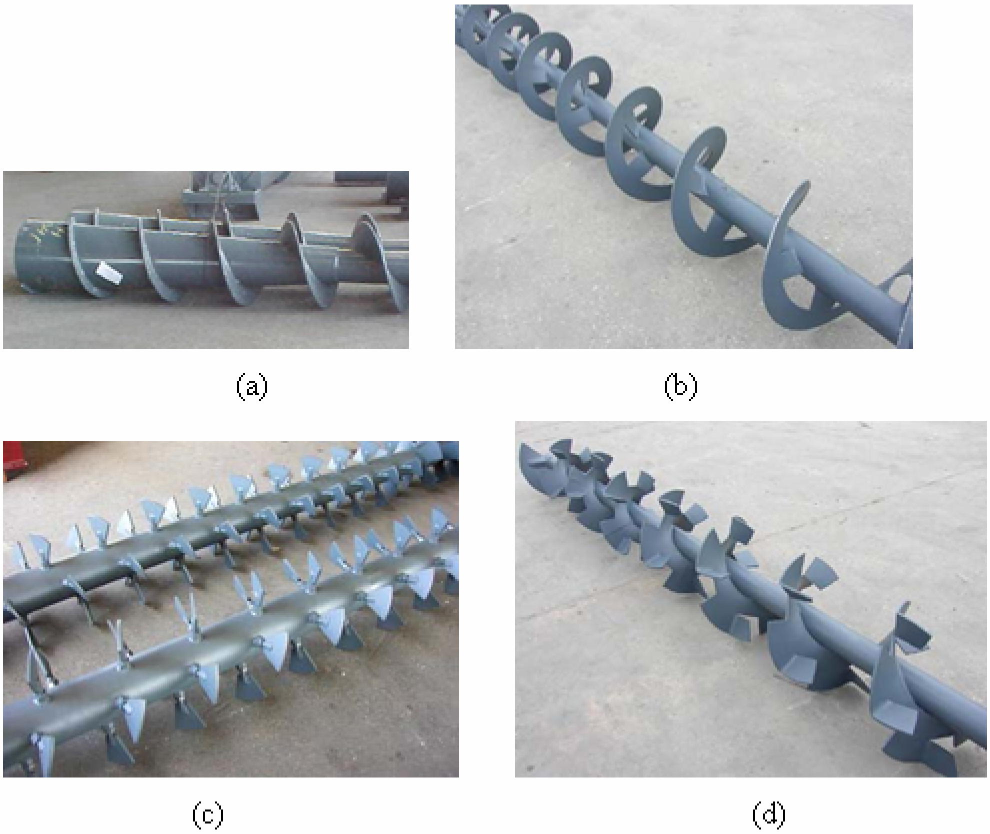
Sonuç olarak; helezon konveyörler, alçak ve orta kapasiteler (100 [$m^3$/saat]) ve kısa taşıma uzaklıkları için kullanılırlar. Genellikle 30 – 40 [m] ve seyrek olarak 50 – 60 [m] uzunluğunda imal edilirler [10].

### 2.2.4 Helezon Konveyörlerin Parçaları




**Şekil 2.8** Helezon konveyör parçaları [9]

Şekil 2.8.'te görülen türde bir helezon konveyörün başlıca parçaları: (1) helezonlu mil, (2) tekne, (3) ara askı yatak, (4) ön yatak, (5) arka yatak (6) besleme oluğu, (7) gözetleme camı, (8) kapaklı ara boşaltma oluğu, (9) uç boşaltma oluğu, (10) elektrik motoru, (11) redüktör, (12) elastik kavrama ve (13) dengeleme kavramasıdır.




**Şekil 2.9** Helezon şekilleri [10]

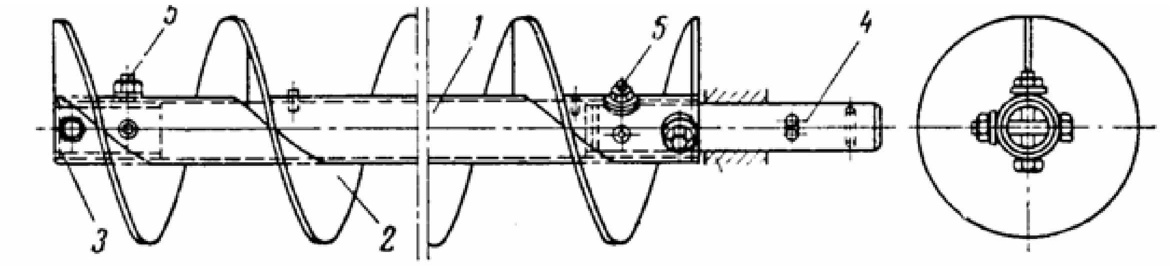
Konveyör helezonu sağ-vida (alışılmış tür), sol-vida, tek, çift veya üç-helisli olabilir. Helezonun tasarımı, taşınacak malzemeye uygun biçimde seçilir.

Eğer konveyör sıkıştırılamayan kuru taneli veya pudra malzemeler taşıyacaksa, kısa adımlı veya sürekli vida (Şekil 2.9a) kullanılır

Kütleli ve yapışkan malzemeler için kordela (ribbon) helis (Şekil 2.9b) uygulanır. Sıkıştırılabilir malzemeler için pervane kanatlı (Şekil 2.9c) veya kesik kanatlı (Şekil 2.9d) helisler elverişlidir. Pala ve kesik kanatlı helezon konveyörler, iki veya daha çok sayıda incelik derecesinde olan bir malzemenin benzer amaçlar için parçalanması, dövülmesi ve eş yapı (homojen) duruma getirilmesinde bir araç olarak kullanılırlar

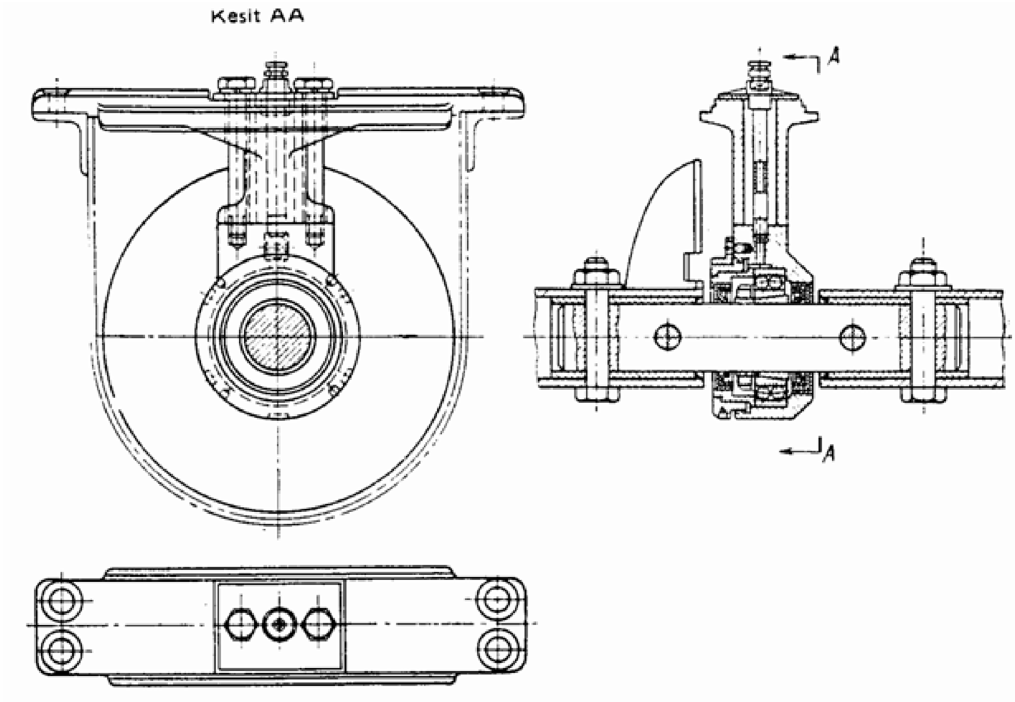
Helezon, genellikle preste basılmış 4–8 [mm] kalınlığındaki çelik saç bölümlerden yapılır. Bölümler mile kaynakla, birbirlerine ise kaynakla veya perçinle birleştirilirler. Bazı durumlarda helezon, soğuk çekilmiş eksiz tek bir şerit olabilir. Helezon ayrıca, mille birlikte dökülmüş ya da mile geçirilmiş borulu döküm dilimlerden oluşabilir.

Pimler, ara ve ana yataklar için muylu görevi yaparlar. Bu birleştirme yöntemi basittir ve az yer kaplar. Ancak, ayrı bölümleri değiştirmek güçtür. T-biçimi tasarımda ara yatak askıları, teknenin üst kapağına bağlanmışlardır. Helezon askı yataklarının bulunduğu noktalarda kesintiye uğrar. Bu nedenle, yatak kısa olmalıdır. (1) mili ve (2) helezonu, genellikle 2 – 4 [m] lik bölümler halinde yapılarak birleştirilirler; içi boş miller, içeriye yerleştirilen (3) burçları ile (4) pimleri aracıyla birleştirilirler ve (5) cıvataları yardımıyla (Şekil 2.10.) birleşim emniyet altına alınır [10].




**Şekil 2.10** İçi Boş Milli Helezon [10]

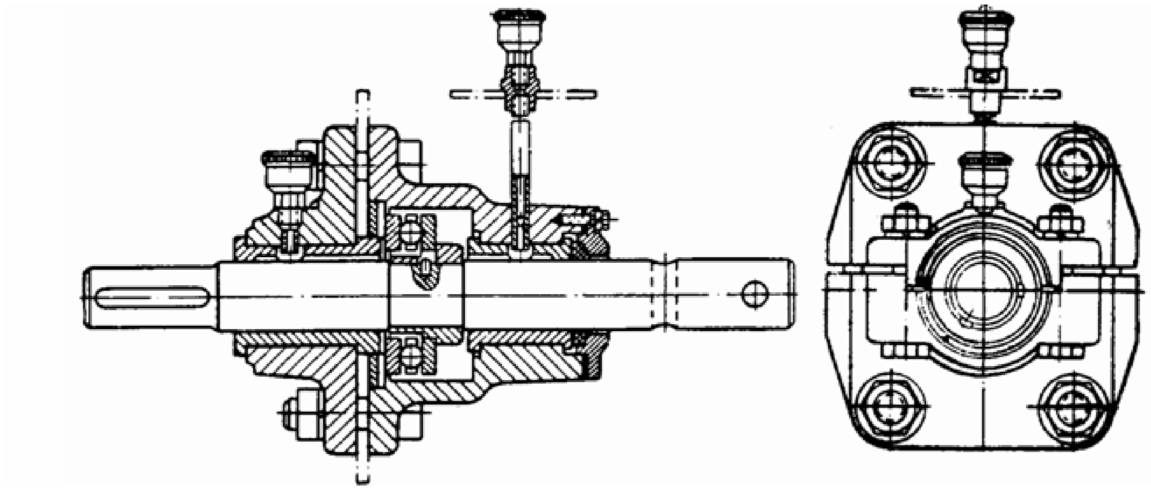
Kendi kendini merkezleyen (küresel yuvalı) ve bronz, sürtünmeye dayanıklı dökme demir, babit ya da sürtünmeye dayanıklı diğer malzemeden yapılmış ara kaymalı yataklar en çok kullanılanlardır. Direnci azaltmak için çift sıra küresel bilyeli yataklar (Şekil 2.11.) kullanılabilir.




**Şekil 2.11** Askılı Ara Yatak [10]

Bilyeli yataklar, malzeme parçacıklarının girmesine karşı güvenilir biçimde korunmalı; ancak sızdırmazlık düzeneği, yatak yuvasını fazla büyütmemelidir. Yataklar gresle yağlamalı olup gresörler, tekne kapağının üzerindeki borulara takılmıştır.

Ana yatak genellikle konveyörün boşaltma ucuna yerleştirilir. Bu bir eksenel yatak olup konveyörün uzun ekseni boyunca etkiyen sürtünme direnci kuvvetini alır. Mile, bütün uzunluğu boyunca çekme gerilmesi etkimektedir. Bu durum, eksenel yatak konveyörün diğer ucunda olduğu zaman gözlenen eksenel basınca göre daha elverişlidir. Eksenel bilyeli yatakla birlikte kullanılan ana kaymalı yatağın yapısı Şekil 2.12.'da gösterilmiştir [10].

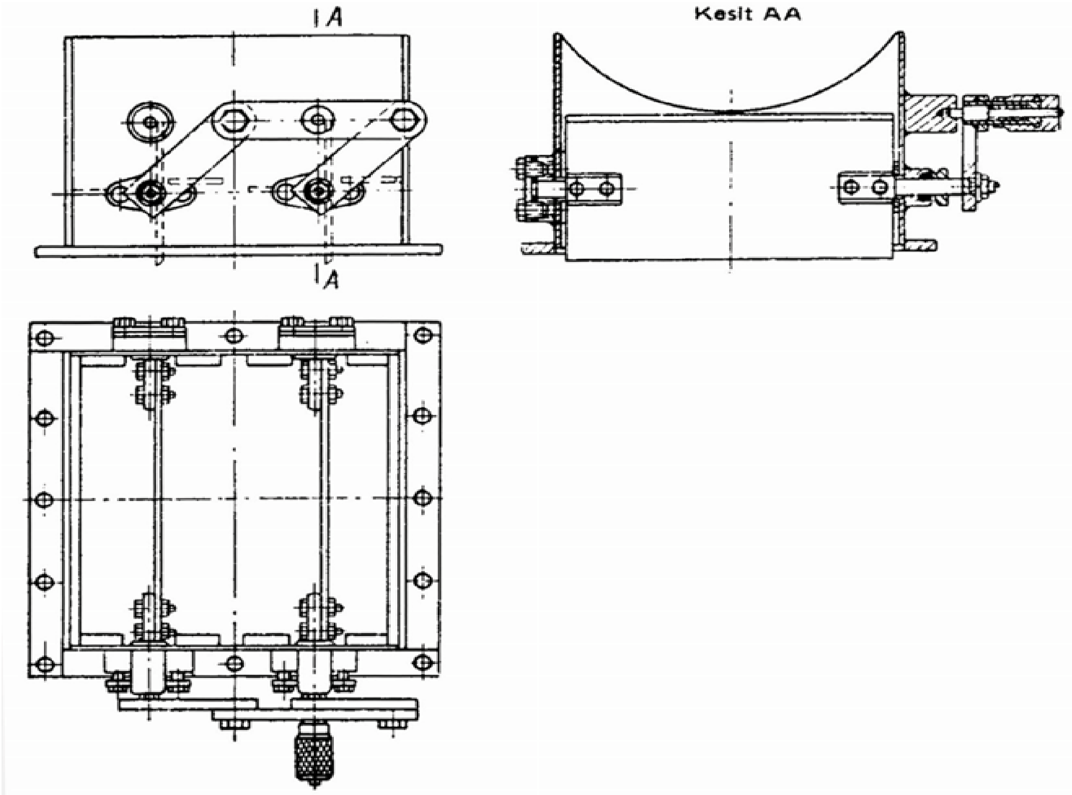


**Şekil 2.12** Ön Eksenel Yatak [10]

Genel amaçlı bir helezon konveyörün teknesi çelik saçtan yapılır. Tekne bölümlerinin uçlarına flanşlı köşebentler kaynatılır. Köşebentler, hem teknenin dayanımını arttırırlar hem de tekne bölümlerinin birbirleriyle ve kapaklarıyla birleştirilmesini sağlarlar. Saç kalınlığı, helezon çapına ve taşınan malzemenin aşındırıcılığına bağlıdır ve genellikle 3 – 8 [mm] arasında değişir.

Teknenin silindirik kısmının iç çapı, helezon çapından biraz büyüktür. Böylece, arada belli bir aralık kalır. Helezon ve teknenin duyarlı bir biçimde yapımı ve bütünleştirilmesi, ancak helezonun kenarı ile tekne duvarı arasında uygun bir çalışma aralığı bırakıldığı zaman mümkün olur. Bu da malzemenin az kırılması ve güç tüketiminin düşük olması sonucunu verir, önerilen aralık 6 – 9.5 [mm] arasındadır. Aralık, helezon çapı ile artar. Tekne, bütün uzunluğu boyunca kaynaklı veya döküm destekler üzerine oturur.

Ara boşaltma oluklarını açma ve kapama için genellikle bir kremayer dişli ve bir krank kullanılır. Daha basit bir kapak açma mekanizması Şekil 2.13.'de gösterilmektedir. Bu mekanizma, orta eksen çevresinde 90° dönen iki eşdeğer kapak (supap) tan oluşur.




**Şekil 2.13** Çift Kapaklı Boşaltma Oluğu [10]

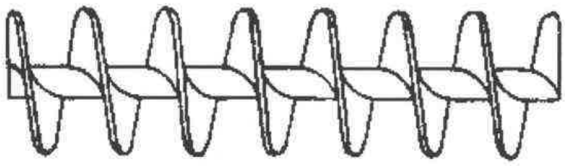
Sökülebilir kapak, birbirine cıvatalanan ayrı bölümlerden yapılmıştır. Teknenin basınç altında tutulmasının zorunlu olduğu durumlarda, kapakla tekne arasına lastik conta konabilir.

Helezon konveyörün çalıştırma birimi şunları içerir: Elektrik motoru, kapalı tip bir dişli ya da sonsuz vidalı redüktör, motorla redüktörü ve redüktörle konveyör milini birbirine bağlayan kavramalar [10].

### 2.2.5 Konveyör Vidasının Hatvesi

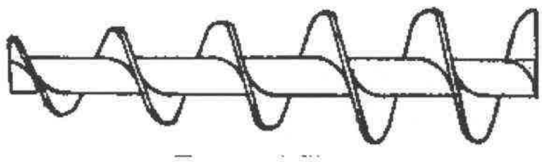
Vidanın Hatvesi genellikle çapıyla eşit yapılır. Değişken hatvesi olan vidalar bazen kademeli diş açıklığına sahip vidalar ile aynı amaç için kullanılabilmektedirler. 1.2 mm ve daha büyük tane yapısına sahip olan malzemeler için kısa vida adımlı ve konik vidalı burgular kullanılmaktadır [9].

Küçük hatveye sahip vidalarda hatve çaptan daha küçüktür. Bunlar diğer ekipmanlar için besleyici olarak ya da standart helezonların parçaları olarak kullanılırlar. Bunlar taşmayı önlemek için $20^o$ ‘yi geçen eğimlerde kullanılırlar.



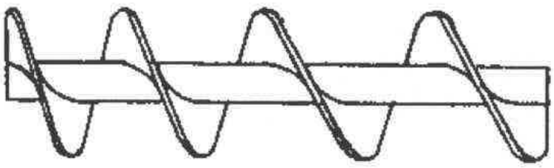
**Şekil 2.14** Küçük Hatveli Konveyör Kanadı [9]

Konik vidalı helezonlar gevrek, kırılgan ve taneli yapıdaki malzemelerin taşınmasında besleyici olarak kullanılırlar.



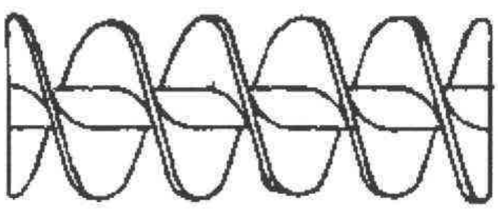
**Şekil 2.15** Konik Vidalı Helezon [9]

Kademeli yapıdaki helezonun kanatları kademeli olarak artar. Tüm besleme uzunluğu boyunca sabit bir serbest akış sağlarlar. Kısa hatveye sahip konveyörlerin gelişmiş şeklidirler [9].



**Şekil 2.16** Değişken Adımlı Konveyör Kanadı

Çift ağızlı vidalar ise serbest akışlı malzemelerin düzgün akışını sağlarlar.

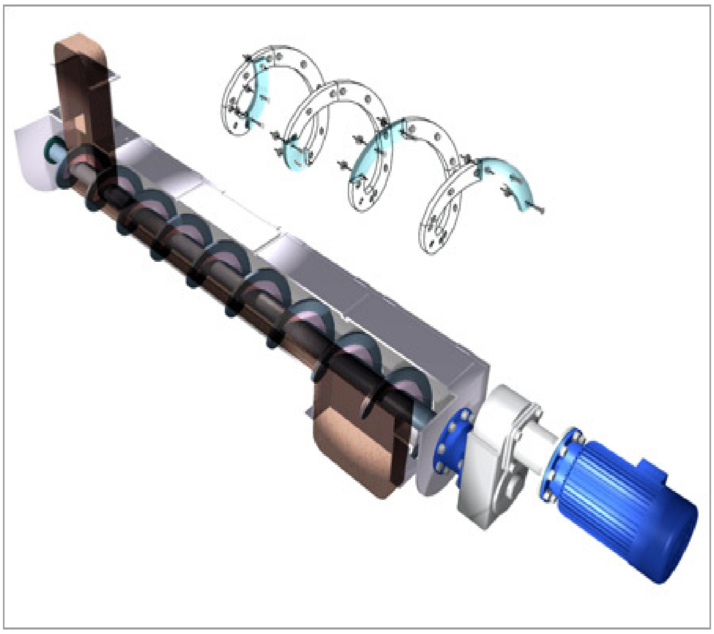


**Şekil 2.17** Çift Ağızlı Konveyör Kanadı [9]

# 3 HELEZON KONVEYÖRLERİN İMAL YÖNTEMLERİ

## 3.1 Eklemeli İmalat

Helezon, genellikle, preste basılmış 4-9 mm kalınlığında sac bölümlerden yapılır. Bölümler mile kaynakla; birbirlerine ise kaynak ya da perçin ile birleştirilirler. Bu yöntemin avantajı, helezonda bir arıza olduğunda arızalı bölmenin sökülüp kolayca tamir edilebiliyor olmasıdır.



**Şekil 3.1** Perçin bağlantısıyla birleştirilmiş helezon

**Şekil 3.2** Kaynak bağlantısıyla birleştirilmiş helezon

## 3.2 Eksiz (Tek Parça) İmalat

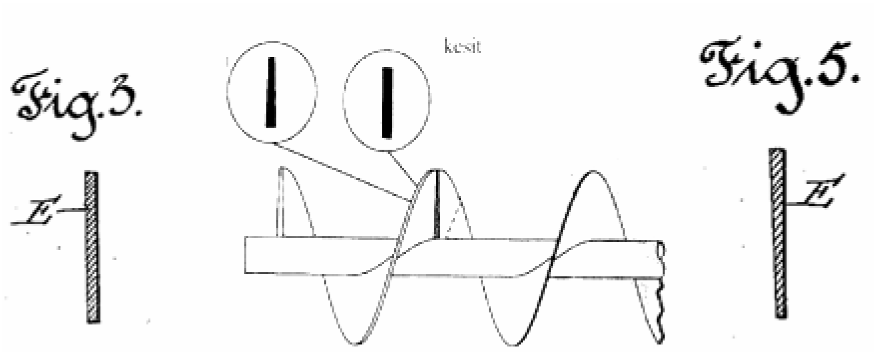
Metal bir şeritten sürekli soğuk çekme yöntemi ile tek parça olarak üretilirler. Bu yöntem sanayide daha fazla kullanım alanına sahiptir. Bu çalışmada sürekli helezon yaprağı çekme işlemi, bu işlemin ilk örnekleri ve spiral parametrelerin tayini üzerinde durulacaktır.

**Şekil 3.3** Sürekli Spiral çekme yöntemi ile imal edilmiş helezonlar

### 3.3 Sürekli ve Kesikli Helezon yapılarının Karşılaştırılması

Sürekli Helezonun dikey kesiti incelendiğinde tabandaki et kalınlığının dış yapıdaki et kalınlığından daha fazla olduğu görülür [9]. Bunun sebebi üzerinde çalışmış olduğumuz Sürekli helezon çekme makinesinin, çekme işlemi sırasında saç metalin bir kısmının konik haddenin geniş yüzeyinden hareket ederek, koniğin dar tarafından hareket eden kısmına göre daha fazla yol kat ederek daha ince bir yapıya kavuşmasıdır.

Aynı inceleme kesikli helezon yapıda yapıldığında ise et kalınlığının kesit boyunca sabit kaldığı görülmektedir [9].




**Şekil 3.4.** Kesikli ve sürekli helezon kesiti karşılaştırması [3]

Kesikli helezon yapıda helezonun bir parçası hasara uğrarsa, helezonun tüm boyutunda işlem yapmaya gerek olmadan, sadece hasarlı parça yada parçalar onarılarak sorun kolaylıkla giderilebilir. Her ne kadar sürekli helezon yapının kullanımı çok yaygın olsa da böyle bir hasarın onarımı için demontajı gereklidir. Bu da kıyaslandıklarında oldukça büyük bir maliyet getirmektedir [9].

Sürekli yapının kesikli yapıya üstünlüğü ise mukavemetinden gelir. Yapı sürekli olduğundan malzemenin birikebileceği boşluk ve yarık yoktur. Sürekli helezon yapı genellikle aşındırıcı olmayan malzemeler ve hububat iletiminde kullanılırlar.

Sürekli yapı özel tasarımlar istendiğinde daha avantajlı olmaktadır. Bu özellikler helezon kanatları için farklı çaplar, büyük çaplar, ekstra kalınlık sertleştirme ve özel malzeme olarak sıralanabilir [9].

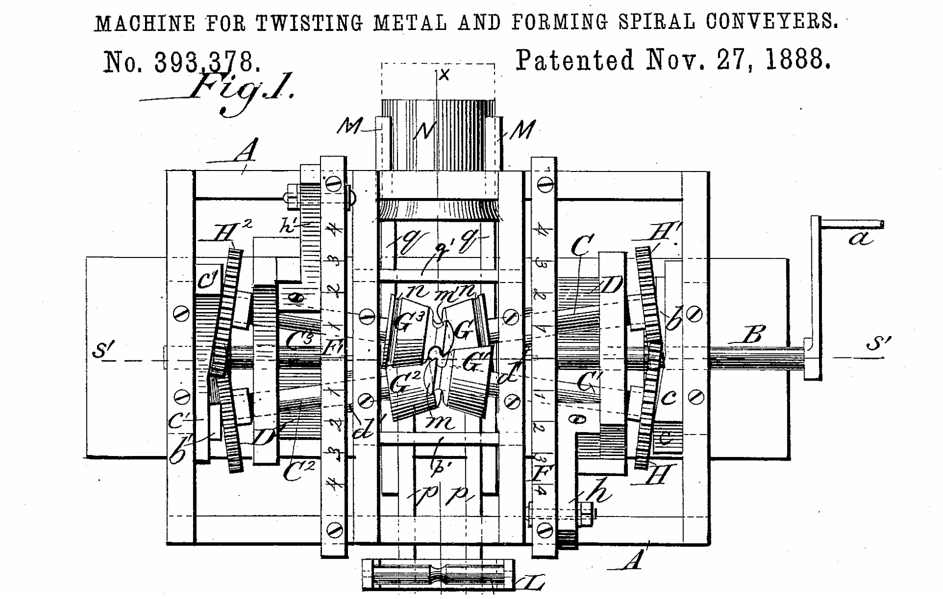
## 3.4 Sürekli Çekme Yöntemi İle Helezon Konveyör Kanadı İmal Eden Makineler Ve Çalışma Prensipleri

1800'lü yılların başlarında artan nüfus ve tahıl transportu ihtiyacı nedeni ile uzun bir aradan sonra yeniden kendine kullanım alanı bulmaya başlayan helezon konveyörler, bu yılların ortalarında geliştirilen çeşitli tasarımlar sayesinde sürekli çekme yöntemi ile çelik saçlardan üretilmeye başlamışlardır.

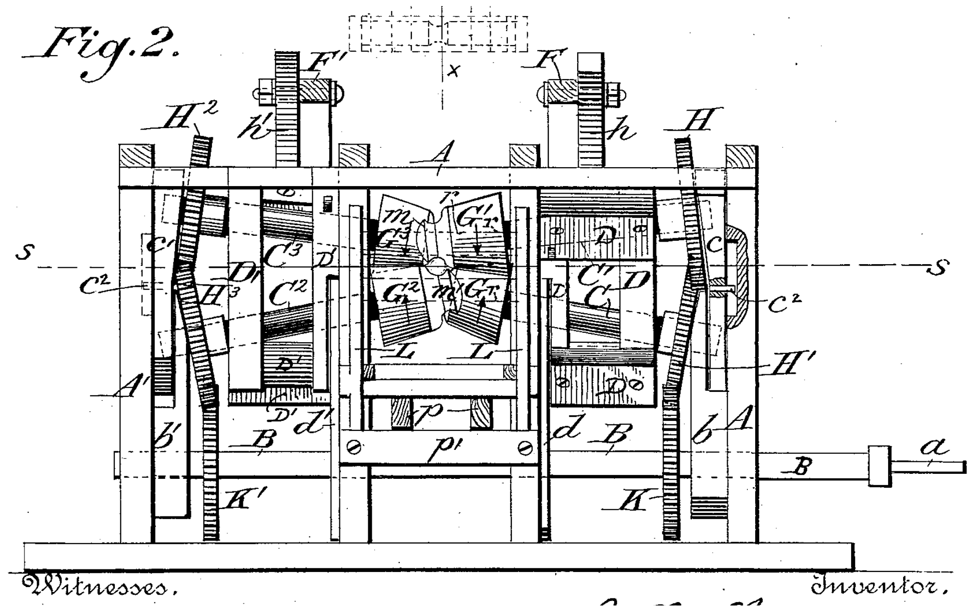
Bu bölümde bu tasarımlara değinilecek ve çalışma bölgesi mercek altına alınacaktır.

### 3.4.1 William C. MARR'ın Yaptığı Tasarım

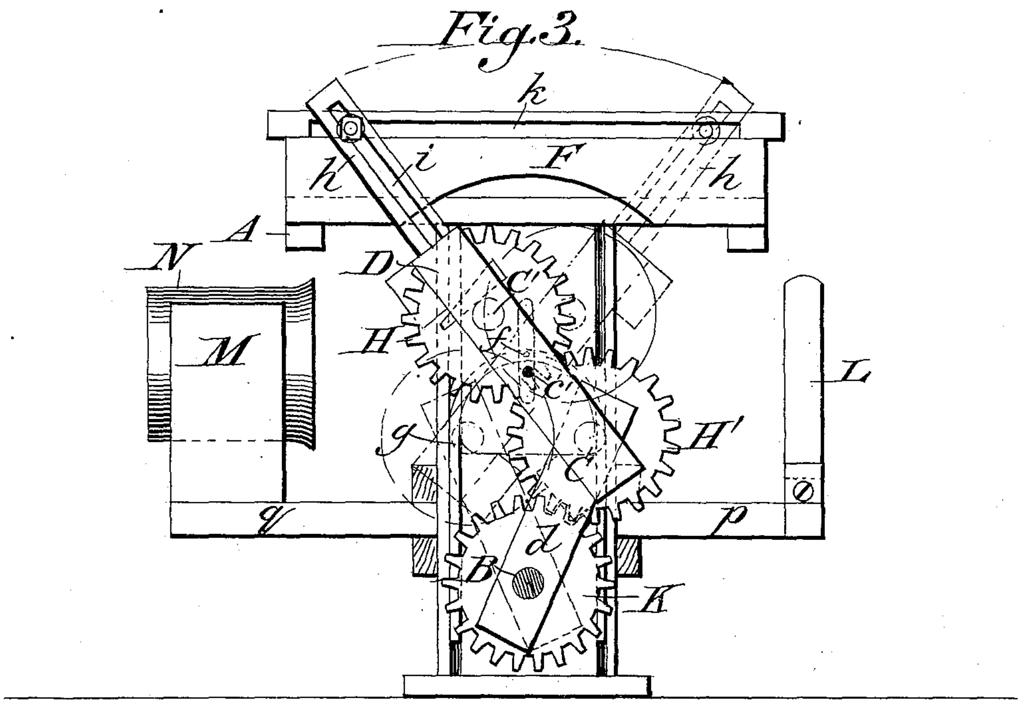
Bu alanda yapılmış ilk çalışmalardan biri, Amerikalı mucit William C. MARR tarafından 27 Kasım 1888 yılında patenti alınmış olan makinedir. Marr bu makineyi, "metali bükme ve spiral konveyör şekli verme makinesi" anlamına gelen "machine for twisting metal and forming spiral conveyor" olarak tanımlamıştır.



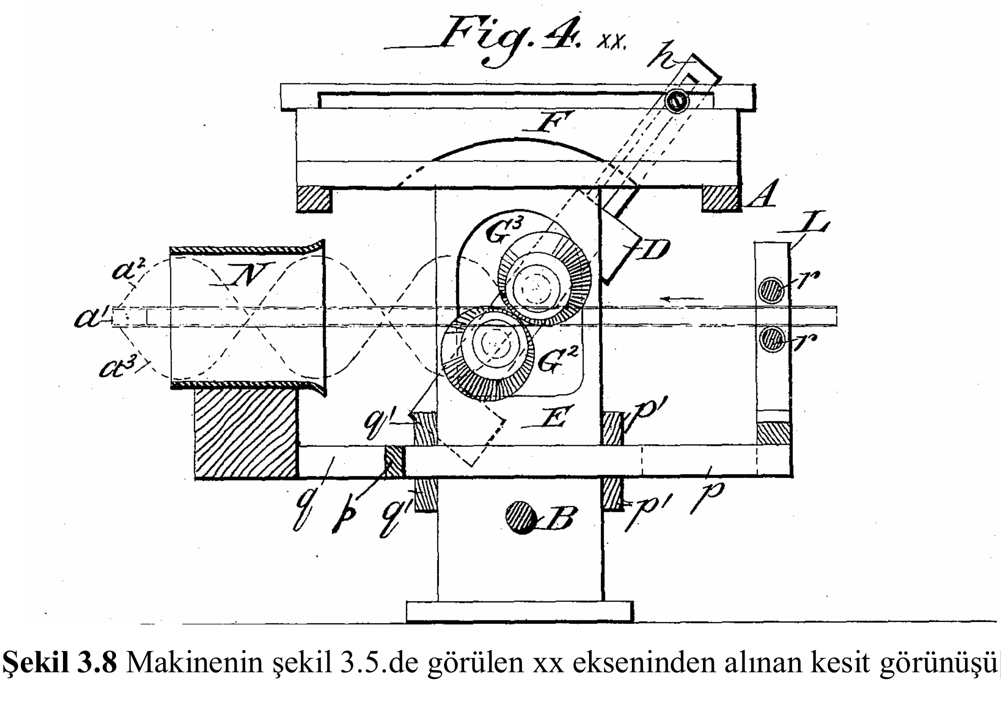

**Şekil 3.5** Makinenin üstten görünüşü [2]



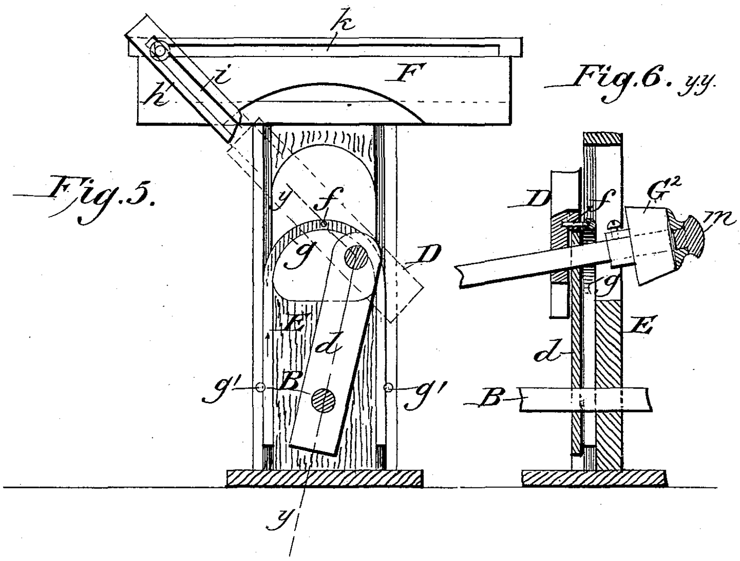

**Şekil 3.6** Makinenin önden görünüşü [2]




**Şekil 3.7** Makinenin sol yan görünüşü [2]




**Şekil 3.8** Makinenin şekil 3.5.de görülen xx ekseninden alınan kesit görünüşü[2]




**Şekil 3.9** Makinenin şekil3.5.te görülen yy ekseninden alınan kesit görünüşü [2]

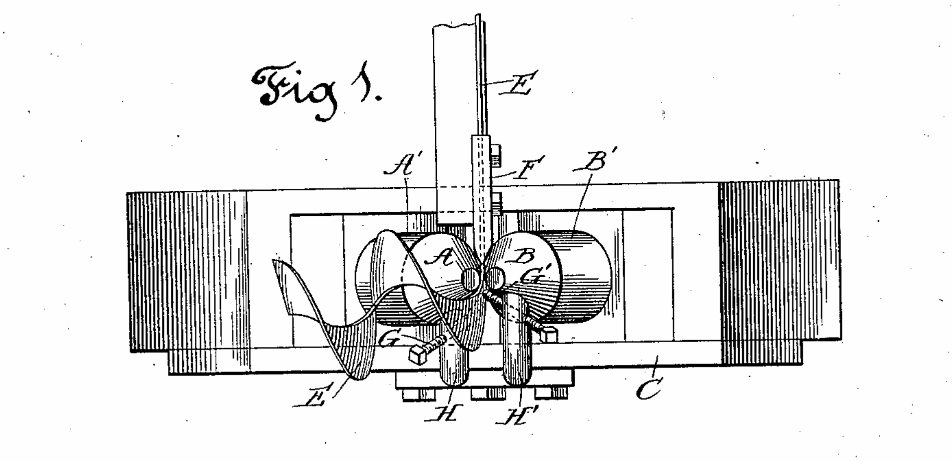
Bu makine Şekil 3.5.te de görüldüğü gibi elle tahrik edilen bir makinedir, ancak mucit bir dişli kutusu tarafından da tahrik edilebileceğini belirtmiştir.

Tahrik kolu döndürüldüğünde tahrik koluna bağlı milin üzerindeki dişli de onunla birlikte dönmekte, bu dişli ona bağlı olan ve uçlarında konik haddelerin bulunduğu diğer mile bağlı olan dişliyi çevirmektedir. Bu sayede çekmeye zorlanan metal sac haddeler arasından geçerken koniklik sayesinde spiral şeklini alarak makinenin öteki ucundan çıkmaktadır [2].

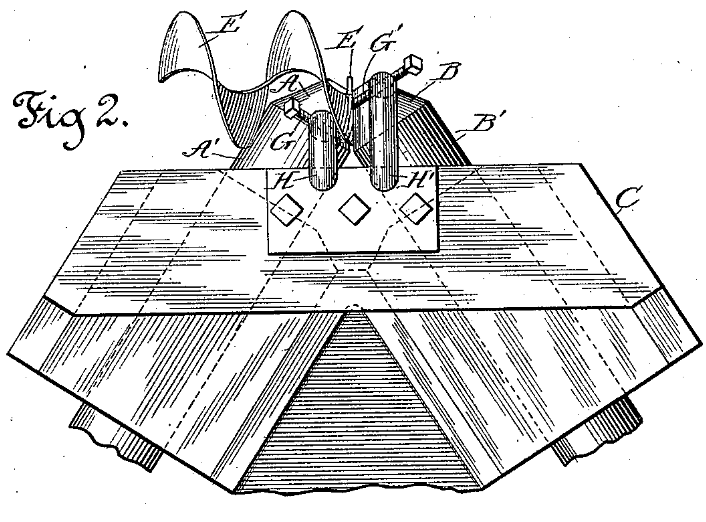
### 3.4.2 Franc C. CALDWELL' in Yaptığı Tasarım

Franc C. CALDWELL ve arkadaşları 1896 yılında geliştirdikleri ve *"Spiral Conveyer Flight and Apparatus For Making Same"* adını verdikleri tasarımda dikey olarak konumlandırılmış ve uçlarına koniklik verilmiş iki mil arasından düz çelik saç geçirilerek kılavuzlar yardımıyla spiral formu vermeyi başarmışlardır.

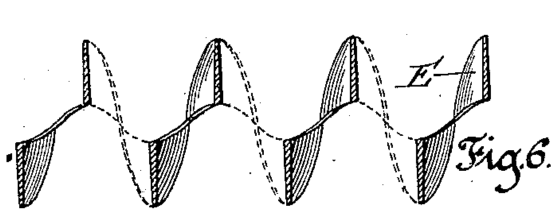
İcadının hedefinde, daha önceden denenmiş fakat ona göre yeteri derecede başarılı olunamamış olan şerit metalden sürekli spiral yaprağı oluşturma makinesini daha yeterli seviyede tasarlamanın yattığı belirtilmiştir. Önceki çalışmalara nispeten Caldwell, daha basit çalışan ancak daha iyi bir makine tasarlamıştır.



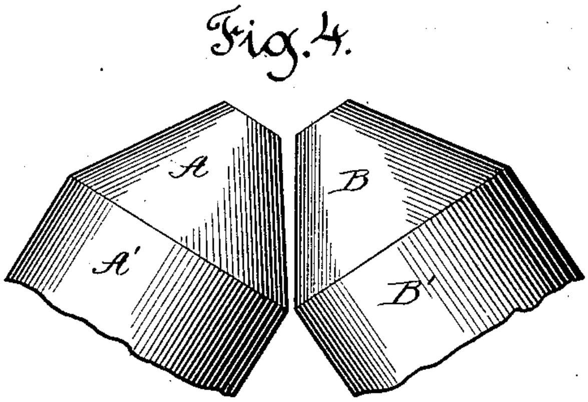

**Şekil 3.10** Makinenin üstten görünüşü [3]




**Şekil 3.11** Makinenin önden görünüşü [3]




**Şekil 3.12** Tamamlanmış spiralin boyuna kesit görünüşü [3]




**Şekil 3.13** Konik haddelerin konumlandırılış biçimi [3]

Bu makinenin çalışma prensibini ve aynı zamanda bu çalışmamızın temel noktasını oluşturan tasarım parametresi; **Şekil 3.13.** da görülen soğuk deformasyon konikleri ve onların birbirleri arasındaki *"Çalışma Bölgesi"* nin inceden kalına doğru giden kesitidir.

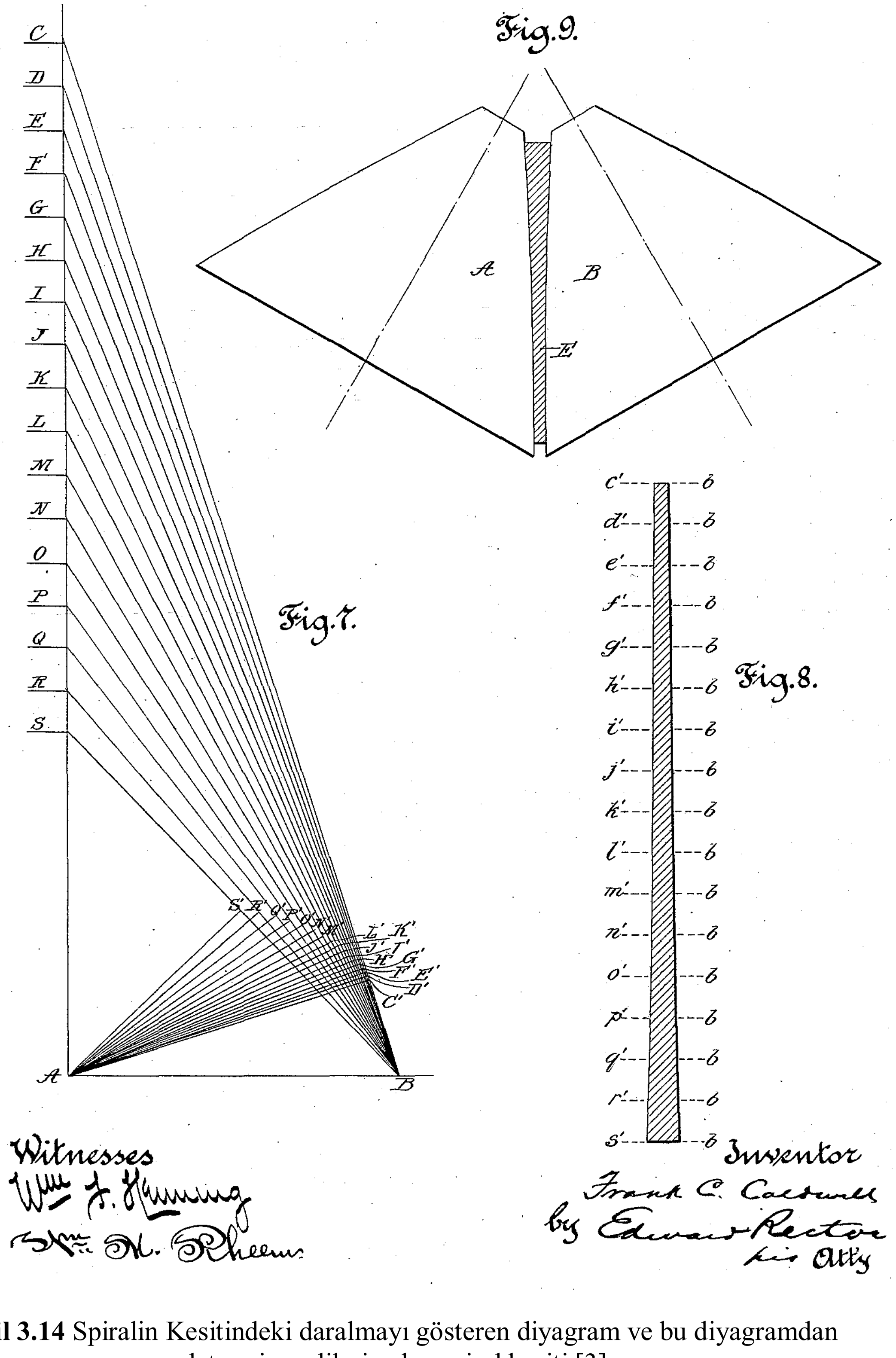
Düzgün dikdörtgensel bir kesite sahip olan metal saç, şekildeki gibi konumlandırılmış konik haddeler arasından geçerken *"Çalışma Bölgesi"* nin şeklini almaya zorlanması sonucu, oluşacak olan spiralin kesiti de **Şekil 3.12.** de de görüldüğü gibi tıpkı "Çalışma Bölgesi" gibidir.

Ancak, dikdörtgensel kesitli metal saç malzemeye spiral şeklini veren asıl parametre deformasyon elemanlarının sahip oldukları konikliktir.
Şöyle ki; Saç metalin, koniklerin dönmesi esnasında aralarından geçerek çekmeye ve uzamaya zorlanmasıyla, saç metalin; koniklerin çaplarının büyük olduğu tarafa gelen kenarı, koniklerin küçük çaplı olan tarafına gelen kenarından daha fazla uzamaya zorlanarak, çalışma bölgesini terk ederken spiral şeklini alması makinenin temel çalışma prensibi olarak açıklanabilir.

Şekil 3.14. de çalışma bölgesi, spiralin kesitindeki daralmayı gösteren diyagram ve spiralin bu diyagramdan hesaplanan kesiti gösterilmektedir. Bu diyagramda;

- AC düzlemi Spiralin Dış kısmının yarıçapı
- AS düzlemi Spiralin İç kısmının yarıçapı
- AB helisin adımını (hatvesi)
- CB helisin dış kenarının izlediği yol ve uzunluğunu
- SB helisin iç kenarının izlediği yol ve uzunluğunu
- SC yaprağın genişliğini

temsil etmektedir [3]. Burada A,B,C ve S noktaları doğrular ile birleştirilmiş ve bu doğrular bize AB,AC,AS vs gibi uzunlukları vermiştir. Daha sonra ise A noktasından bu doğrulara çizilen dikmeler ile bu doğruların kesişim noktalarının B noktasına olan uzaklıkları sırasıyla a',b',c' gibi isimlerle isimlendirilip c'b, d'b gibi değerler elde edilerek spiralin daralan kesitini gösteren diyagram oluşturulmuştur.

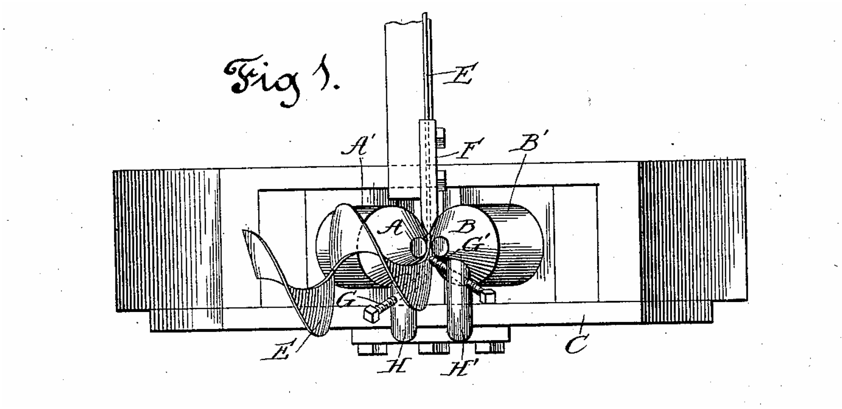



**Şekil 3.14** Spiralin Kesitindeki daralmayı gösteren diyagram ve bu diyagramdan determine edilmiş olan spiral kesiti [3]

- SC çizgisini eşit aralıklara ayıran AR, AQ, AP vs. doğrular, AC ve AS ile eşmerkezli dairelerin çevrelerine karşılık gelmektedir.
- RB, QB, PB vs. doğruları ise, bu dairelere ait helisoidlere karşılık gelmektedirler.
- A noktasından çizilen ve SB,QB,RB.vs ye dik olan çizgiler onları S′,R′,Q′ vs. noktalarında keserler
- S′B çizgisi spiral kanadının iç kenarının et kalınlığını verir.
- R′B,Q′B,P′B…,RB,QB,PB..vs helislerinin iç kenar et kalınlıklarını verir [3].

Konik haddelerin arasından spiralin dönme hareketi yaparak ayrılışı şekil 3.10 ve 3.11 deki çizimlerde çok net görülemese de, Şekil 3.14 deki diyagram ve şekillerden ve de yapılan açıklamalardan rahatlıkla anlaşılabilmektedir.

Dikdörtgen kesite sahip metal şerit, bu haddelerin arasından geçerken, iç kenarlarından dış kenarlarına doğru genişleyerek istenilen gerçek kesitine kavuşarak haddelerden ayrılır.
Bu esnada şerit üzerinde karşılıklı kenarlar arasındaki her noktanın besleme hızları eşittir [3].




**Şekil 3.15** Makinenin üstten görünüşü [3]

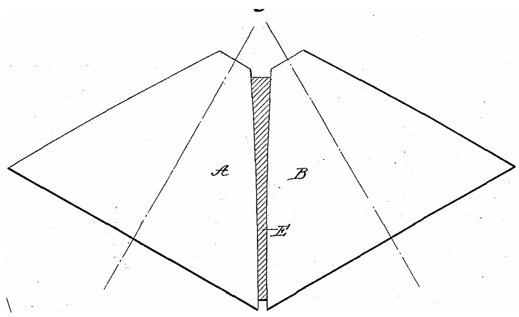
G kılavuzu metal şerit haddeler arasından çıktığı sırada şeridin bir kenarının alt veya üst kısmına doğru konumlandırılmıştır. G′ kılavuzu da aynı durumda şeridin diğer tarafında alt ayda üst kenara doğru konumlandırılmıştır.

Bu iki kılavuz metal şeridi istenen spiral formuna kavuşması için yönlendirme yapacak şekilde ayarlanır.

Bazı durumlarda bu kılavuzlar sökülebilir ancak bu vida kılavuzlar genellikle üniform bir hatve ve spiral formu için gerekli ve önemlidir [3].

Bu çalışmalardan elde edeceğimiz sonuçlara göz atacak olursak; ortaya çıkan en önemli tasarım parametrelerini

- Konik haddelerin aralarındaki boşluğun, elde etmek istediğimiz spiral kesiti ile aynı şekilde olması,



**Şekil 3.16** Konik haddeler arası çalışma bölgesi [3]

- Konik haddelerin deformasyona uğramayacak rijitlikte bir malzemeden üretilmiş olması,
- Çalışma parçasının (metalin haddeler arasından geçtiği durumda) en dar noktasında haddelerin çevrelerinin oranları ile en geniş noktasındaki çevreleri oranları birbirlerine eşit olmalı. Diğer bir deyişle hadde koniklerinin en dar yerleri ile en geniş yerleri aynı düzlemde olmalıdır.
- Haddelerin aralarında bulunan geçidin-yani haddelerin birbirleri ile olan konumlarının- elde etmek istediğimiz spiralin iç,dış çapı ve de hatvesine bağlı olarak şekil 3.14 teki diyagramdan determine edilecek olan kesit ile aynı forma sahip olması en önemli koşulların başında gelir.
- Son olarak da Konik haddelerin birbirinin aynı olması ve üniform hızda tahrik ediliyor olmaları bu makinelerin tasarlanmasındaki en önemli kriterler olduğu saptanmıştır.

# 4 YÖNTEM

## 4.1 Sonlu Elemanlar Yöntemi

Mühendislik hesaplamalarında amaçlanan asıl ölçüt minimum hata payı ile tasarımı gerçekleştirebilmektir. Daha önceleri- bilgisayarın bu hesaplamalarda kullanılmasından önce-karmaşık sistemlerin çözümleri ya yapılamıyordu yada hata oranları oldukça yüksek değerlerde olduğu için, bir prototip imal edilmek suretiyle deneysel olarak sonuca ulaşılmaya çalışılıyordu. Bu da tasarım aşamasında ciddi maliyetler getirmekteydi.

1950'li yıllardan itibaren bilgisayar kullanımının başlaması ile hesaplama gerektiren araştırmaların ana hedefi sayısal hesaplamalarda yaklaşım yöntemlerinin geliştirilmesi olmuştur. Bu çalışmalar öncelikle daha doğru ve verimli sayısal çözüm yöntemleri geliştirme doğrultusunda idi [11].

En eski ve yaygın sayısal hesap yöntemlerinden birisi sonlu farklar yöntemidir. Sonlu farklar yönteminde ele alınan sistem bölgesi küçük kafes bölgelere ayrılmakla beraber, sistemin ele alınan bölgede davranışını yeterli doğrulukta tespit edebilmek için çok sayıda bilinmeyenin hesaplanmasına gerek duyar. Sonlu farklar yönteminde sistem sınırlarında verilen sınır şartlarına uyulmaya dikkat edilmekle beraber sistemin iç kısımlarında ve iç kısımlarındaki bölgeler arası geçişlerde hata sonlu elemanlara göre daha fazla olabilmektedir [11].

Sonlu Elemanlar Yöntemi (SEY) diğer bir yaklaşım yöntemi olup, bu yöntemde ilgilenilen bölge sonlu farklardaki gibi küçük bölgelere ayrılır. Sonlu farklardan ayrılan yönü ise, çözümü istenen fonksiyonun, bilinen polinomlar(deneme fonksiyonları) ve hesaplanacak katsayılar cinsinden tanımlanması ve yaklaşım nedeniyle ortaya çıkan hatanın bu küçük bölge içerisinde minimize edilmesidir [11].

Dolayısıyla sadece sınırlarda değil ele alınan bölgenin tamamında hata minimize edilmiş olur.

Bilim dünyasındaki genel kanı Sonlu elemanlar yöntemi fikrinin ilk olarak Courant'ın 1943'deki makalesi ile başladığıdır. Makalesinde Courant, deneme fonksiyonlarının türetilmesinde üçgen elemanlar kullanmış ve bunu varyasyönel yöntem çerçevesinde sütun gerilim problemlerinin çözümüne uygulamıştır. Ele alınan bölgenin daha küçük alt bölgelere ayrıştırılarak bu küçük bölgelerde deneme fonksiyonları veya diğer bir deyişle "şekil fonksiyonları" 'nın kullanımı ilk olarak yapı mekaniği çalışmalarında gözlenmiştir. Bu ilk çalışmaların ardından SEY hızlı bir biçimde diğer mühendislik alanlarının bilgisayarlı hesaplarında kullanılmaya ve geliştirilmeye başlanmıştır [11].

SEY'in sonlu farklara nazaran üstün yanlarından biri karmaşık geometrileri ve her çeşit sınır şartlarını ele almadaki üstünlüğü sayılabilir. Yüksek dereceli polinomların, hesaplanması istenen fonksiyonu temsil etmede kullanılması, verilen bir kafes büyüklüğü için sonlu fark yöntemine nazaran daha doğru hesabın yapılabilmesine imkan sağlar ve ayrıca daha büyük kafes hücrelerinin kullanılabilmesi mümkün kılınarak daha az bilinmeyenli denklem takımlarının çözümüne olanak sağlar.

SEY'in sorunlu yanı ise oluşturulan matrislerin tekilliğe yakın olabilmeleri ve bu sebeple matris terslerinin kolayca ve/veya yeterli doğrulukta hesaplanmasındaki güçlüktür. Ayrıca matrisler dağınık(sparse) matrislerdir. Yani matrisin boyutuna oranla çok az sayıda matris elemanları sıfırdan farklı büyüklüğe sahiptirler ve bilgisayar hafızasında boşuna yer kaplayacak sıfır değerli matris elemanları sorun yaratır. Bu sorunların her biri için sayısal yöntemler geliştirilmiştir [11].

### 4.1.1 Varyasyonel Yöntem

Birçok diferansiyel denklemde istenilen çözüm, V gerçel uzayında belirtilmiş bir $F$ fonksiyonelini minimize etme özelliğine sahiptir. Çözümü sağlayan fonksiyon, o fonksiyonu durağan yapmaktadır. Dolayısıyla sınır değer probleminin çözümü, V uzayında *F* fonksiyonu bilmekle aynı anlama gelmektedir. Bu yüzden problem, o sınır değer problemin varyasyonel formülasyonu olarak adlandırılır.

Bu metodun avantajları iki ve üç boyutlu sistemlere uygulanabilmesinin yanında dezavantajı belirli problemlerde varyasyonel fonksiyonun bulunmasıdır ki zamana bağlı problemlerin varyasyonel formu yoktur [11].

Varyasyonel yöntemde, diferansiyel denklemin fonksiyonelini oluşturmada zaman zaman sıkıntılar yaşanmaktadır. Ritz tarafından geliştirilen yöntemle sınır değer problemine yaklaşık sonuçlar bulabilmek için ayrıklaştırma çoğunlukla gerekmektedir. Ritz yöntemiyle bu ihtiyacı V uzayına ait N boyutlu bir $V_N$ alt uzayı seçerek yerine getirmektedir. $V_N$ alt uzayında $u_{yak}(\vec{r})$ fonksiyonu, birbirinden lineer bağımsız N adet şekil fonksiyonları takımı ile belirtilir, Dolayısıyla,

$$u_{yak}(\vec{r}) = \sum_{i=1}^{N} c_i \; S_i(\vec{r}) \qquad (4.\ 1)$$

olacaktır. Denklemdeki $c_i$' ler bilinmeyen Ritz katsayılarıdır. $u_{yak}(\vec{r})$, $u(\vec{r})$ fonksiyonuna getirilen yaklaşımı gösterirken $S_i(\vec{r})$' ler ise şekil fonksiyonlarını göstermektedir. Bu metodun tanımlanabilmesi için aşağıda belirtilmiş olan tanımlara ihtiyaç duyulmakta olup Scaler çarpım için;

$$(g,\ f) = \int_v g(\vec{r})f(\vec{r})dV \qquad (4.\ 2)$$

Öklit $L_2$ normu için

$$\|u(\vec{r})\| = (u(\vec{r}),\ u(\vec{r}))^{1/2} \qquad (4.3)$$

Ve bilineer form olan A için,

$$A(u,\ u) = \int_v \{ D(\vec{r})[\vec{\nabla} u(\vec{r})]^2 + B(\vec{r})\, u^2(\vec{r})\}dV \qquad (4.\ 4)$$

tanımlarını kullanacağız. Biliyoruz ki $u(\vec{r})$ aşağıda belirtilen fonksiyoneli minimize etmektedir.

$$F[u(\vec{r})] = A(u,\ u) - (q,\ u) \qquad (4.5)$$

Burada (4. 1) yaklaşımı ve (4. 4) bilineer olma durumu, (4. 5)' de yerine konulduğunda

$$F[u(\vec{r})] = A\left(\sum_{i=1}^{N} c_i\ S_i(\vec{r}),\ \sum_{j=1}^{N} c_j\ S_j(\vec{r})\right) - \left(q_{yak}(\vec{r}),\ \sum_{i=1}^{N} c_i\ S_i(\vec{r})\right), \tag{4. 6}$$

$$= \sum_{i=1}^{N}\ \sum_{j=1}^{N} c_i c_j\ A(S_i S_j) - \sum_{j=1}^{N} c_i\ (q_{yak},\ S_i), \tag{4.7}$$

ya da matris notasyonu kullanılması ile

$$F[u(\vec{r})] = C^T KC - C^T f \tag{4. 8}$$

Burada,

$C^T = [c_1\ c_2\ c_3\ \ldots\ c_N]$,

$$F = \begin{bmatrix} q_{yak}, & S_1 \\ q_{yak}, & S_2 \\ \cdot & \\ \cdot & \\ \cdot & \\ q_{yak}, & S_N \end{bmatrix},$$

$$K = \begin{bmatrix} A(S_1,\ S_1) & A(S_2,\ S_1) & A(S_N,\ S_1) \\ A(S_1,\ S_2) & A(S_2,\ S_2) & A(S_N,\ S_2) \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ A(S_1,\ S_N) & A(S_2,\ S_N) & A(S_N,\ S_N) \end{bmatrix}, \tag{4. 9}$$

$S_i$ şekil fonksiyonların belirlenmesiyle, (4. 1) denklem takımındaki $c_i$ katsayıları kolayca hesaplanır ve skaler çarpım işlemlerinden sonra, fonksiyonel, katsayıların indirgenmiş fonksiyonu haline gelir. Bilinmeyen katsayılar ise $F[u(\vec{r})]$ ' nin $c_i$' lere göre,

$$\frac{dF}{dc_i} = 0,\quad i = 1,\ 2,\ \ldots,\ N, \tag{4. 10}$$

türevlerinin alınması ile belirlenir. Sonuç olarak,

$$KC - f = 0 \quad (4.\ 11)$$

matris notasyonu ile gösterilen, cebirsel denklem takımı elde edilmiş olur.

Bu işlem dizileri sonucu oluşturulan matris, K, dağınık yapıda simetrik bir matristir. Çözülmek istenen bölge pratikte sonlu elmanlar adını alan alt bölgelere ayrılırlar. Her bir eleman için denklem (4. 11) ayrı ayrı uygulanır ve oluşturulan eleman matrisleri bütün sistemi temsil eden matrise bir kural dâhilinde uygulanır [11].

### 4.1.2 Ağırlıklı Kalanlar Yöntemi

Bu yöntem, lineer kendine ek problemlerin çözümünün yanında kendine ek olmayan problemlerde de çözüm sağlayabilmektedir. L lineer bir diferansiyel operatöre değinirsek, bu yöntemin kullanılabilmesi için yaklaşık çözüm öngörüsü yapılır,

$$Lu(\vec{r}) = q(\vec{r}) \quad (4.\ 12)$$

$$u_{yak}(\vec{r}) = \sum_{i=1}^{N} c_i\ S_i(\vec{r}) \quad (4.\ 13)$$

Burada amaç önerilen $S_i$' lerin birbirinden lineer bağımsız olmasıdır. Şekil fonksiyonların değişken bağımlılığında bir veya daha fazla değişkenin fonksiyonu olabilirler. $c_i$ katsayıları ise, bilinmeyen katsayılar ya da daha fazla bağımsız değişkenin fonksiyonları olabilirler. Burada bir yakınsamadan bahsedildiğinden eşitliğin sağlanması beklenmeyecek ve R kalanı olarak isimlendirilen bir hata ortaya çıkacaktır.

$$R = q_{yak}(\vec{r}) - L\sum_{i=1}^{N} c_i \; S_i(\vec{r}) \qquad (4.\ 14)$$

Bu ifadede $q_{yak}$, kaynak terimine de benzer yaklaşımın uygulandığını belirtir. Şekil fonksiyonlarının sayısı arttıkça kalan yok olmayacak ama küçülecektir. Hatayı yani kalanı yok etmek için kalanın, ele alınan bölgenin üzerinden ağırlaştırılmış integralini sıfıra eşitlemek gerekecektir. Burada ci, belirsiz parametre olmayıp fonksiyonsa,

$$\int_V W(\vec{r})R(\vec{r})dV = 0 \qquad (4.\ 15)$$

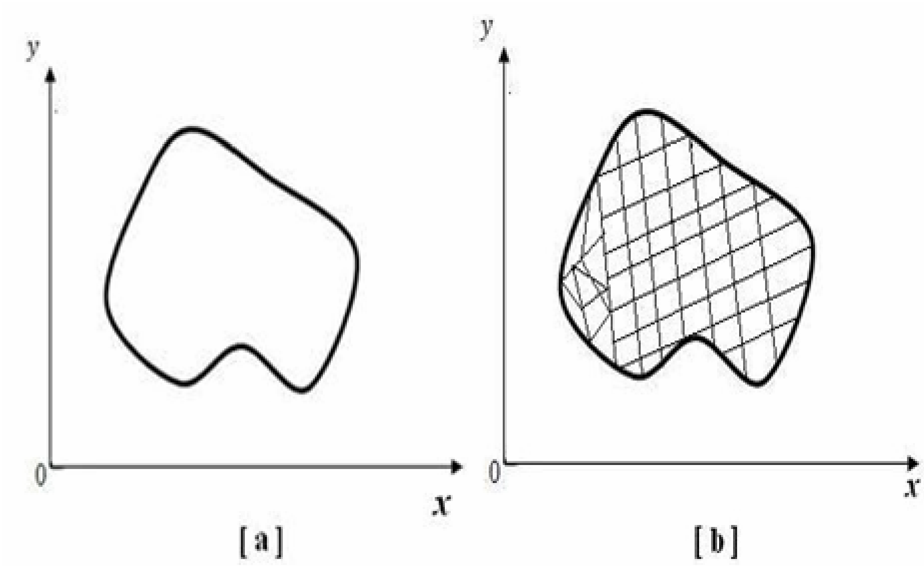
$c_i$ fonksiyonların bağlı olduğu değişkenler üzerinden diferansiyel denkleme indirgenir. Böylece (4. 14) denkleminin (4.15) denklemine uygulanmasıyla (4. 16) denklemi elde edilir.

$$(W, \; Lu_{yak}) = (W, \; q_{yak}) \qquad (4.\ 16)$$

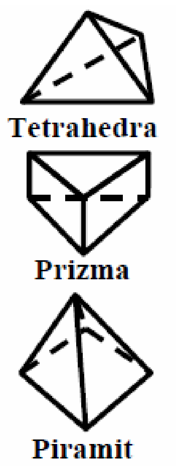
Ritz ve ağırlaştırılmış kalıntılar yöntemi, diferansiyel denklemde deneme fonksiyonlarının olmasından doğan hataları çözüm bölgesi içerinde en aza indirgemek için kullanılmaktadır. Varyasyonel yöntem olan Ritz yönteminde seçilen deneme fonksiyonları sadece gerekli sınır şartları sağlamak durumundayken ağırlaştırılmış kalıntılar yöntemi, doğal sınır şartı denilen boşluk sınır şartını da sağlamak zorundadır. Ağırlaştırılmış kalıntılar yöntemindeki bu sorun kendine ek problemlere uygulanmasında Gauss teoremi ile çözülebilir [11].

### 4.1.3 Eleman Tipleri ve Şekil Fonksiyonları

İki boyutlu bir bölge sonlu elemanlar yönteminin uygulanması için Şekil 4. 1a, Şekil 4. 1b' de görüldüğü gibi alt bölgelere ayrılır. Bu alt bölgelere "elemanlar" adı verilmektedir.



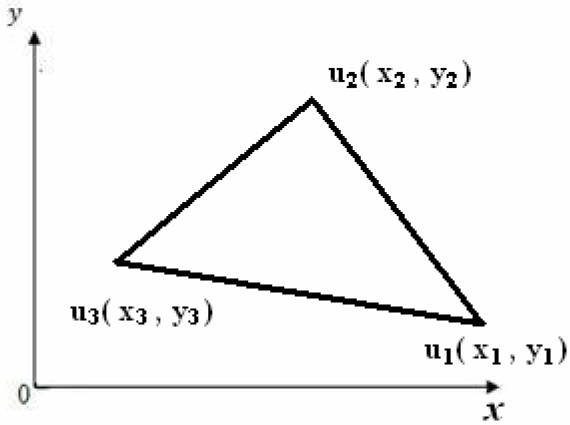

**Şekil 4.1 a)** Hesaplamanın yapılacağı bölge **b)** Sonlu alt bölgelerle gösterimi




**Şekil 4.2** Sayısal ağda kullanılan tetrahedra, prizma, piramit elemanlar. [11]

Bölge küçük elemanlara ayrılarak her eleman için çözümü aranan fonksiyona uygun bir yaklaşım belirlenir. Yaklaşım fonksiyonunun biçimi seçilen elemanın şekline ve ele alınan probleme bağlıdır. Probleme göre elemanlar arası sınırlarda sürekliliğin kaçıncı dereceden türeve kadar olması gerekliliği ortaya çıkar.

Bu gerekliliğe uygun eleman "sağlayan eleman" adını alırken pratikte süreklilik şartını sağlamayan elemanlarda kullanılmaktadır.




**Şekil 4.3** Üçgen sonlu eleman bölgesi. [11]

Üçgen bir sonlu eleman Şekil 4.2.' de gösterilmektedir. İncelenecek olan bölgenin bir alt bölgenin belirlenmesi istenen fonksiyonuna u(x, y) dersek şekildeki eleman bölge içerisinde yapılan yaklaşım,

$$u^{(e)}(x, y) = c_1 + c_2x + c_3y \quad (4.\ 17)$$

Fonksiyonun eleman üzerinde belirli düğüm noktalarda değerinin belirlenmesini sağlayacak hale getirildiğinde,

$$u^{(e)}(x, y) = \sum_{i=1}^{m} u_i^{(e)} S_i^{(e)}(x, y) \quad (4.\ 18)$$

(4. 17). denkleminde $u_i^{(e)}$' ler fonksiyonun üçgen köşelerinde belirlenecek katsayılar, şekil fonksiyonları $S_i^{(e)}(x, y)$' lerdir. Kullanılan elemanda belirlenen düğüm nokta sayısı denklem (4.18).' de kullanılan m ile ifade edilir ve Şekil 4.2.' deki elemanın düğüm sayısı 3' tür. Sistemi bir bütün olarak ele alındığında eleman ve elemanlara uygun yaklaşım fonksiyonları tanımlanarak sistem içerisinde tanımlı fonksiyon u(x, y)' ye yaklaşım $u^{(e)}(x, y)$ fonksiyonlarının tüm elemanlar için toplamı olarak denklem (4. 19). ifade edilir. Kısacası sistemi tanımlayan matris denklemleri oluşturulur.

$$u(x, y) \approx \sum_{e=1}^{E} u^{(e)}(x, y) \quad (4.\ 19)$$

Sonlu elemanlar kullanılan şekil fonksiyonları ile tanımlanmaktadır. Elemanın düğüm noktaları sayısı, yaklaşımda kullanılacak şekil fonksiyonlarındaki terimlerin sayısı ile belirlenir. Düğüm noktaları "iç" ve "dış" düğüm noktaları olarak ayrılırken dış noktalar elemanı komşu elemanlara bağlarken, iç düğüm noktaları komşu elemanlarca ortak kullanılmayıp elemanın kendi tanımlandığı sınırlar dahilinde kullanılır. Düğüm noktalarında hesap edilecek bilinmeyen fonksiyon sayısı olarak adlandırılan serbestlik derecesi terimi eleman başına bir olmaktadır. Düğüm noktalarında fonksiyonun kendisi ile birinci ve ikinci türevleri de hesaplanırsa elemanın düğüm başına serbestlik derecesi üç olur.

Burada düğüm noktalarının yerleştirilmesi esnasında dikkat edilmesi gerekenlerin başında, sınır yüzeylerde malzeme özelliği ani değiştiğinden matematiksel olarak sınır yüzeyler tekil noktalar oluşturduğu için sistem içerisinde değişik malzemelerden oluşan kısımlar varsa, bu kısımların sınırlarına yakın yerlerde düğümlerin daha sık aralıklarla yerleştirilmesi gerekmektedir. Aynı zamanda sayısal değerinin bulunması istenen fonksiyonun bulunduğu yerlere düğümlerin yerleştirilmesi gerekmektedir. Sistemin çözümlenmesinde ne kadar sık düğüm noktası atanırsa sonuçların kesinliğine o kadar yaklaşılmış olmakla beraber bilinmeyen sayısının artması da daha çok bilgisayar hafızasına gereksinim olacaktır [11].

# 5 ÇALIŞMA BÖLGESİNİN SONLU ELAMANLAR ANALİZİ

Bu bölümde Franc C. CALDWELL'in tasarımı örnek alınıp, bilgisayar ortamında çalışma bölgesi modellenerek, sonlu elemanlar yöntemini temel alan bir metal şekillendirme programında bu deformasyonun analizi yapılacaktır.

Bu tür Sonlu Elemanlar Analizlerinde izlenen temel yol şu şekildedir;

1. Sorun Ortaya Konur ve Çözüm için gerekli parametreler belirlenir,
2. Fiziksel Model oluşturulur (CAD),
3. Malzeme ve Analiz tipine göre Eleman tipi belirlenir(Element Type)
4. Sonlu Elemanlar Ağı (mesh) oluşturulur,
5. Fiziksel Modelden Yola çıkılarak Matematiksel Model oluşturulur,
6. Sınır Şartları Tanımlanır (BCC),
7. Analiz işlemi yapılır(solve),
8. Analiz sonuçları değerlendirilir (post process).

## 5.1 Tasarım Parametrelerinin Tayini

Bu çalışmada tasarımı yaparken, elimizde Caldwell'in yaptığı tasarıma ait herhangi bir sayısal veri olmadığı için çizimlerden ölçeklendirme yaparak tayin ettiğimiz değerler kullanıldı.

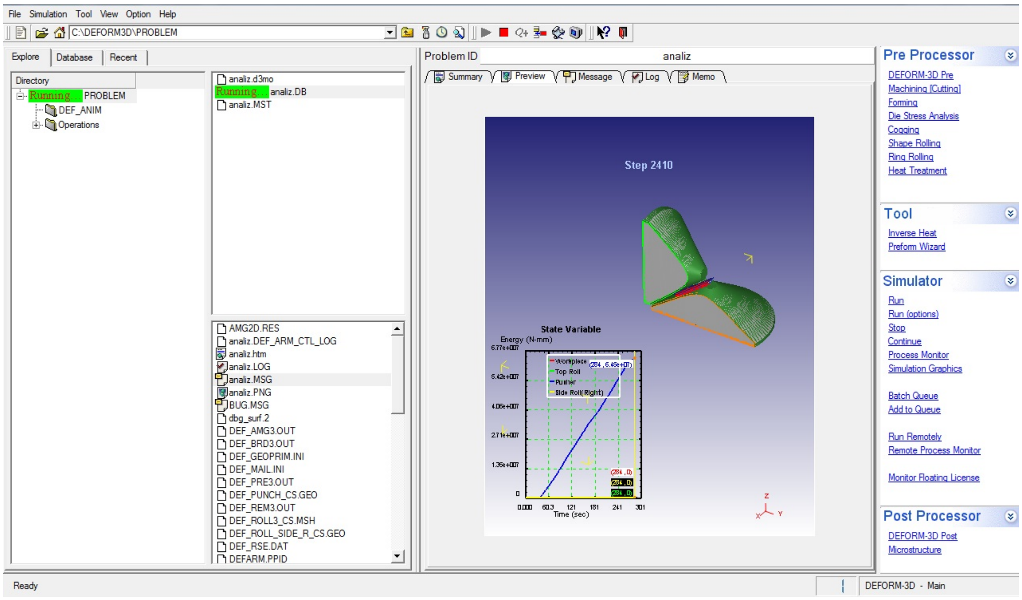
Tasarımda en önemli noktanın "çalışma bölgesindeki geçit" yani (roll pass) olduğunu belirten Caldwell, bunun yanında konik haddelerin aynı hızda tahrik edilmelerinin de dikkat edilecek ikinci bir nokta olduğunu vurgulamıştır.

## 5.2 Fiziksel Modelin Bilgisayar Ortamında Oluşturulması ve Analizi

Bu parametrelere göre çalışma bölgesinin tasarımı sonlu elemanlar analiz programında aşağıdaki adımlar izlenerek gerçekleştirilmiştir:

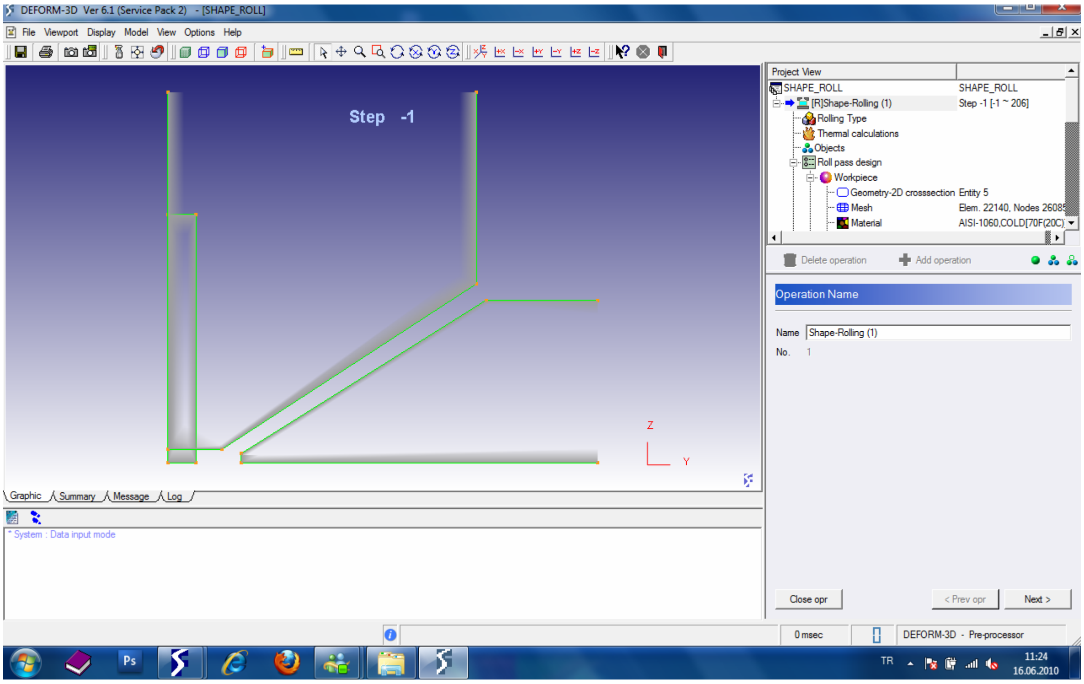
Öncelikle programın ana menüsünde ekranın sağ üst kısmında görülen Pre Processor kısmından analiz tipimize uygun olan şekillendirme Modülünü seçmemiz gerekmektedir.

Bu çalışmada programın “Shape Rolling” modülü kullanılmıştır.



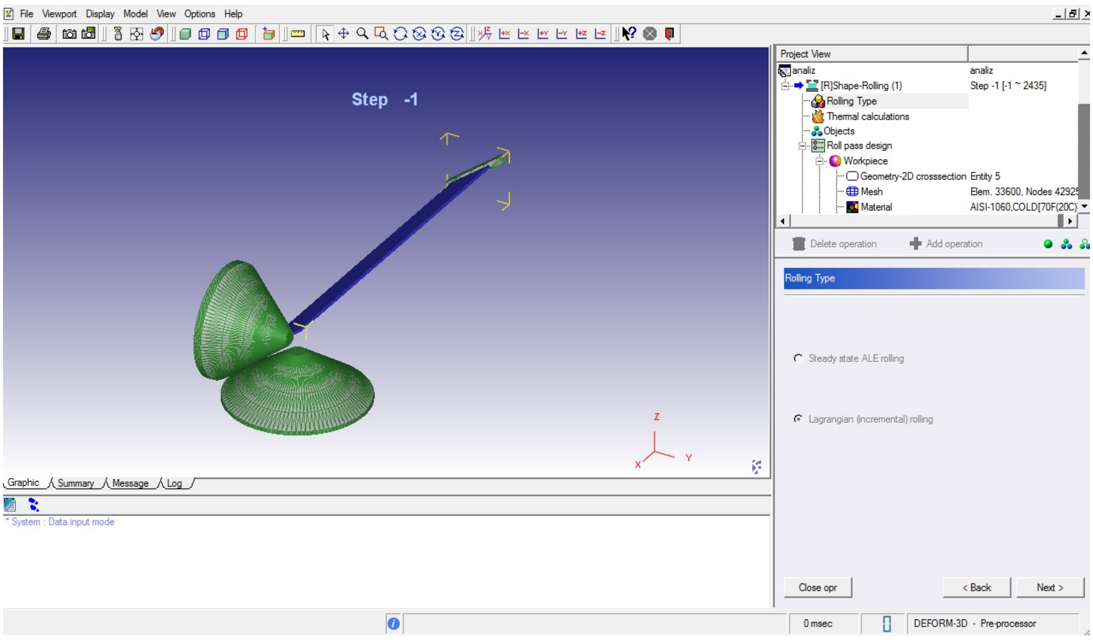

**Şekil 5.1** Ana Menü

Ana menüden Shape Rolling modülü açılıp gerekli bilgiler bu bölümden açılacak menülerde girilecektir.



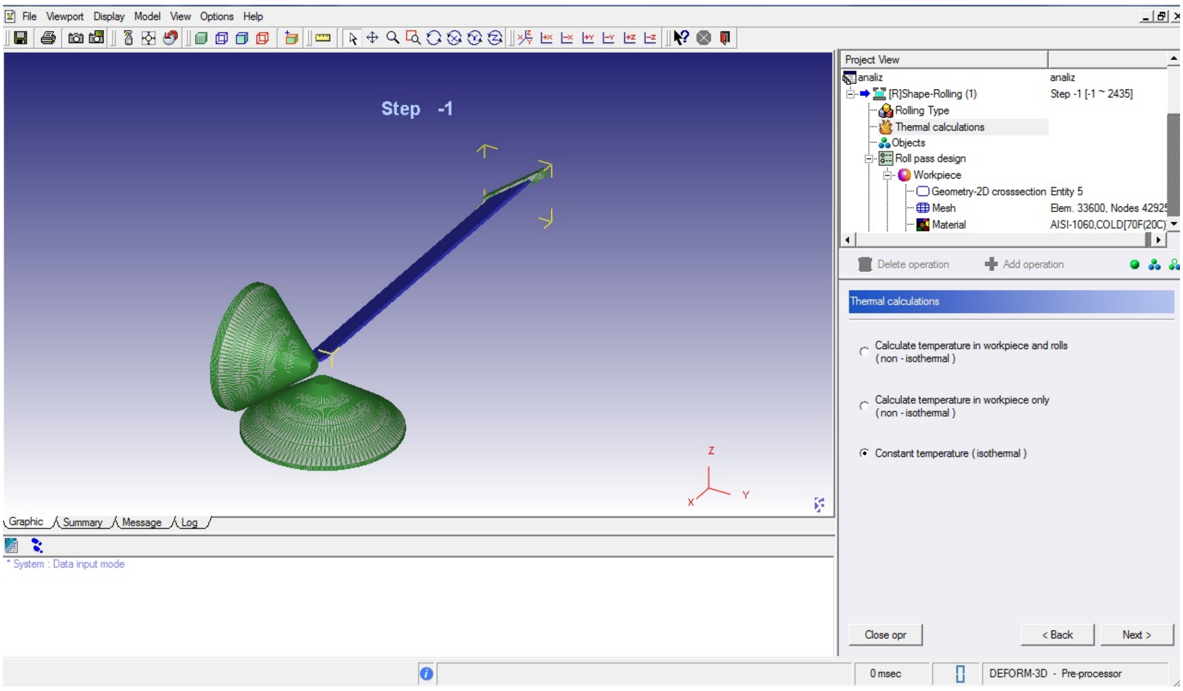

**Şekil 5.2** Shape Rolling Menüsü

Burada Rolling Type bölümünde, analiz tipi olarak Steady State ve Lagrangian(incremental) Rolling seçenekleri arasından Lagrangian Rolling seçilir. Bunun nedeni analiz tipinin zamana bağlı değişkenler içeren bir analiz tipi olmasıdır.



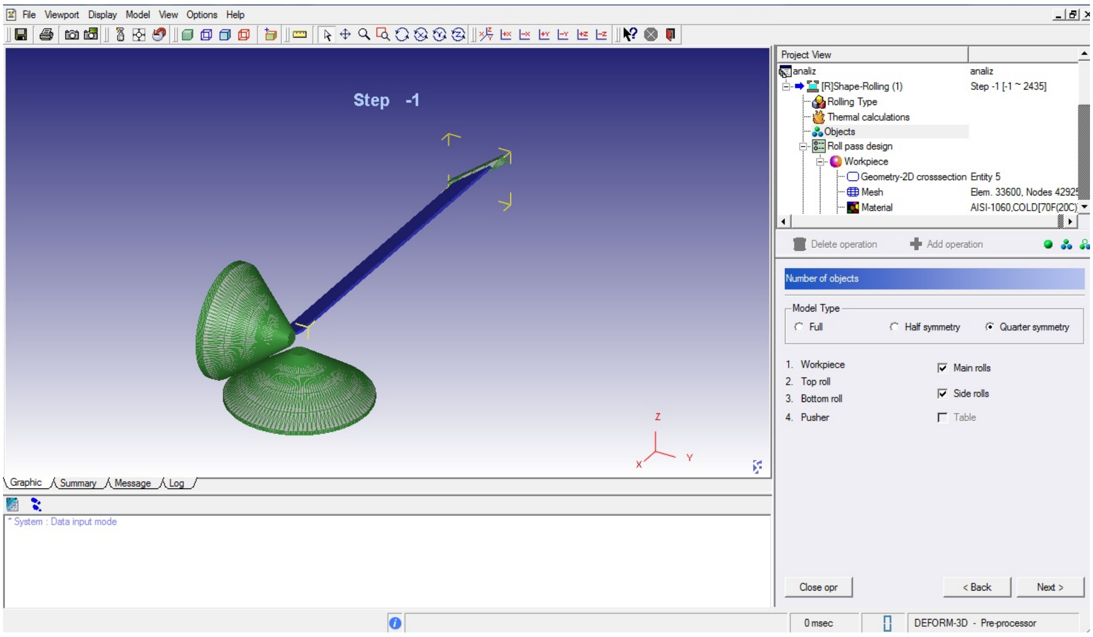

**Şekil 5.3** Rolling Type

Bunda sonraki adımda ( Thermal Calculations ) ısıl hesaplamaların nasıl yapılacağı ile ilgili veriler girilir. Yaptığımız çalışma ısıl işlem içermeyen, soğuk şekillendirme olduğu için bu kısımda “Constant Temperature” yani sabit sıcaklık seçeneği seçilir.



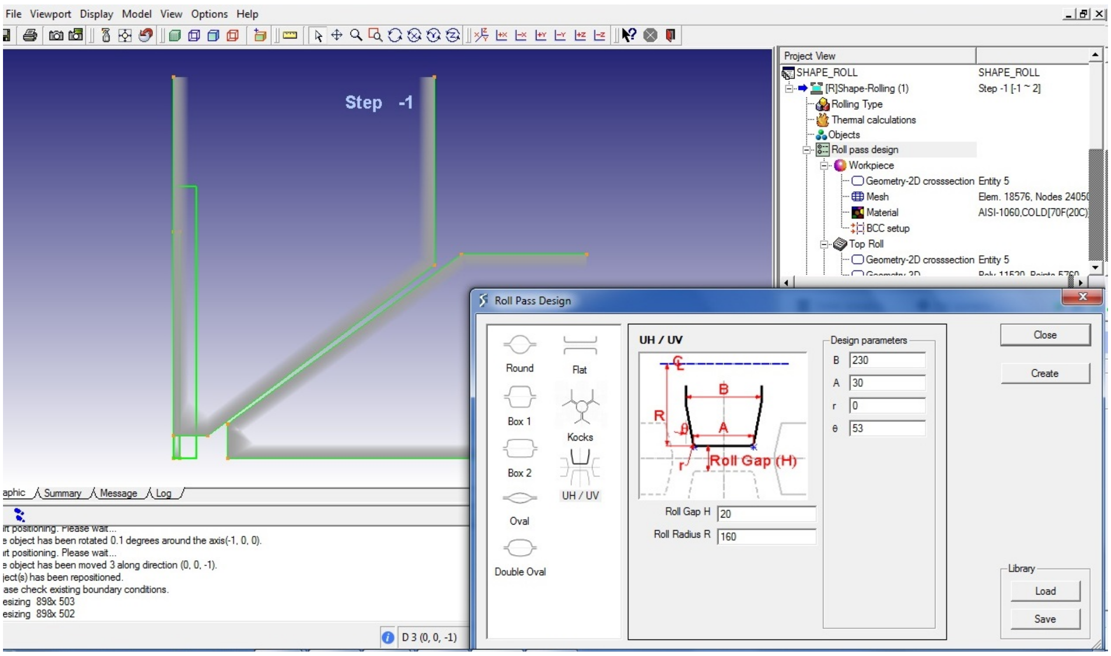

**Şekil 5.4** Thermal conditions

“Objects” kısmında çalışma bölgesinde bulunan konik haddeler ve çalışma parçasının tam,yarım yada çeyrek simetrik seçeneklerinden hangisi ile modelleneceğinin seçildiği kısımdır. Burada tasarımın simetri şartlarından faydalanılarak 4’te 1 oranında simetrik olarak tasarlanmıştır. Çünkü çalışmada sadece 4’te 1’lik bölüm analizimiz için yeterli olacaktır.

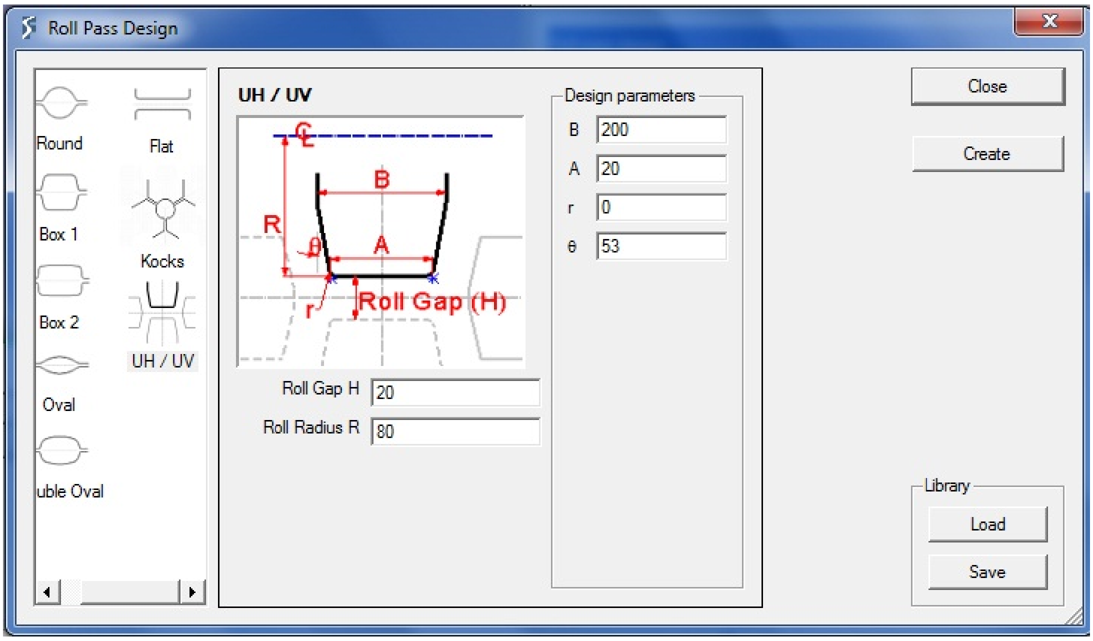



**Şekil 5.5** Objects

Roll Pass Design (haddeler arasındaki geçit) kısmında da haddeler ve çalışma parçasının boyutları girilip tasarım oluşturulur.




**Şekil 5.6** Main Roll




**Şekil 5.7** Main Roll'un (ana haddenin) boyutları

Ana hadde boyutları Şekil 5.7 de görüldüğü gibi;

B: Hadde genişliği = 200mm

A: Hadde alt genişliği = 20mm

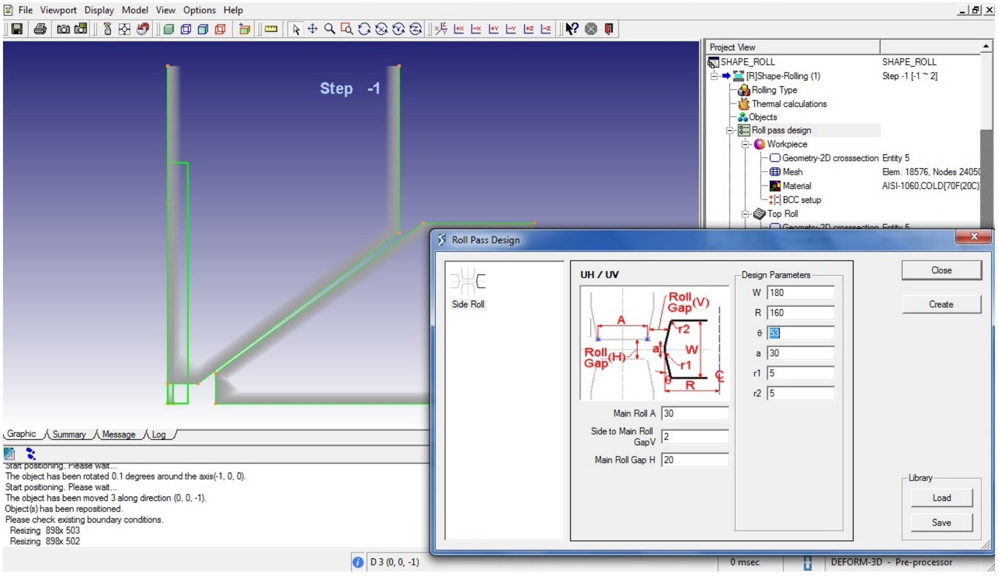
r: Yuvarlatma yarıçapı = 0

θ : Hadde eğim açısı = 53°

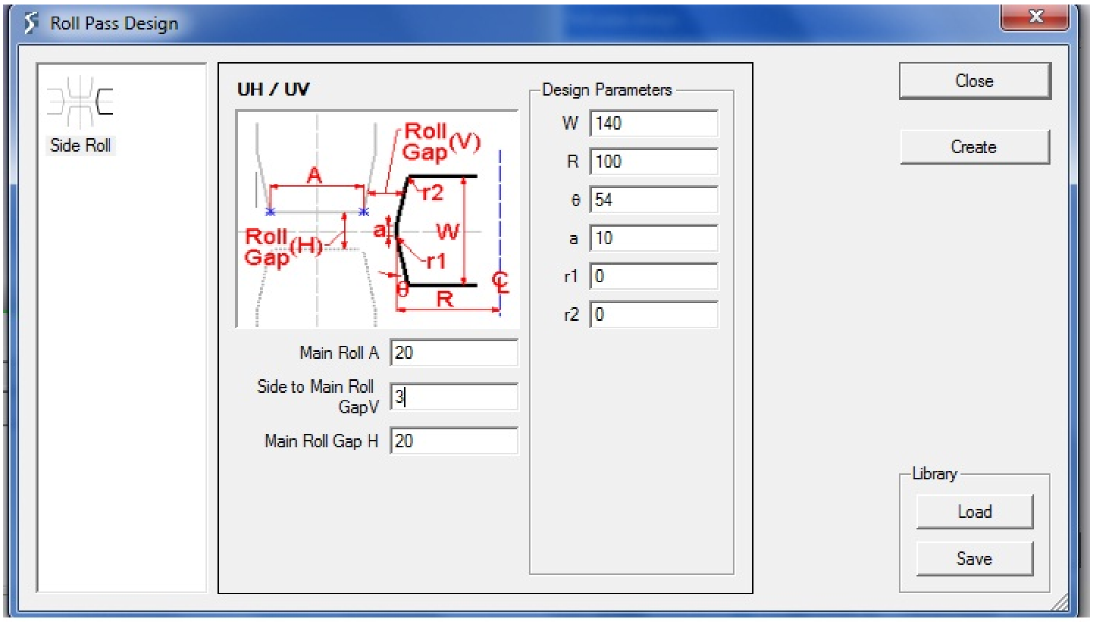
H: büyük haddeler arası mesafe = 20mm

R: Hadde yarıçapı = 80mm olarak girilir.

Ardından Side Roll'un (yanal haddenin) boyutları aynı şekilde girilir.



**Şekil 5.8** Side Roll(Yanal Hadde)




**Şekil 5.9** Side Roll(yanal hadde) boyutları

Yanal hadde boyutları Şekil 5.9 da görüldüğü gibi;

W: Hadde genişliği = 140mm

R: Hadde yarıçapı = 100mm

a: Hadde alt genişliği = 10mm

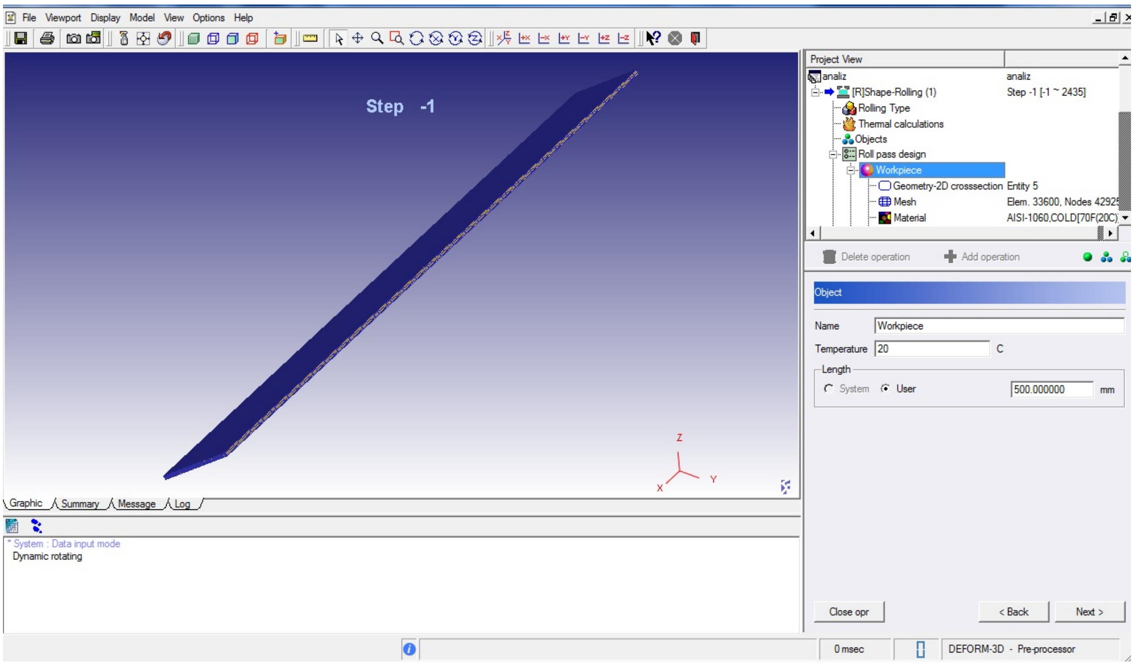
r1:  Yuvarlatma yarıçapı = 0

θ : Hadde eğim açısı = 54º

H: büyük haddeler arası mesafe = 20mm

V: Ana hadde ile yanal hadde arası mesafe  = 3mm

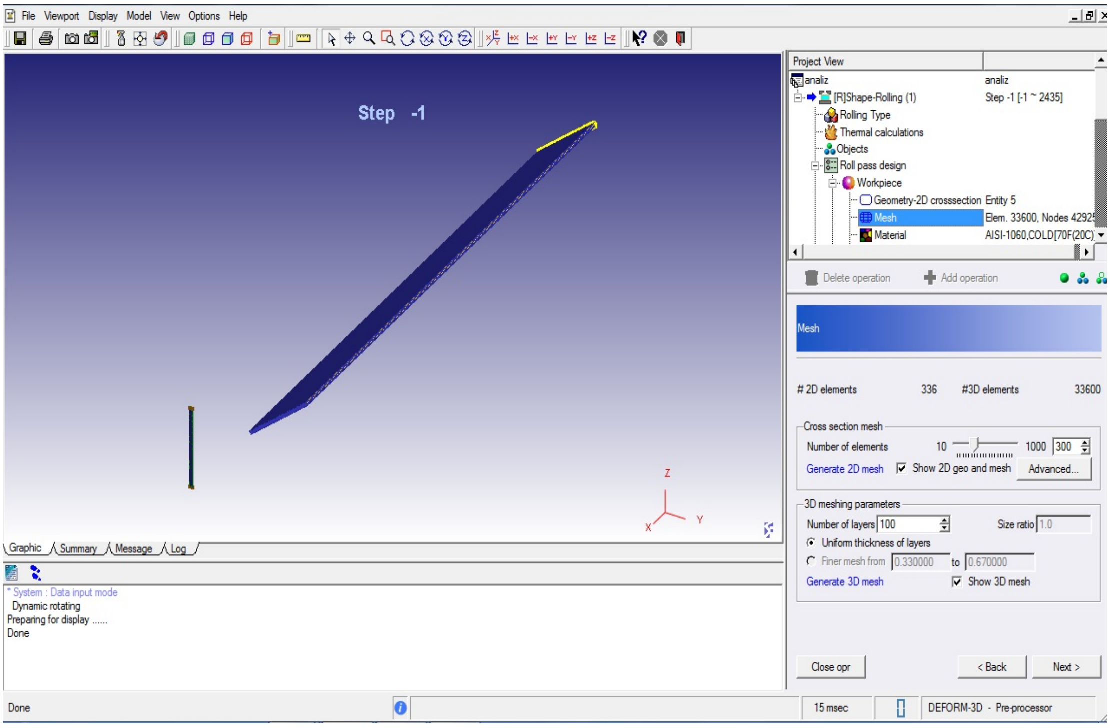
Hadde boyutlarının girilmesinin ardından bir sonraki menüden çalışma parçamızın uzunluk ve sıcaklık değerleri girilir.




**Şekil 5.10** Workpiece (çalışma parçası) boyutları

Parça uzunluğunun aşırı uzun belirlenmesinin; sonlu eleman ağının oluşturulması, oluşacak sonlu eleman sayısı ve dolayısıyla da analiz süresi gibi unsurları olumsuz etkileyeceği için uzunluğu 500 mm, saç kalınlığı 3mm olarak belirlendi.  Sıcaklık değeri ise-analizde ısı transferi hesaba katılmayacağından dolayı- programın default değeri olan 20ºC seçildi.

Bu adımın ardından çalışma parçasının sonlu elemanlar ağı (mesh) ile kaplanması işlemi gelmektedir.

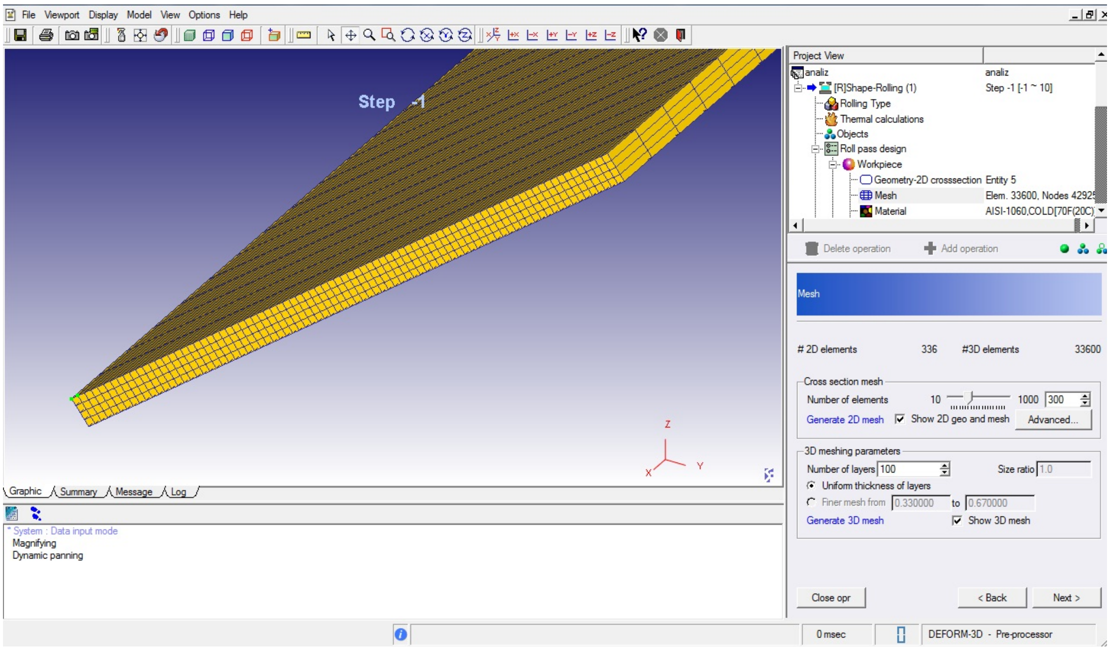



**Şekil 5.11** Çalışma parçasının sonlu eleman ağı (Mesh) ile örülmesi

Burada belirttiğimiz son analizden önce yapmış olduğumuz 60'a yakın sayıda analizin sonucunda görülmüştür ki; gerek istenilen formda bir şekil elde edebilmek, gerek parçalar arasında düzgün kontak noktaları oluşturabilecek bir ağ yapısı oluşturabilmek, gerekse analizin süresini optimum bir değere çekebilmek için en uygun meshin yaklaşık 300 eleman ve 100 katmandan oluşması gerekmektedir.

*"Number of elements"* kısmına 300, *"Number of layers"* kısmına ise 100 değeri girildi. Böylelikle 300 eleman ve 100 katmandan oluşan bir sonlu eleman ağı saç parça için belirlenmiş oldu. Eleman tipi konusunda bir değişiklik ya da seçim yapılmadı. Çünkü kullanmış olduğumuz program, saç ve metal şekillendirme işlemleri için geliştirilmiş bir analiz programı olduğu için, kendi seçeceği elemanlar en düzgün elemanlar olacaktır.

Bu değerlerin girilip meshin oluşturulmasının ardından Şekil 5.12 de sonlu elemanlar ağının düzgün olup olmadığı kontrol edilmiştir. Burada da görüldüğü gibi program en uygun ve temiz mesh yapısı için gerekli eleman tipini kendisi ayarlamıştır.




**Şekil 5.12** Çalışma parçasının sonlu eleman ağı kontrolü

Parçalar ve mesh ile ilgili istatistiki değerler ise Şekil 5.13'te verilmiştir.

**Current Step Information**

- Operation No 1 : Shape-Rolling (1)
- Mesh No : 1
- Step No : 10

- Number of object(s) : 5

- Object 1 : Workpiece
- Type : Plastic
  Mesh : Elements 33600 , Nodes : 42925
  Material : AISI-1060,COLD[70F(20C)]

- Object 2 : Top Roll
- Type : Rigid
  Primary die
  Geometry : Polygons 2600 , Points : 1302

- Object 4 : Pusher
- Type : Rigid
  Geometry : Polygons 60 , Points : 32

- Object 5 : Side Roll(Right)
- Type : Rigid
  Geometry : Polygons 2800 , Points : 1400

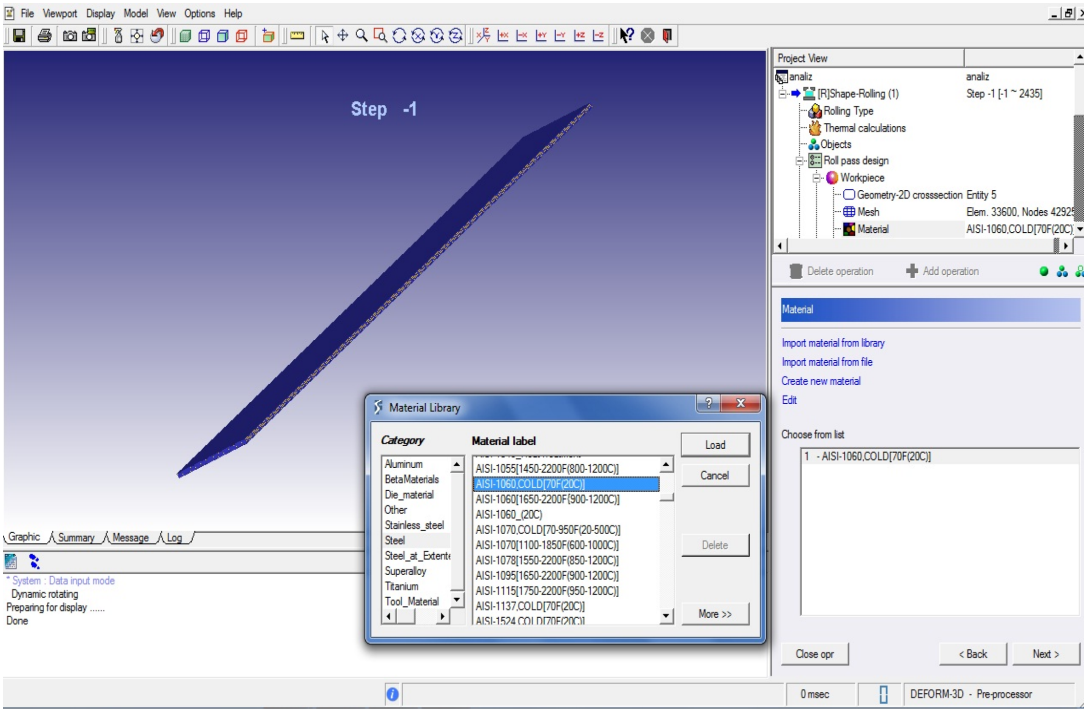
**Şekil 5.13** Çalışma parçasının parça ve sonlu eleman ağı bilgileri

Burada da görüleceği gibi sonlu elemanlar ağımız toplam 33600 eleman ve 42925 node (düğüm noktası) ‘ndan oluşmuştur.

Mesh işleminin kontrolünün yapılmasının ardından analizi yapılacak olan parçanın malzeme bilgisi sisteme tanıtılır.

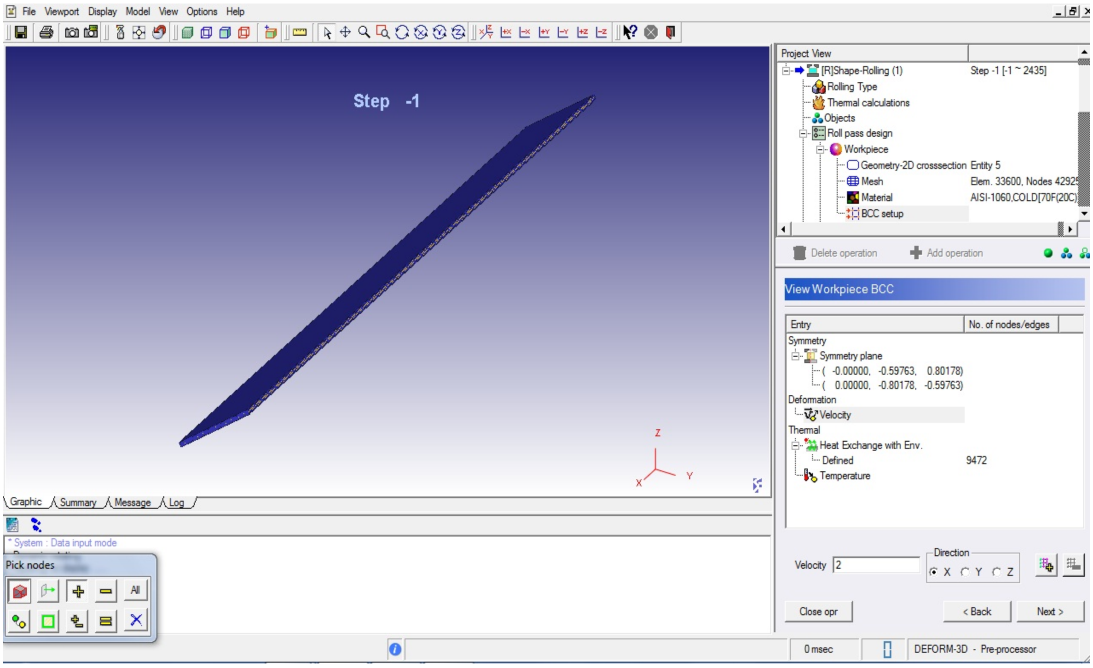
Bunun için bir sonraki menüden *Material* bölümünden programın veritabanında bulunan malzemelerden *AISI 1060 COLD[70ºF(20ºC)]* kodlu çelik malzeme seçilir. Bu malzemenin seçilme nedeni 20ºC oda sıcaklığında soğuk deformasyona uygun ve helezon imalatında St-37 ile birlikte kullanım alanına sahip bir çelik oluşudur.

Çalışma parçasının dışında kalan haddeler ve itici parçayı rijit kabul edip onlarda bir deformasyonun olmayacağı kabulü ile hareket ettiğimiz için onlara bir malzeme tayin etmemiz gerekmemiştir.




**Şekil 5.14** Çalışma parçasının malzeme bilgisinin girilmesi

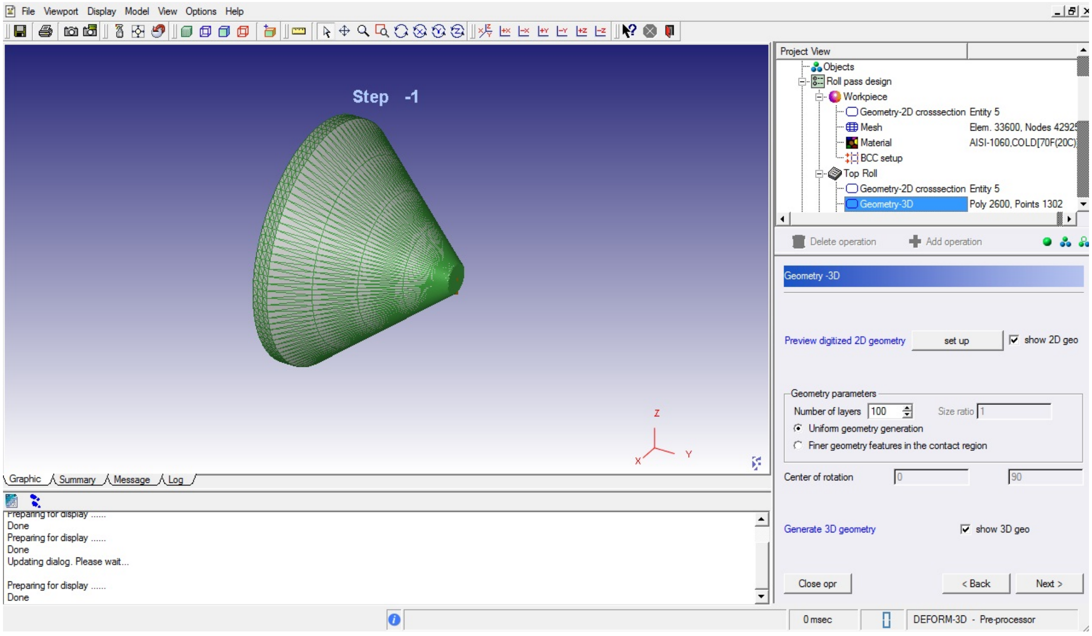
Bu işlemin tamamlanmasının ardından analiz ortamının sınır şartlarını programa tanıtma işlemi gelir. Bunu yaparken analizi yapılacak olan malzemenin simetri şartları, hareket yönü ve hızı, varsa termal şartları gibi başlangıç koşullarının programın ilgili menüsünden sisteme girilmesi gerekmektedir.




**Şekil 5.15** Sınır şartlarının girilmesi

Burada saç metal parçamızın modellenmesinde bir simetri olmadığı için bu kısımla ilgili bir değişiklik yapılmasına gerek yoktur. Hız değeri olarak X ekseninin pozitif yönünde 2 [mm/sn] hız değeri tanımlanır. Isı transferi olmadığı kabulünü yaptığımız için sıcaklık şartlarında da bir değişiklik yapılmaz.

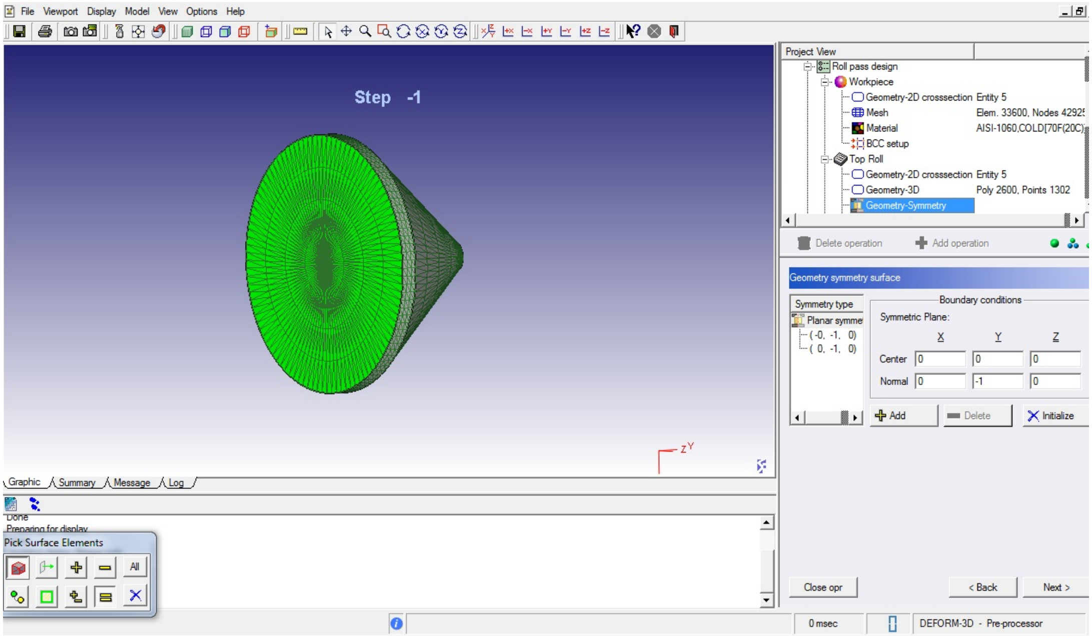
Sınır şartlarının girilmesinin ardından konik haddelerin ve itici elemanın 3D modellerinin oluşturulmasına geçilir.




**Şekil 5.16** Konik haddelerin 3D modelleri ve sonlu elemanlar ağı

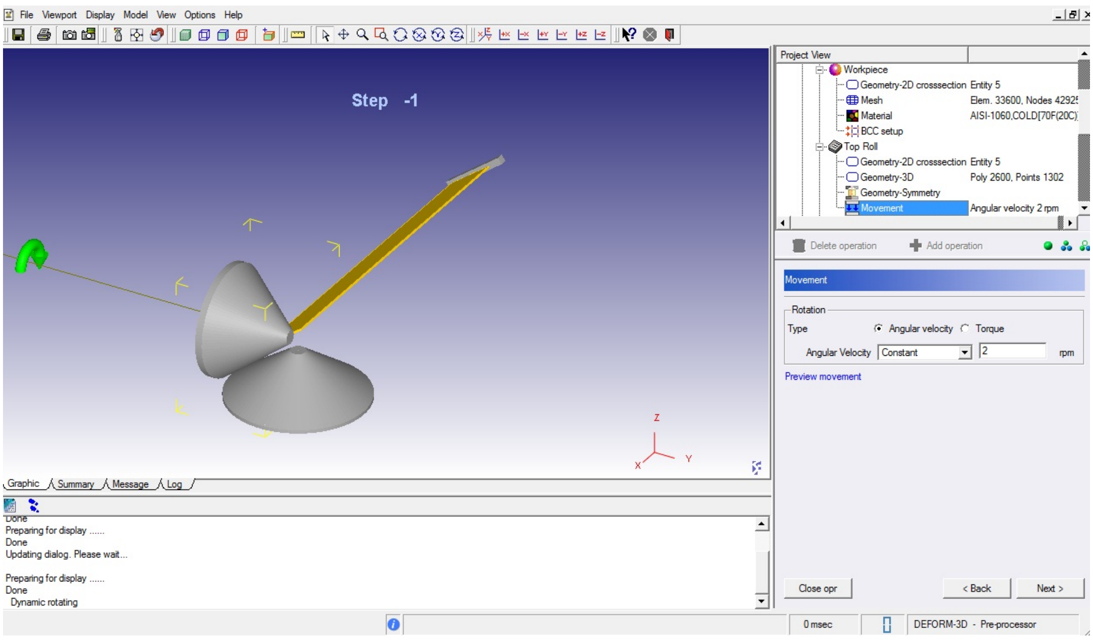
Bu bölümde daha önce boyutlarını tanımladığımız konik haddelerimizden *Top Roll'un* (ana haddenin) üç boyutlu modelinin ve sonlu elemanlar ağının oluşturulması işlemi gerçekleştirilir. Analiz süresinin kısa tutulması için ve de bu haddelerde deformasyon oluşmayacağı için haddelerdeki eleman sayısını saç metaldekilerden daha düşük tutmak daha mantıklı olacaktır. Eleman sayısını şekil 5.16'da da görüldüğü gibi 100 seçtik.

Bir sonraki adımda; hadde sisteminin modellenmesi esnasında quarter symmetry (çeyrek simetri) seçeneği seçildiği için simetrik olan yüzeylerin programa tanıtılması gerçekleştirilir.



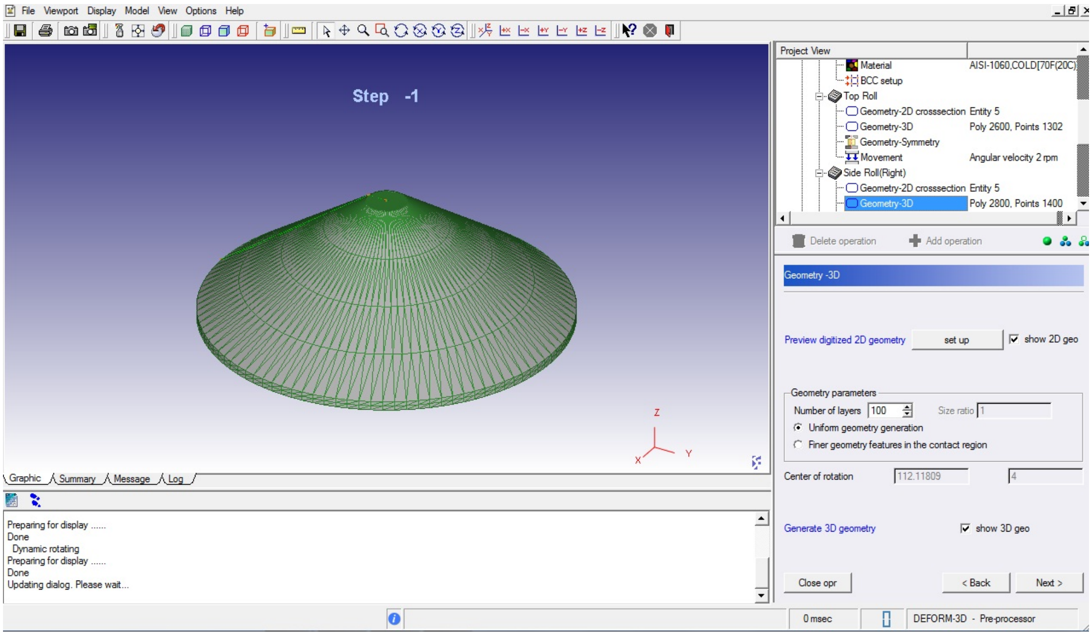
**Şekil 5.17** Top Roll(ana hadde)'un simetri şartı

Şekil 5.16.da da görüldüğü üzere haddenin arka yüzeyi simetri şartı tanımlanırken işaretlenir ve bir sonraki adıma geçilir. Burada ana haddenin dönme hızı belirlenir.

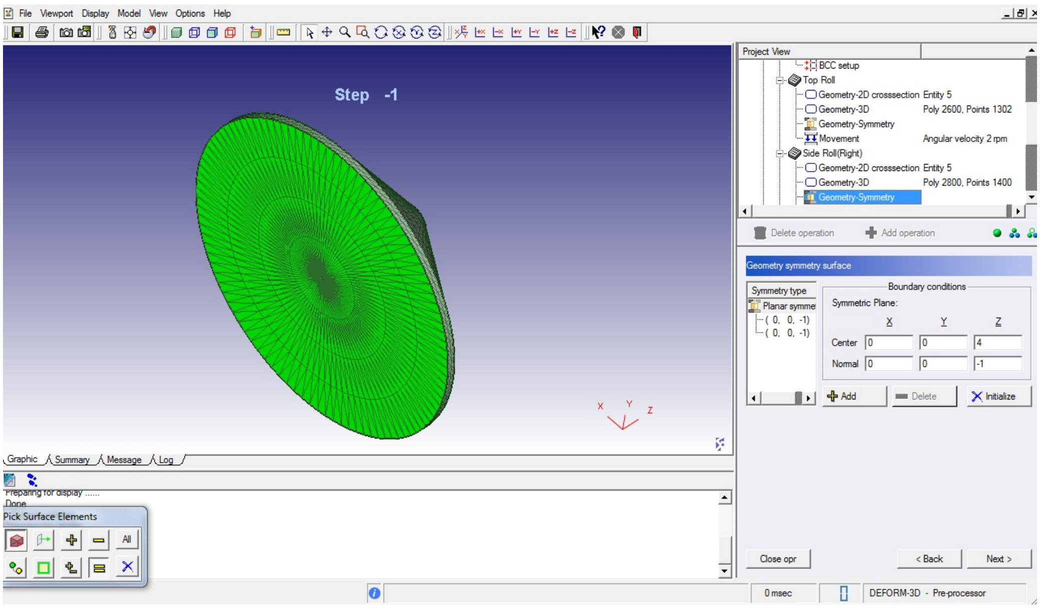


**Şekil 5.18** Top Roll(ana hadde)'un dönme hızı

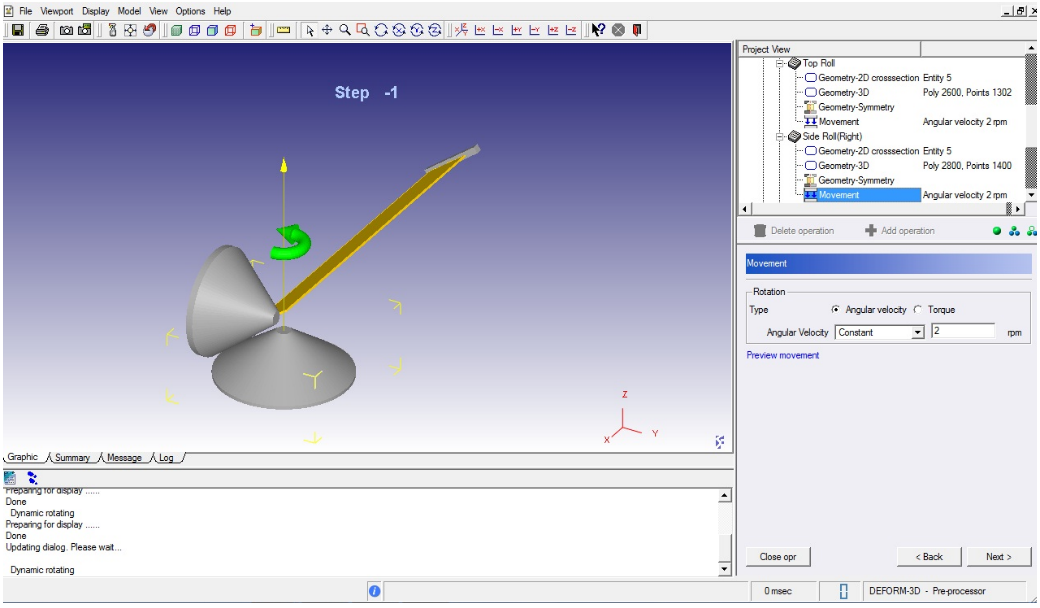
Ana haddenin hareketi dönme olarak belirlenir ve hızı da 2 [dev/dk] seçilir. Ardından *Side Roll'*un (yanal haddenin) 3D geometrisi ve sonlu elemanlar ağı oluşturulur. Ana hadde için yapılan işlemler ve değerlerin aynıları yanal hadde için de geçerlidir.




**Şekil 5.19** Side Roll'un (yanal hadde) 3D modeli ve mesh yapısı



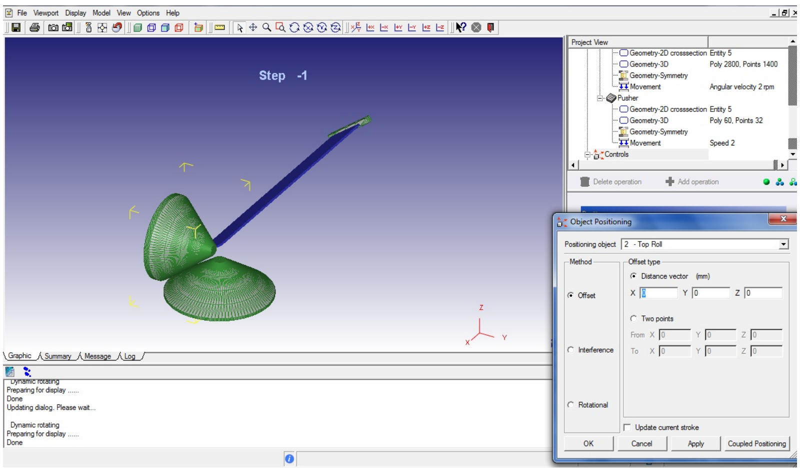

**Şekil 5.20** Side Roll'un (yanal hadde) simetri şartı



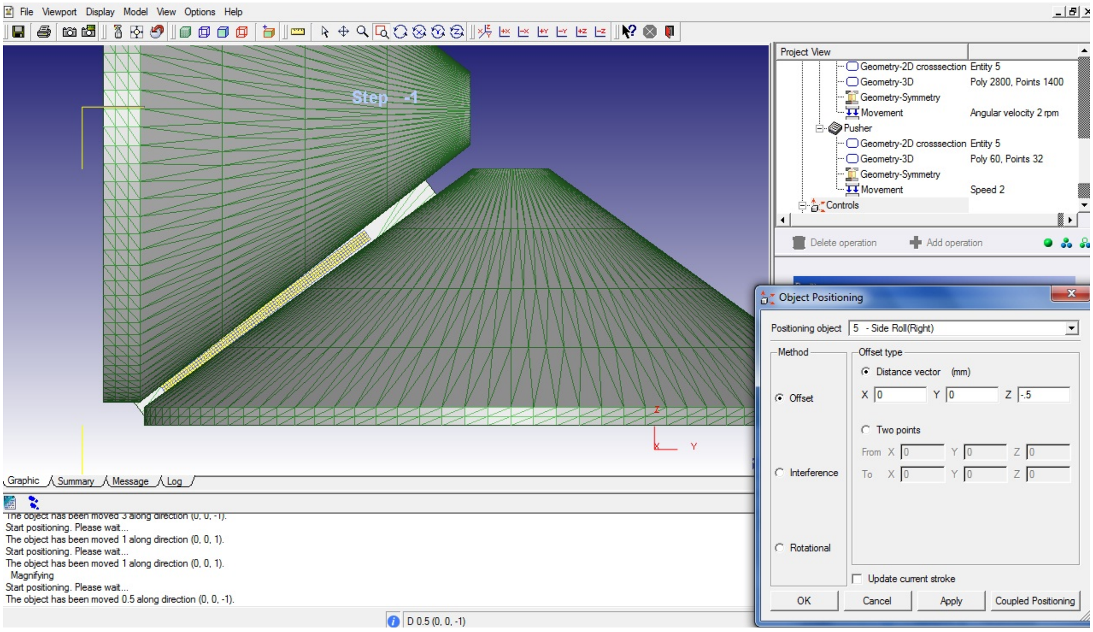

**Şekil 5.21** Side Roll'un (yanal hadde) dönme hızı

Yanal haddenin dönme hızı da ana hadde ile aynı ,yani 2 [dev/dk] olarak belirlenir.

Tüm bu tasarım işlemlerinin ardından çalışma bölgemizin nihai pozisyonunu vermek için *"object positioning*"(nesne konumlandırma) işlemi yapılır. Burada haddelerin birbirlerine göre konumları, saç metalin bu haddeler arasındaki konumu, itici elemanın saç metal ile temasının sağlanması gibi işlemler yapılır.

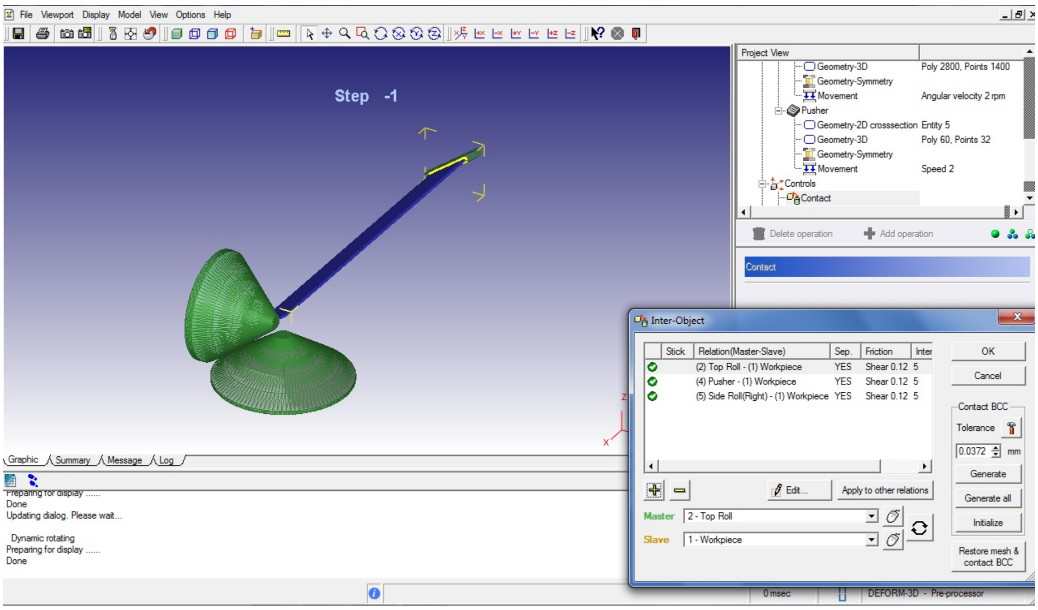



**Şekil 5.22** Nesnelerin konumlandırılması




**Şekil 5.23** Nesnelerin nihai konumları ve çalışma bölgesinin karşıdan görünüşü

Konumlandırma işleminin tamamlanmasının ardından analiz için gerekli olan kontak şartlarını belirler ve programa tanıtırız.



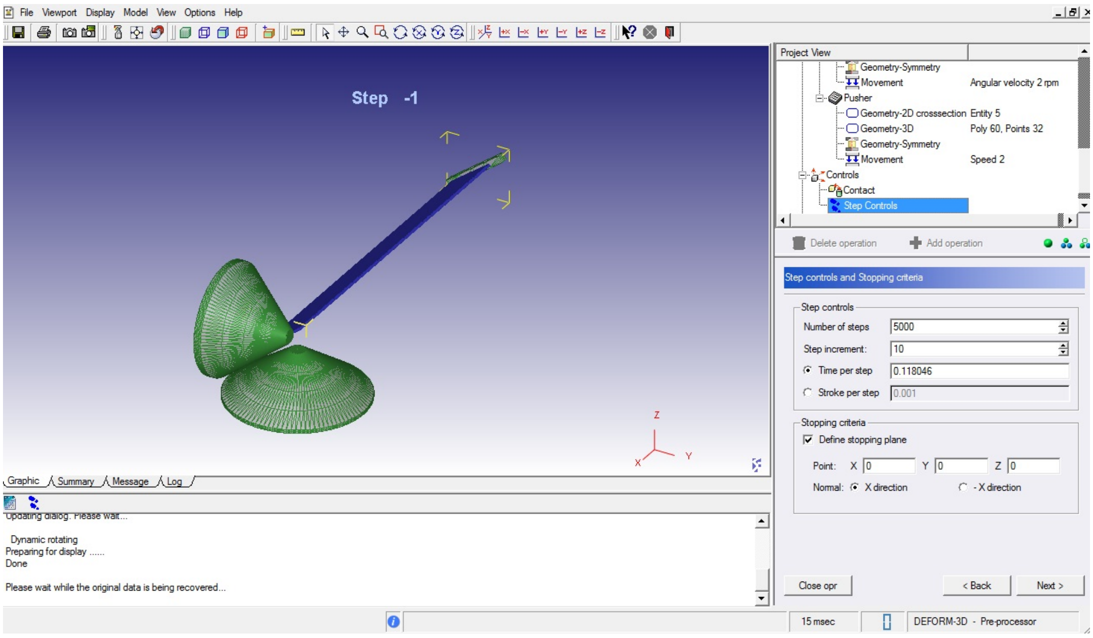

**Şekil 5.24** Nesnelerin arasındaki kontak şartlarının tanımlanması

Bu adımda parçalar arasındaki sürtünme katsayıları, birincillik ikincillik ilişkisi, ısı transferi katsayıları gibi temas şartları tanımlanır.

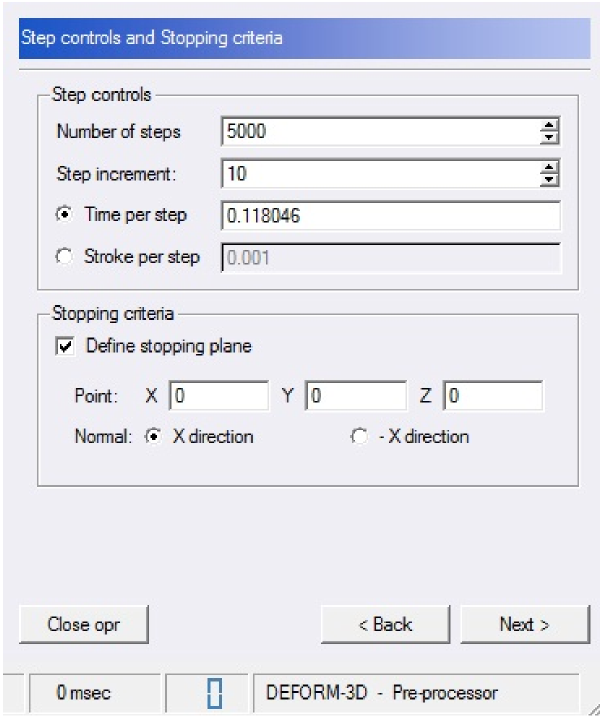
Bu analizde belirlediğimiz değerler;

- Sürtünme katsayısı: programın soğuk çekme işlemi için verdiği değer olan 0,12 değeri seçildi. Bu değer tüm parçalar arasındaki sürtünme için ortak değer olarak belirlendi. Asıl önemli olan konik elemanlar ile saç metal arasındaki sürtünme değeri olduğu için itici eleman ile saç arasındaki değer de 0,12 kabul edildi.
- Master (birincil) eleman olarak ana hadde,
- Slave (ikincil) eleman olarak ise saç metal seçildi.

Son olarak da *"Step Controls"* kısmında analizin kaç adımda çözdürüleceği, her bir adım arasında ne kadar sürenin geçmesi gerektiği gibi değerler girilerek analiz başlatılır.




**Şekil 5.25** Step controls menüsü

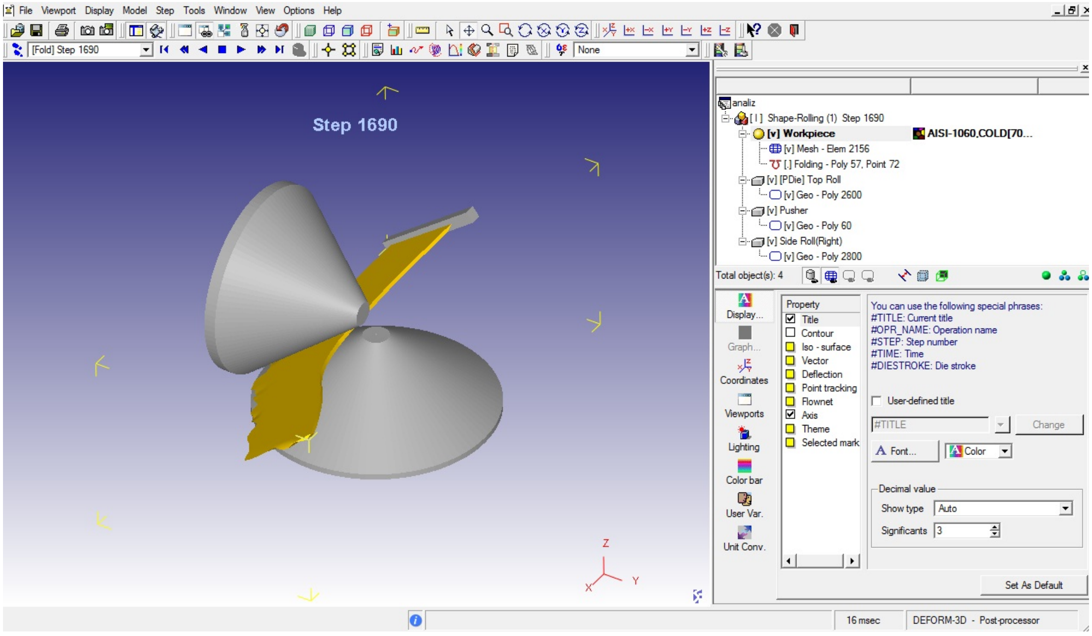



**Şekil 5.26** Basamak kontrol verilerinin girilmesi

Bu işlemin de tamamlanması ile analiz başlatılmaya hazır hale gelmiş olur. Çözdürme işleminin bitmesi ile birlikte saç metalin alacağı şekil kontrol edilecektir.

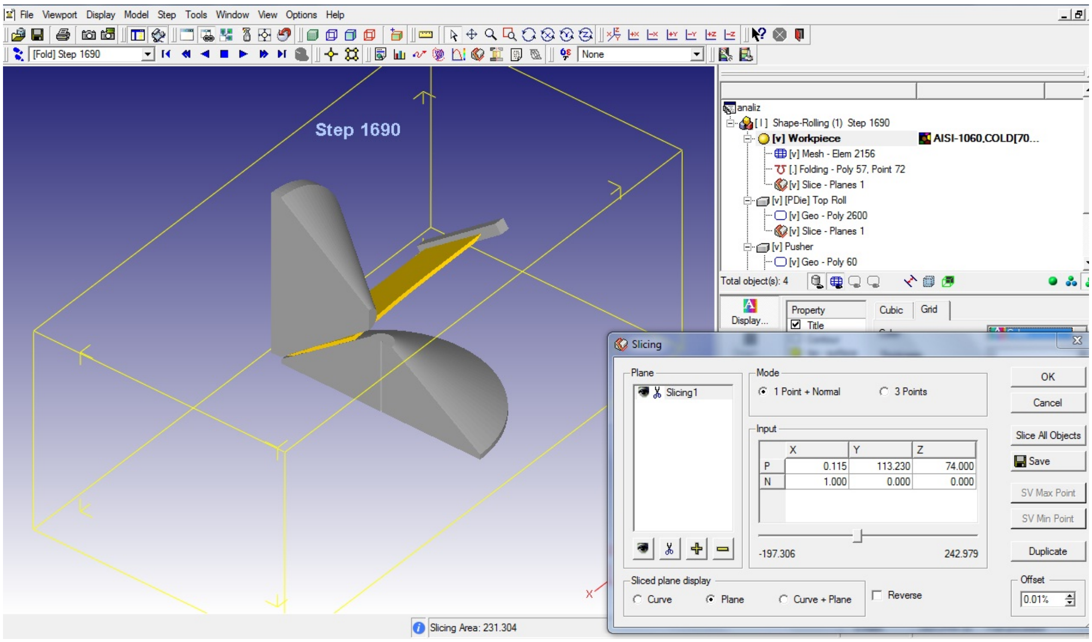
## 5.3 Analiz Sonuçlarının Elde Edilmesi ve Değerlendirilmesi

Çözüm işleminin bitmesinin ardından programın *"Ppost Process"* modülü açılarak analiz sonucunda malzemenin almış olduğu şekli,oluşan deformasyonu, çeşitli grafikleri ve mesh yapısındaki değişimi gibi verilere ulaşılabilir.

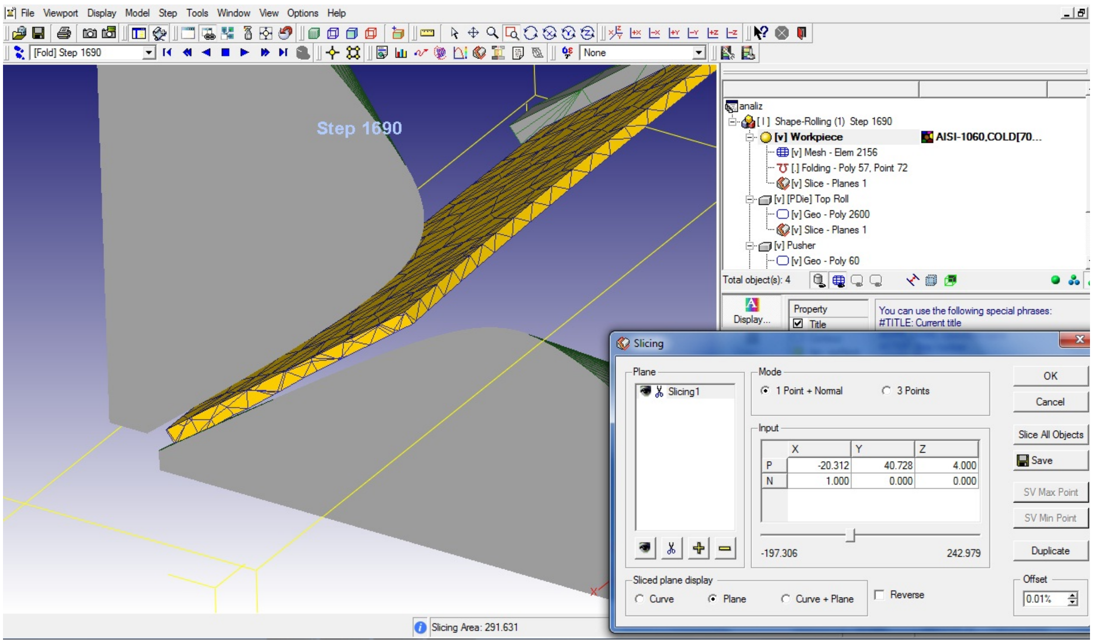


**Şekil 5.27** Post process menüsü

Burada da görüldüğü gibi haddeler arasından geçen saç öngörüldüğü gibi bir kıvrım göstererek haddelerin arasındaki geçitten geçmiştir. Programın bu modülünde kılavuz modelleme şansımız olmadığından dolayı saç metale tam anlamıyla spiral formu kazandırılamamıştır. Ancak görüldüğü üzere; saç metalin, koniklerin büyük çaplı olan yüzeyleri ile temas halindeki kenarının; koniklerin küçük çaplı kısımları ile temas halinde olan kenara oranla daha fazla uzamaya zorlanması sonucunda saç metal bizim istediğimiz forma yakın bir form kazanmıştır.

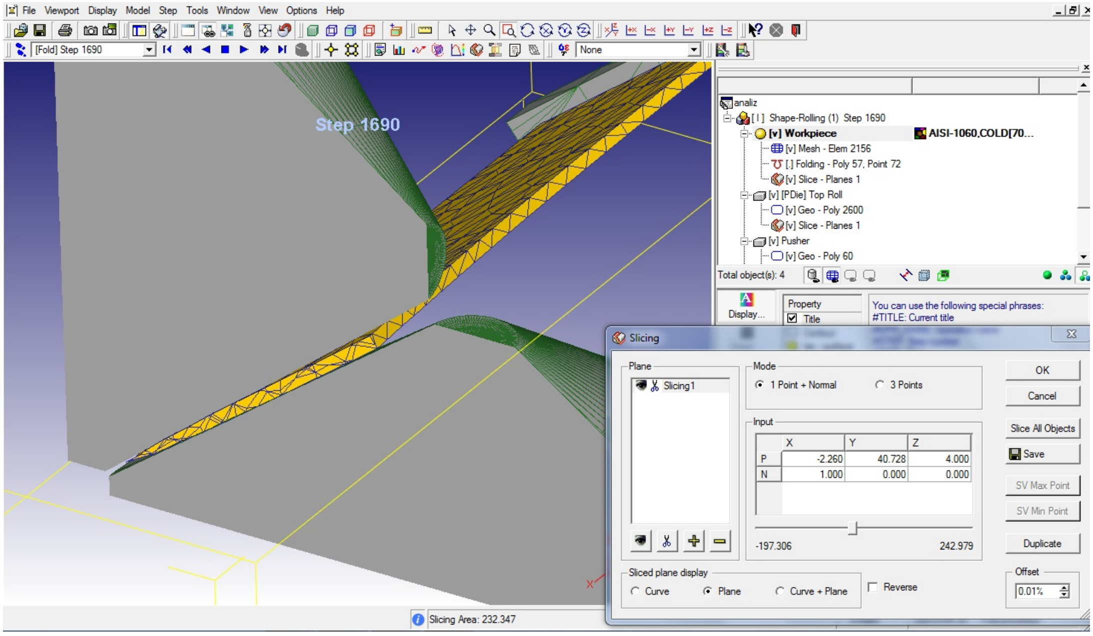


**Şekil 5.28** Saç metalin konikler arasından geçerken alınan kesit görünüşü

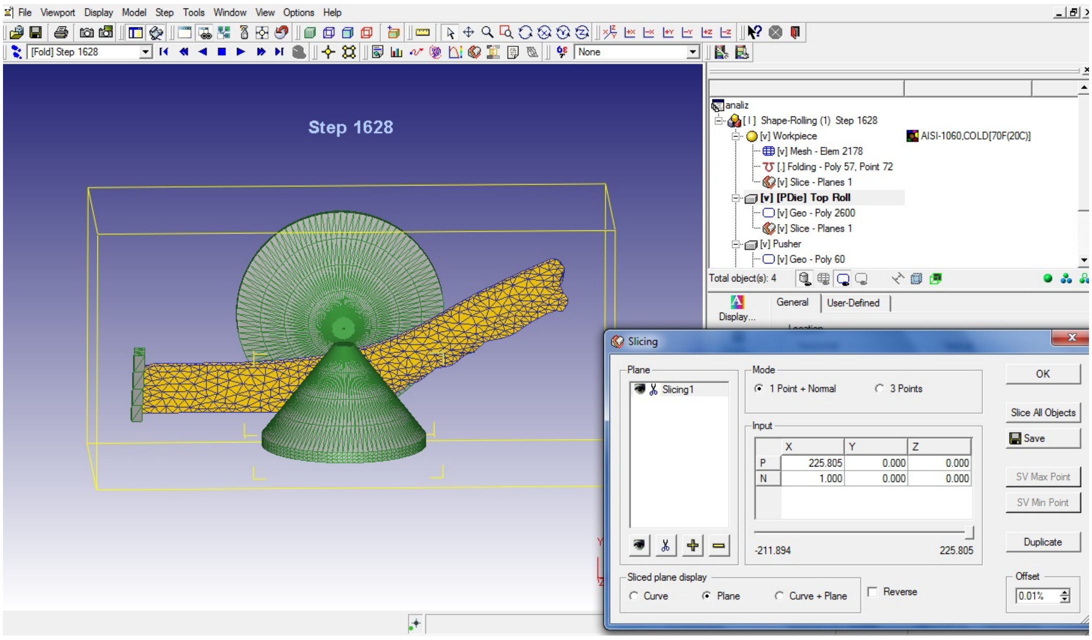


**Şekil 5.29** Saç metalin konikler arasından geçerken mesh yapısı

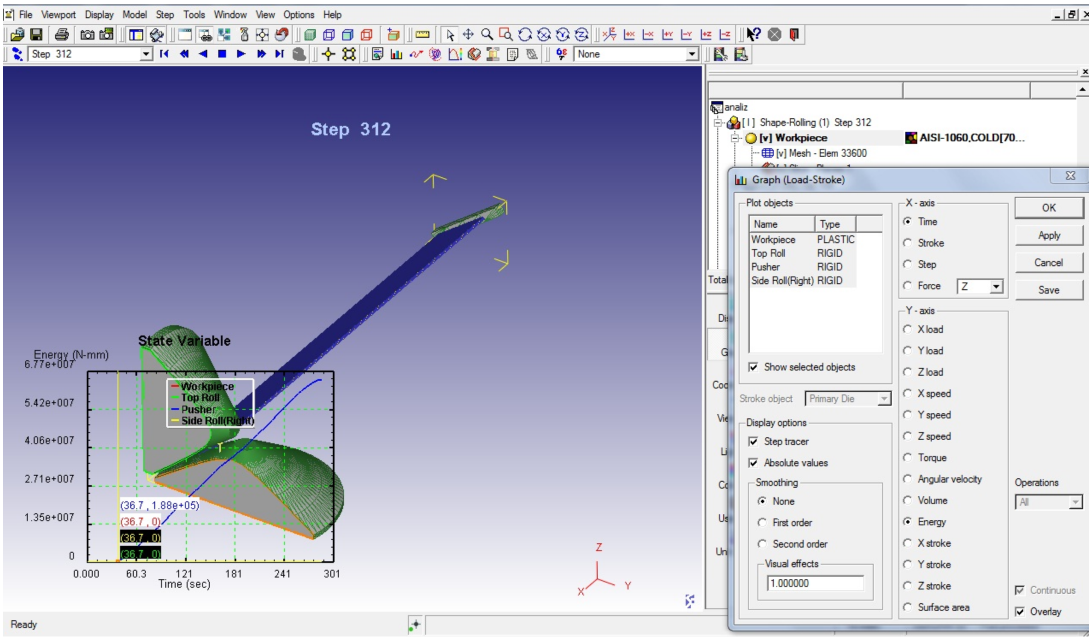
Şekil 5.29 ‘de saç metalin; koniklerin arasından geçerken henüz konikler tarafından deformasyona zorlanmadan önceki kesiti ve sonlu elemanlar ağ yapısı görülmektedir.



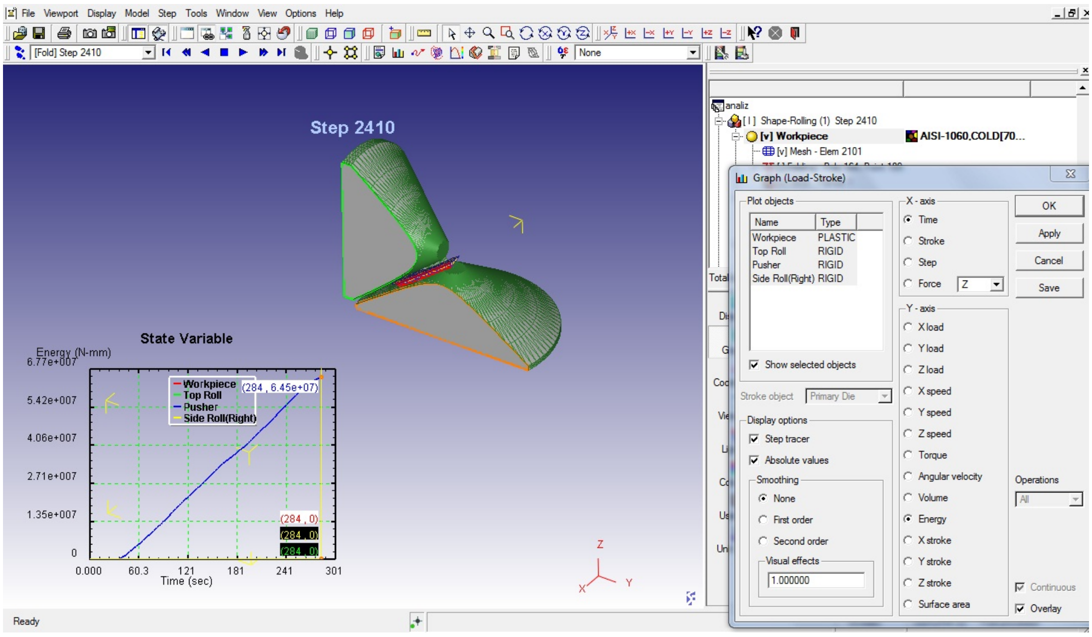

**Şekil 5.30** Saç metalin konikler arasındaki deformasyon başlangıcı




**Şekil 5.31** Saç metalin kıvrılması



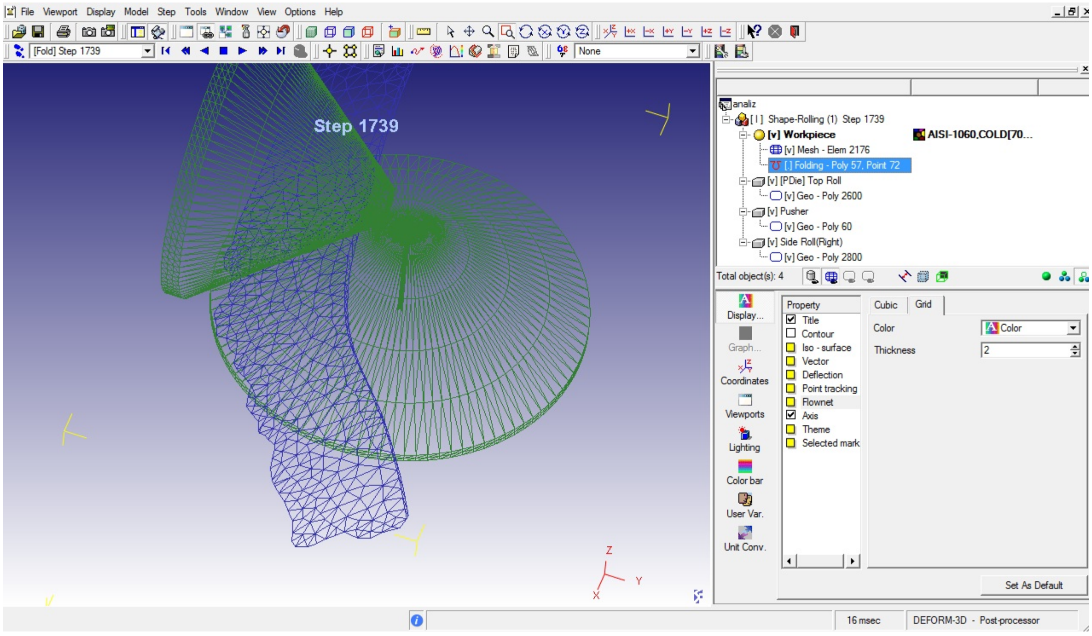

**Şekil 5.32** Saç metalin deformasyon başlangıcında absorbe ettiği enerji




**Şekil 5.33** Saç metalin deformasyon sonunda absorbe ettiği toplam enerji

Saç metalin bünyesinde oluşan şekil değiştirme enerjisi olarak nitelendirebileceğimiz enerjinin max. değeri yaklaşık olarak 6,45x$10^7$ [Nmm]dir.

Yani 64500000 [Nmm] lik bir enerjiye tekabül eden bu enerji değeri, saç metalin şekil değiştirirken tane sınırlarındaki bağların koparılabilmesi ve yeni kafes yapısının oluşması için gerekli enerjiyi bize yaklaşık olarak verir. Diğer bir deyişle toplam deformasyon enerjisi $6{,}45 \times 10^7$ [Nmm] dir.




**Şekil 5.34** Deformasyon sonrası mesh yapısı

# 6 SONUÇLAR VE TARTIŞMA

Yapılan uygulamada saç metalin kıvrıldığı ancak tam spiral şeklini almadığı görülmektedir. Bunun sebebi; kullanılan programda shape rolling modülünde kılavuz modelleme şansının olmayışından ötürü kılavuzsuz bir tasarım oluşturmak zorunda kalınmasıdır. Tasarım sahibi Franc C. CALDWELL'in patentinde belirttiği konumlara kılavuz konulması halinde arzu edilen spiral formun elde edilebileceği öngörülebilir.

Bununla birlikte daha detaylı ve daha esnek analiz ve mühendislik programlarının kullanılması ile, daha gerçekçi analiz sonuçları elde etmemizin mümkün olduğu olası görülmektedir.

Ayrıca saç metalin daha çok uzamaya, dolayısıyla daha fazla deformasyona maruz kalan kenarında yırtılmalar gözlemlenmiştir. Bunun muhtemel sebebi saç metalin yeterince sayıda sonlu elemana bölünememesidir. Ne kadar fazla eleman kullanılırsa, malzemede oluşacak şekil değişiklikleri o kadar iyi ifade edilebilir. Diğer bir deyişle analiz sonuçları gerçeğe daha yakın olur. Ancak kullanılan bilgisayarın bu çözümü gerçekleştirecek kapasitede olmayışı buna engel olmuştur.

Daha iyi sonuçlar için daha özel mesh programları kullanılarak, mevcut analiz daha güçlü bilgisayarlarda çözdürülebilir.

Bu analizde Core 2 Duo T8100 2.10 GHz işlemcili, 2 GB Ram özellikli bir bilgisayar kullanılmış ve analiz süresi yaklaşık olarak 74 saat sürmüştür.

Bunların yanında söylenebilir ki, sayısal analizler gerçek uygulamalar ve deneylerle desteklenir ve sonuçlar karşılaştırılırsa, daha optimum tasarımlar elde etme şansı artırılabilinir.

# 7 GENEL SONUÇLAR

Yapılan tasarım arzu edilen kıvrılmayı sağlamıştır. Ancak tam spiral forma ulaşılabilmesi için daha farklı ve esnek bir analiz programı kullanılabilir.

Bu yapılacak olan tasarımda kılavuzların, eklerde verilecek olan Franc CALDWELL'in tasarımındaki konumlara yerleştirilmesi sonuca yaklaşmak açısından önem taşımaktadır.

Bir diğer önemli husus ise daha kaliteli ve daha sık bir sonlu eleman ağı kullanılmasıdır. Bu sayede malzemedeki şekil değişikliği daha başarılı bir şekilde ifade edilebilir.

## EKLER

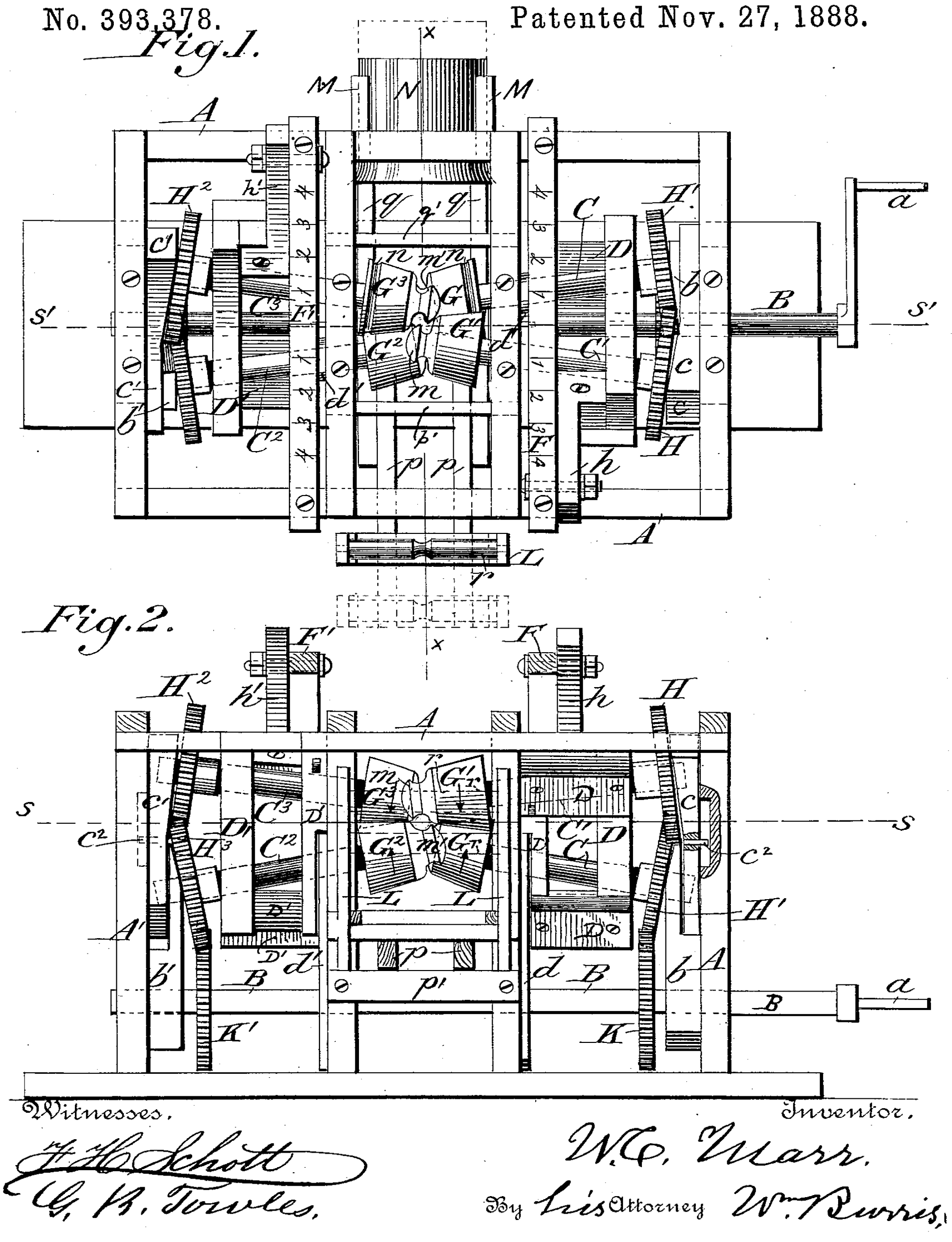
## EK A William C.MARR'ın Almış Olduğu Patent

(Model.) 3 Sheets—Sheet 1.

W. C. MARR.

MACHINE FOR TWISTING METAL AND FORMING SPIRAL CONVEYERS.

No. 393,378. Patented Nov. 27, 1888.




N. PETERS. Photo-Lithographer. Washington. D. C.

(Model.) 3 Sheets—Sheet 2.

W. C. MARR.

MACHINE FOR TWISTING METAL AND FORMING SPIRAL CONVEYERS.

No. 393,378. Patented Nov. 27, 1888.

Fig. 3.

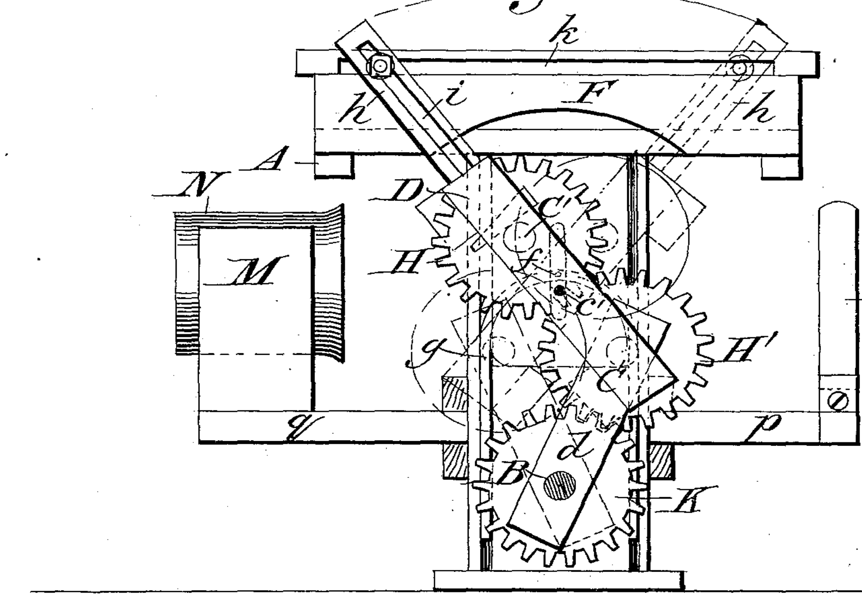
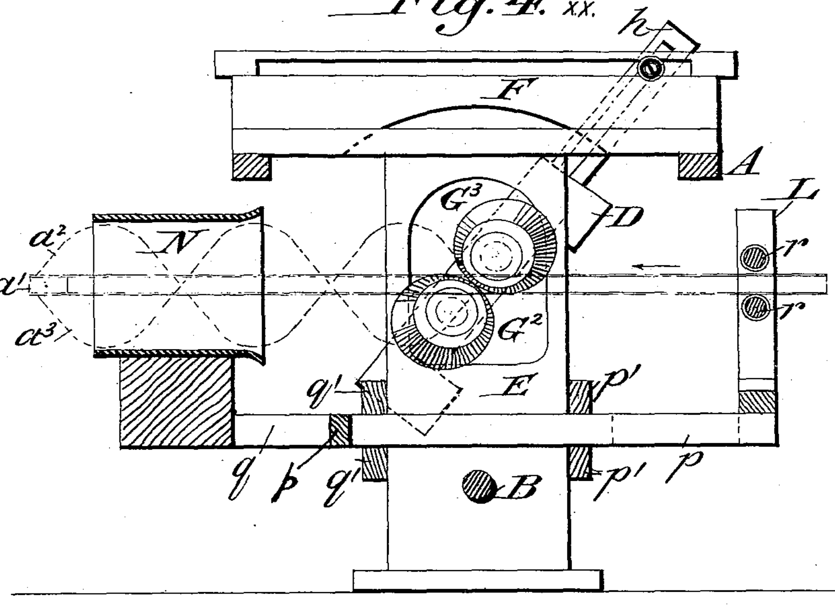



Fig. 4. XX.




Witnesses.
F. H. Schott,
G. B. Towles.

Inventor,
W. C. Marr,
By his Attorney Wm. Burris.

N. PETERS, Photo-Lithographer, Washington, D. C.

(Model.) 3 Sheets—Sheet 3.

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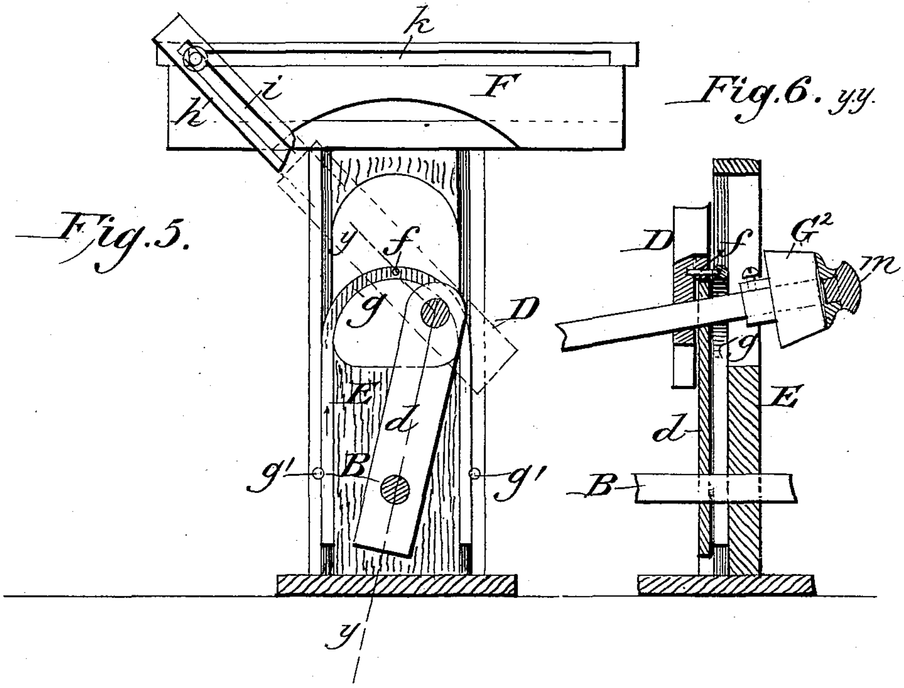
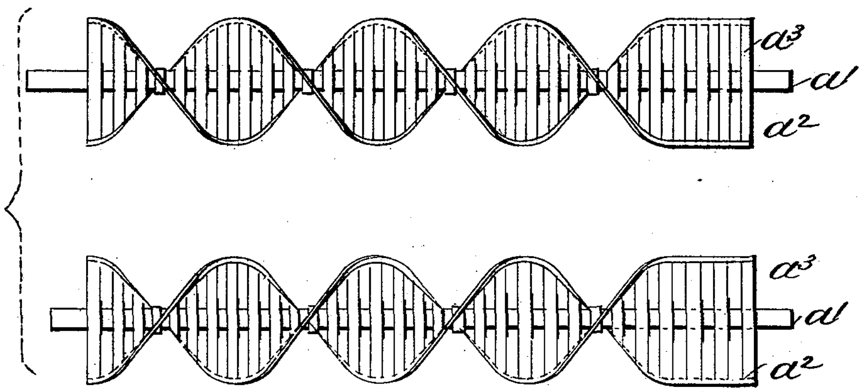



Fig. 7.




Witnesses,
F. H. Schott
G. B. Towles,

Inventor,
W. C. Marr,
By his Attorney W. T. Burris.

N. PETERS. Photo-Lithographer, Washington, D. C.

# UNITED STATES PATENT OFFICE.

WILLIAM C. MARR, OF ONAWA, IOWA.

## MACHINE FOR TWISTING METAL AND FORMING SPIRAL CONVEYERS.

SPECIFICATION forming part of Letters Patent No. 393,378, dated November 27, 1888.

Application filed November 3, 1887. Serial No. 254,162. (Model.)

*To all whom it may concern:*

Be it known that I, WILLIAM C. MARR, a citizen of the United States of America, residing at Onawa, in the county of Monona and State of Iowa, have invented certain new and useful Improvements in Machines for Twisting Metal and Forming Spiral Conveyers, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to machines for twisting metal and forming spiral conveyers; and it consists in certain improvements in the construction of such machines, as hereinafter described and claimed.

In the accompanying drawings, Figure 1 is a plan view of the machine. Fig. 2 is a front elevation of the same. Fig. 3 is an end view, parts being removed. Fig. 4 is a cross-section taken on line *x x* of Fig. 1. Figs. 5 and 6 illustrate certain details of the machine. Fig. 7 represents spiral conveyers with right and left twists, respectively.

A designates the frame adapted to carry the operative devices of the machine, in the main standards of which the driving-shaft B has its bearings, said shaft being provided with a crank, *a*, or with power-gearing, (not shown,) as desired. Above the driving-shaft are mounted four converging shafts, two of said shafts, C and C′, converging from one end of the frame toward the center, and two shafts, $C^2$ and $C^3$, converging from the opposite end. These shafts do not have bearings in the main frame, but in supporting-pieces, chiefly supported by the driving-shaft, as hereinafter stated.

On the shafts C and C′ is mounted a frame, D, the shafts passing through the side pieces of the frame, which is adjustably supported in an inclined position, as hereinafter stated. The outer ends of the shafts C C′ have their bearings in the movable pieces *b* and *c*, which are close to an end standard of the frame A, the piece *c* being provided with a fixed pin, which extends into a vertical slot in said standard, as indicated at $c^2$. The lower piece, *b*, is pivotally mounted on the driving-shaft B, and the shaft C, at its outer end, has bearing in said piece *b* at its upper end and also extends into the upper piece, *c*, at its lower end. The outer end of shaft C′ extends into the piece *c* at its upper end and has bearing therein. The inner part of shaft C has bearing in the upper end of a piece, *d*, which is pivotally mounted on the driving-shaft. The inner bearing of the shaft C′ is in the frame D, through which said shaft passes, as before stated.

Adjacent to the frame D is a yoke, *g*, the legs or bifurcations of which are loosely placed in grooves in vertical portions E of the frame, so that the yoke has a slight vertical movement in the adjustment of frame D, hereinafter mentioned, the yoke having a pivotal connection at *f* with said frame. The pivotal connection with yoke *g* on one side of the frame D, and the piece *c* with the fixed pin entering a slot in the standard at the other side, serve to retain the frame in position and prevent its lateral or irregular movement, but allow its adjustment.

The upper end of frame D has an extension or slotted arm, *h*, which is adjustably connected with a cross-piece, F, at the top of frame A by means of a bolt passing through a slot, *i*, in arm *h* and a slot, *k*, in cross-piece F, and a securing-nut. This adjustable connection allows the adjustment of frame D in its inclination as desired, and also the reversing of the frame in position from an inclination in one direction to an inclination in the opposite direction, for the purpose herein set forth.

On the inward ends of shafts C C′ are placed conical rollers G and G′, the inclined shafts holding the rollers with their surfaces adjacent to each other and with their inward ends on oblique line corresponding with the inclination of frame D. These conical rollers are adjustable longitudinally on their respective shafts, and are provided with detachable heads *m*, which are secured to their inward ends in any suitable manner. The shafts C C′ are provided with connecting gear-wheels H H′, to which motion is imparted through wheel K on the driving-shaft.

At or near the opposite end of frame A another frame, D′, is mounted on the converging shafts $C^2$ and $C^3$, said frame D′ being in construction similar to the frame D and having a slotted arm, *h*′, connected in like manner with a slotted cross-piece, F′. The shafts $C^2$ $C^3$ have bearing-pieces $b'$, $c'$, and $d'$, of like construction and arrangement of those before described in relation to shafts C C', and a yoke similar to yoke $g$ is also in like position and has a pivotal connection with the frame D'. Headed pins or screws $g'$ are inserted in the pieces E in position to form the external guides for the legs of the yokes, as shown in Fig. 5 of the drawings. The inward ends of said shafts have conical rollers $G^2$ $G^3$ placed thereon, the same being adjustable and provided with detachable heads $m'$. The shafts are also provided with connecting gear-wheels $H^2$ $H^3$, one of which engages with a wheel, K', on the driving-shaft. The said heads $m$ $m'$ are detachably connected with the conical rollers for the purpose of enabling the rollers to be used without the heads in twisting plates having no central shafts. The rollers and this shaft are inclined, and the rollers are made conical in shape to enable them to form and readily travel over the different surfaces of the spiral wings. The conical rollers being adjustable longitudinally on their shafts, the rollers G G' may be set closer to or farther from the rollers $G^2$ $G^3$ to adapt the machine for twisting plates of different widths and plates having smaller or larger central shafts. In forming the spiral conveyer shown in Fig. 7 the heads $m$ $m'$ are attached to the rollers for the purpose of swaging the metal closely around the central shaft, $a'$. To adjust the rollers in operative positions the frames D D' must be reversely inclined, placing the rollers G G' on one inclined plane and the rollers $G^2$ $G^3$ on a reversely-inclined plane corresponding with the inclinations of the frames. The relative positions of the conical rollers may be best described by reference to three planes—viz., a vertical plane on line $x$ $x$ of Fig. 1, a horizontal plane on line $s$ $s$ of Fig. 2, and a vertical plane on line $s'$ $s'$ at right angles to plane $x$ $x$ of Fig. 1.

Rollers G G' are on one side and rollers $G^2$ $G^3$ are on the other side of plane $x$ $x$. Rollers G' $G^3$ are mostly above and rollers G $G^2$ are mostly below plane $s$ $s$. When the machine is adjusted to form a right-hand spiral conveyer, the rollers G' $G^2$ are mostly in front and the rollers G $G^3$ are mostly in the rear of the plane $s'$ $s'$; but when the machine is adjusted to form a left-hand spiral conveyer the positions of the rollers are reversed in relation to the last-named plane, so that G' $G^2$ are in the rear and G $G^3$ are in front of plane $s'$ $s'$.

L designates an adjustable frame located on the front side of the machine, provided with guide-rollers $r$ $r$, adapted to guide a metallic plate as it is introduced into the machine. This frame is attached to the front ends of horizontal bars $p$, arranged to slide longitudinally between the guide-bars $p'$ and extended under the conical rollers.

M designates another frame located on the rear side of the machine, and provided with a cylindrical guide, N, adapted to receive and guide the twisted portion of a metallic plate as it passes through the machine. This frame is attached to the rear ends of the horizontal bars $q$, arranged to slide longitudinally between guide-bars $q'$ $q'$ and extended by the sides of bars $p$ under the conical rollers. These frames are adapted to slide longitudinally for the purpose of adjusting them in the different positions required for properly supporting and guiding plates of different lengths as they are passed through the machine.

The two sets of rollers being adjusted to form a right-hand spiral conveyer, as shown in Figs. 1 and 2 of the drawings, and the driving-shaft being revolved in the required direction to rotate the rollers in the reverse directions, (shown by the arrows in Fig. 2,) one end of a plate to be twisted is inserted between the guide-rollers $r$ and is projected forward in position for the ends of the wings to be caught between the rollers, and the plate is then fed through the machine by the reverse movements of the rollers. The plate being introduced into the machine, as above stated, the ends of the wings come in contact first with the rollers G' $G^2$ and afterward with the rollers G $G^3$, the right wing, $a^2$, passing under and bearing against the lower surface of roller G', and then passing over and bearing upon the upper surface of roller G, while the left wing, $a^3$, passes over and bears upon the upper surface of roller $G^2$, and then passes under and bears against the lower surface of roller $G^3$. Hence it will be readily seen that the forward portion of the right wing is being twisted upward by the roller G while the forward portion of the left wing is being twisted downward by the roller $G^3$, and that the roller G' bears downward the portion of the right wing immediately in front of roller G, while the roller $G^2$ bears upward the portion of the left wing immediately in front of the roller $G^3$, and thus the rollers G G' twist the right wing while the rollers $G^2$ $G^3$ twist the left wing. To form a left-hand conveyer the positions of the frames carrying the conical rollers are reversed, thus reversing the relative positions of the two sets of rollers, so that the end of the plate to be twisted, being inserted through the guide-rollers, comes in contact first with rollers G and $G^3$ and then with the rollers G' $G^2$.

In the operation of forming a left-hand spiral conveyer the driving-shaft and rollers are rotated in the same directions, as above described, and the functions of the conical rollers in twisting the wings of this conveyer are precisely similar to their functions in forming the right-hand conveyer.

These spiral conveyers may be formed by this machine of slitted plates such as are shown in the drawings of this application, and are fully set forth in the patent, No. 323,944, granted August 11, 1885, to W. C. and N. C. Marr; or the conveyers may be formed by this machine of solid seamless plates, as fully set forth in the patent, No. 371,609, granted to me October 18, 1887, in which last-named patent it is stated the plates may be rolled with a central enlargement extended at the ends to form the journals; or the plates may be rolled flat, to be provided with journals formed separately and adapted to be attached to the conveyers; and it is evident that in twisting a slitted plate, a flat solid plate, or a solid plate having a central enlargement the operation of this machine will be substantially the same. Two of the rollers—one of each of the sets G G′ and G² G³—are provided near their outer ends with annular grooves *n*, for the purpose of forming beads near the edges of the wings of the conveyer to strengthen the said edges. These beads are formed upon the wings by the pressure of the rollers upon the plate as it is passed in a red-hot condition through the machine in the twisting operation, the rollers being adjusted to produce upon the portions of the plate adjacent to that portion which becomes the bead sufficient pressure to reduce the thickness of those portions of the plate and press the heated metal into the grooves in a manner similar to the well-known process of rolling metallic substances. To enable the said beads to be formed with the least possible pressure and friction of the twisting-machine rollers upon the plates, the portions of the wings to be beaded may be thickened in forming the plates for this purpose in a rolling-mill, so that the pressure of the twisting-machine rollers will be mostly upon the beaded portions of the wings.

When it may be desired to dispense with the beads on the wings, plane rollers may be substituted in the places of the grooved rollers.

I claim—

1. In a metal-twisting machine, the combination of the conical rollers G G′, mounted on one side of a vertical plane upon inclined shafts which are adjustable on reversely-inclined planes, and the conical rollers G² G³, mounted on the opposite side of the said vertical plane upon inclined shafts adjustable on reversely-inclined planes, and means adapted to rotate the rollers in reverse directions, whereby a metallic plate is fed between and twisted by the rollers, substantially as and for the purposes described.

2. In a metal-twisting machine, the combination, with the frames D D′, connected with mechanism whereby the frames are adjustable on reversely-inclined planes at any required inclination, of the conical rollers G G′, mounted on one side of a vertical plane upon shafts adjustable with the frame D, and the conical rollers G² G³, mounted on the other side of the said vertical plane upon shafts adjustable with the frame D′, and means adapted to rotate the rollers in reverse directions, whereby a metallic plate may be fed between the rollers and twisted to the right or left at any required angle, substantially as and for the purposes described.

3. In a metal-twisting machine, the conical rollers G G′, mounted on one side of a vertical plane, and the conical rollers G² G³, mounted on the opposite side of the said vertical plane, in combination with the heads *m m′*, detachably connected with the rollers, and means adapted to rotate the rollers, substantially as and for the purposes described.

4. In combination with the slotted bars F F′, attached to the frame A of a metal-twisting machine, the reversible frames D D′, provided with slotted arms *h h′*, the conical rollers G G′, mounted on one side of a vertical plane upon the shafts C C′, connected with the said frame D, the conical rollers G² G³, mounted on the other side of the said vertical plane upon the shafts C² C³, connected with the said frame D′, and mechanism adapted to rotate the rollers, the said slotted bars being provided with measuring-scales, and the said slotted arms being adjustably connected with the slotted bars, whereby the conical rollers may be adjusted at the different positions required for twisting the flights of spiral conveyers at different angles, substantially as and for the purposes described.

5. In combination with the slotted bars F F′, attached to the frame of a metal-twisting machine, the reversible frame D, provided with the slotted arm *h*, adjustably connected with the slotted bar F, the movable bearings *b c d*, as constructed and connected, the conical rollers G G′, mounted on the inclined shafts C C′, extended through the frame D and having their bearings in the frame and in the said movable bearings, the reversible frame D′, having the slotted arm *h′*, adjustably connected with the slotted bar F′, the movable bearings *b′ c′ d′*, as constructed and connected, the conical rollers G² G³, mounted on the inclined shafts C² C³, extended through frame D′ and having their bearings in the frame D′ and in the said movable bearings, and means adapted to rotate the rollers, substantially as and for the purposes described.

6. The combination, with the frame of a metal-twisting machine, of the movable frame L, located on the front side of the machine and provided with the guide-rollers *r r*, adapted to guide a metallic plate as it is introduced into the machine, and the movable frame M, placed on the rear side of the machine and provided with the cylindrical guide N, adapted to guide the twisted portion of the plate as it passes through the machine, substantially as and for the purposes described.

7. The movable bearings *b d*, mounted on the drive-shaft B, the movable piece *c*, having pivotal connection with a standard of the frame A, a vertically-reciprocating yoke, *g*, the reversible frame D, having pivotal connection with the yoke, the shafts C C′, carried by the said movable bearings and by the frame D, and the conical rollers G G′, mounted on the said shafts, in combination with the movable bearings *b′ d′*, mounted on the said drive-shaft, the movable piece *c′*, having pivotal connection with a standard of frame A, a vertically-reciprocating yoke, the reversible frame D′, having pivotal connection with the said yoke, the shafts C² C³, carried by the said

movable bearings and the said frame, and the conical rollers $G^2$ $G^3$, mounted on the said shafts, substantially as and for the purposes described.

8. In a metal-twisting machine, the combination of the conical rollers G G′, mounted on one side of a vertical plane upon inclined shafts which are adjustable on reversely-inclined planes, and the conical rollers $G^2$ $G^3$, mounted on the opposite sides of the said vertical plane upon inclined shafts, adjustable on reversely-inclined planes, and means adapted to rotate the rollers in reverse directions, two of the said rollers—one on each side of the said vertical plane—being provided with annular grooves *n*, whereby thickened raised beads may be formed on the wings of a spiral conveyer as the metallic plate is passed between the rollers, substantially as and for the purposes described.

In testimony whereof I have affixed my signature in presence of two witnesses.

WILLIAM C. MARR.

Witnesses:
GEO. A. OLIVER,
A. J. MAUGHLIN.

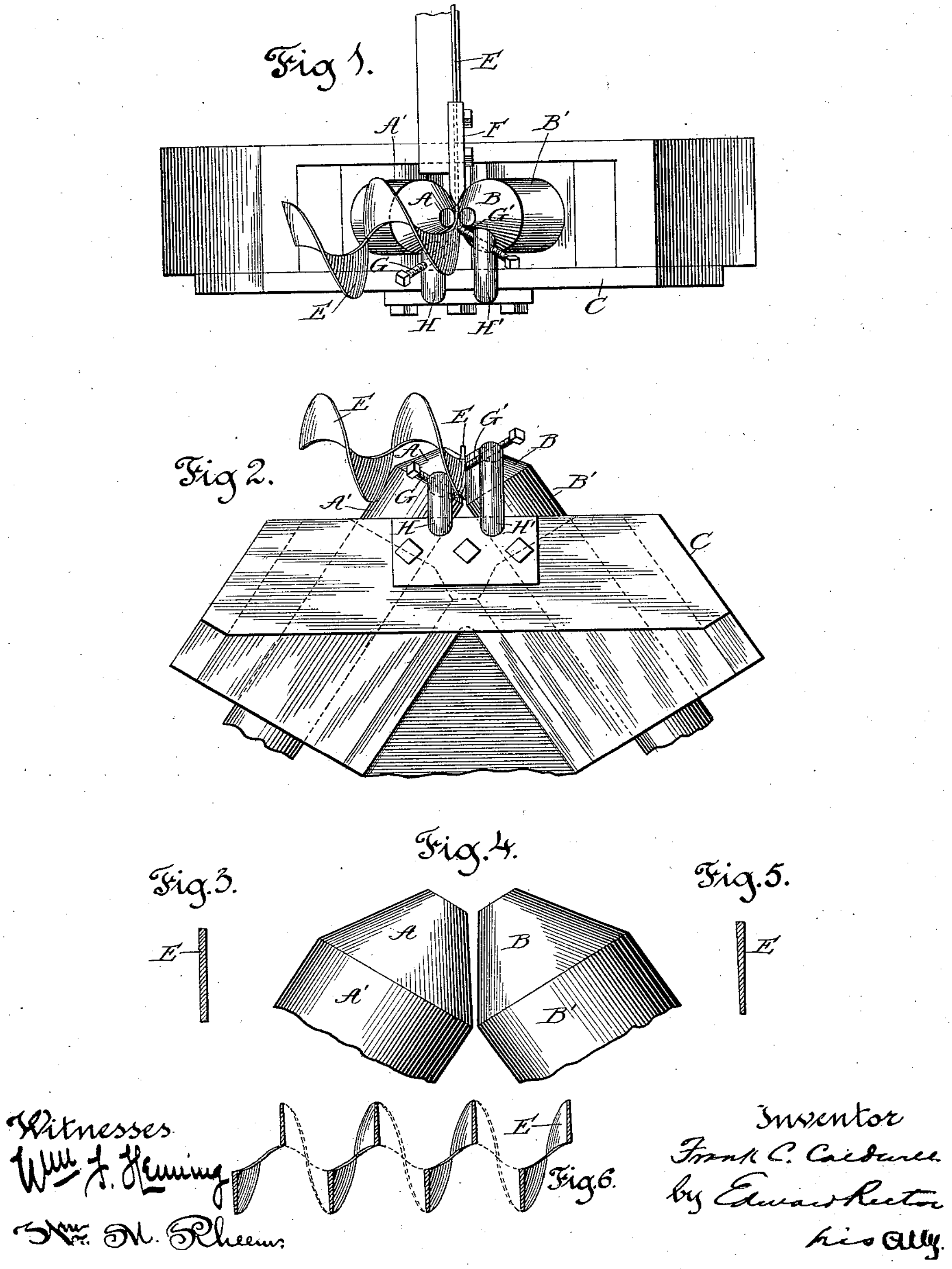
**EK B FRANK C.CALDWELL’in Almış Olduğu Patent**

(No Model.) 2 Sheets—Sheet 1.

F. C. CALDWELL.

SPIRAL CONVEYER FLIGHT AND APPARATUS FOR MAKING SAME.

No. 601,429. Patented Mar. 29, 1898.

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(No Model.) 2 Sheets—Sheet 2.

# F. C. CALDWELL.

## SPIRAL CONVEYER FLIGHT AND APPARATUS FOR MAKING SAME.

No. 601,429. Patented Mar. 29, 1898.

Fig. 9.

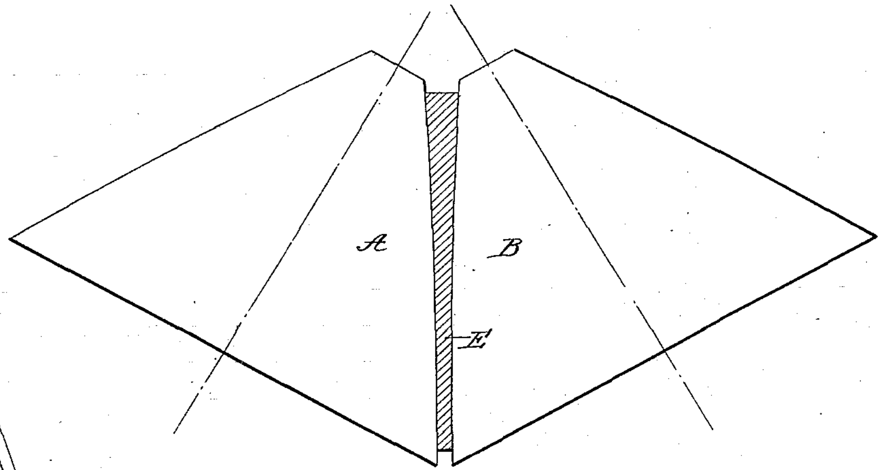



Fig. 7.

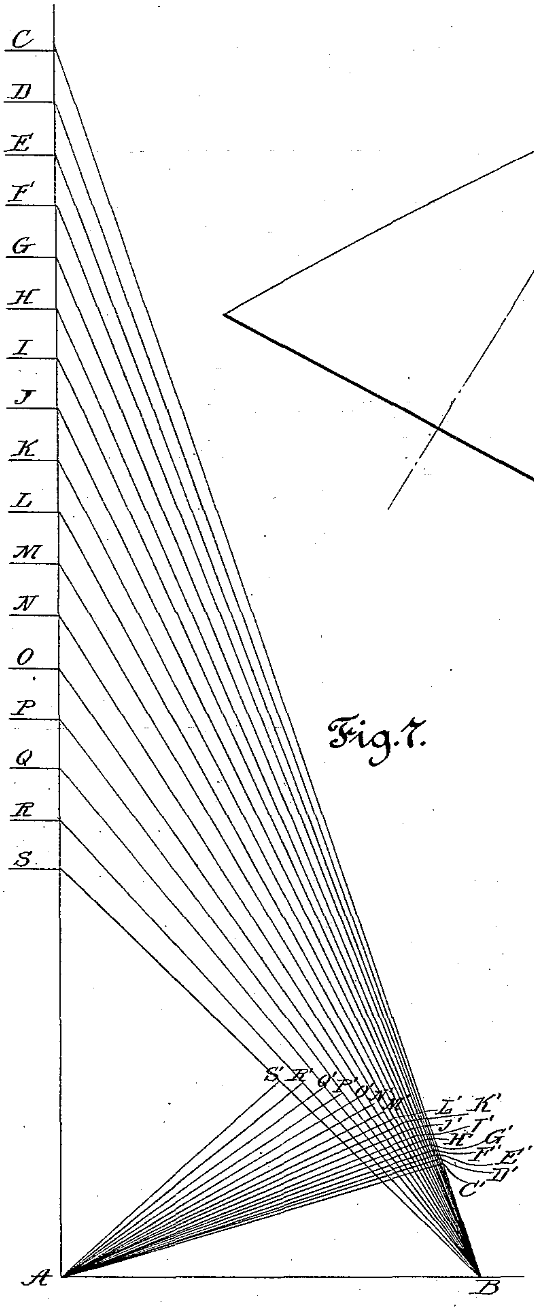
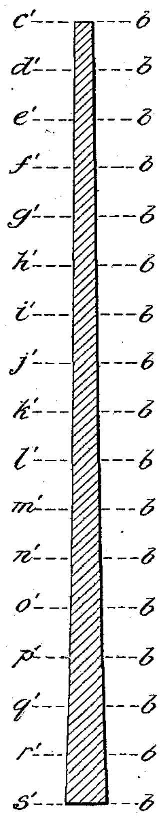



Fig. 8.




Witnesses
Wm. F. Henning
Wm. H. Rheem

Inventor
Frank C. Caldwell
by Edward Rector
his Atty

# UNITED STATES PATENT OFFICE.

FRANK C. CALDWELL, OF OAK PARK, ILLINOIS.

## SPIRAL CONVEYER-FLIGHT AND APPARATUS FOR MAKING SAME.

SPECIFICATION forming part of Letters Patent No. 601,429, dated March 29, 1898.

Application filed February 24, 1898. Serial No. 671,521. (No model.)

*To all whom it may concern:*

Be it known that I, FRANK C. CALDWELL, a citizen of the United States, residing at Oak Park, in the county of Cook, in the State of Illinois, have invented certain new and useful Improvements in Spiral Conveyer-Flights and Methods of and Apparatus for Making the Same, of which the following is a description, reference being had to the accompanying drawings, forming part of this specification.

My invention has for its object the production of a continuous spiral conveyer-flight formed from a single strip of metal; and it consists in the novel means for converting a single continuous strip of metal into such spiral conveyer-flight and in the novel form of the conveyer-flight thus produced.

I am aware that it has heretofore been proposed in various prior patents to form a conveyer-flight from a continuous strip of metal, and as a practical manufacturer of conveyer-flights I am also aware that numerous attempts in this direction have been made; but to the best of my knowledge no successful method or apparatus for producing such continuous conveyer-flights has heretofore been devised, and there is not now and never has been upon the market or in practical use any conveyer-flight of this description, all conveyer-flights which are now and have heretofore been in use being built up of separate sections. I have devised novel and successful means for converting a continuous strip of metal into a conveyer-flight of novel form by which the work may be easily and expeditiously accomplished with complete success and satisfaction.

In carrying out my invention I employ a continuous strip of metal of substantially uniform thickness throughout, and I convert this strip of metal into a continuous spiral conveyer-flight of tapering form in cross-section by passing it between a pair of pressure-rolls of novel form and especially adapted for the purpose, as hereinafter described. Suitable guides are preferably provided to receive the spiral strip as it issues from the rolls and direct it therefrom in proper form, all as hereinafter more fully explained in connection with the accompanying drawings, in which—

Figure 1 is a detail top plan view showing the two pressure-rolls, the metal strip passing between them, and the guides for receiving and directing the same; Fig. 2, a detail front elevation of the same parts; Fig. 3, an enlarged cross-section of the metal strip; Fig. 4, an enlarged detail of the rolls, showing the tapering form of the pass between them; Fig. 5, a cross-section of the strip of Fig. 3 after it has been passed between the rolls; Fig. 6, a middle longitudinal section through a piece of the completed spiral conveyer; Fig. 7, a diagram illustrating the method of determining the cross-section of the spiral; Fig. 8, an enlarged and somewhat exaggerated view of the cross-section of a spiral as determined by the method illustrated in Fig. 7, and Fig. 9 a similar view of the two pressure-rolls.

The same letters of reference are used to represent corresponding parts in the several views.

In the course of experiments having for their object the production of a continuous-strip spiral I have discovered that while a strip of metal of uniform thickness may be readily rolled into a disk or ring of tapering form in cross-section by passing it between a pair of truly-conical rolls having their working faces set at the proper angle to each other, it is wholly impossible to roll such strip into a helix or spiral by passing it between such rolls, no matter how proportioned and adjusted in relation to each other. In the course of repeated efforts to convert a continuous strip of metal into a spiral by means of such rolls I discovered that the difficulty and the cause of failure arose from the fact that the pass between such rolls (under any possible adjustment of them) did not conform to what would necessarily be the cross-section of the strip of metal when transformed into a spiral, inasmuch as the cross-section of a spiral produced from such a strip would be substantially different from the cross-section of a disk or ring produced from it. Following up this discovery I ascertained, by further experiments, that if the faces of the conical rolls were so ground as to produce a pass between them corresponding to what would be the exact cross-section of a strip of metal of uniform thickness when transformed into a spiral such strip could then be readily converted into spirals by passing them between such rolls. As a result of these experiments I found that a spiral of any given pitch might be formed from a continuous strip of metal of uniform thickness and of any desired width by first determining mathematically what would be the exact cross-section of such a spiral and then providing cone-like rolls so shaped and adjusted that the pass between them would correspond to such a cross-section and so proportioned that the circumference of the rolls at the one end of the pass would bear the same ratio to their circumference at the other end thereof as the length of one edge of the spiral strip to be formed bore to the length of the opposite edge thereof.

In carrying out my invention, therefore, the first step consists in determining the exact mathematical cross-section of the spiral to be produced and in then providing the necessary cone-like rolls having their working faces so shaped that when the rolls are properly assembled the pass between them will conform to the cross-section of the spiral to be produced and so proportioned that their circumference at one end of the pass—*i. e.*, end of the working portion thereof—will bear the same ratio to their circumference at its opposite end as the length of one edge of the spiral strip to be formed bears to the length of the opposite edge thereof. The cross-section of the spiral may be arrived at by either an arithmetical or geometrical solution of the problem. I have illustrated the latter method in Figs. 7 and 8, which may be briefly explained as follows:

In Fig. 7 let A C equal the circumference of the conveyer-flight at its outer edge, A S its circumference at its inner edge, and A B the pitch of the helix. C B will then equal the length of the helix at the outer edge of the flight and S B its length at the inner edge of the flight. Dividing the line S C (the width of the flight) into any convenient number of parts, A R, A Q, A P, &c., will represent the circumference of circles concentric to A S and within A C, and R B, Q B, P B, &c., will represent the corresponding helices. Lines drawn from A perpendicular to the lines S B, R B, Q B, &c., will intersect the latter at the points S′ R′ Q′, &c. Let S′ B equal the thickness of the metal at the inner edge of the conveyer-flight. Then R′ B, Q′ B, P′ B, &c., will represent the thickness of the metal at the points where the helices R B, Q B, P B, &c., are taken. Assuming now the thickness of the inner edge of the spiral which it is desired to produce to be one-eighth of an inch, for instance, the dimension S′ B will be scaled to such thickness, and the dimensions R′ B, Q′ B, &c., be then read by the same scale. By using the thicknesses thus found the cross-section of the spiral may be delineated as shown in Fig. 8 and the necessary contour of the rolls be readily determined therefrom.

In the present instance the rolls A B, Figs. 1, 2, and 4, are formed upon the upper ends of shafts or spindles A′ B′, having convergent axes and suitably journaled in bearings in the framework C of the machine and driven at a uniform speed by any suitable means. The circumference of the rolls at the narrower end of the working part of the tapering pass between them bears the same ratio to their circumference at the wider end thereof that the length of the outer edge of the helix to be formed bears to the length of the inner edge thereof, while at all intermediate points the circumference of the rolls corresponds to the length of the intermediate helices of the spiral. The departure of the rolls from a truly-conical shape is not appreciable in views of the size found on Sheet 1 of the drawings, but will be readily understood from Sheet 2 and the explanation heretofore given of the method of determining the shape of the rolls. When the rectangular metal strip is passed between these rolls, it is expanded from its inner toward its outer edge in exactly the proportions necessary to conform it in cross-section to the cross-section of a spiral, and the ratio of feed at all points between its opposite edges is such as to draw the strip in evenly between the rolls throughout its width and deliver it therefrom in the form of a spiral.

In Fig. 1, E represents the metal strip, which is fed to the rolls A B through a suitable guideway F, and as it issues from the rolls it passes between two guides G G′, consisting in this instance of adjustable screws mounted in supports H H′ upon the framework. As seen in Fig. 2, the guide G bears against one side of the metal strip near its lower or outer edge as it issues from the rolls, while the guide G′ bears against its opposite side near its upper or inner edge. These two guides are so set and adjusted as to properly direct the strip from the rolls in the spiral form shown in Figs. 1 and 2. The action of the rolls themselves upon the strip causes the strip to tend to issue from them in spiral form, and under some conditions and for some purposes the guides may perhaps be dispensed with; but they are advantageous and desirable for insuring a uniform pitch in the spiral, even if not absolutely essential in all cases, and may be employed in the form shown or in any other suitable form for the purpose, and they may be arranged to direct the strip into a right-hand spiral or a left-hand one, as desired.

While my invention has been designed more especially for the production of spiral conveyer-flights, and while, being a manufacturer of conveyers, that is the only use I have made of it, it will be evident that it may be advantageously employed for the production of spirals for other purposes than conveyer-flights—such, for instance, as springs—and that spirals may be formed of strips of different widths and thicknesses and of varying pitch and of varying internal diameter or bore by properly arranging the size, proportions, and adjustment of the rolls.

In the practical use which I have thus far made of my invention I have heated the metal strips before passing them through the rolls to facilitate the action of the rolls upon them; but I contemplate the employment of heavier and more powerful rolls, by which the strips may be rolled into form without heating.

Having thus fully described my invention, I claim—

1. As a new article of manufacture, the herein-described spiral rolled from a continuous strip of thin wrought metal of substantially uniform thickness, said spiral tapering in cross-section from its inner toward its outer edge and having its sides curved slightly inward, as set forth.

2. The herein-described apparatus for producing spirals from continuous strips of thin wrought metal, consisting of a pair of cone-like pressure-rolls having convergent axes and so shaped and proportioned as to provide a tapering pass between them corresponding to a mathematical cross-section of the spiral to be produced, the circumference of said rolls at the narrower end of the pass between them bearing the same ratio to their circumference at the wider end of the pass as the length of the outer edge of the spiral to be produced bears to the inner edge thereof, and means for driving said rolls, as set forth.

3. The herein-described apparatus for producing spirals of the form specified, consisting of a pair of cone-like rolls having convergent axes and so proportioned and set relatively to each other as to provide a pass between them tapering from their apices toward their bases and corresponding to a mathematical cross-section of the spiral to be produced, suitable guides for receiving the strip as it issues from the rolls and directing it in spiral form therefrom, and means for driving the rolls, as set forth.

4. The herein-described apparatus for producing spirals of the form specified, consisting of a pair of cone-like rolls so proportioned and set relatively to each other as to provide a pass between them tapering from their apices toward their bases and corresponding to a mathematical cross-section of the spiral to be produced, the two guides located on opposite sides of the path of the strip as it issues from the rolls and bearing against the opposite sides of the same near its outer and inner edges, respectively, and means for driving the rolls, as set forth.

5. The herein-described apparatus for producing spirals of the form specified, consisting of the cone-like rolls A B carried by the ends of the shafts A′ B′ and having the tapering pass between them, the guideway F for the metal strip E, located upon the entering side of the rolls, the adjustable screws G G′ located upon the opposite side of the rolls and operating as guides for the outer and inner edges of the spiral strip as it issues from the rolls, and means for driving the shafts A′ B′, as set forth.

FRANK C. CALDWELL.

Witnesses:
EDWARD RECTOR,
LEONORA WISEMAN.

## EK C CHARLES O. GUSTAVSEN'in Almış Olduğu Patent

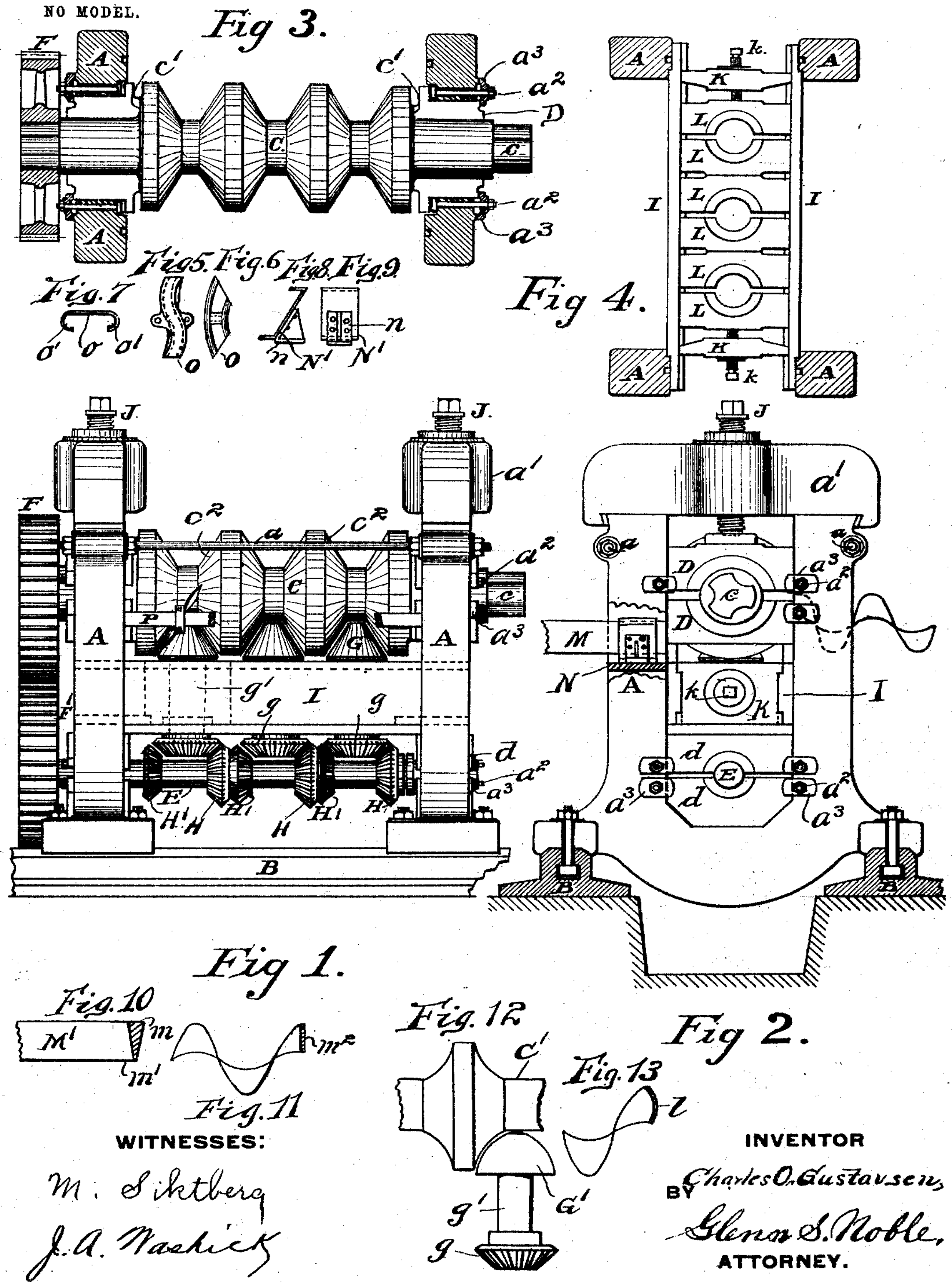
No. 760,448. PATENTED MAY 24, 1904.

C. O. GUSTAVSEN.

MACHINE FOR ROLLING HELICOIDS OR SPIRAL CONVEYERS.

APPLICATION FILED JULY 24, 1903.

NO MODEL.




THE NORRIS PETERS CO. PHOTO-LITHO., WASHINGTON, D.C.

# UNITED STATES PATENT OFFICE.

CHARLES O. GUSTAVSEN, OF CHICAGO, ILLINOIS.

## MACHINE FOR ROLLING HELICOIDS OR SPIRAL CONVEYERS.

SPECIFICATION forming part of Letters Patent No. 760,448, dated May 24, 1904.

Application filed July 24, 1903. Serial No. 166,843. (No model.)

*To all whom it may concern:*

Be it known that I, CHARLES O. GUSTAVSEN, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Machines for Rolling Helicoids or Spiral Conveyers, of which the following is a specification.

This machine relates more particularly to means for forming regular helicoids having substantially straight faces or helicoids having the flights provided with dished or curved surfaces; and its objects are to provide a machine of this character which will be simple in construction and durable in operation and which may be readily adjusted to form a plurality of spirals concurrently of either right or left hand formation or both right and left hand.

It consists in the combination, with a suitable framework, such as ordinarily used for rolling-mills, of various operative parts and driving mechanism necessary for forming a helicoid from a continuous strip of suitably-shaped material.

Other features and details will be pointed out more specifically hereinafter.

In the drawings, Figure 1 represents an elevation of a machine embodying this invention viewed from the rear or discharge side. Fig. 2 represents an end elevation of the same. Fig. 3 is a sectional detail showing the method of adjusting the forming-roll. Fig. 4 is a sectional plan detail showing adjusting mechanism for the cones. Fig. 5 is a rear view of the guide for the helicoid as it is being formed. Figs. 6 and 7 are side and end views, respectively, of the same. Figs. 8 and 9 are front and side views, respectively, of the guide for the material as it is fed into the machine. Fig. 10 is a detail showing a portion of the stock to be formed into the helicoid. Fig. 11 is a detail showing a section of the completed helicoid. Fig. 12 is a detail showing a formation of the roller and cone for forming dished or curved-faced helicoids. Fig. 13 is a detail showing a portion of the dished helicoid.

Upright frame members A A are secured to a suitable base or bed plate B. These upright members form the ends of the frame for the machine and are connected together at the top by tie-rods $a$ and are provided with cap-pieces $a'$. The end frames A are provided with boxes D for the horizontal roll C. For reasons which will appear hereinafter this roll is adapted to be adjusted longitudinally of the frame, and for this purpose the bearings D are allowed a slight play between the shoulders $c'$ on the roll and the inner sides of the frame A. Bolts $a^2$, having countersunk heads, are provided with clips $a^3$, which bear against the outer sides of the frames A and the outer ends of the bearings D. It will be readily seen that when it is desired to move the roll C in one direction the bolts are loosened at the end toward which the roll is to be moved. Then by tightening the nuts of the bolts at the opposite end the clips $a^3$ will press the bearings $d$ toward the opposite side, and thereby move the roll C. It will be observed that this adjustment is simply for a very limited movement. The roll C is provided at one end with a gear F, which meshes with a gear F' on a shaft E, which is located below the roll C. The shaft E is also carried in bearings $d$ in the end frames A, and these bearings $d$ are provided with a similar adjustment to that just described for moving the shaft longitudinally of the frame. On the shaft E are secured bevel-gears H and H', which are adapted to engage at times with corresponding bevel-gears $g$ on the ends of vertical shafts $g'$, which carry at their upper ends conical rolls G. The shafts $g$ are secured in bearings L, which are carried by cross-plates I, connecting between the end frames A. The bearings L are slidably secured to the plates I and may be adjusted by means of screws $k$ $k$, which engage with rigid cross-pieces K and bear against the end bearings L. The bearings D and $d$ and the plates I are all removably secured in the end frames A and are rigidly secured by means of the set-screws J.

At the front of the machine is a cross-bar N, which carries the guides N' for the material as it is fed into the machine. The guides N' are simply angular-shaped pieces which are held by brackets $n$ and direct the material into the proper rolls. At the opposite or rear side of the machine is a cross-bar P, which carries the forming-guides O. These guides are shaped similar to a portion of the helicoid to be formed and are formed of a flat plate *o*, which is turned over at the edges to form grooves *o′* for the material.

The machine may be driven in any convenient manner by connecting the shouldered end *c* of the roll C with any suitable source of power.

The stock, which consists of a long strip M of suitable material, is directed into the aperture between the conical face $c^2$ of the roll C and the cone G by the guide N′. As it passes between said conical surfaces it is formed thereby into the desired spiral and is directed through the guide O in order to give it the properly-finished shape.

By means of having the cones G between two conical surfaces of the roll C it is obvious that the helicoids may be formed on either side of the cone. It is for this reason that the roll C is made longitudinally adjustable in the frame, and for the same reason the shaft E is also longitudinally adjustable, which allows its being shifted to throw the gears H out of engagement with the gears *g* and allows the gears H′ to be thrown into engagement therewith. By thus changing the gears the cones are turned in the proper direction to correspond with the motion of the conical surfaces of the roll. By means of this adjustment right and left hand helicoids may be formed with the same cone, and by means of the plurality of cones a number of helicoids may be formed at the same time. The relative speed of the roll and the cones may be changed by changing the gears F F′ or the bevel-gears H *g*. Any desired pitch may be given to the cone and the corresponding conical surfaces of the roll to form the different-shaped helicoids.

An important feature of this invention lies in the fact that the roll which comprises one of the sides of cones may be rigidly held by having the two bearings, and the lower cones are also rigidly held in their bearings in the framework and are preferably not moved except to adjust them for wear.

In forming a helicoid from a straight piece of metal it is obvious that the portion forming the outer part must be stretched or worked out in order to provide the material necessary for this elongated part of the flights. I prefer to form the helicoids from a special shape of bar M′, such as shown in Fig. 10, which has one edge *m* somewhat thicker than the other. When a strip of this shape has passed through the machine, the rolls flatten and draw out this thickened edge to form the outer part of the helicoid, so that it will have a substantially even thickness when completed, as shown at $m^2$ in Fig. 11. However, I do not wish to be limited to this method of forming the spiral, as it is apparent that a strip of even thickness may be used, in which case the resulting helicoids will be thinner at the outer edge and taper toward the inner edge.

It is frequently desirable to use a helicoid having flights of dished or curved cross-section. In order to form a flight of this nature, I use a roll C with a correspondingly-curved face, as shown in Fig. 12, which coacts with an oppositely-curved cone G′. By using this form of rolls a helicoid will be formed with a section such as shown at *l* in Fig. 13. It will be noted that the curvature is somewhat exaggerated in these views, as the amount necessary would be very slight, and, in fact, it is frequently desirable to give a slight amount of curvature to the so-called "straight-faced" cones in order to facilitate the forming of the spirals. However, this amount of curvature is so slight as to be inappreciable in the drawings of the scale shown.

It is obvious that various changes in the details of construction may be made without departing from the spirit of my invention, which I consider to be broadly new in various features and do not wish to limit to the exact construction herein shown and described; but

What I claim, and desire to secure by Letters Patent, is—

1. In a machine for forming helicoids, the combination with a forming-roll having substantially conical surfaces, of a cone adapted to coact at times with each of a pair of said surfaces to engage the stock and form a helicoid and means for causing said cone to coact with said conical surfaces.

2. In a machine for making helicoids or spiral conveyers, the combination of a framework, a forming-roll secured in said framework, a plurality of cones having their bearings in said framework and adapted to coact with said forming-roll, and means for turning said roll and cones.

3. In a machine of the nature set forth, the combination with the spiral-forming mechanism, of a guide adapted to engage the spiral after passing through the forming mechanism, said guide being formed with substantially the same outlines as the spiral to be formed.

4. In a machine of the nature set forth, the combination of a frame, a forming-roll adjustably secured in said frame and having conical surfaces formed thereon, vertically-arranged cones adapted to engage with said conical surfaces at the lower side of said roll, shafts on which said cones are mounted, gears on said shafts, a shaft adjustably secured in said frame, gears on said shaft adapted to engage with said first-named gears, spur-gears whereby said shaft may be driven from said roll, and means for adjusting said roll whereby oppositely-disposed conical faces may be brought to coact with said cones, and means for ad-

justing said shaft whereby oppositely-disposed gears may be brought into engagement with the gears on the cone-shafts, substantially as described.

5. Means for forming a helicoid, having flights of curved cross-section, said means comprising cone-shaped forming-rolls having curved faces and cone-shaped rolls adapted to coact therewith, having faces oppositely curved to the faces of the first-named conical members, substantially as described.

CHARLES O. GUSTAVSEN.

Witnesses:
M. SIKTBERG,
J. A. WASHIEK.

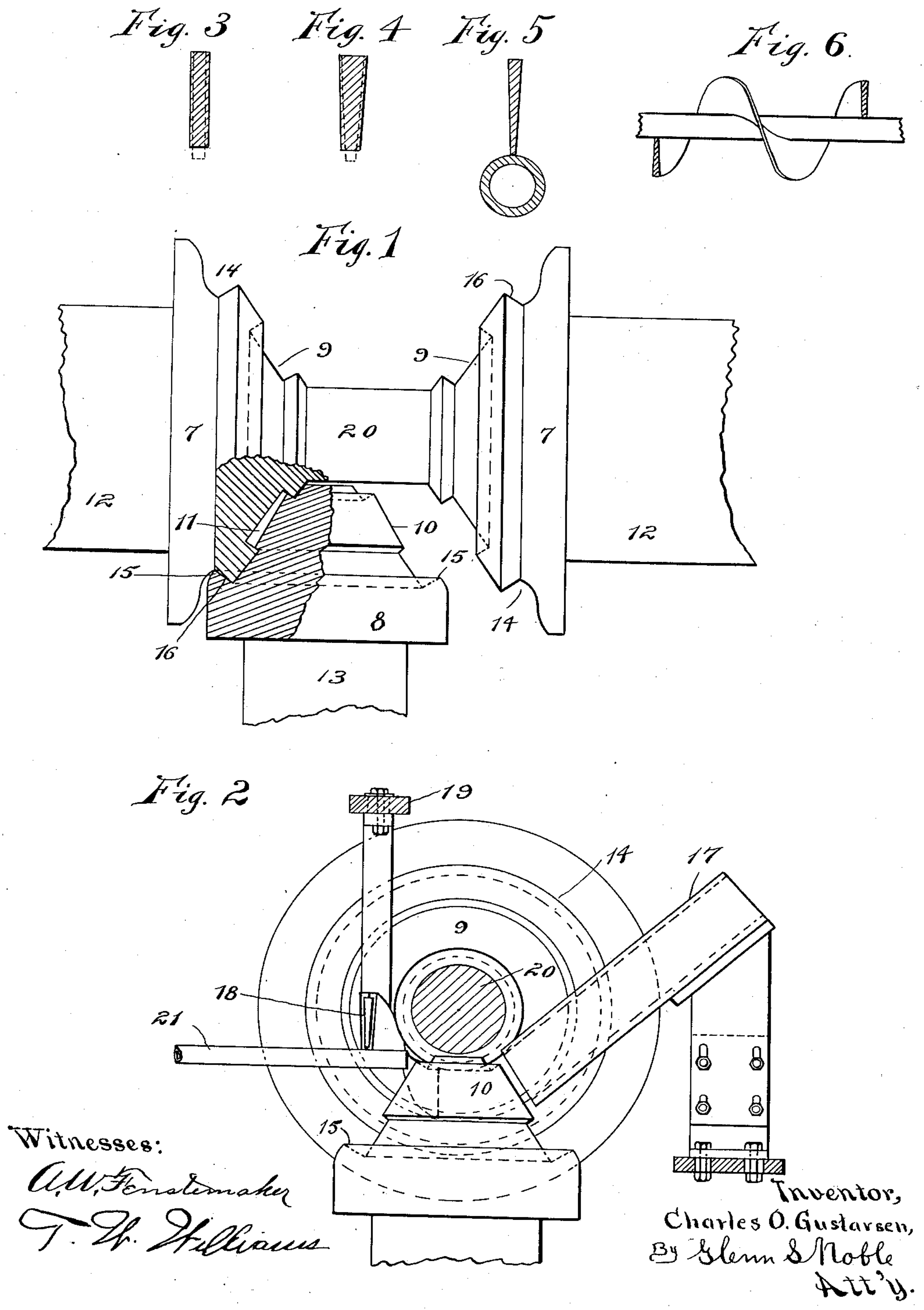
**EK D CHARLES O.GUSTAVSEN'in Almış Olduğu Patent**

C. O. GUSTAVSEN.

MACHINE FOR MAKING HELICOID OR SPIRAL CONVEYERS.

APPLICATION FILED APR. 23, 1906.

**908,860.** Patented Jan. 5, 1909.



# UNITED STATES PATENT OFFICE.

CHARLES O. GUSTAVSEN, OF COLUMBUS, OHIO, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE JEFFREY MANUFACTURING COMPANY, A CORPORATION OF OHIO.

## MACHINE FOR MAKING HELICOID OR SPIRAL CONVEYERS.

**No. 908,860.** **Specification of Letters Patent.** **Patented Jan. 5, 1909.**

**Original application filed March 13, 1905, Serial No. 249,803. Divided and this application filed April 23, 1906. Serial No. 313,349.**

*To all whom it may concern:*

Be it known that I, Charles O. Gustavsen, a citizen of the United States, residing at Columbus, county of Franklin, and State of Ohio, have invented certain new and useful Improvements in Machines for Making Helicoid or Spiral Conveyers, of which the following is a specification.

This invention relates more particularly to machines which are adapted to roll or form a continuous helicoid or conveyer from a strip of suitable material, and its objects are to provide a machine of this character which will roll certain forms of helicoid as will be explained hereinafter.

In the accompanying drawings illustrating this invention, Figure 1 represents a side view, partly broken away, of the rolls used in my improved machine; Fig. 2 is a sectional or end view showing a pair of rolls, with guides for feeding the material and for taking it away; Fig. 3 is a view showing a section of the material from which the helicoid is to be rolled, the dotted lines representing the cross-section of the material after it has been formed into a spiral or helicoid of uniform thickness; Fig. 4 represents a cross-section of material of another form which may also be used, the dotted lines showing the shape of the cross-section of the resulting spiral; Fig. 5 shows a cross-section of a spiral or helicoid with its outer edge of greater thickness than its inner edge, the latter being nearest to the pipe or shaft upon which the spiral is secured; and Fig. 6 represents a portion of completed spiral with its outer edge thicker than its inner edge.

Heretofore it has been considered possible only to roll spirals or helicoids from continuous strips in such a manner that the outer edge of the spiral would be of less thickness than the corresponding edge of the strip from which it was formed. For instance, if the strip from which the spiral was made was of uniform thickness, then the resulting spiral would be tapering in cross-section with its outer edge considerably thinner than its inner edge; or if the strip were thicker at one edge than at the other and the thick edge were used to form the outer part of the spiral, then the resulting spiral would be of uniform thickness. By means of my improved machine, spirals or helicoids can be rolled from a continuous strip of suitable metal in such a way that the resulting spiral formed from a strip of uniform thickness may thus be of uniform thickness or may be thicker at its outer edge than at its inner edge. And in a similar way, using a strip of stock having one edge thicker than the other, a spiral may be formed, having its outer edge thicker than its inner edge, in a manner corresponding to the stock from which it was rolled.

As shown in the accompanying drawings, Figure 1 illustrates a pair of rolls of the form which I prefer to use, 7 representing a large roll, and 8, a smaller roll which coacts with the large roll to form the spiral. These rolls may be supported in any suitable manner and may, for instance, be arranged and driven substantially as shown in my previous patent No. 760,448 of May 24, 1904, or may be arranged and driven in any desired manner. The roll 7 is provided with a peripheral groove 9 into which extends a peripheral or annular ring or portion 10 of the roll 8. The ring 10 does not extend to the full depth of the groove 9, but leaves a passage or box-pass 11 between its outer surface and the bottom of the groove 9. This pass may be either rectangular in outline, as when a helicoid of uniform thickness is to be produced, or it may be wider at its outer edge than at its inner edge, as shown in the drawings, so that the resulting spiral will be thicker at its outer edge than at its inner edge. These conical rolls may be considered as having a common pitch line which passes from the intersection of the axial lines of said cones substantially through the center of the pass 11, and the corresponding imaginary cones contacting along this line could be considered as the pitch cones of the two rolls. These rolls also embody a novel feature whereby they are interlocked to prevent too great a strain on the bearings 12 and 13, and also to prevent the opening or distortion of the pass when the stock is being rolled therethrough. This interlocking means comprises a second groove 14 which is cut in the roll 7, and an annular engaging flange or member 15 on the roll 8, which interlocks with the shoulder 16 formed by the groove 14. It will readily be seen that this interlocking shoulder and flange will prevent the rolls 7 and 8 from being pressed apart or sprung when the helicoid is being formed. This engaging shoulder and flange also perform the further function of holding the cones in proper alinement, so that the lower cone 8 will not creep or shift up toward the other cone and thereby become jammed or have its ring 10 or small end become burred or injured by engaging with the cone 7 or its connecting shaft 20. The rolling contact between these members, which are driven so that they have the same peripheral speed, is preferable for the purpose mentioned, to ordinary boxes and collars which would become worn more rapidly and cause more friction.

A further novel feature of this invention consists in setting the feed guide 17 at such an angle to a plane passing through the axes of the rolls, that the material will be so presented to the rolls as to allow the latter to crowd or squeeze the material across the width of the stock bar so that the helicoid produced may remain of uniform thickness or may even be thicker at its outer, than at its inner edge. This angle, as shown in the drawings, may be considered as being an angle of less than 90° from the pitch line of the cones, when measured from the intersection of the axial lines of the cones; or an acute angle to a plane perpendicular to the pitch line or line of tangency of the pitch cones.

As shown in Fig. 2, the straight feed guide 17 is considerably higher at its outer end than at the inner end so that the material or stock fed into the machine will first engage at its upper-forward corner which is nearest to the center, and thus the material travels, as it were, at an angle through the pass. The guide 17 may be supported from the frame in any desired manner, and may be made adjustable in order to readily secure the proper angle.

The discharge or forming guide 18 is made in the form of the helicoid to be produced and strips the metal directly from the rolls, thus preventing it from wrapping itself around either of the rolls as might otherwise occur. This guide may also be supported in any desired manner as from a cross-bar 19 secured in the frame (not shown) of the machine.

It will be obvious that a plurality of rolls may be arranged with coacting cones, as shown in my previous patent, so that right or left hand spirals, or a plurality of spirals of different sizes may be made in same machine. It will be observed that the cone 8 could be placed above the cone 7 or at any angle thereto for convenience in arranging the feed and forming guides to prevent scale from falling upon the bearings of the cone 8.

In operation, the material is heated in a suitable furnace to a proper degree of temperature and is then fed through the feed guide directly to the rolls. These crowd the material from the inner edge toward the outer, and simultaneously elongate the outer edge sufficiently to form the desired spiral. The spiral or helicoid thus formed is trued up or completed by passing through the forming guide, which gives it the shape desired. A mandrel or pipe 21 is placed adjacent to the rolls and the forming guide to receive the helicoid as it comes from the machine.

The angle between the center lines of the cones may be made 90 degrees as shown, or at a different angle, if desired to change the pitch of the helicoid.

This application is a division of my former application No. 249,803, filed March 13, 1905; and I do not claim herein the method or product, but

What I claim and desire to secure by Letters Patent is:

1. In an apparatus for rolling helicoids or the like, the combination with a pair of conical rolls, of a feed guide arranged at an acute angle to a plane perpendicular to the pitch line of said cones.

2. In an apparatus of the character set forth, the combination with a pair of coacting conical rolls, of a feed guide arranged at an angle of less than 90° to a line of tangency or pitch line between said cones, said angle being measured in the direction of the point of intersection of the axial lines of said cones.

3. The combination of a relatively large forming roll having grooves cut therein, a smaller roll with its axis arranged at substantially 90° to the axis of said first-named roll, said smaller roll being provided with a ring entering part way into the groove of the first roll to form a box pass, and an adjustable feed guide arranged at an angle of less than 90° toward the smaller ends of said rolls to a pitch line or line common to said rolls.

CHARLES O. GUSTAVSEN.

Witnesses:
SADIE CLYMER,
S. J. WHITE.

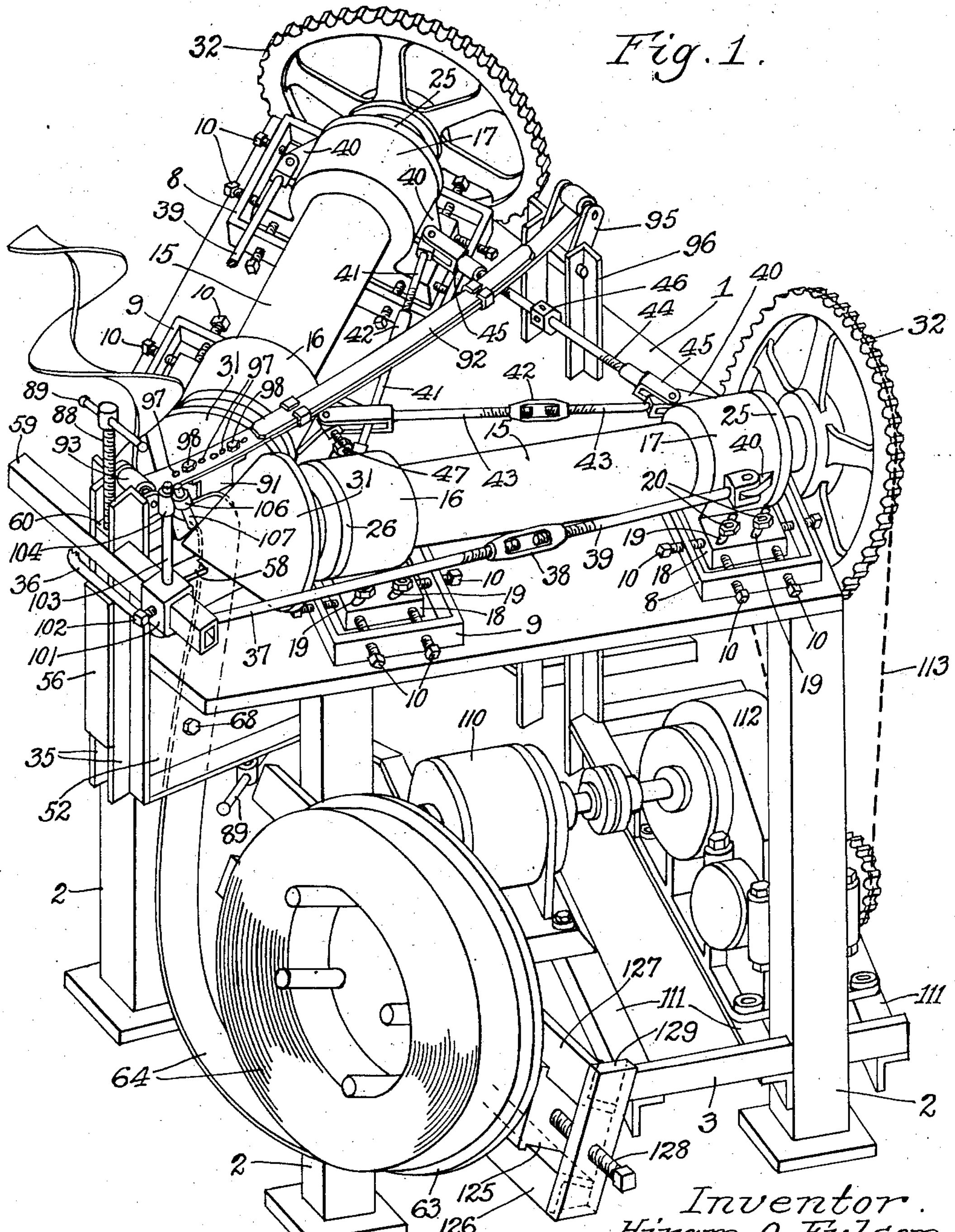
**EK E HİRAM O.FULSON'un Almış Olduğu Patent**

**Nov. 11, 1941.** **H. O. FULSON** **2,262,227**

APPARATUS FOR ROLLING HELICOID CONVEYER FLIGHT

Filed Nov. 25, 1938 8 Sheets-Sheet 1

Fig. 1.



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APPARATUS FOR ROLLING HELICOID CONVEYER FLIGHT

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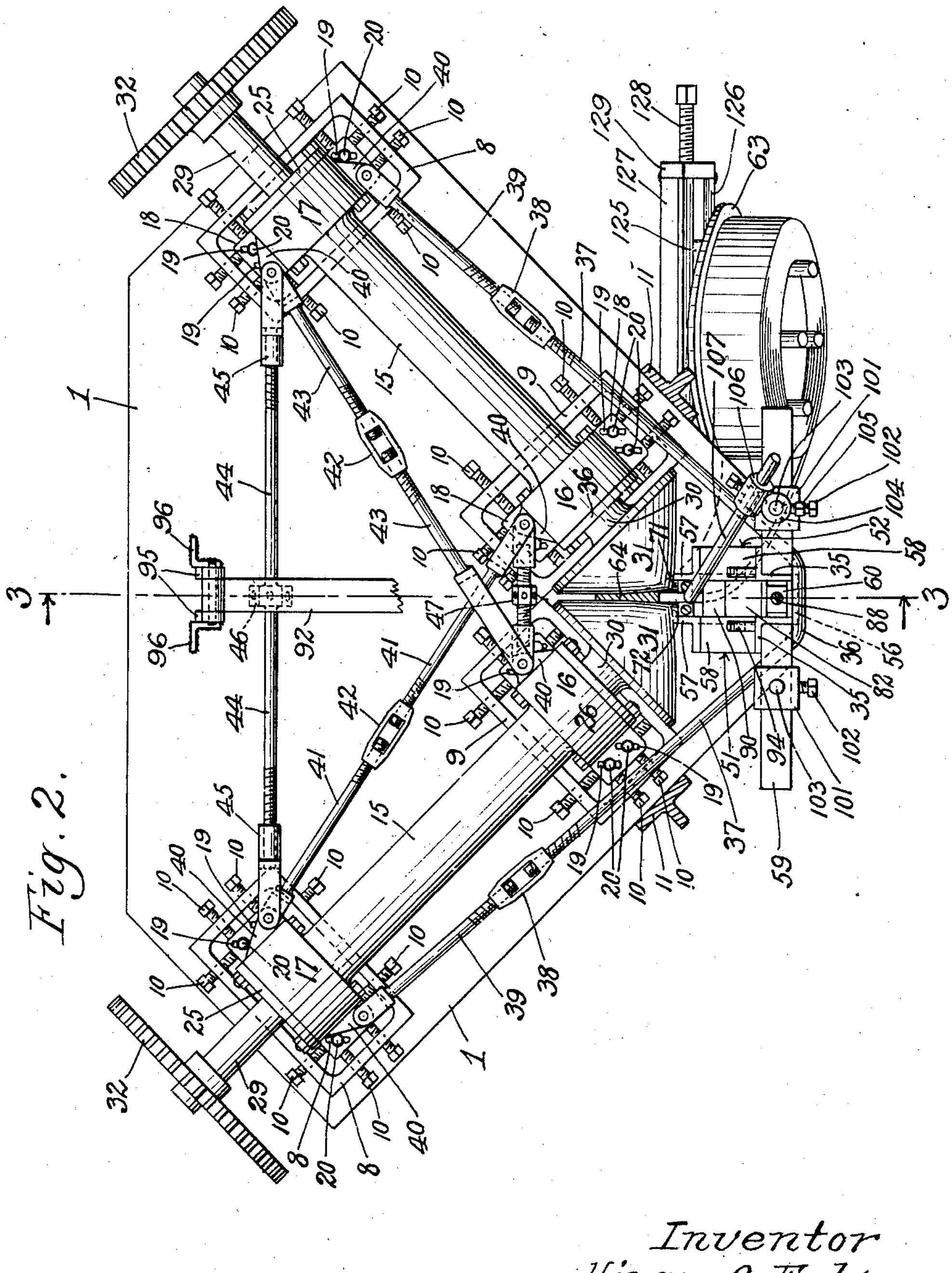

Fig. 2.

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APPARATUS FOR ROLLING HELICOID CONVEYER FLIGHT

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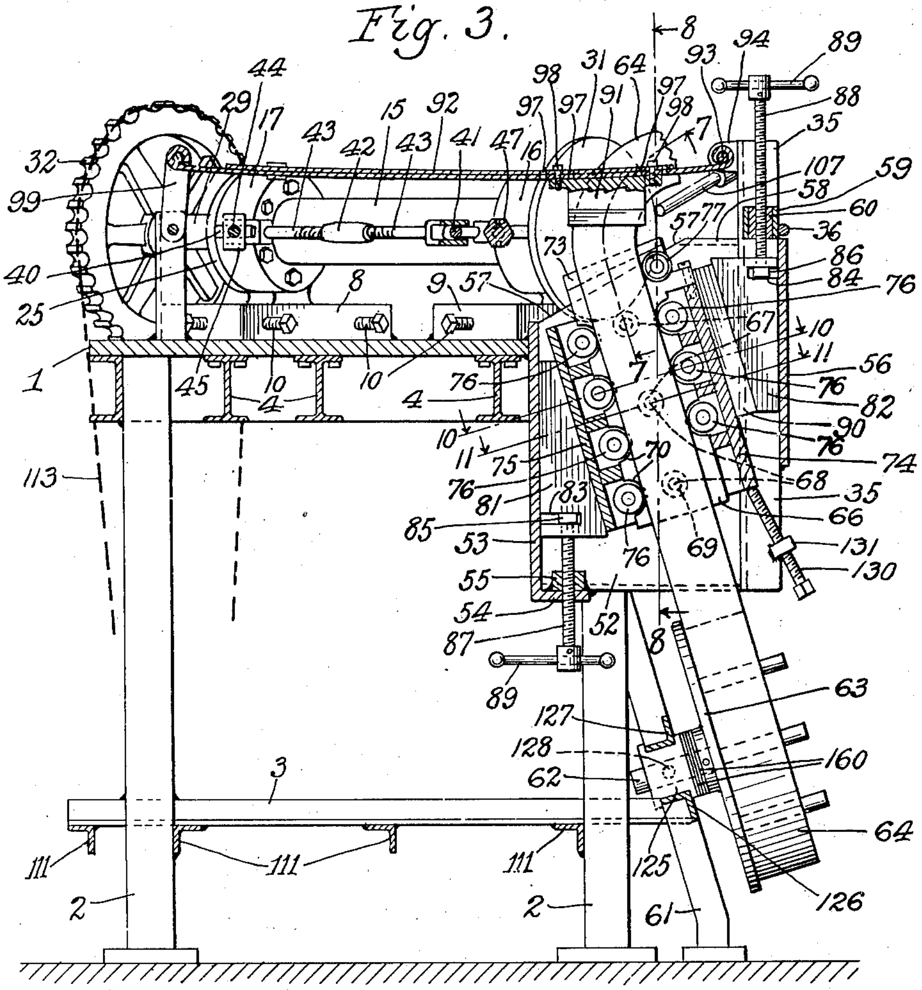
Fig. 3.



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APPARATUS FOR ROLLING HELICOID CONVEYER FLIGHT

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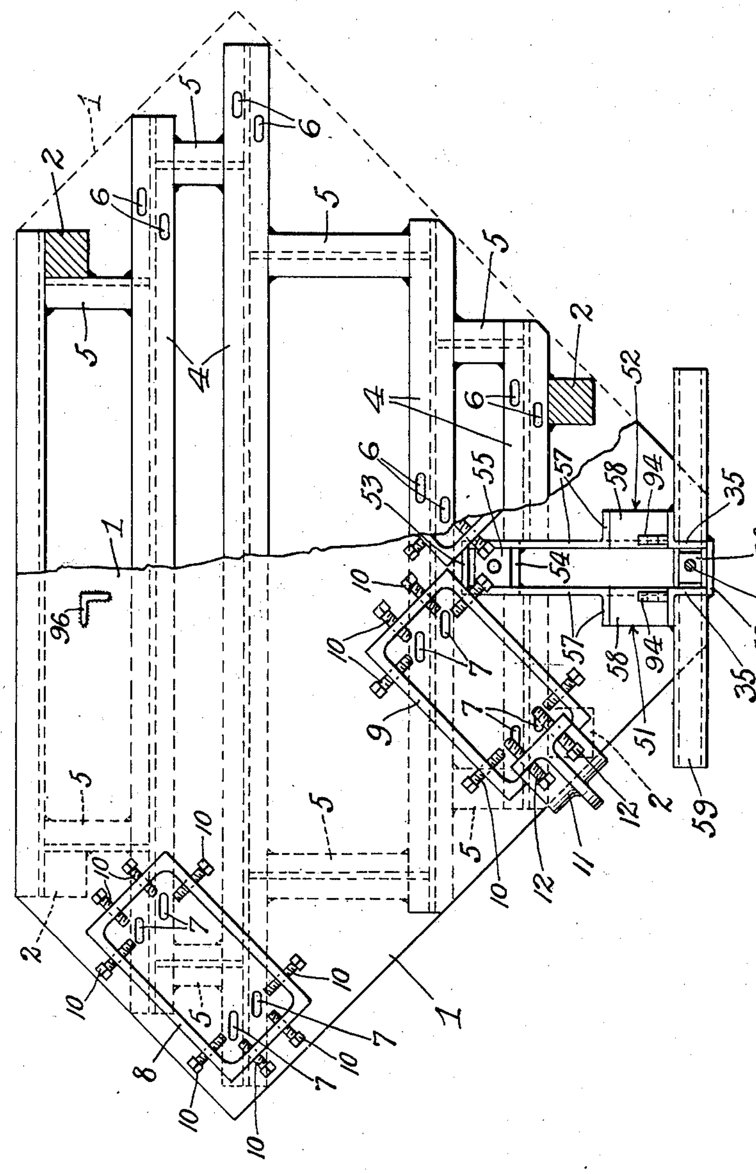

*Fig. 4.*

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*Fig. 5.*

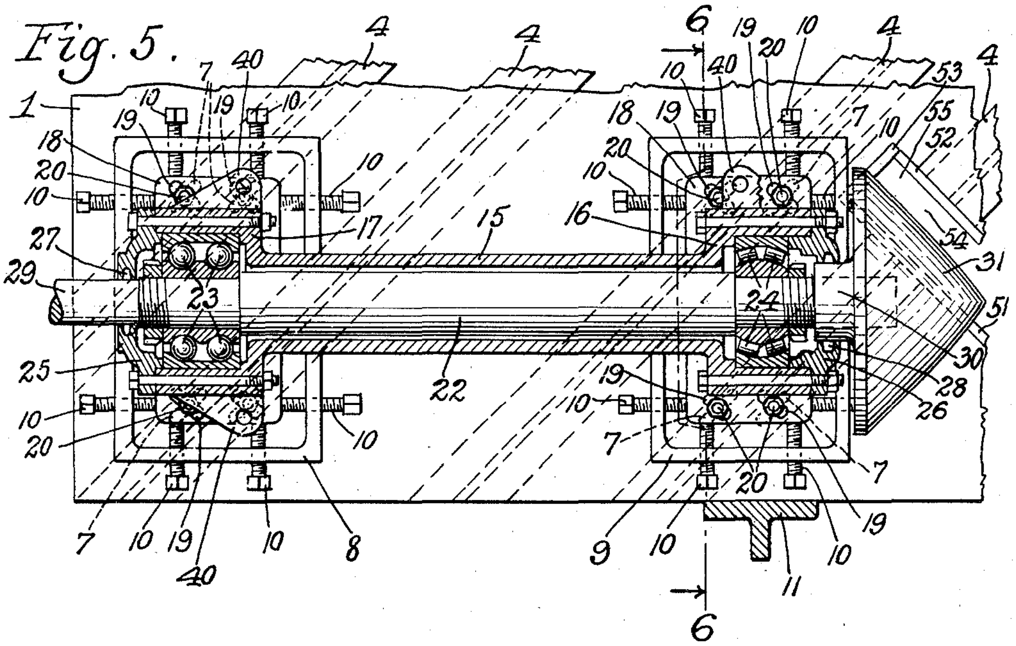

*Fig. 6.*

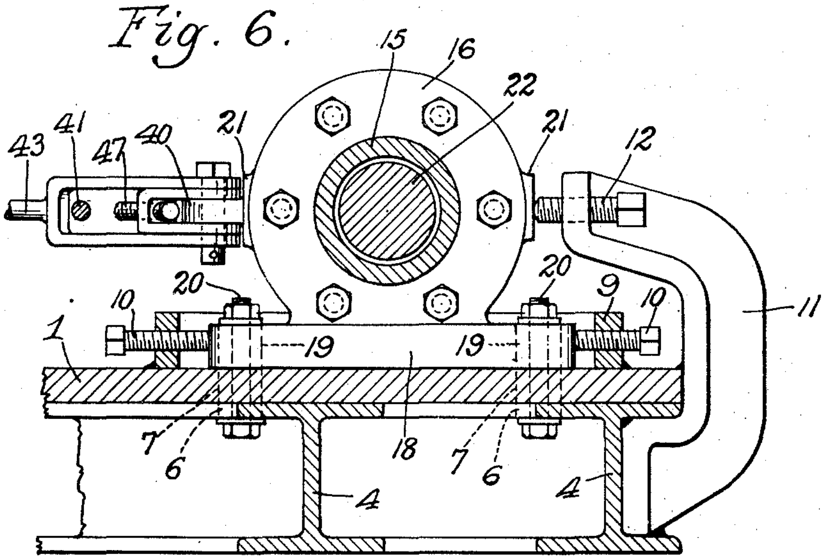

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Fig. 7.

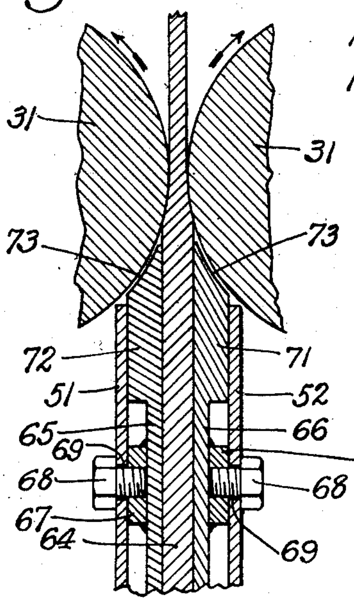



Fig. 8.

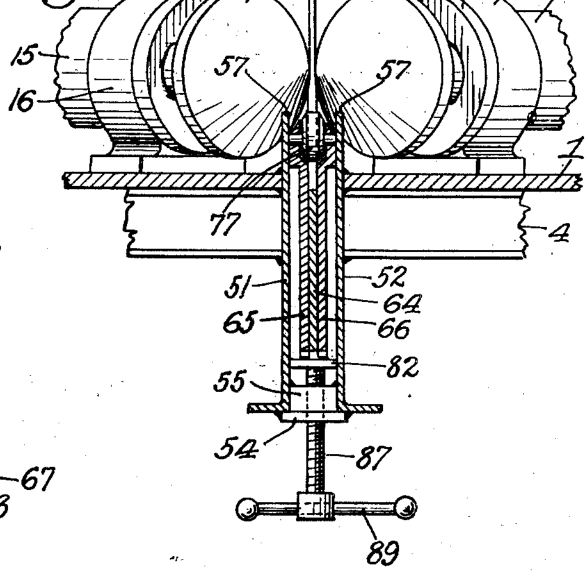



Fig. 9.

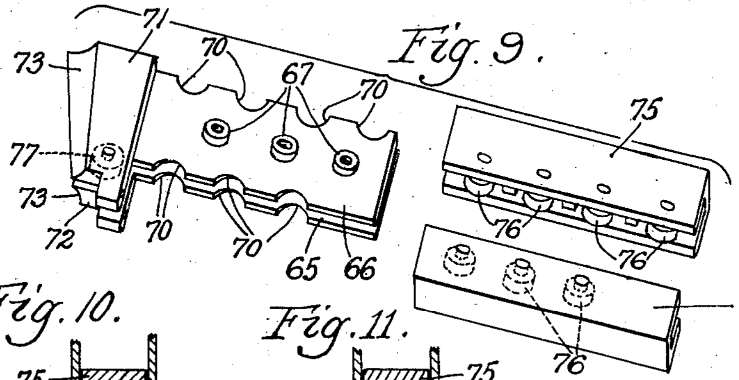



Fig. 10.

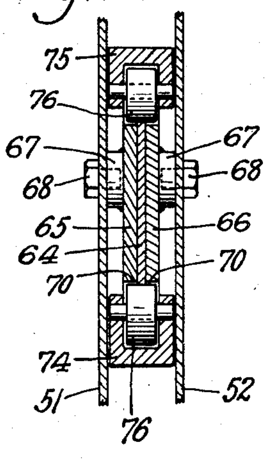
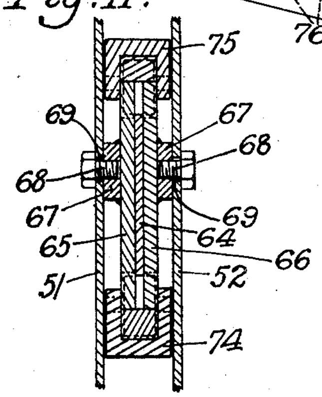



Fig. 11.

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APPARATUS FOR ROLLING HELICOID CONVEYER FLIGHT

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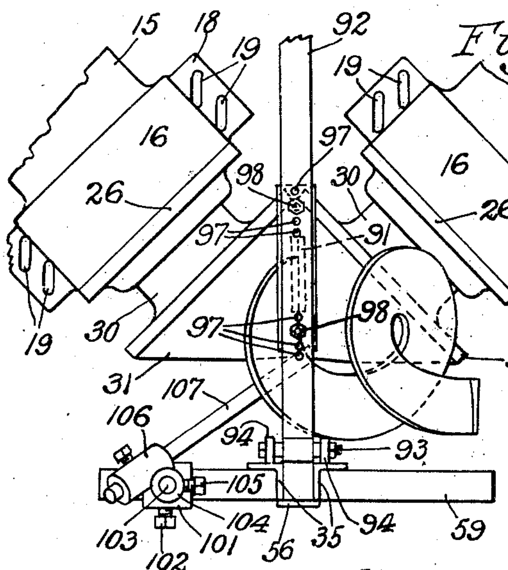
Fig. 12.

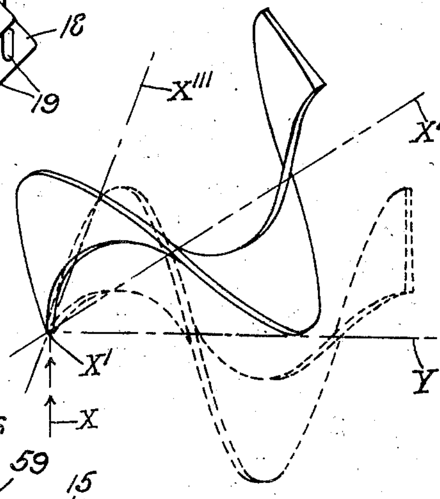
Fig. 15.

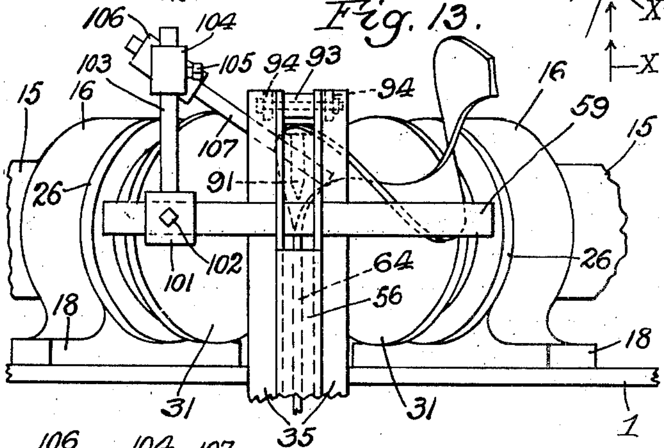
Fig. 13.

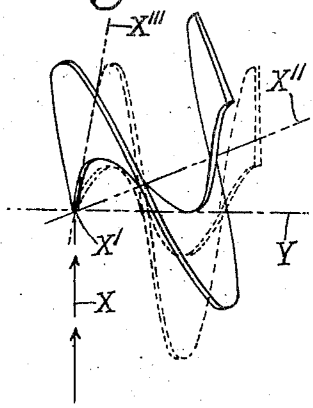
Fig. 16.

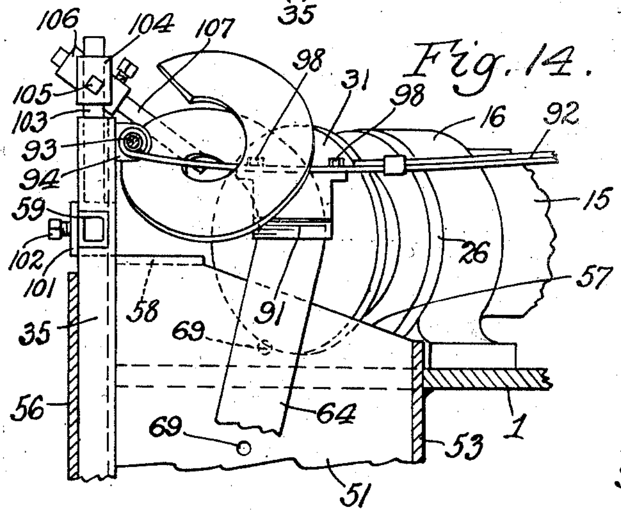
Fig. 14.

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APPARATUS FOR ROLLING HELICOID CONVEYER FLIGHT

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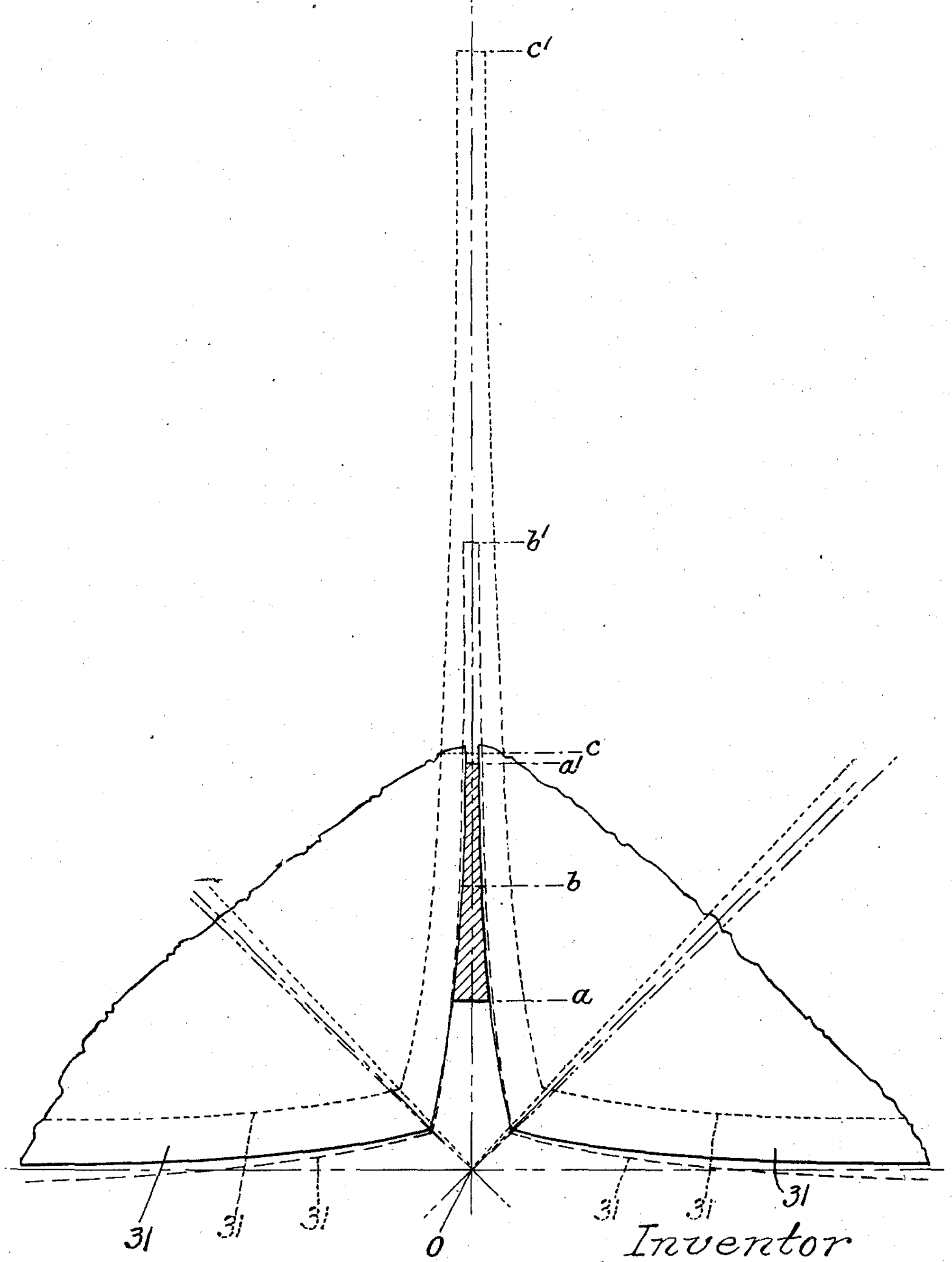
Fig. 17.

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Patented Nov. 11, 1941

2,262,227

# UNITED STATES PATENT OFFICE

2,262,227

## APPARATUS FOR ROLLING HELICOID CONVEYER FLIGHT

Hiram O. Fulson, Chicago, Ill., assignor to Link-Belt Company, a corporation of Illinois

Application November 25, 1938, Serial No. 242,198

13 Claims. (Cl. 80—31.1)

My invention relates to apparatus for cold rolling helicoid flight such as is used in connection with spiral or screw conveyers.

One object of my invention is to provide new and improved means whereby various sizes and dimensions of helicoid conveyer flight may with a minimum of difficulty be cold rolled on the same machine.

Another object of my invention is to provide an apparatus for cold rolling helicoid conveyer which is durable, accurate and relatively inexpensive to manufacture.

Another object is to provide a device which, with a minimum of adjustment can roll right hand or left hand helicoid flight of different pitches.

Another object is to provide means whereby adjustment for wear and slight changes may be easily and conveniently made.

Other objects will appear from time to time throughout the specification and claims.

Conveyer flight was first made by slitting and bending washers to form short sections of spiral flight which were welded or otherwise fastened together and mounted upon a pipe. Later metal strip was heated and then hot rolled and latterly apparatuses were built which would cold roll spiral conveyer. However, all flight conveyer apparatuses with which I am familiar involve the use of different rolls or relatively expensive adjustments for forming different sizes and shapes of conveyer flight within narrowly restricted ranges. The result of this is that when a change in the product is to be made outside of the narrowly restricted range of a current setting, the machines heretofore used must have expensive adjustments made or be dismantled, new parts interchanged with the parts previously used, the machine must again be adjusted and a number of trial runs made with adjustment between runs until the proper size and shape of flight is obtained. It thus requires a relatively large expenditure to change the machines hitherto in use when a different product is to be produced.

With my apparatus, on the other hand, one set of rolls will handle a wide range of helicoid conveyer flight and the adjustments necessary to change from one size or shape to another are reduced to a relatively small expenditure.

My invention is illustrated more or less diagrammatically in the accompanying drawings, wherein:

Figure 1 is a perspective view of the machine with parts omitted;

Figure 2 is a plan view with parts omitted;

Figure 3 is a section along the line 3—3 of Figure 2;

Figure 4 is a plan of the table top with the top partly broken away to disclose the I-beam reinforcing below and with many parts omitted for the sake of clearness;

Figure 5 is a partial plan view of the table top with roll shaft housing and associated parts in section;

Figure 6 is a section along the line 6—6 of Figure 5;

Figure 7 is a section along the curved line 7—7 of Figure 3;

Figure 8 is a section along the line 8—8 of Figure 3;

Figure 9 is a perspective of a type of stock guide plates and roller cages in disassembled arrangement;

Figure 10 is a section along the line 10—10 of Figure 3;

Figure 11 is a section along the line 11—11 of Figure 3;

Figure 12 is a plan view of the conical forming rolls showing a right hand conveyer take-off with a wedge and forming pin;

Figure 13 is a front elevation of the parts shown in Figure 12;

Figure 14 is a diagrammatic side elevation of the elements shown in Figure 13 with parts in section showing a right hand conveyer flight issuing from the machine;

Figure 15 is a detail showing conveyer wherein pitch and outside diameter are approximately equal;

Figure 16 is a detail showing conveyer wherein pitch is approximately one-half of outside diameter; Figures 15 and 16 also illustrate the contrasting angles of the inner helix and the outer helix and also show the difference between the angle of discharge of the conveyer flight rolled on my machine and that heretofore used;

Figure 17 is a diagrammatic lay-out of the conveyer parts to illustrate method of computation of contour of parts, location of stock and adjustment of rolls.

Like parts are indicated by like characters throughout the specification and drawings.

1 is a table top. It is supported by legs 2. The top is generally triangular in cross section. The legs are tied together at the bottom by a horizontal framework 3, and at the top by a plurality of vertical parallel I-beams 4, joined by short perpendicular intermediate members 5, upon which the table top 1, rests, all uniting to

make a rigid stiff, solid structure. At the opposed ends of some of the I-beams are oblong bolt holes or slots **6**, registering with similar holes **7**, in the table top **1**, as indicated. The purpose of these apertures will subsequently appear.

Welded or otherwise permanently attached to the table top **1**, are four spaced rectangular sockets **8** and **9**. These sockets all have inwardly extending set screws **10**, which may be adjustable toward and from one another and the sockets **9** have associated with them brackets **11**, which are rigidly attached to the I-beam structure below the table top, are welded to the table top as indicated and overhang the socket **9**, each bracket having a plurality of set screws **12**, which may be adjusted as indicated. The sockets **8** and **9** are arranged in two opposed pairs, one along each edge of the table top **1**, along intersecting axes.

Supported on the table top are two hollow shaft housings **15**, each terminating in enlarged bearing pockets or sleeves **16**, **17**. Each of these two bearing sleeves has a foot **18**, adapted to rest upon the table top and each foot has a plurality of diagonal slots **19**. When these feet are placed within the sockets **8** and **9**, the slots **19** intersect the slots **6**, so that holding bolts **20** may pass through both slots and because of the fact that the slots intersect, they permit adjustment of the foot in its position within the socket. The set screws **12** may also be manipulated to exert a pressure upon the pads **21**. **22** is a roll shaft, there being one in each sleeve **15**. These roll shafts are supported on anti-friction bearings **23**, **24**, which bearings are contained within the enlarged pockets **16** and **17**. These pockets are closed at their outer ends by covers **25**, **26**, which covers are provided with grease seals **27**, **28**, the seal **27** being associated with the reduced end **29**, of the shaft **22**. The seal **28** being associated with a sleeve **30** at the rear end of the conical roll **31**, which is rigidly mounted on the shaft **22**. **32** is a driving sprocket on the reduced end **29**, of the shaft. There are two such shafts and the arrangement for driving, mounting, supporting and lubricating them is the same in each case, there being one shaft in each of the shaft housings **15**, so that the conical rolls at the front of the machine as indicated in Figure 1 come together to provide a pass between them for the stock to be worked as will hereinafter appear.

Projecting upwardly above the table top and extending below it are two opposed angle members **35**, rigidly attached by suitable means to the table top and other parts of the frame of the machine. **36** is a tension yoke welded or otherwise rigidly attached in position, extending across the front of the machine and on both sides thereof extending rearwardly as indicated at **37**, to engage turnbuckles **38**, which turnbuckles also engage tension members **39**, pivoted on lugs **40**, on the two sleeves **17**, furthest removed from the conical rolls.

Interposed between similar lugs **40** respectively on the sleeve **17**, associated with one roll housing and the sleeve **16**, associated with the other, is a tension member **41**, including two separate threaded rods joined by a turnbuckle **42**. A similar tension member **43** joins the other pair of sleeves **16** and **17**, this member **43** being bifurcated intermediate its two ends to permit passage of the member **41**, and being provided with a similar turnbuckle **42**. Joining the lugs **40**, on the two sleeves **17**, is a compression-tension member **44**, which includes yokes **45**, into which are threaded in opposite directions the capstan member **46**. Also joining the two lugs **40**, on the two sleeves **16**, adjacent the rolls is a similar compression-tension member **47**.

By manipulation of these compression-tension members, after releasing the set screws and holding bolts which hold the feet upon which the shaft housings are supported, it is possible by manipulating the various compression-tension members to adjust the relative positions of the conical rolls, the rolls may be moved longitudinally parallel with their axes. They may be moved transversely by adjustment at either end, thus making it possible to provide a wide range of adjustment of the size and shape of the pass or area between the opposed portions of the two conical rolls. If desired, the set screws associated with the sockets may be used to assist in making this adjustment and once it is made all the set screws, holding bolts, tension-compression members may all be tightened up to rigidly hold, so far as that is possible in any machine, the two conical rolls in desired working relation.

In line with the angles **35**, the table top **1** is slotted and two opposed horizontal channel members **51**, **52**, extend vertically through this slot, being welded to the table and to the front I-beams which are cut away to permit passage of the channel plates. **53** is a plate welded to the rear end of the two channels and extending vertically from a point above to a point below the table top **1**, and having a right angle extension **54**, which underlies and is welded to the channel flanges. This extension is perforated in line with a nut **55**, the purpose of which will hereinafter appear.

**56** is a plate joining the front edges of the channels **51** and **52**, just as the plate **53** joins their rear edges. The upper portions of the channels **51** and **52** are cut away as at **57**, adjacent the rolls **31**, so that the flanges **58** along the upper edges of the channels terminate adjacent the apices of the rolls. **59** is a hollow square tube intersecting the forwardly extending flanges of the angles **35**, which are cut away for that purpose. This tube is welded to the angles, projects across the machine and supports and contains welded therein a nut **60**, the purpose of which will hereinafter appear.

**61** is a bracket associated with one of the table support columns **2**. It carries an inclined stub shaft **62**, on which is mounted for rotation a reel **63**, adapted to carry the stock or steel ribbon **64**, which is to be used to form the helicoid flight. This steel ribbon is adapted to be fed upwardly from below into the pass between the rolls whereby it is formed into conveyer flight.

The means for guiding the stock include two opposed wear plates **65**, **66** having a plurality of bosses **67**, threaded to be engaged by studs **68**, which enter through the channels **51**, **52** by holes **69**. These holes may be somewhat larger than the studs so as, if desired, to permit some measure of adjustable movement of the studs where they engage the bosses to assist in positioning the wear plates **65**, **66**. These wear plates are notched as indicated at **70**, and terminate at their upper ends in guide members **71**, **72**, having tapered extremities **73**, adapted to conform generally to the contour of the rolls so that these wear plates may guide the stock as closely up to the pass between the rolls as possible. **74**, **75** are channel cages adapted to enclose the notched edges of the wear plates and terminating in heads **71**, **72**. Each of these cages carries preferably three rollers 76, which fit within the recesses or notches 70, and are adapted to engage the opposed edges of the stock. There is an additional roller 77, carried by the guide heads 71, 72, immediately adjacent the pass where the stock enters the rolls. All this mechanism, including wear plates, cages, etc. is contained within the box formed between the two channel plates 51, and 52, and the wear plate and cage assembly may be removable and interchangeable to provide for a range of stock of different width and different thickness.

To roll conveyer flight of different diameters, it is important to be able to adjust the position of the stock as it is fed to the rolls. This is accomplished by the two wedges 81, 82, which are slotted at 83, 84, as indicated to engage screw heads 85, 86, on screws 87, 88, threaded respectively in the nuts 55 and 60. These screws are provided with capstan bars 89. If desired, a filler plate 90, may be interposed between the wedge 82, and the cage 74, or the wedge 81, and the cage 75, as the case may be, depending upon the position on the rolls that it is desired to have the stock enter. The use of the two opposed wedges makes it possible to move the whole feed box assembly including the wear plates, the rollers, the cage and the bosses in a direction perpendicular to the plane defined by the axes of the two rollers so that the stock may enter the rolls close to or far from their apices. The wedges may also be used to supply a sufficient initial pressure upon the opposed edges of the stock to insure proper operation.

When it is desired to disassemble the feed box, the pressure on the wedges is released and the box may then be withdrawn from below because the flanges of the channels are outwardly disposed. When the box has been withdrawn, it is then possible to withdraw the two wedges by moving them laterally in a direction perpendicular to the plates 53, 56, to disengage them from the nuts 84, 85.

As the stock is fed up through the pass between the rolls, it is distorted. The thickness remains constant or substantially constant at its inner periphery and is greatly decreased at its outer periphery. As a result, the inner periphery of the flight is short relatively to the outer periphery, this causes the stock to take generally the shape shown in Figure 8. Whichever way it goes, however, to the right or left as it comes out of the pass decides the question whether the flight is going to be a right hand or left hand flight. In order to control this, I use a wedge 91, which will be yieldingly held in the space between the rolls immediately adjacent the discharge side of the pass by a spring support 92, pivoted at 93, on a bracket 94, supported by the upper ends of the angles 35. At its rear end, this spring is supported by links 95, on angles 96, which extend up through the table top 1. The wedge 91 is adjustably positioned on the spring lever 92, by means of a plurality of spaced holes 97, engaged by studs 98, so that the wedge may be longitudinally adjusted in consonance with longitudinal adjustment of the position of the feed box and stock for different positions of the pass along the face of the rolls.

If the flight is to be discharged to the right, the wedge is placed on the right hand side of the flight instead of as would at first thought be expected on the left hand side. In other words, the wedge is placed on the side of the flight toward which the flight is to go. The reason for and effect of this will hereinafter appear.

101 is a bracket slidable along the shaft 59. It is adapted to be locked in position by means of a set screw 102. This bracket carries the upright 103, upon which is slidably mounted a sleeve 104, which may be angularly and vertically adjusted and held in position by the set screw 105; projecting laterally from this sleeve 104, is another sleeve 106, inclined to the sleeve 104. Under some circumstances, the sleeves 106 and 104 may be angularly adjustable with respect to one another or under other circumstances they may be adjusted once and for all and welded or otherwise rigidly fastened together. The sleeve 106 carries axially adjustable therein a flight guide 107, adapted to be adjusted in position to engage the flight as it passes out from between the pass in opposition to the wedge 91.

110 is a motor mounted on a platform 111, beneath the table top 1. This motor drives by means of a gear reducer 112, and chain 113, one of the sprockets 32. A similar motor gear reducer and chain drives the other sprocket 32 so that there is a separate drive and separate gear reduction for each of the two rolls, there being no mechanical connection between them except that provided by the stock in the pass between them, which, experience teaches is entirely sufficient to maintain the rolls in proper coordination.

Figures 12, 13, and 14 diagrammatically show the discharge of the stock from the pass between the rolls. Figure 13 shows the rolls as you would look at them standing in front of the machine. Figure 12 shows the rolls as you would look down on them from above. Figure 14 shows the roll if the near roll and associated elements were removed. In each case a right hand helicoid conveyer flight is shown.

Considering first the aspect of the flight as in Figure 13, the rolls are so positioned that the thickest part of the flight is nearest to the apices of the rolls and nearest to the point at which the axes of the rolls prolonged, intersect, that is, at the point of minimum diameter of the roll the flight is the thickest and as the diameters of the rolls increase, the pass between them decreases and the flight decreases in thickness.

As the stock comes up through the pass, the tendency is for it to form a washer, the decreased thickness of the outer periphery resulting in an increased peripheral length and if nothing were done about it, the stock would tend to form a flat or nearly flat series of washers.

The guiding means applied to the flight after it has come through the pass determine whether or not the flight shall be right or left hand and determine the pitch. It will be noted that the stiffest part of the flight is at the inner periphery where the thickness has been little if any reduced. There is a tendency for the stock to come straight up, bisecting the angle between the opposed roll faces. The flight guide member 107 engages the near face of the flight, and wedge 91 engages the forward side of the flight, as seen in Figure 13. The wedge tends to bend the thinner less resistant portion of the flight to the left, in Figures 12 and 13 in the direction opposite to the direction the flight is going to take in leaving the rolls. The guide 107 tends to cause the flight to discharge from the rolls toward the right. The operation of these two guide members fixes the direction of travel and the angle or pitch and the change in direction of the stiffer central portion of the flight is a minimum while the change in direction or change in angle of the lighter, thinner, more flexible portion of the flight is a maximum. These two cooperating guide elements are all that is required to determine the direction of travel and the pitch. The wedge 91, forcing the thinner portion of the flight over to the left causes the flight itself to form as it is discharged from the roll, the desired pitch of the stock to conform to the pitch imposed upon it by the guide 107.

The idea of cold rolling helicoid conveyer flight is not new. The important thing about my device is that on one machine with one pair of rolls by merely adjusting the apparatus, I am able to roll a variety of diameters inside and outside and a variety of pitches and by substituting a single easily removable and easily adjustable feed box, I am able to roll stock of different width and thickness.

In setting up my apparatus, it is essential that the proper location of the stock within the rolls, that is the proper position and shape of the parts be predetermined, and the starting point for this is a determination of the distance from the inside edge of the stock to the point of intersection of the axes of the rolls.

Figure 17 is a diagrammatic fragmentary showing of the position of the rolls for rolling six inch flight showing in dotted lines the position of the rolls for sixteen inch flight and in dash lines the position of the rolls for a nine inch flight.

It will be noted that in each case the angles between the rolls varies from size to size, also that the distance between the roll apices and the starting point O also varies from size to size, thus demonstrating the necessity of providing in a machine of this type means for adjusting the rolls axially along the center line of the rolls, laterally at the front ends of the roll shafts and laterally at the back ends of the roll shafts.

This three-way adjustment of the roll shafts as indicated in Figure 17, in my experience is of the utmost importance. The rolls having a curved contour only generally conical may be adjusted to fit any shape of pass desired and they might be so adjusted to fit this shape of pass satisfactorily but the machine will not make a satisfactory conveyer unless the center lines of the axis of the two rolls intersect at a point common to all sizes of conveyers.

Under some circumstances, a wire range of interchangeable wear plates may be used, and the holes in the channels 51, 52, under these circumstances will be of such size and shape that when the studs are inserted into the bosses for any pair of wear plates, the wear plates will be fixed in position. The proper wear plates will be selected and will be bolted into position, the wedges being used both to assist in registering the wear plates with the stud holes in the channels and to help carry the load on the bolts. Such an arrangement insures a positive nonchanging positioning of the wear plates for each size of flight.

One reason for the use of the filler plate 90 is that by using it a minimum wedge screw travel will be needed to fix the position of the cages and wear plates which form a part of the stock feed box.

If desired, the slots which permit the lateral disassembly of the wedges may have substituted for them a pocket which can be aligned with a hole in one or both of the channel plates so that access may be had to the end of the screw to pin or weld the head to the screw in the pocket in the wedge.

The stub shaft 62, which carries the reel 63, is mounted on a slide block 125, which travels between the channels 126, 127, on the frame. This block may be horizontally displaced by a screw 128, threaded in the nut 129, rigidly supported on the channels 126, 127, so as to adjust the position of the reel to insure that the stock as it is paid off the reel into the feed box will always be discharged tangentially from the reel and will travel a straight path from such tangential discharge to the feed box.

In order to assist in positioning the feed box in place, it may be supported by a diagonal screw 130, threaded in a nut 131, supported between the angles 35. This nut is sufficiently forward that the feed box when the pressure on the wedges has been released may be rotated enough to pass down between the wedge 81, and the nut 131, and the inner end of the screw 130, to permit withdrawal of the box. The slight inclination of the screw is not sufficient to interfere with this operation.

Although the wedge 91, might under some circumstances, be rigidly supported, experience teaches that it is better to have it spring supported, because a smoother action results and there is less danger of scarring the flight as it is discharged from between the rolls or of obstructing the movement of the flight between the rolls.

With particular reference to Figure 5, the antifriction bearing, immediately adjacent the roll takes only radial load. The bearing at the rear end of the shaft takes both radial and thrust load. Of course, the radial load is a maximum adjacent the roll so that by having that bearing take only radial load, the total burden on the two bearings is satisfactorily divided.

Another important function of the feed box adjusting wedge is in connection with the initial setting up of the apparatus for a new size of helicoid conveyer flight. When the calculations have been made for setting up the rolls to properly shape and position the pass and for positioning the feed box in proper alignment with the pass, the various roll adjusting means and the feed box adjusting wedges will be manipulated to set the machine up according to the desired adjustment, then flight may be rolled. If it happens that because of slight inaccuracies of adjustment or because of yielding of the parts or wear of the parts, the adjustment is not absolutely correct, this will appear by measuring the flight, then the various adjustments including the feed box wedges may be manipulated to compensate for such inaccuracies. A further run may be made, the flight again measured and this process can continue until proper correct conveyer flight is discharged from the machine, then the positions of the various parts may be scribed or otherwise indicated on the table top and on the feed box support and at that time the feed box bosses may be welded in place so that whenever it is necessary to set the machine up again for the particular conveyer flight, the parts may be reset without further calculations.

In connection with Figures 15 and 16, conveyer flight has been shown both as discharged from the rolls according to my invention and as to devices of the past for the purpose of pointing out and emphasizing the fact that by my arrangement with the conveyer flight so discharged and so guided that the central axis of the helix makes an acute angle with a plane tangent to the forming rolls extending from them in the general direction of discharge, the stiffer thicker portion of the helix is given a minimum bend, thereby decreasing the burden upon the rolls and guiding elements and also decreasing the distortion of the metal.

Referring especially to Figures 15 and 16, which show two right hand helicoid flights of different pitch but the same outside diameter, and adapted to be mounted on the same size pipe, the stock in each case approaches the rolls along the line $x$—$x'$. As the helicoid is formed by the rolls, the wedge 91 forces the outer thinner, less resistant portion of the helicoid to the left, and the thicker, stiffer, more resistant inner portion of the helicoid is deflected slightly to the right. The thinner portion that was first deflected to the left as the helicoid is rolled out, travels in unison with the inner thicker portion winding about it so that the whole helicoid is discharged along the line $x'$—$x''$ which is the center of the helix. The line $x'$—$x'''$ is the line of the inner stiffer helix. Thus there is a minimum of distortion of the thicker portion of the helicoid as it is discharged from the roll. This is in sharp contrast with previous practice as indicated by the dotted line helicoid where instead of causing the two edges of the helicoid to discharge from the rolls, one on each side of the line of approach, the whole helicoid is forcibly bent to the right so that the thinner portion of the helicoid is discharged generally parallel with the line of approach and the deflection of the thicker, stiffer edge of the helicoid is greatly increased.

As a result, the distortion of the metal in my apparatus is reduced to a minimum in contrast with previously known devices where the distortion is a maximum. Because I allow the stiff portion of the helicoid so far as possible to travel the path it normally would travel doing the maximum amount of bending with respect to the thin, rather than the thick edge, I am able to use much lighter and cheaper guiding and positioning means. The wear on them and on the flight and the danger of scoring or distorting the flight is reduced to a minimum and even more important experience teaches that by my method the power requirements are substantially cut in half. The reverse of the above deflections would apply for left hand conveyer. The line $x'$—$y$ indicates the center line of the helicoid discharged according to the old method.

It will be realized that while I have described and illustrated an operative machine, still many changes might be made in the size, shape, arrangement and disposition of parts without departing materially from the spirit of my invention and I wish, therefore, that my showing be taken as in a large sense diagrammatic.

I claim:

1. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls.

2. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls, means adapted to yieldingly urge the wedge in a direction opposite to the direction of movement of the flight from the rolls.

3. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls, means for adjustably positioning the wedge in a direction longitudinally of the pass between the rolls.

4. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls, a guide member adapted to engage the side of the flight opposite to the side engaged by the wedge at a point in its travel entirely out of register with and beyond the area of engagement of the wedge.

5. In an apparatus for rolling helicoid conveyer flight, a bed plate, a pair of conical rolls supported on one side thereof, and adapted to rotate about axes generally parallel with the plate, a box frame structure projecting from the side of the bed plate opposite the side upon which the rolls are supported in general alignment with the pass between the rolls, a stock guide within the box frame adapted to guide the stock toward the pass between the rolls, means for laterally displacing the guide in a plane generally perpendicular to the plane of the bed plate and bisecting the angle between the roll axes and for locking the guide in adjusted position, and means for holding the guide against angular displacement.

6. In an apparatus for rolling helicoid conveyer flight, a bed plate, a pair of conical rolls supported on one side thereof, and adapted to rotate about axes generally parallel with the plate, a

rangement with the conveyer flight so discharged and so guided that the central axis of the helix makes an acute angle with a plane tangent to the forming rolls extending from them in the general direction of discharge, the stiffer thicker portion of the helix is given a minimum bend, thereby decreasing the burden upon the rolls and guiding elements and also decreasing the distortion of the metal.

Referring especially to Figures 15 and 16, which show two right hand helicoid flights of different pitch but the same outside diameter, and adapted to be mounted on the same size pipe, the stock in each case approaches the rolls along the line $x$—$x'$. As the helicoid is formed by the rolls, the wedge 91 forces the outer thinner, less resistant portion of the helicoid to the left, and the thicker, stiffer, more resistant inner portion of the helicoid is deflected slightly to the right. The thinner portion that was first deflected to the left as the helicoid is rolled out, travels in unison with the inner thicker portion winding about it so that the whole helicoid is discharged along the line $x'$—$x''$ which is the center of the helix. The line $x'$—$x'''$ is the line of the inner stiffer helix. Thus there is a minimum of distortion of the thicker portion of the helicoid as it is discharged from the roll. This is in sharp contrast with previous practice as indicated by the dotted line helicoid where instead of causing the two edges of the helicoid to discharge from the rolls, one on each side of the line of approach, the whole helicoid is forcibly bent to the right so that the thinner portion of the helicoid is discharged generally parallel with the line of approach and the deflection of the thicker, stiffer edge of the helicoid is greatly increased.

As a result, the distortion of the metal in my apparatus is reduced to a minimum in contrast with previously known devices where the distortion is a maximum. Because I allow the stiff portion of the helicoid so far as possible to travel the path it normally would travel doing the maximum amount of bending with respect to the thin, rather than the thick edge, I am able to use much lighter and cheaper guiding and positioning means. The wear on them and on the flight and the danger of scoring or distorting the flight is reduced to a minimum and even more important experience teaches that by my method the power requirements are substantially cut in half. The reverse of the above deflections would apply for left hand conveyer. The line $x'$—$y$ indicates the center line of the helicoid discharged according to the old method.

It will be realized that while I have described and illustrated an operative machine, still many changes might be made in the size, shape, arrangement and disposition of parts without departing materially from the spirit of my invention and I wish, therefore, that my showing be taken as in a large sense diagrammatic.

I claim:

1. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls.

2. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls, means adapted to yieldingly urge the wedge in a direction opposite to the direction of movement of the flight from the rolls.

3. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls, means for adjustably positioning the wedge in a direction longitudinally of the pass between the rolls.

4. In an apparatus for rolling helicoid conveyer flight, a pair of opposed generally conical rolls, means for guiding the stock to be formed toward the pass between the rolls and for constraining it in its travel to a plane perpendicular to the plane defined by the axes of the rolls and bisecting the angle between said axes, a wedge member whose width is substantially equal to the width of the stock, means for holding the wedge member in position between the rolls on the side opposed to the guide means in substantially the plane of approach of the stock, the thin edge of the wedge being presented to the formed flight as it emerges from the pass between the rolls, a guide member adapted to engage the side of the flight opposite to the side engaged by the wedge at a point in its travel entirely out of register with and beyond the area of engagement of the wedge.

5. In an apparatus for rolling helicoid conveyer flight, a bed plate, a pair of conical rolls supported on one side thereof, and adapted to rotate about axes generally parallel with the plate, a box frame structure projecting from the side of the bed plate opposite the side upon which the rolls are supported in general alignment with the pass between the rolls, a stock guide within the box frame adapted to guide the stock toward the pass between the rolls, means for laterally displacing the guide in a plane generally perpendicular to the plane of the bed plate and bisecting the angle between the roll axes and for locking the guide in adjusted position, and means for holding the guide against angular displacement.

6. In an apparatus for rolling helicoid conveyer flight, a bed plate, a pair of conical rolls supported on one side thereof, and adapted to rotate about axes generally parallel with the plate, a

box frame structure projecting from the side of the bed plate opposite the side upon which the rolls are supported in general alignment with the pass between the rolls, a stock guide within the box frame adapted to guide the stock toward the pass between the rolls, means for laterally displacing the guide in a plane generally perpendicular to the plane of the bed plate and bisecting the angle between the roll axes and for locking the guide in adjusted position, means for moving the guide longitudinally in a direction generally parallel with the direction of travel of the stock and for locking the guide against such movement, and means for holding the guide against angular displacement.

7. In an apparatus for cold rolling helicoid conveyer flight and the like, a bed plate, a supporting frame therefor, a pair of inclined roll shafts supported on the bed plate and constrained to adjustable movement in a plane parallel with the plane of the bed plate, a conical roll on the end of each shaft, the rolls being in juxtaposition to one another to form a pass between their opposed faces, separate power means for each shaft, supported on the frame below the bed plate and a separate flexible drive connection between each power means and its associated shaft whereby each shaft may be longitudinally, angularly, and transversely displaced without interference with the drive connection between each shaft and its associated power source.

8. In combination, a pair of shafts having intersecting axes, a generally conical forming roll on the end of each shaft nearest the point of intersection of the axes, bearings spaced along each shaft, one of them being near each roll, a foot associated with each bearing, projecting away from the plane of the roll axes, means associated with each foot for positively, and micrometrically, moving it in all directions in a plane parallel with the plane of the roll axes and for locking it in position after such movement, separate adjustable means located in the plane of the roll axes for positively preventing displacement in said plane, of the roll axes in response to pressure applied at the rolls.

9. In combination, a pair of shafts having intersecting axes, a generally conical forming roll on the end of each shaft nearest the point of intersection of the axes, bearings spaced along each shaft, one of them being near each roll, a foot associated with each bearing, projecting away from the plane of the roll axes, and means associated with the feet for supporting the bearings and adjustable means located in the plane of the roll axes for positively preventing displacement in said plane, of the roll axes in response to pressure applied at the rolls.

10. In combination, a pair of shafts having intersecting axes, a generally conical forming roll on the end of each shaft nearest the point of intersection of the axes, bearings spaced along each shaft, one of them being near each roll, a bed plate generally parallel with the plane of the axes, a foot associated with each bearing, resting upon the plate, means associated with each foot and the bed plate for positively and micrometrically, moving the foot in all directions in a plane parallel with the bed plate and for locking it in position after such movement, separate adjustable means located in the plane of the roll axes for positively preventing displacement in said plane, of the roll axes in response to pressure applied at the rolls.

11. In combination, a pair of shafts having intersecting axes, a generally conical forming roll on the end of each shaft nearest the point of intersection of the axes, bearings spaced along each shaft, one of them being near each roll, a bed plate generally parallel with the plane of the axes, a foot associated with each bearing, resting upon the plate, and means associated with the feet for supporting the bearings and adjustable means located in the plane of the roll axes for positively preventing displacement in said plane, of the roll axes in response to pressure applied at the rolls.

12. In combination, a pair of shafts having intersecting axes, a generally conical forming roll on the end of each shaft nearest the point of intersection of the axes, bearings spaced along each shaft, one of them being near each roll, a supporting sleeve encircling each shaft and positively aligning the bearings associated therewith, a bed plate generally parallel with the plane of the axes, a foot associated with each end of each sleeve for supporting the sleeve upon the bed plate, means associated with each foot and the bed plate for positively and micrometrically moving the foot in all directions in a plane parallel with the bed plate and for locking it in position after such movement, separate adjustable means located in the plane of the roll axes and engaging the sleeves for positively preventing displacement in said plane of the roll axes in response to pressure applied at the rolls.

13. In combination, a pair of shafts having intersecting axes, a generally conical forming roll on the end of each shaft nearest the point of intersection of the axes, bearings spaced along each shaft, one of them being near each roll, a supporting sleeve encircling each shaft and positively aligning the bearings associated therewith, a bed plate generally parallel with the plane of the axes, a foot associated with each end of each sleeve for supporting the sleeve upon the bed plate, adjustable means located in the plane of the roll axes and engaging the sleeves for positively preventing displacement in said plane, of the roll axes in response to pressure applied at the rolls.

HIRAM O. FULSON.

**EK F JOSEPH O. BAILEY'in Almış Olduğu Patent**

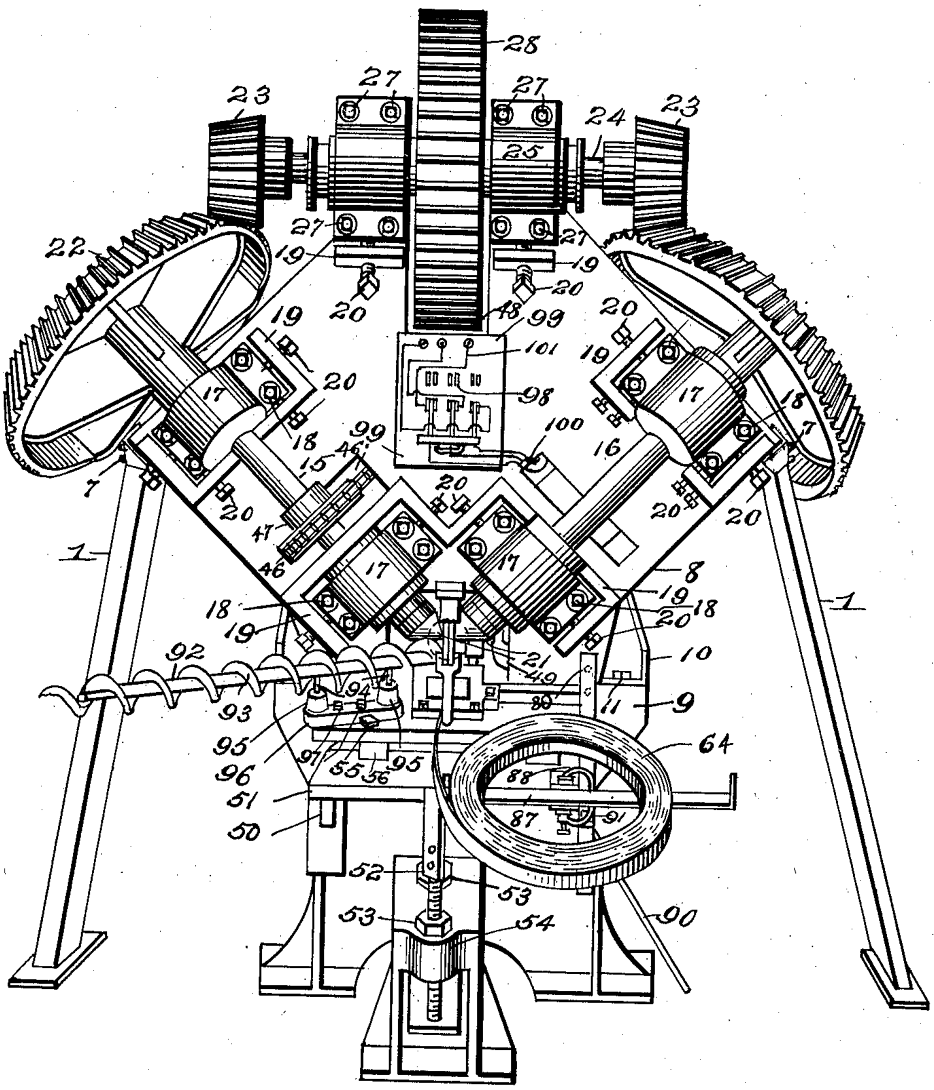
**Jan. 8, 1929.** **1,698,149**

J. O. BAILEY

MACHINE AND PROCESS FOR MAKING CONTINUOUS HELICOIDS OR CONVEYERS

Filed April 13, 1926 4 Sheets-Sheet 1

Fig. 1.

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Jan. 8, 1929. 1,698,149

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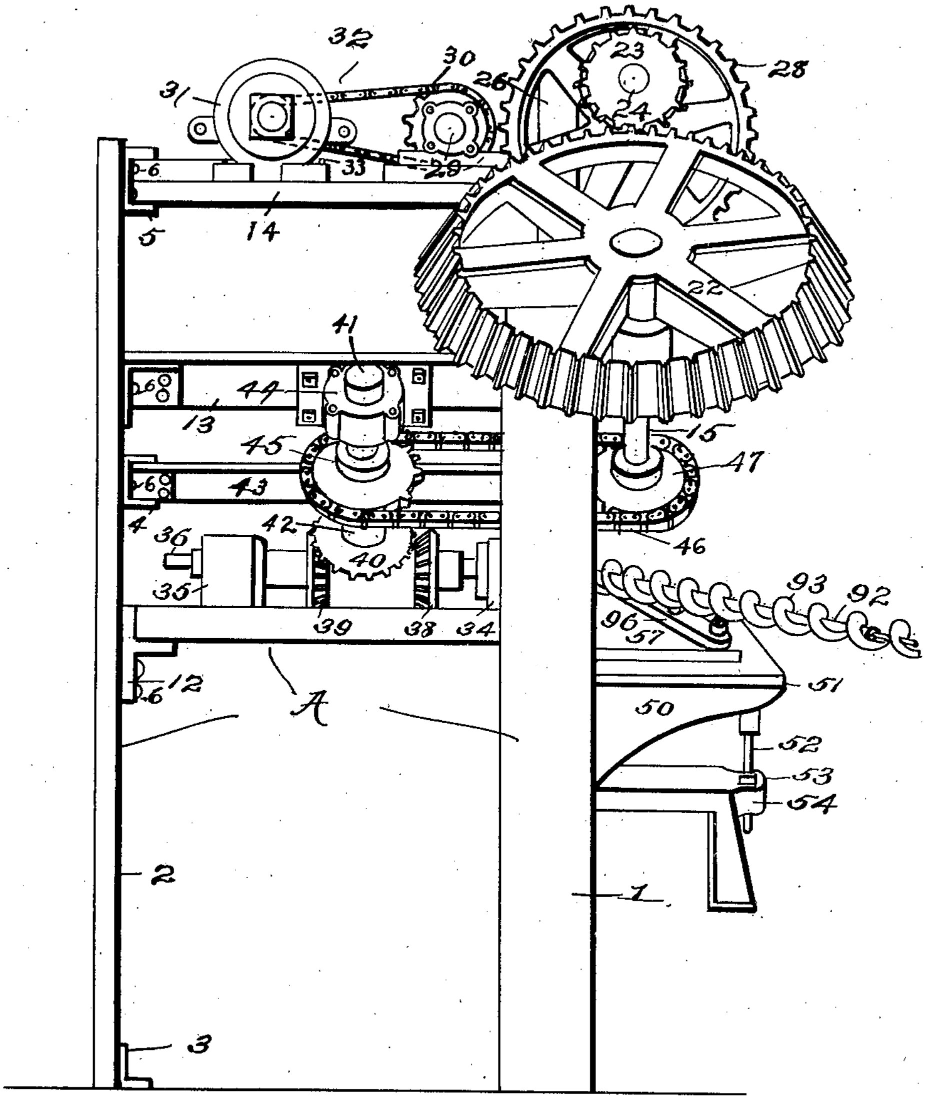
MACHINE AND PROCESS FOR MAKING CONTINUOUS HELICOIDS OR CONVEYERS

Filed April 13, 1926 4 Sheets-Sheet 2

Fig. 2.

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MACHINE AND PROCESS FOR MAKING CONTINUOUS HELICOIDS OR CONVEYERS

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4 Sheets-Sheet 3

Fig. 3.

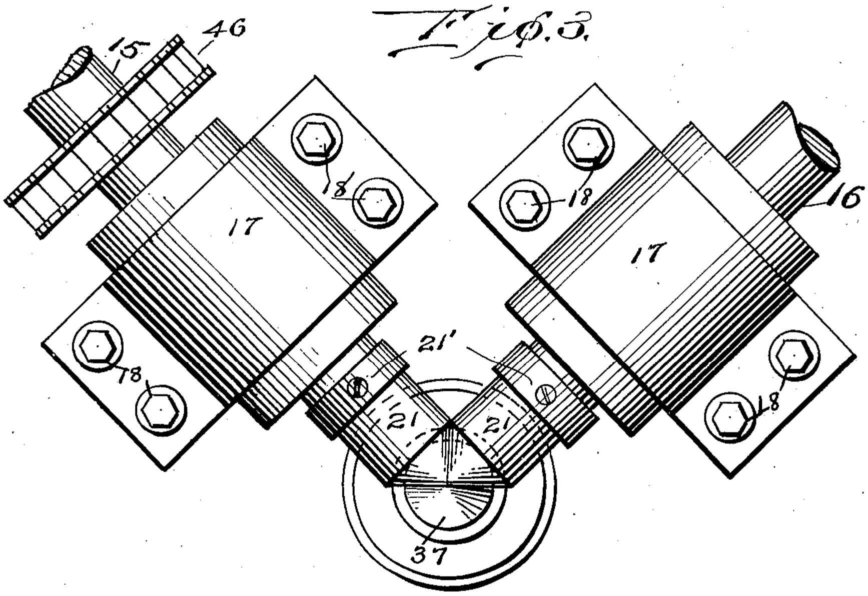
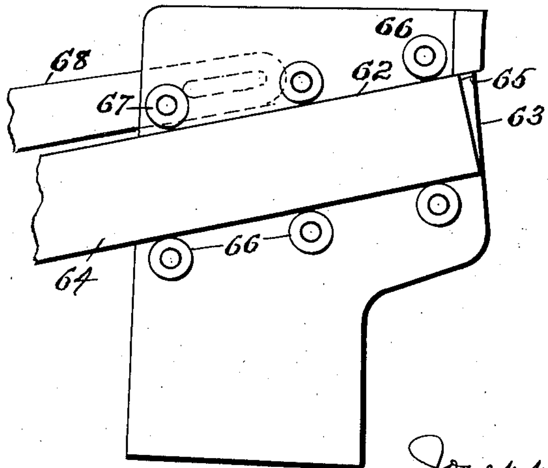



Fig. 6.

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MACHINE AND PROCESS FOR MAKING CONTINUOUS HELICOIDS OR CONVEYERS

Filed April 13, 1926 4 Sheets-Sheet 4

Fig. 4.

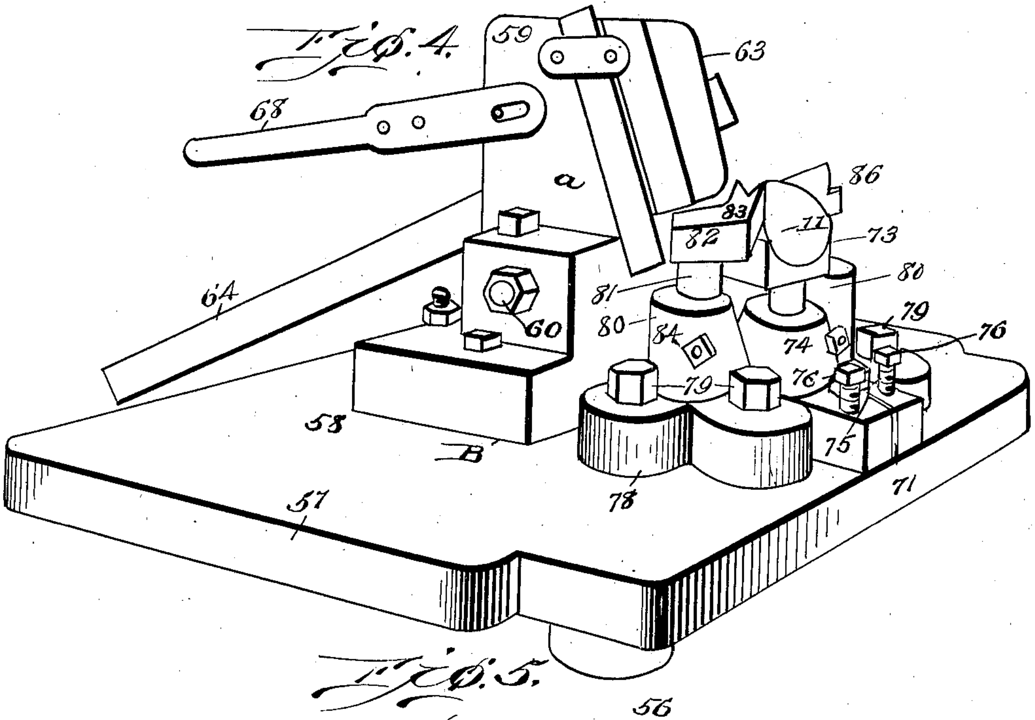
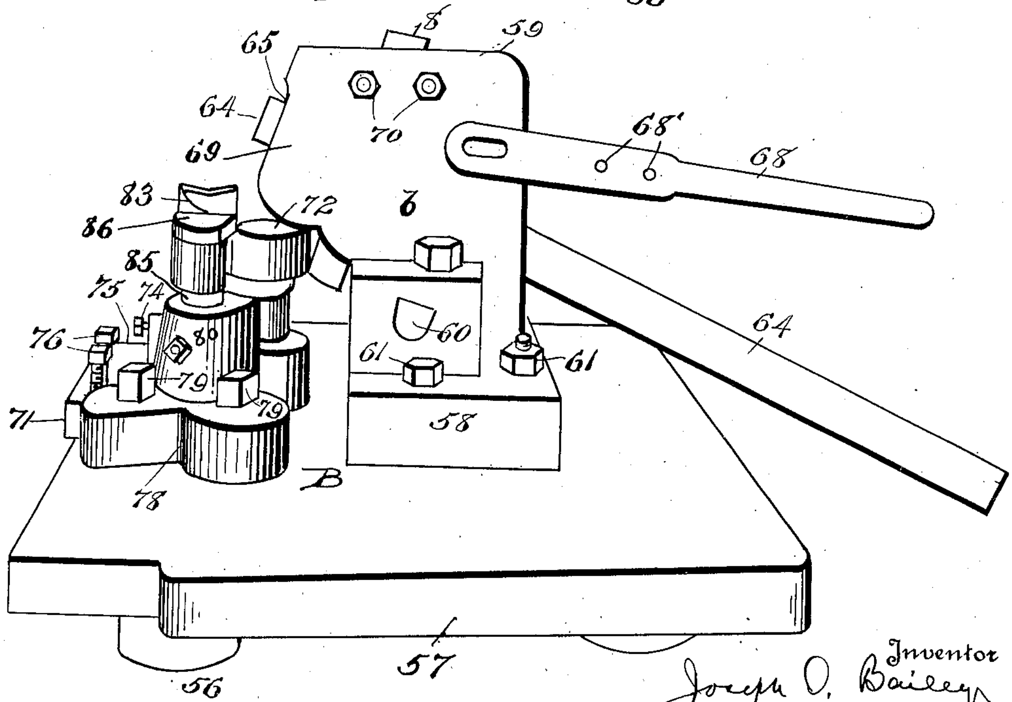



Fig. 5.

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Patented Jan. 8, 1929. **1,698,149**

# UNITED STATES PATENT OFFICE.

JOSEPH O. BAILEY, OF ATLANTA, GEORGIA.

## MACHINE AND PROCESS FOR MAKING CONTINUOUS HELICOIDS OR CONVEYERS.

Application filed April 13, 1926. Serial No. 101,716.

This invention broadly relates to metal shaping machines, but it more especially comprehends the type adapted to expeditiously form a bar of steel cold into a continuous helicoid or spiral conveyer.

A principal object of this invention is to design a machine provided with three cone-like pressure rolls angularly positioned with respect to each other, with their cone apices converging to substantially a common point, and adapted to form a bar or a strip of steel cold into a helicoid or endless conveyer as it travels therebetween.

While two beveled or cone-shaped rolls have heretofore been employed to shape a bar of heated steel into a spiral, such construction has proven incapable of satisfactorily functioning when the bar was not heated, therefore, an important object of this invention is the provision of a third roll, the points of all three rolls being in true alignment, and while all three rolls travel at the same speed, the third roll is adjustable to effect a slightly faster feeding movement for encouraging flow of the stock through said shaping rolls, and adapted for selective cooperation with either of said first mentioned rolls to effect either a right or left hand helicoid conveyer as desired.

A further object of this invention is to provide a stock feeding guide mechanism adjustable with respect to the meeting ends of the rolls to regulate the pitch and to enlarge or lessen the orifice in the center of the spiral, depending upon the size of the stock and type of spiral desired.

A still further object of this invention is the provision of a stock feeding guide embodying an adjustable roller structure for guiding and lessening the friction on the stock as it is drawn into the shaping dies or rolls.

Another object of this invention is the provision of adjustable deflecting quids or guides cooperating with the respective rolls for directing the course of the stock and assisting in shaping same into the desired configuration or helicoid.

With these and other objects in view, which will become apparent as the description proceeds, the invention resides in the construction, combination and arrangement of parts, hereinafter more fully described and claimed, and illustrated in the accompanying drawings, in which like characters of reference indicate like parts throughout the several figures, of which:

Fig. 1 is a front elevation partly in perspective of my improved machine for forming helicoids;

Fig. 2 is a side elevation of the same;

Fig. 3 is a detail front elevation of the forming rolls;

Fig. 4 is a perspective view of the feeding guide assembly;

Fig. 5 is a similar view from the opposite side of the same; and

Fig. 6 is a detail interior elevation of one half of the feeding guide showing the diagonal channel and rollers in position.

I am aware that spiral conveyers formed while the stock is in a heated condition is well known to the art, but the formation of a continuous helicoid conveyer from a bar of steel cold has proven to be commercially impossible and the attainment of which is a problem that has occupied for many years the attention of those skilled in the art, with scant success.

In the method of conveyer construction heretofore in use, and in order to manufacture the product in all sizes, it has been necessary to heat the bar to as nearly as possible a uniform heat, with the result of fire marks, damage to material, heavy and uneven places, charred and burned material, soft spots, and other troublesome and unsatisfactory conditions incident to the heating process, and it was to overcome such deficiencies, and render it possible to roll the bar cold thereby preserving all of the original qualities of the metal, effecting hardening of the outer surface and uniformity in strength and appearance, that I designed the device forming the subject matter of this invention, and which accomplishes the above result with ease and facility through the instrumentality of powerful gears mounted in heavy ball bearings adjacent each of the conical dies or forming rolls, and which in conjunction with the deflecting quids or shaping guides, owing to the scientific distribution of load stresses, enables the forming of continuous flight conveyers cold with rapidity and with a minimum of power.

In the illustrated embodiment characterizing this invention there is shown a supporting frame A comprising front standards 1 and rear standards 2, which latter are interconnected by cross beams 3, 4, and 5, respectively, firmly secured to said standards by bolts 6. The upper ends of front standards 1 are secured by bolts 7 to the longitudinally opposite corners of substantially square vertical frame plate 8, the lower corner of which rests on and is secured to the supporting stand 9. The said stand 9 is rigidly braced by angle bars 10 having their front ends fastened to either side of the upper face of the stand 9 by fastening elements 11 with their other ends resting on and firmly secured to T-bar 12 carried by the supporting standards 2. The longitudinally opposed corners of frame plate 8 supported by standards 1 are connected to rear standards 2 by bars 13, and the upper end of said plate is connected to cross-beams 5 by spaced parallel bars 14.

Mounted on the frame plate 8 parallelly spaced from each of its lower sides are roller shafts 15 and 16, respectively. Mounted in heavy thrust bearings 17 suitably secured to plate 8 by elements 18, and substantially surrounding each of said bearings is an upstanding integral flange 19 through which extends set screws or bolts 20 for adjusting laterally and longitudinally said bearings for a purpose which will hereinafter more fully appear. Shafts 15 and 16 terminate at their lower or meeting extremities in detachable conical rolls or dies 21 secured by a plurality of countersunk screws 21′ which structurally and functionally will hereinafter be described in more particular detail.

Secured on the upper ends of shafts 15 and 16 are large bevel gears 22 adapted to mesh with pinions 23 secured on the ends of horizontal shaft 24 mounted in bearings 25 secured to plate 8 and to the extensions 26 of said plate 8 by fastening element 27. Also mounted on shaft 24 intermediate bearings 25 is large gear wheel 28 adapted to mesh with a pinion (not shown) carried by drive shaft 29 mounted in bearings suitably secured and supported by parallel bars 14. Properly keyed or otherwise secured on one end of shaft 29 is sprocket wheel 30 connected to the motor 31 by drive chain 32, the said motor 31 being supported on and suitably secured to parallel bars 14 by fastening elements 33. Adjustment of the bearings 25 is effected similar to bearings 17 by set screws or bolts 20 threadedly engaging the flange-like projections 19 formed integral with the frame plate 8.

Mounted in bearings 34 and 35 supported on stand 9 and T-bar 12, respectively, is a third roller shaft 36 formed with a detachable cone-shaped roll or die 37 similar to rolls 21 and operatively positioned so that the apices of all three rolls will meet at substantially a common point as clearly shown in Fig. 3 of the drawings. Shaft 36 is adapted to effect longitudinal adjustment of the conical roll or die 37 with respect to rolls 21 for a purpose hereinafter more fully appearing.

Longitudinally slidable on the shaft 36 intermediate the bearings 34 and 35 are a pair of spaced bevel gears 38 and 39 adapted for respective selective engagement with a complemental bevel gear 40 mounted on the end of drive shaft 41 to effect reversal of the rotatable direction of shaft 36 and roll 37 to form either right or left hand continuous helicoid or spiral flight conveyer as desired. The lower end of drive shaft 41 is mounted in bearings 42 secured to beam 43, one end of which is attached to frame plate 8 and the other to cross-beam 4, the upper end of said shaft being mounted in bearing 44 supported by bar 13. Mounted on shaft 41 intermediate bearings 42 and 44 is sprocket 45 connected by chain 46 with sprocket 47 secured on roller shaft 15 from which it is driven.

It will be noted that shaft 24 through the instrumentality of pinions 23 and large gears 22 imparts powerful rotational force to shafts 15 and 16 and conical rolls 21 in directions towards each other, and to shaft 36 and conical roll 37 from shaft 15 through sprocket 47, chain 46, sprocket 45, shaft 41, gear 40 and gear 38 or 39 dependent upon whether it is desired for shaft 36 to cooperate with and rotate in the direction of shaft 15 or 16.

The frame plate 8 is recessed at its upper end as at 48 to receive the gear wheel 28, and at its lower end as at 49 surrounding the three cooperating rolls or dies 21 and 39 as clearly shown in Fig. 1 of the drawings, and is also formed with openings 46′ through which is adapted to extend chain 46.

A movable frame 50 is positioned adjacent stand 9 adapted to support a table 51 suitably secured thereto and vertically adjustable with respect to said stand 9 by jack screws 52 provided with threaded nuts 53 vertically supported in the base 54. Detachably secured to top 51 by fastening elements or bolts 55 spaced from said top by spacer washers 56 is a board or shelf 57 on which is adapted to be mounted the material or stock guide assembly B immediately facing the converging apices of the conical rolls 21 and 37, which will now be described in detail.

The stock guide assembly B comprises a pair of base blocks 58 between which is firmly clamped and vertically supported an inverted substantially L-shaped stock guide 59 by bolt 60, said blocks 58 being secured to board 57 by bolts or fastening elements 61. The said guide 59 comprises a pair of complemental members *a* and *b*, respectively.

Each of the members *a* and *b* are diagonally recessed on their inner surfaces as at 62 to form when operatively positioned the guide channel 63 through which the stock 64 is adapted to flow or be directed to the shaping rolls 21. Owing to the power exerted on the stock by the shaping rolls 21, a great tortional stress is imparted to the guide 59, and in order to reduce the wear and reduce friction an inlay 65 of very hard steel is inserted in the side walls of opening 63. To further reduce friction the stock is adapted to travel through the guide 59 between hardened steel rollers 66 positioned along the top and bottom of the channel 63. The initial top roller 67 is eccentrically mounted in the bifurcated end of the handle 68, which is detachably secured to the main portion of the handle as at 68′, and as the handle is brought down the roller exerts a pressure on the stock which tends to steady it on each of the other rollers, and which construction permits a slight variation in stock widths without any adjustment of the other rollers. While the rollers 66 in the present instance are shown as fixed, it is to be understood that they may be adjustably mounted to accommodate varying widths of stock, as desired.

The inner edge of guide 59 is wedge-shaped as at 69 to extend substantially between the beveled surfaces of rolls 21 when operatively positioned so as to deliver the stock 64 directly to said rolls. The upper ends of the complemental members *a* and *b* are firmly secured together by bolts or fastening elements 70.

Mounted on the board 57 intermediate the stand 9 and guide 59 is a substantially rectangular base block 71 formed with integral upstanding portions at its inner end and centrally thereof vertically bored to receive the stem portions of the hardened steel frictionless roller guide 72 and the steel housing member 73 adjustably secured by set screw 74, the said base block 71 being movably secured to shelf or board 57 by bolt or fastening element 75 and longitudinally and arcuately adjustable with respect to said guide 59, additionally secured in such adjusted position by set screw 76. As apparent from the above, the friction steel roller guide 72 is adjustable either to the right or left as occasion may require, and has a controlling influence in guiding the stock out to the diameter and spiral pitches required. The hardened steel member 73 has its upper face hollowed out as at 77 to fit the cone surface of roll 37 constituting a housing or guard therefor to prevent jamming of the stock and is suitably recessed on its under side to allow free rotation of the roller guide 72.

Positioned adjacent base block 71 spaced from block 58 is a substantially triangular base member 78 secured to board 57 by fastening elements 79 and formed with an integral upstanding portion 80 centrally bored to receive the vertical stem 81 of the deflecting guide or quid 82 formed integral therewith. The deflector or guide 82 projects from said stem 81 laterally and upwardly with its upper surface hollowed or dished as at 83 and is adapted to partially extend back of conical roll 21 adjacent roll 37 so as to contact the outer surface of the helicoid as its emerges from conical rolls 21 and 37, directing it from the machine and assisting in maintaining uniformity in diameter and pitch, when forming a left hand helicoid conveyer. The said deflector guide 82 is arcuately and vertically adjustable by stem 81 which is held in any desired position by set screw 84.

A similar base block 78 identically positioned on the opposite side of block 71 secured by elements 79 to board 57 and with the centrally bored upstanding portion 80 adapted to receive the vertical stem 85 integrally formed with the deflecting guide or quid 86 corresponding to deflector 82 in structure and function, except being positioned on the opposite side of the housing 73, is adapted to take off the stock or helicoid from the opposite side of the machine when the rotational direction of the third or horizontal roll 37 is towards said deflector 86 to form a right hand spiral conveyer.

An adjustable and detachable spider-like frame 87 adapted to support the stock 64 prior to its delivery to the guide 59 is positioned at one side of the machine, in the present instance secured to the corner of board 57 by clamp 88 and to stand 9 as at 89 and supported by leg 90 secured to said frame as at 91, as clearly shown in Fig. 1 of the drawings, and supporting arm 92 over which is adapted to travel the finished right hand spiral conveyer 93 as it emerges from the machine, is formed with standards 94 adapted to be vertically supported in the upstanding portions 95 integrally formed with the base 96 secured to board 57 by fastening elements or bolts 97. In forming a left hand spiral or continuous flight conveyer the stock is taken off the machine from the opposite side to that shown in Fig. 1, and in which case the relative positions of frame 87 and arm 92 with respect to the machine are reversed.

The motive power of the device is controlled by switch 98 secured centrally of frame plate 8 as at 99 and connected to electric motor 31 by wires 100 and 101.

While the operation of the device is clear from the above description, it might be well to explain in more detail the operation with respect to certain features of the invention.

Before passing the stock 64 to the rolls from guide 59, the said rolls 21 and 37 are adjusted to the proper spacing, preferably to compress the metal or stock on its outer edge and thicken it on its inner edge, the direction and pressure of the third roll 37 being towards and against the roll 21 on the side of the machine from which the finished helicoid or continuous conveyer flight is taken.

While the diameter of the helicoid is primarily controlled by the thickness of the stock, the outside of the diameter and the inside of the orifice through the spiral is controlled by raising or lowering the bar or stock with respect to the conical faces of the rolls 21 through the instrumentality of table 51, and adjusting the deflecting guides 82, 86, and 72 to the desired size of the helicoid to be formed.

The desired curvature or helical to form a spiral conveyer of given size and pitch is further regulated by an adjustment of the flow of the stock to the conical rolls and longitudinal adjustment of roll 37.

After the device has been properly adjusted as above, the stock 64 is passed between conical rolls 21 around and between one of said rolls and roll 37 on the side of the machine from which it is to be taken, where it is engaged by the deflecting guides 82 or 86 and directed from the machine on arm 92 in the form of the desired helicoid or continuous spiral conveyer.

It is apparent from the above that I have designed a machine of simple construction, easily adjusted, and adapted to exert a powerful shaping force on a bar of cold metal or steel to expeditiously form the same into the desired type of continuous helicoid or spiral conveyer.

Although in practice I have found the form of my invention illustrated in the accompanying drawings and referred to in the above description as the preferred embodiment, is the most efficient and practical, yet realizing the conditions concurrent with the adoption of my device will necessarily vary, I desire to emphasize that various minor changes in details of construction, proportion and arrangement of parts, may be resorted to within the scope of the appended claims without departing from or sacrificing any of the principles of this invention.

Having thus described my invention, and without enumerating variations and equivalents, what I desire protected by Letters Patent is as set forth in the following claims:

1. A method for forming a helicoid consisting subjecting the stock to the spiraling action of a trio of coacting surfaces having their longitudinal axes located in planes at substantial right angles to each other.

2. A method for forming a helicoid consisting in successively passing the stock between pairs of a trio of coacting rotary surfaces having their longitudinal axes located in planes at substantial right angles to each other.

3. In a machine for forming continuous helicoids or spiral conveyers, the combination of a trio of conical pressure rolls having their apices converging to a common point adapted to engage the stock to form a helicoid, and means for driving the rolls.

4. In a machine for forming continuous helicoids or spirals, the combination of three conical pressure rolls angularly positioned with respect to each other, one of said rolls adapted for selective cooperation with either of the other rolls for engagement with the stock to form a helicoid.

5. In a machine for forming continuous helicoids or spirals, the combination of a pair of conical rolls mounted in substantially a vertical plane, a third conical roll mounted in a longitudinal plane and adapted for selective cooperation with either of the other rolls for engagement with the stock to form a helicoid.

6. In a machine for forming continuous helicoids or spiral conveyers, the combination of two conical pressure rolls mounted in the same axial plane, a third conical pressure roll mounted at substantial right angles to the first mentioned rolls and longitudinally adjustable with respect thereto.

7. In a machine for forming continuous helicoids or spiral conveyers, the combination of three rotatable shafts having conical rolls detachably secured to their lower ends with their apices converging to a common point, and means for driving said shafts.

8. In a machine for forming continuous helicoids or spiral conveyers, the combination of two shafts formed with conical pressure rolls mounted in the same axial plane, a third shaft formed with a similar conical pressure roll mounted at substantial right angles to the first mentioned shafts, means for driving said first mentioned shafts, and additional means for driving the third shaft from one of said other shafts.

9. In a machine for forming continuous helicoids or spiral conveyers, the combination of a trio of conical rolls, means for guiding the stock to the rolls, and means for effecting vertical adjustment of the guiding means with respect to said rolls.

10. In a machine for forming continuous helicoids or spirals, the combination of a plurality of conical pressure rolls, means for guiding the stock to said rolls, means for guiding the stock from said rolls, and means for effecting simultaneous vertical adjustment of both of said means with respect to said rolls.

11. In a machine for forming continuous helicoids or spirals, the combination of a plurality of conical pressure rolls, means for guiding the stock to said rolls, means

for guiding the stock from said rolls, both of said means being mounted as a unit, and means for effecting vertical adjustment of the unit with respect to the rolls.

12. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical pressure rolls, means for guiding the stock from said rolls, said means comprising a rotatable deflector guide.

13. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical pressure rolls, means for guiding the stock to said rolls, means for guiding the stock from said rolls, said latter means comprising fixed and rotatable deflector guides.

14. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical pressure rolls, means for directing the stock to said rolls, means for assisting in shaping and guiding the stock as it emerges from said rolls comprising a deflector guide vertically and transversely arcuately adjustable with respect to the longitudinal axes of said rolls.

15. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical pressure rolls, means for directing the stock to said rolls, means for assisting in shaping and guiding the stock as it emerges from said rolls, said means comprising deflector guides certain of which are vertically and transversely arcuately adjustable with respect to the longitudinal axes of said rolls.

16. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical pressure rolls, means for directing the stock to said rolls, means for assisting in shaping and guiding the stock as it emerges from said rolls, said means comprising deflecting guides cooperating with the rolls on opposite sides thereof, one of said guides adapted to engage the stock when forming a right hand conveyer and the other when forming a left hand conveyer.

17. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical pressure rolls, means for directing the stock to said rolls, means for assisting in shaping and guiding the stock as it emerges from said rolls, said means comprising deflecting guides cooperating with the rolls on opposite sides thereof, certain of said guides adapted to engage the stock when forming a right hand helicoid and others when forming a left hand helicoid, and an additional guide adapted to engage the stock when forming either a right or left hand helicoid or conveyer.

18. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical pressure rolls, means for guiding the stock to said rolls comprising roller bearings between which the stock is adapted to pass, certain of said rollers being eccentrically mounted.

19. In a machine for forming continuous helicoids or spiral conveyers, the combination of a plurality of conical rolls, means for guiding the stock to said rolls comprising roller bearings between which the stock is adapted to pass, one of said rollers being eccentrically mounted, and means for operatively contacting the eccentric roller with the stock.

20. In a machine for forming helicoids or spiral conveyers, the combination of a plurality of conical rolls, means for guiding the stock to the rolls, deflecting guides for directing the stock from said rolls, and an adjustable guard means associated with one of said rolls for preventing jamming of the stock.

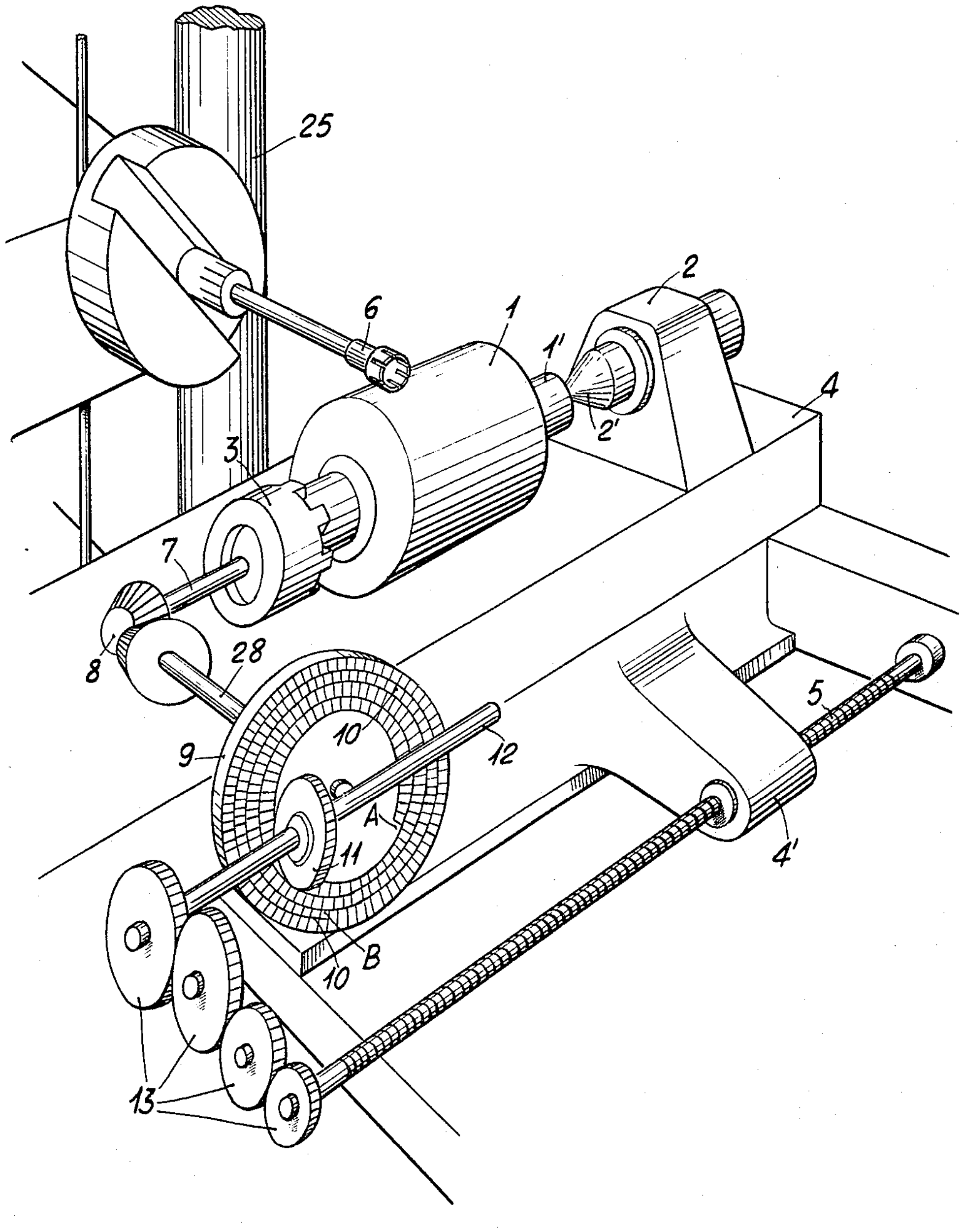
JOSEPH O. BAILEY.

**EK G LUIGI DANIELI'nin Almış Olduğu Patent**

**Nov. 8, 1966** L. DANIELI **3,283,661**

APPARATUS FOR MACHINING VARIABLE PITCH HELICOID GROOVES IN ROLLING MILL ROLLS

Filed July 14, 1965

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# APPARATUS FOR MACHINING VARIABLE PITCH HELICOID GROOVES IN ROLLING MILL ROLLS

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Hot rolling mills for producing balls directly from the bar are already known.

For a particular type of rolling mill being the subject of another patent application by the same applicant, there are employed rolls each of which is peripherically provided with a variable pitch helicoidal groove, having a semi-circular cross-section corresponding to that of the balls it is wanted to obtain.

Subject of the present invention in now an apparatus which, mounted on conventional machine tools such as milling machines, boring machines and the like, is apt to realize on a rolling mill roll of this type the helicoid groove mentioned above.

More exactly, subject of this invention is an apparatus for realizing variable pitch helicoid grooves on rolling mill rolls, characterized by the fact that it includes, in combination: a movable table of any whatever machine tool, provided with a milling cutter, on which the apparatus is mounted; two supports carried on said table and apt to support respectively by means of a spindle and a tailstock, the roll to be grooved so as to have it rotated at a variable speed under the milling cutter; a disc carrying on one face, in its central zone, a spiral rack, and peripherically a flat cylindrical gear merging with the (spiral) rack, the disc being apt to transmit to the spindle, and therefore to the roll, a variable speed revolving motion, through two shafts coupled by means of a pair of bevel gears; a sprocket wheel keyed on a splined shaft, transmitting the movement to the disc by meshing with the spiral rack and with the flat cylindrical gear; transmission and driving systems respectively apt to transmit the rotational motion to the sprocket and to generate the travelling motion of the table carrying said supports in the same direction of the axis of the roll to be worked.

The attached drawing, in its single figure, represents schematically in the way of a non limiting example a perspective view of the apparatus being the subject of the present invention, mounted on a conventional milling machine.

With reference to said figure, one can see that the apparatus being the subject of the present invention includes a movable table **4**, of any whatever machine tool, for instance of the milling machine **25**, on which the subject apparatus is mounted.

On said table **4** there are mounted two supports, one of which is indicated by the numeral **2**, and carries the tailstock **2'**, while the other, for sake of simplicity, is not shown in the figure and carries the spindle **3**.

Between the spindle **3** and the tailstock **2'** there is mounted the rolling mill roll **1** that has to be grooved on its upper lateral surface, the spindle **3** and the tailstock clamping the axis **1'** of said roll **1**.

On said lateral surface of the roll **1** is apt to make engagement a milling cutter **6**, carried by the milling machine **25**.

The spindle **3** is driven by a shaft **7**, receiving in turn its motion, through a pair of bevel gears **8** and a shaft **28**, from a disc **9** fast with the shaft **28** itself. Such a disc **9** carries on one face a spiral rack **10**, starting in a point A and ending in a point B, where it merges with a flat cylindrical gear **10'**, representing practically the closed loop extension of the rack **10**.



With said rack **10** meshes the cylindrical sprocket **11**, keyed on the splined shaft **12**, driven by a four gear transmission **13**, receiving its motion from the screw threaded shaft **5**, actuating the travelling motion of the table **4**. The screw threaded shaft **5** which is driven in any suitable way by the machine tool on which the apparatus subject of this invention is mounted, causes the displacement of the table **4** in the same direction of the axis of the roll to be machined **1**, thanks to a lead nut provided on a bracket **4'** protruding from the table **4**.

As stated above, the groove on the roll **1** is machined by the milling cutter **6**, driven from the above machine tool or by an independent drive.

The particular path of the variable pitch groove is obtained by means of the sprocket **11** and the rack **10–10'** system as follows:

At the beginning of the cycle, the milling cutter **6**, rotating at a constant speed, is positioned at the end of the roll **1** to be grooved, almost in contact with same; the disc **9**, carrying the rack **10** is still, so that the initial point A of said rack **10** be on the axis of the shaft **12** which has a diametrical direction in respect to the disc **9**, while the sprocket **11** is meshing in the point A.

Through rotation of the screw threaded shaft **5**, there is started simultaneously the rotational movement of the roll **1** and the travelling motion of the table **4**, and the milling cutter **6** begins to cut into the roll **1**.

The table **4** has a constant speed travelling motion and the sprocket **11** has a constant rotational speed. The roll **1** instead has a variable rotational speed since it is driven by the disc **9**, also having a variable rotational speed, and namely a decreasing speed inasmuch as it is made to rotate by the sprocket **11** through the spiral rack **10**.

Beginning from point A, the sprocket **11** travels on the rack until it reaches the point B, where it switches over the flat cylindrical gear **10'**, continuing then to rotate peripherically on the disc **9**. While the sprocket **11** meshes with the rack **10**, there is thus produced on the roll **1** a variable increasing pitch groove the increments whereof, at each pitch, are proportioned to the speed increments affecting a point travelling on a rotating flat spiral having a constant pitch. Instead, as soon as the sprocket **11** meshes with the flat cylindrical gear **10'**, the groove machined by the milling cutter **6** on the roll **1** result with a constant pitch, since in this stage the rotational speed of the roll **1** is constant.

Other expedients besides those described above may be applied to improve the apparatus subject of the present invention, without therefore departing from the protective field of the present invention.

In particular, the apparatus may be independent, that is provided with its own drive, both for the milling cutter and for the table travelling motion, and for the rotation of the roll to be machined.

What is claimed is:

1. An apparatus for providing variable pitch helicoid grooves on rolling mill rolls, including in combination: a movable table of any whatever machine tool provided with a milling cutter, on which the apparatus is mounted; two supporting members carried on said table and apt to support respectively, by means of a spindle and a tailstock, the roll to be grooved, so that it will rotate at a variable speed under the milling cutter; a disc carrying on one face, in its central zone, a spiral rack and peripherically a flat cylindrical gear, merging with the rack, said disc being apt to transmit to the spindle, and therefore to the roll, a variable speed rotational motion through two shafts coupled through a bevel gear pair; a sprocket, keyed on a splined shaft, transmitting the movement to the disc by meshing with the rack spiral and with the flat-cylin-

drical gear; transmission and driving means apt to respectively transmit the rotational movement to the sprocket and to generate the travelling motion of the table carrying said supports in the same direction of the axis of the roll to be machined.

2. An apparatus for providing variable pitch helicoid grooves on rolling mill rolls, including in combination: a movable table of any whatever machine tool provided with a milling cutter, on which the apparatus is mounted; two supporting members carried on said table and apt to support respectively, by means of a spindle and a tailstock, the roll to be grooved, so that it will rotate at a variable speed under the milling cutter; a disc carrying on one face, in its central zone, a spiral rack and peripherically a flat cylindrical gear, merging with the rack, said disc being apt to transmit to the spindle, and therefore to the roll, a variable speed rotational motion through two shafts coupled through a bevel gear pair; a sprocket keyed on a splined shaft, transmitting the movement to the disc by meshing with the rack spiral and with the flat-cylindrical gear; transmission and driving means apt to respectively transmit the rotational movement to the sprocket and to generate the travelling motion of the table carrying said supports in the same direction of the axis of the roll to be machined, said transmission and driving means being constituted by a four gear transmission, the end gears whereof are respectively keyed on the end of the screw threaded shaft controlling the table travel, and on the end of the splined shaft carrying the sprocket, said four gear transmission being suitably designed for every groove section to be obtained.



3. An apparatus for providing variable pitch helicoid grooves on rolling mill rolls, including in combination: a movable table of any whatever machine tool provided with a milling cutter, on which the apparatus is mounted; two supporting members carried on said table and apt to support respectively, by means of a spindle and a tailstock, the roll to be grooved, so that it will rotate at a variable speed under the milling cutter; a disc carrying on one face, in its central zone, a spiral rack and peripherically a flat cylindrical gear, merging with the rack, said disc being apt to transmit to the spindle, and therefore to the roll, a variable speed rotational motion through two shafts coupled through a bevel gear pair; a sprocket, keyed on a splined shaft, transmitting the movement to the disc by meshing with the rack spiral and with the flat-cylindrical gear; transmission and driving means apt to respectively transmit the rotational movement to the sprocket and to generate the travelling motion of the table carrying said supports in the same direction of the axis of the roll to be machined, said transmission and driving means being constituted by a screw driven in any suitable way by the machine tool on which the apparatus is mounted, and by a lead nut with which is provided a protruding bracket of the table itself.

No references cited.

WILLIAM W. DYER, Jr., *Primary Examiner.*

G. A. DOST, *Assistant Examiner.*

## KAYNAKLAR


[1] DC industrial Review, July 2007 (www.kwsmfg. comaboutnewsarticlescrew-conveyor-systems-article.htm)

[2] MARR,W.C. , *"Machine For Twisting Metal and Forming Spiral Conveyers"* 393,378, U.S. Patent Office, (1888)

[3] CALDWELL, F.C., *"Spiral Conveyer Flight and Apparatus For Making Same"* 601,429, U.S. Patent Office, (1898)

[4] GUSTAVSEN, C.O., *"Machine For Rolling Helicoids or Spiral Conveyer"* 760,448, U.S. Patent Office, (1904)

[5] GUSTAVSEN, C.O., *"Machine For Making Helicoid or Spiral Conveyers"* 908,860, U.S. Patent Office, (1909)

[6] FULSON, H.O., *"Apparatus For Rolling Helicoid Conveyer Flight"* 2,262,227, U.S. Patent Office, (1941)

[7] BAILEY, J.O., *"Machine and Process For Making Continious Helicoids or Conveyers",* 1,698,149, U.S. Patent Office, (1929)

[8] DANIELI, L., *"Apparatus For Machining Variable Pitch Helicoid Grooves in Rolling Mill Rolls"*, 3,283,661, U.S. Patent Office, (1966)

[9] NOGAY, N., "*Helezon Konveyörlerin Tasarım Kriterleri",* Yüksek Lisans Tezi,Yıldız Teknik Üniversitesi,Mak.Müh.Anabilim Dalı, İstanbul,(2007)

[10] GERDEMELİ, İ., *"Sürekli Transport Sistemleri"*, Mak.534, İTÜ, İstanbul

[11] UTKU, H., *"Sonlu Elemanlar Yöntemi"*, ISBN 978-9944-0344-0-1,Eylül, (2008)